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Final
Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota

Prepared for:

Minnesota Environmental Quality Board
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FINAL GENERIC ENVIRONMENTAL IMPACT STATEMENT ON TIMBER HARVESTING AND MANAGEMENT IN MINNESOTA

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ABSTRACT: A Generic Environmental Impact Statement (GEIS) on timber harvesting and management in Minnesota was requested by the Environmental Quality Board to examine the effect expanded timber harvesting might have on the environment. The GEIS assesses environmental and related impacts at three different levels of statewide timber harvesting intensity. Mitigation strategies are suggested to address those impacts identified as being significantly adverse.

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EXECUTIVE SUMMARY

Overview

Indicative of a growing concern about the impact of increased timber harvesting on Minnesota's environment, a citizens' petition was brought before the Minnesota Environmental Quality Board (EQB) in July 1989. The petition requested the EQB to prepare a Generic Environmental Impact Statement (GEIS) on the cumulative impacts associated with timber harvesting and forest management in Minnesota. In December 1989, the EQB unanimously passed a resolution authorizing the preparation of such a GEIS and designated itself the responsible governmental unit for the study's preparation.

The EQB's resolution also established a ten-person citizen's Advisory Committee to help provide a direction and oversight through recommendations to the EQB. Specifically, the Advisory Committee was asked to assist in the preparation of the Final Scoping Decision (FSD), advise on selection of a project consultant, review and comment on all project work products, and make mitigation strategy recommendations.

The FSD was prepared during 1990 and issued in December 1990. The objectives called for in the FSD were to:

- develop a basic understanding of the status of timber harvesting and related forest management activities in Minnesota, and how this level of statewide activity relates to long-term sustainable levels of timber removals;
- identify and assess the environmental and related (i.e., economic and social) impacts associated with current and potential elevated levels of statewide timber harvesting and forest management activity; and
- develop strategies to mitigate potential significant adverse impacts that are identified.

A number of EQB-specified assumptions were used to prepare the GEIS. Key among these were:

Geographic Coverage and Forest Lands Under Consideration. The GEIS examines the impacts of timber harvesting and forest management on Minnesota's environment and on relevant sectors of the state and regional economies. The study was charged to consider all forest lands and resources within the state's boundaries to determine statewide cumulative impacts. This included commercial forest lands (timberlands), reserved, and unproductive forests. Emphasis was on the examination of cumulative impacts of timber harvesting and forest management activities occurring on all timberlands in Minnesota. This includes, to the extent possible, all public forest lands owned and/or managed by federal, state, county, or municipal governments as well as forest land owned by industrial and nonindustrial private interests.

Relationship to Timber Harvesting and Forest Management. The GEIS analyzes only those impacts resulting from timber harvesting and associated forest management activities in Minnesota. These include a broad range of human-induced activities such as logging, site preparation, reforestation, and forest road construction. In addition, changes due to ecological processes are also examined. Examples of these changes include aging of forest stands and the incidence of pests and diseases.

The GEIS assessed three levels of statewide timber harvesting activity that were prescribed by the EQB. These levels were the basis for incremental analyses of the potential impacts of timber harvesting and forest management:

- **4.0 million cords**. This was the level of statewide timber harvesting activity that occurred in 1990, the most recent year for which data were available at the time the study was undertaken;

- **4.9 million cords**. This is the level of statewide timber harvesting activity estimated to occur by 1995 if all announced or considered forest products industry expansions fully materialize; and

- **7 million cords**. This is the estimated maximum sustainable annual volume of timber growth available for harvest statewide for all tree species in the year 2000.

These three pre-established levels are referred to as the *base, medium,* and *high* scenarios, respectively. *Note that these are not recommended levels of harvest nor should their development and analysis be considered a plan. Rather, they are levels the study was asked to analyze to determine what the impacts would be if these harvests were to occur.*

All three scenarios project the spatial and temporal distribution of timber harvesting activity that might occur across the state over a 50-year planning horizon. This included projecting what tree species might be harvested as well as when and where that occurred. The USDA Forest Service's Forest Inventory and Analysis (FIA) database served as the primary data input for modelling these three scenarios. The FIA data (13,536 forest plots and other information) provided a statistical sample of existing forest conditions including estimates for location, types and extent of tree species and covertypes present, timber volume, growth, and mortality and various site, stand, and surrounding area descriptors. These data were assumed to represent Minnesota's forest resources.

Modelling and Assumptions

The FIA plots provided a spatial approximation of the total resource and were used as the basic *units* for allocating timber harvesting activity. Computer models were then used to generate realistic harvesting scenarios by incorporating the most recent available data covering the following:

- the volume (by size and species), location, and ownership of wood potentially available;
- existing, planned, or potential wood-based industries and their locations;
- costs associated with timber harvesting, transport, and forest management activities;
- the regional transport network to link the wood supplies with the processing facilities;
- forest management practices and the implications of these on the structure and species composition of the forests and yields of timber in the short- and long-term;
- criteria used by industries to select stands when making purchases of timber; and
- existing land management policies that influence the availability of timber for harvest.

The forest growth model used is an individual tree-based model that projects individual tree growth and mortality on each FIA plot. That model output was also analyzed each decade to assess covertype change via growth and stand dynamics. As the forest was projected, harvesting and associated forest management activities were scheduled by models that addressed individual stands in a way that made the most economic sense, given the mitigations and constraints on the various locations and ownerships. Resulting data from the scenarios formed the basis for most of the subsequent impact analysis undertaken by the study groups. Examples of harvest and management options for stands included: clearcutting, thinning, selective harvesting, or no harvesting. After harvest, the choices included natural regeneration or planting. The most appropriate option for each stand at each decision point was selected by a scheduling model that matched demand for a product with the stand or forest area best able to supply that product and in consideration of mitigations and other constraints. Forest and timberland area change from 1990 to 2040 was also implemented gradually throughout the 50-year period using estimates of annual change rates.

Outputs from the model runs included plots harvested by ten-year planning period; the type of harvesting; the products harvested and their cost; and assumed management activities. FIA plot expansion factors were then used to convert this to stand, ecoregion and state level descriptions of the forest and outputs. The study groups used various parts of this output, depending on their specific requirements for conducting environmental impact assessments. For example, the forest soils study group required information on the amount of timber removed by covertype and the frequency of harvests; whereas the wildlife group required data including the presence or absence of certain key tree species, the age and size class structure of stands, and any changes in covertype. Additional assumptions in those study areas are described in the following sections on those subjects.

Importantly, the model runs included ownership constraints and mitigations that reflect current and prospective management procedures and policies applied by the major forest land managers. Examples include:

- extended rotation forests (ERF), i.e., lengthened (usually by 50 percent) minimum rotation ages for approximately 20 percent of the timberland on state and USDA Forest Service ownerships (note that the Superior National Forest does not currently have an ERF program);
- greater use of uneven-aged management;
- designation and reservation of old growth and old growth replacement acreage;
- best management practices (BMPs), i.e., thinning or ERF within 100 feet of water; and
- wildlife buffers (thinning only within 200 feet of water) on the national forests and in the southeastern part of the state.

In addition, estimates of the actual availability of timberlands for harvest or management, developed separately by ownership, were used to set aside a portion of the timberland as *not available* for various economic, environmental and social concerns.

Note that if these ownership constraints and mitigations are not routinely applied to all timber harvesting and forest management activities during the next 50 years, the number and severity of significant impacts identified (see Base Scenario Review below for examples) will increase for all three harvest levels.

The percent of timberland assumed available for harvest ranged from 98 percent for forest industry lands to 53 percent for the Superior National Forest. State and county timberlands were assumed to be 95 percent available. These model runs also incorporated the USDA Forest Service allowable cut limits for yields from their timberlands for the base and medium scenarios, i.e., the lower two levels of harvest. The USDA Forest Service constraints were then relaxed for the high scenario model run, even though the actual constraints on USDA Forest Service lands have the potential to become more stringent in the future.

Inclusion of the above constraints and mitigations suggests that the base and medium scenarios were reasonable depictions of current and future timber availability and predominant land management practices.

Issues Addressed
By utilizing these three levels of timber harvesting and their related forest management activities the GEIS examines how current and increased levels of timber harvesting and forest management affect a number of important issues identified in the study's FSD. These FSD issues identify important attributes and characteristics of Minnesota's forests which are collectively defined in the study as *forest resources*. The issues identified were:

- *maintaining productivity of forests for timber production*: examining primarily sustainable harvest levels, all ownership classes, geographic regions, and forest types today and in the future;
- *forest resource base*: conducting a historical assessment of the state's forest land base including current condition and its evolution;
- *forest soils*: examining impacts on nutrient cycling, erosion, compaction, and overall site productivity;
- *forest health*: examining insect and disease infestation risks across all landowners, geographic regions, tree species, and forest types;
- *plant and animal diversity in forest ecosystems*: examining forests' biological diversity at genetic, species, and ecosystem levels, as well as covertype spacial patterns; species of special concern, threatened, or endangered species; and old growth and old forests;
- *forest wildlife and fish*: examining forest dependent species and their specific habitat requirements;
- *water quality*: examining changes in sedimentation and nutrient loading levels and runoff in lakes, rivers, streams, and wetlands, including impacts of fertilizers, compost, sludge, and pesticides on water quality;
- *forest recreation*: examining quantitative and qualitative recreation opportunity impacts covering various consumptive and nonconsumptive recreation activity types;
- *economics and management*: examining regional and state direct economic relationships, the tourism and recreation industry statewide, habitats of game species and economic relationships, and timber stumpage distributions among various uses; and
- *aesthetics and unique historic and cultural resources*: examining visual quality and unique heritage resources found in forested areas.

Other areas requiring analysis were: (1) recycled fiber opportunities and their timber harvesting relationships; (2) possible impacts of global warming on Minnesota's forests; (3) Minnesota's public forestry organizations and policies; (4) harvesting systems; and (5) silvicultural systems.

Detailed analyses of these issues were carried out through development of nine technical and five background papers. Focus of the analysis in all papers was assessing cumulative impacts occurring across the state, by region, and for various ecoregions. Figure I.1 indicates the ecoregions used in these analyses.

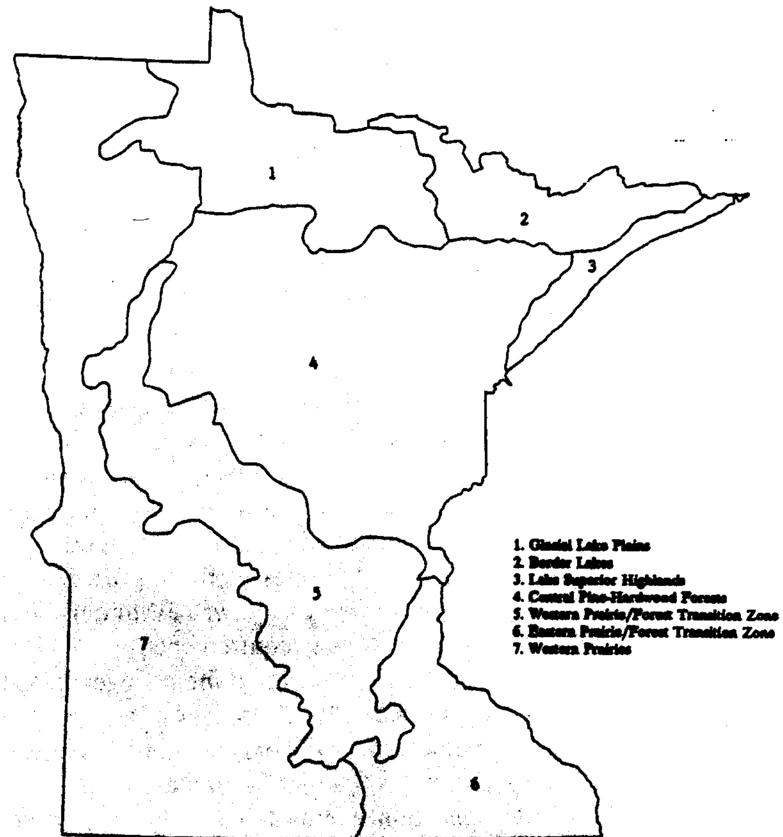

Figure I.1. Ecoregions used in the GEIS study. **(Source: Jaakko Pöyry Consulting, Inc. 1992a.)**

Data availability limited the extent to which impacts could be quantitatively assessed for certain issues. The GEIS study does identify areas where future research is needed to collect data that are currently unavailable, but that are necessary to completely address all GEIS-scoped issues.

GEIS Study Components

The study components, as summarized here, were designed to address the requirements outlined in the previous section:

- *Feasibility Study*: established the study's structure;
- *Workplan*: outlined the study's methodology;
- *Statewide Timber Harvesting Scenarios*: initial analyses of the three harvesting levels used to help identify probable impacts for all FSD issues;
- *Study Criteria*: criteria developed to help assess significant impacts, mitigation alternatives, and mitigation strategies;
- *Technical papers*: nine stand alone studies addressing collectively the FSD technical issues of concern;
- *Background papers*: five support studies addressing the other identified areas of interest (e.g., global warming, recycled fiber, etc.);
- *Draft GEIS document*: initial report targeted to fully synthesize and integrate the materials from the nine technical and five background papers, clearly summarize all relevant impacts, and describe recommendations to address the identified impacts; and
- *Final GEIS document*: subsequent and final report to address the above contents as modified to reflect review, commentary, and inputs from the peer review process, the Advisory Committee, the EQB, and the public at large.

Given these eight study components, the study criteria require some elaboration to put the balance of the executive summary into perspective.

First, the GEIS employed a number of models and submodels singly and in combination to develop projections for the study period. The models used, particularly those describing changes, were developed and/or employed to approximate the processes under study, natural or otherwise. However, there are limitations to any such modelling. Second, the interested study reviewer would benefit from examining work products associated with all eight study components. The criteria were developed to specifically evaluate each issue of concern from the perspective of cumulative impacts geographically and over time. Eighteen *categories* of impacts were discussed, based on the ten issue areas identified in the FSD. For each significance criterion developed, background information was used to determine levels or thresholds when impacts are likely to be considered significant. Similarly, a criterion was developed to identify possible mitigation measures and to select preferred strategies.

Minnesota's Forest Resources

Forest lands currently occupy about 16.7 million acres in Minnesota, or about 33 percent of the state's 50.8 million acres of land. This is approximately half the area of forest prior to European settlement (about 1850). The loss of forest area has occurred as a consequence of expanding agriculture and urbanization. In addition to a loss of forest area, timberland area (now 14.8 million acres) also declined by 3.4 million acres or 19 percent over the last 50 years. This was a result of a 700,000 increase in reserved forest area during the 1970s when the Boundary Waters Canoe Area Wilderness (BWCAW) and Voyageurs National Park were legislatively established, and 2.7 million acres of conversion of timberland to other land uses. Recent trends and projections of land use suggest the forest area in the north will continue to decline, largely due to development for other uses. However, the forest area in the southern part of the state is increasing due to reversion from marginal agricultural lands and that is projected to continue. Overall, the forest area in Minnesota is expected to increase slightly over 1990–2040.

The volume of timber in Minnesota's forests has increased severalfold since the 1930s as once small trees have matured from seedling/sapling status to pole- and sawtimber size. This accumulation of volume is due to net growth exceeding harvest rates for a number of decades.

Currently, timberland, reserved, and unproductive forest comprise about 88, 7 and 5 percent, respectively, of all forest land.

Minnesota's forest land can be classified into fourteen *forest types* (sometimes called *covertypes*), which was done for the GEIS. Each forest type bears the name of one or more tree species that form a majority of wood volume in the stand. Most stands have a considerable mixture of species and typically contain five or six species of trees. This can complicate the process of classifying stands into forest types.

Currently, the aspen forest type occupies about one-third of the state's total forest area. However, many aspen stands contain a high proportion of other hardwoods or conifers, so there is more diversity than this figure suggests. Black spruce occupies the largest area of any conifer type, due to its ability to grow on Minnesota's extensive peatland soils. Other major forest types include maple-basswood, oak-hickory, and elm-ash-soft maple, each comprising 7 to 8 percent of the total forest land area. The current forest landscape comprises a lower proportion of jack, red, and white pine forests; swamp conifers; northern hardwoods; and more aspen than in presettlement times.

Much of Minnesota's forest land was harvested in the late nineteenth and early twentieth centuries. In addition, other areas were cleared for agricultural uses, only to be returned to forest following the failure of these enterprises. Forests have reestablished on many formerly cutover and cleared lands and, once established, timber volume growth has exceeded removals (harvesting) and mortality. Therefore, despite ongoing harvesting, an increasing proportion of stands have grown into the older, larger size classes. The acreages in many forest types are now comprised of stands that are much older, on average, than they were in 1953, especially forest types that are of low commercial value. Although the average age of stands has been increasing recently, and most stands are in a mature state, there is still nowhere near the amount of old growth (>120 years old) that there was prior to European settlement, either as a percentage of the forest or in absolute acreage. Currently, there are about 610,000 acres of forest greater than 120 years old in the state (3.9 percent of all forest lands), compared with an estimated 13.9 million acres (51 percent of all forest) prior to European settlement (Jaakko Pöyry 1992e). This large shift in age structure, reduced forest acreage, and the species composition changes mentioned above, have reduced the biological diversity of Minnesota forests.

Minnesota's forest resources provide a variety of nontimber values important to addressing environmental, economic, and amenity interests and objectives. Among these are the following:

Water Resource Protection. Forest cover functions to affect the quantity, quality, and timing of water resources for human use and for aquatic species. Forest cover and the biological systems it includes has important mitigating effects on various land use practices in terms of protecting water quality.

Outdoor Recreation. Forests provide the habitat for wildlife species and the setting for many outdoor recreation activities, as well as for the very substantial resort industry that has developed in northern Minnesota.

Aesthetic Values-Attractiveness of the Forest. Maintenance of these values is important to insure that the forests continue to provide attractive recreational settings.

Cultural and Historical Values of the Forest. Forests contain a variety of heritage resources including sites that provide the most complete record of pre-European land use history, and sites of significance to contemporary Native Americans.

Biological Values of the Forest. The biological diversity of forests is of immense ecological, social, and economic importance to all regions of the world, for many reasons. Ultimately, the sustainability of forest resources, measured in either economic or ecological terms, depends on maintaining biodiversity.

Timberland Ownership and Timber Usage

Private individuals and corporations, other than the forest industry, own the largest area of Minnesota timberland—about 6.4 million acres or 43 percent. The state is the largest public landowner with over 3 million acres or 21 percent of timberland, followed by counties with 2.5 million acres or 17 percent; the national forests with 1.8 million acres and 12.3 percent; and the forest industry, 750,000 acres or 5 percent of all timberland in the state.

The six major forest products industries in Minnesota include: pulp and paper, hardboard, waferboard (also known as flakeboard) and oriented strand board (OSB), sawmills, veneer, and wood preservation.

The Minnesota forest products industry is in the midst of a significant expansion of output and wood consumption. Total demand from industrial, fuelwood, and nonindustrial uses increased from just over 1 million cords in 1960 to 1.5 million cords in 1975. Today, approximately 4.0 million cords are harvested statewide each year on approximately 200,000 acres. This includes wood consumption for pulpwood, paper and paperboard, OSB, lumber, fuelwood, and other uses. The greatest expansion has taken place in pulpmills, waferboard, and OSB mills. Much of the increase in the demand for pulpwood has been met by increasing the level of harvesting in the aspen forest type.

Sawmill roundwood receipts have also increased significantly, rising by 80 percent from 1960 to 1988. In contrast, there was little overall change in the demand for roundwood from other forest industries over this period.

The expansion of the wood industry in Minnesota is projected to continue for at least the next five years. Current forest industry expansion plans are based on previously discussed and/or permitted projects and include $1.6 billion in investments in new plants and equipment. These new mills, if built, will consume an estimated 790,000 cords of pulpwood per year in addition to the 4.0 million cords currently consumed as pulpwood, sawtimber, fuelwood, and other products.

Given the configuration of the state's pulp and paper mills, it is unlikely that market deinked pulp will replace *existing* virgin pulp production in Minnesota. However, use of market deinked pulp produced from Minnesota could replace up to 400,000 cords of pulpwood otherwise harvested in the state annually, if recycled pulp were used as a substitute for projected increases in virgin chemical pulp capacity. In addition, market deinked pulp could be used to replace purchased kraft pulp, which is the more likely ultimate scenario for Minnesota. Key here is that accurate projections regarding future use of recycled fiber are very difficult to make due to constantly changing technology and government policy.

Resource Management Framework

Minnesota, like other states, is faced with a highly complex natural resources decisionmaking environment. Minnesota's resources management framework is built on a myriad of policies, planning, coordination, programs, laws, regulations, guidelines, practices, and public participation. It involves federal, state, and county agencies; departments; commissions; boards; committees; and individuals, whose interests often overlap.

Key observations on the current status of forest land management are as follows:

- Minnesota has a substantial forest resource base today, regardless of how the overall effectiveness of its existing natural resources decisionmaking is viewed or judged;
- the complexity of these decisionmaking mechanisms and their present overlapping nature, both organizationally and functionally, create the potential for significant problems with development and implementation of future policies and decisions; and
- the natural resources decisionmaking process has grown inherently more complex over the past decade, consequently, the state will be faced with increasing potentials for difficulties in managing Minnesota's forest resources.

Contrasts Among the Timber Harvesting Scenarios

Comparison of the impacts projected to occur at the three different timber harvesting scenarios (base, medium, and high) illustrate important changes in forest resource conditions and associated values in response to these degrees of timber harvesting and forest management activities. The following highlights some of these major differences identified.

Acres Harvested Overview

Table I.1 contrasts the 1990 acres harvested one or more times and that not harvested during 1990-2040 for the three scenarios. Under the base scenario, 7.2 million acres are harvested while 7.6 million acres of timberland and 1.9 million acres of reserved and unproductive forest are not disturbed by harvesting over the study period. Thus, for the base scenario, a total of 9.5 million acres, or 57 percent of the forest, is not disturbed by harvesting over the study period. Timberland acreage is unharvested because it is still too young or under rotation age, of low productivity, uneconomic, or simply unneeded to achieve the specified harvest level. Although succession and stand development are controlled to some degree by humans in some managed forests (e.g., aspen managed to regenerate as aspen after harvest), 57 percent of Minnesota's forest landscape will not be harvested under the base scenario over the 50-year study period, so that natural forces of succession and stand development will be the primary influence on the landscape with or without timber harvesting. The percentage of the forest harvested increases considerably under the medium and high scenarios, but natural forces still play an important role in forest change.

Table I.1. Original acres harvested one or more times and not harvested during 1990–2040.*

Forest land use and harvest status	Total (thousand acres)
Total forest land acres	16,714.8
Reserved/unproductive	1,941.4
Timberland	14,773.4
Base Scenario	
Acres not cut	7,600.0
Acres cut	7,173.4
Medium Scenario	
Acres not cut	6,156.4
Acres cut	8,617.0
High Scenario	
Acres not cut	4,308.2
Acres cut	10,465.2

*Table 7.6 provides a breakdown of this acreage and harvest by ecoregion. See also section 5.1.1 for a discussion of assumptions and interpretation.

Forest Covertype Changes

Table I.2 contrasts the forest covertype acreage for timberland and all forest plots, 1990 and projected 2040, statewide for the three scenarios. Note that the forest covertypes used, by definition, contain a number of different tree species (see section 2.3.1). Perhaps most important is that acreage in various covertypes *is* sensitive to the level of harvesting. The increase in aspen timberland acreage with increasing harvest is an example of change due in part to harvesting. The overall forest and timberland acreage is expected to increase slightly, but the combination of harvesting and natural succession lead to important changes in future acreages by forest type. These changes argue for mitigations to slow such changes or at least to develop and seek to achieve covertype goals statewide. Failure to do so jeopardizes the timber and nontimber benefits the various forest types provide.

Note especially changes to selected covertypes. Jack pine experiences a significant reduction across all three timber harvesting scenarios, as does balsam fir. However, paper birch, which also shows a marked decline, seems to be less affected by harvest level. The same is found for black spruce. These changes indicate that a number of forces are affecting such changes, not just timber harvesting.

Table I.2. Forest type acreage for timberland and all forest plots under the base, medium and high scenarios, 1990 and projected 2040, statewide (thousand acres). Based on GEIS covertype algorithm. Each forest type contains a number of tree species. The reader should consult appendix 2 for forest covertype determination, and table 5.11 of this document for projected changes in individual tree species.

	1990		2040					
			Timberland			All Forest Land		
Forest Type	Timberland	All Forest Land	Base Scenario	Medium Scenario	High Scenario	Base Scenario	Medium Scenario	High Scenario
Jack pine	487.1	614.2	329.6	307.4	272.6	387.0	365.8	330.0
Red pine	350.6	430.1	452.4	454.4	433.2	541.0	543.0	521.8
White pine	137.3	148.3	141.0	136.0	120.2	174.9	169.9	154.1
Black spruce	1,320.8	1,997.9	1,001.2	945.4	957.8	1,637.0	1,581.2	1,593.6
Balsam fir	1,012.5	1,151.4	657.4	598.4	589.6	748.8	689.8	681.0
Northern white cedar	322.4	367.9	360.9	370.4	370.6	410.1	419.6	419.8
Tamarack	696.2	822.2	678.7	704.4	701.7	803.8	829.5	826.8
White spruce	137.0	181.0	227.9	202.7	158.2	334.6	309.4	264.9
Oak-Hickory	1,288.0	1,315.6	1,370.2	1,322.3	1,354.1	1,407.6	1,359.8	1,391.5
Elm-Ash-Soft maple	1,564.2	1,662.5	1,744.0	1,714.8	1,721.5	1,874.6	1,845.5	1,852.1
Maple-Basswood	1,301.8	1,334.5	1,460.2	1,368.6	1,255.2	1,497.1	1,405.5	1,292.1
Aspen	4,496.0	4,888.0	5,238.7	5,496.5	5,730.0	5,669.0	5,926.8	6,160.3
Paper birch	1,179.3	1,295.1	803.4	806.2	741.7	933.5	936.4	871.8
Balsam poplar	480.1	506.1	413.7	451.8	473.0	437.7	475.8	497.0
Nonstocked	0	0						
Other	0	0						
Total	14,773.4	16,714.8	14,879.4	14,879.4	14,879.4	16,857.0	16,857.0	16,857.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Stand Age Changes

Table I.3 compares the average stand age by covertype and scenario for timberland 1990-2040. Notable is the continued aging of the forest despite increased harvesting, which has important implications for aesthetics as older and larger trees are a positive component of such values. For most covertypes, the base and medium scenarios suggest the forest would be on average older and the largest trees larger in 2040 than at present. Notable exceptions to increasing average covertype age for these two scenarios are aspen and related forest types (e.g., balsam poplar) experiencing high demand. Under the high scenario, the mean age and size class of the forest would return to 1977-90 conditions (approximately) in the year 2040.

Table I.3. Average stand age by covertype and harvest scenario for timberland 1990-2040.

Forest Type	1990	2040		
		Base	Medium	High
Jack pine	48	77	69	42
Red pine	44	54	54	41
White pine	80	104	102	87
Black spruce	59	89	61	50
Balsam fir	46	82	71	58
Northern white cedar	97	116	106	94
Tamarack	57	99	85	55
White spruce	42	90	82	76
Oak-Hickory	69	78	71	63
Elm-Ash-Soft maple	56	86	75	60
Maple-Basswood	58	90	80	58
Aspen	41	34	33	28
Paper birch	58	92	81	61
Balsam poplar	41	33	31	31

Source: Jaakko Pöyry Consulting, Inc. (1992a). Projected ages for stands not clearcut were determined by adding 50 years to current age. See appendix 2 for more detail.

The changes in average age for aspen are due largely to harvesting, as demand is projected to be strong. At the same time, stands in reserved or otherwise unavailable status will continue to age. Consequently, aspen (and most other covertypes) will show a wider range of age classes than in the recent past.

Stand and tree age is also important as a major factor in determining tree size, quality, and value. For red oak, however, age may be deceptive as demand has been high for sometime and the quantity of high-quality timber is a concern. Locally, quality is problematic and depends heavily upon the history of stands with respect to grazing, logging, fire, etc.

Nominal rotation ages by covertype are shown in section 2.3.1 and range from 50 to 80+ years, but the actual age class distribution (many stands already older than the rotation age) and the need to schedule harvests over the entire study period precluded harvesting at rotation age for many stands.

Soil Resources Impacts
Soil resource impacts were developed by overlaying harvest locations on soil maps at a statewide scale. Harvest of merchantable bole did not remove either nitrogen or phosphorus beyond their rates of replenishment. Areas at risk for loss of calcium are most closely associated with harvest of aspen-birch and upland hardwoods on medium-textured soils and especially on coarse-textured soils (approximately 5 million acres are at risk for calcium loss). Loss of magnesium beyond rates of replenishment is especially associated with harvest on coarse-textured soils and organic soils. Under the base scenario, about 2.5 million acres are at risk for magnesium loss. Finally, potassium loss is primarily associated with harvest of aspen-birch on coarse-textured soils and the harvest of all deciduous types on organic soils. Under the base scenario, about 1.5 million acres are at risk for potassium loss.

For full tree harvesting, calcium losses increase slightly compared to merchantable bole harvest. In contrast, nutrient losses for magnesium and potassium are significantly increased.

The effect of nutrient losses on long-term site productivity are uncertain. Expectations are that nutrient losses, unless countered by inputs, will lead to diminished productivity in the long-term. Uncertainty remains over the levels of nutrients at which productivity may decrease.

Compaction and related disturbance would be most frequent on the well-drained medium-textured soils, which are the most common soils in the state, and the poorly-drained medium and poorly-drained fine soils which have the lowest strength.

Surface erosion rates were significant on less than 1 percent of the area harvested plus haul roads, and this significant impact was predominantly limited to well-drained soils which exist on steeper slopes in ecoregion 6.

Results for the medium and high scenarios are closely related to the acreage subject to harvesting and show a greater extent of impacts than under the base scenario.

Forest Health Impacts
All timber harvesting and forest management activities affect forest health; all have impacts. Those impacts range from nearly none (where the management activity is minimal) to very large (where major changes are brought about in the forest). Given changes, vulnerability to impacts is a function of the insect, disease, or health vector, the harvesting or management related disturbance that would hinder or favor its expansion or development, and the susceptibility of the forest as defined by vegetation patterns, forest age class structure, etc.

Certain assumptions were made as part of the analysis of significant impacts on forest health. In particular, it was assumed that the MNDNR pest management guidelines and other guidelines would be followed by all ownerships. If the guidelines are not followed, impacts of harvesting on the health of Minnesota's forests could be more severe. This is because the guidelines are intended to prevent pests and diseases from becoming established by avoiding the creation of conditions that are suitable for pests. The significant impacts projected to occur under the base level harvesting by forest type groups are developed for the major present and prospective pests and diseases. For most covertypes, insect and disease problems are closely related to the age class structure with older stands often, but not always, being the most susceptible. Thus harvesting, as it affects the age class structure, is an important factor in managing forest health. With the exception of unanticipated catastrophic outbreaks of pest or disease problems, forest health is manageable and can be improved.

Water Quality and Fisheries Impacts

Timber harvesting is, by nature, a disturbance to the forest and the landscape. As such, it could affect sedimentation, nutrient loading, changes to key aspects of the aquatic environment, and the amount, duration, and timing of runoff. The degree to which a given disturbance represents an *impact* is a matter of scale. For example, few if any landscape modifications associated with timber harvest will be detectable in large rivers such as the upper Mississippi. As one progresses further upstream, the probability of detecting impacts increases as changes outside of the identified standards and tolerances become more noticeable.

Application of the study significance criteria to the impacts identified indicates that the effects of timber harvest at the ecoregion level will not cause significant impacts. However, there will be a series of changes in the landscape and water resource. Most of those changes will be relatively local and short-term. Timber harvest which complies with Minnesota BMPs will have significantly fewer local water resource impacts than timber harvest carried out in the absence of such practices.

Projected Wildlife Species Impacts

Impacts on wildlife species were assessed by several criteria. Two of these are emphasized here. The first criteria was that an impact was significant if the available habitat of a species was projected to be changed by 25 percent or more *in any ecoregion.* Note that with this criterion, an impact occurred whenever a species in any ecoregion and decade met the criterion. The second criteria involved species federal or state listed as of special concern, threatened, or endangered or their habitat. With this criteria, an impact was significant if any timber harvest or forest management activity is projected to decrease the habitat and disturb a listed species by 5 percent or more *statewide*. In all of these analyses, area of available habitat for each species serves as an index of population. It is this index that is modelled, rather than actual numbers of animals. Additional criteria considered lowland habitat, food species, habitat fragmentation and genetic variability.

Projected adverse significant impacts of timber harvesting on forest wildlife are shown in Table I.4. For the 173 species examined, 27, 44 and 53 percent are projected to be negatively impacted by the base, medium, and high scenarios on an ecoregion basis. Among species groups, no large mammals would be adversely impacted by any of the three harvest scenarios. Six small mammal species would be adversely impacted by the base and medium scenarios and eight would be impacted under the high scenario. Herps (amphibians and reptiles) show a similar pattern with the same number of impacts for the base and medium scenarios, but more species were negatively impacted under the high scenario. Forest birds are projected to have a major increase in the number of species negatively impacted as harvesting moves from the base to the medium scenario level (from 28 percent to 50 percent impacted). The high scenario shows a further but less dramatic increase in the number of species negatively impacted compared to the medium scenario. Fifty-six percent of the bird species are negatively impacted in one or more ecoregions under the high scenario.

Table I.4. Number of species projected to be significantly and negatively impacted on all forest lands by harvest scenario. The first number in a cell is the number of species showing a 25 percent or more decline for a species *in any ecoregion* or a 5 percent or more decline *statewide* for a species listed as endangered, threatened or of special concern. Values in parentheses show number of species projected to decline *statewide* by 5 percent or more for species listed as endangered, threatened, or of special concern or 25 percent or more for all other species.

Species Group (Number of species)	Scenario		
	Base	Medium	High
Small Mammals (22)	6 (0)	6 (2)	8 (5)
Large Mammals (5)	0 (0)	0 (0)	0 (0)
Birds (138)	39 (5)	69 (8)	78 (44)
Herps (amphibians and reptiles) (8)	1 (0)	1 (1)	5 (1)
All (173)	46 (5)	76 (11)	91 (50)

Table I.5 illustrates the projected changes in habitat-based wildlife population indices on a statewide basis, but interpretation is important. The table shows the number of species by species group that increase, remain stable or decrease statewide. However, an increase in already common species does not in a biological sense balance a decline in a rare species. Further, harvesting tends to favor early successional species or, in some instances, those that are not obligatory forest inhabitants, i.e., species that do not necessarily require forest habitat.

Table I.5. Number of species of interest that are projected to decrease by 25 percent or more, remain stable, or increase by 25 percent or more, statewide on all forest lands by harvest scenario.*

Species Group (number of species)	Decreasing			Stable			Increasing		
	Base	Med.	High	Base	Med.	High	Base	Med.	High
Small Mammals (22)	0	2	4	21	19	16	1	1	2
Large Mammals (5)	0	0	0	5	4	4	0	1	1
Birds (138)	5	8	43	111	106	61	22	24	34
Herps (amphibians and reptiles)(8)	0	1	1	6	5	6	2	2	1
All (173)	5	11	48	143	134	87	25	28	38

* *Stable* is a change of less than 25 percent. No special consideration given to species listed as endangered, threatened, or of special concern.

Recreation and Aesthetic Impacts

Harvesting and the development of roads needed to access timber from forests within unroaded areas (primitive or semiprimitive categories of land) is indicative of an increased level of disturbance. The total forest area in primitive and semiprimitive categories is 3.1 and 9.6 percent, respectively. Of these, 0.4 and 7.2 percent, respectively, occur on timberlands. Improved access provides opportunities for additional use by people who depend on motorized access. However, this will likely displace a proportion of existing users and will impact animals that are adversely affected when the level of human contact increases. Based on study criteria, the significantly impacted areas under the base scenario correspond to approximately 32 and 26 percent of the timberland area in the primitive and semiprimitive nonmotorized categories, respectively. Under the medium scenario these impacts would rise to 34 and 29 percent. Under the high scenario the impacts would be 43 and 35 percent, respectively, for primitive and semiprimitive categories.

The study also considered the use of visual management guidelines (VMGs), which are planning tools used by the federal and state ownerships to reduce visual impacts. Significant impacts can be avoided where visual planning is used to identify *where* and *how* harvesting and associated forest operations should take place, i.e., road location and design, use of buffers, size and shape of cut, and slash and debris disposal practices. Harvesting can reduce the aesthetic experience for subsequent users, therefore limiting the recreation value of harvested areas and the adjacent unharvested areas. However, harvest operations and associated roading can also create additional recreation opportunities of a more developed type.

Based on study criterion, significant visual impacts occur when timber harvesting and forest management activities do not follow VMGs. Only the USDA Forest Service and the MNDNR are assumed to use VMGs. Analysis of all other ownerships found that 58.7 percent of these timberland areas harvested under the base scenario would not be treated according to VMGs and these are therefore judged to be significantly impacted. As determined by the higher acreage harvested, the medium and high scenarios showed higher levels of impacts on the other ownerships, 67.1 percent and 74.1 percent, respectively.

Impacts on Unique Cultural and Historic Resources

Heritage resources include cultural landscapes, structural remains, archaeological remains, Native American traditional use sites, and cemeteries. These were considered significantly impacted if destroyed or, in the case of cemeteries, disturbed. However, use of this significance criterion requires that the term *destroyed* be defined. The term destroyed has been interpreted as damage to a site such that its scientific, cultural, or spiritual values are diminished in whole or in part. This interpretation results in a *conservative* assessment of impact by including those sites with a partial loss of values; however, this is appropriate for the purpose of a GEIS.

Given these definitions and interpretation the significant impacts are predicted for each type of heritage resource. There is insufficient data to assess, even qualitatively, the extent that sites will be impacted. However, the number of impacts will increase as the level of harvesting increases.

Economic Impacts Overview

Development of precise conclusions on the overall state economy impacts from increased timber harvesting were not possible. The available data and the modelling tools used did indicate that employment in certain sectors of the economy would increase. However, due to limited data availability, conclusions on economic changes in the tourism and recreation industries and related costs of possible mitigation efforts were not possible. These limitations prevented the study from assessing detailed impacts to Minnesota's overall economy associated with increased timber harvesting.

Additionally, the study did not seek to analyze potential costs and benefits of increased timber harvesting or alternative management scenarios except in the limited area related to the timber industry's increased employment and financial flows. Because of the necessitated narrow scope of this economic analyses, they should be viewed as suggestive of trends or directions only.

With the limitations noted, table I.6 summarizes economic impacts in terms of employment, additional employee compensation and total industrial output for the three harvesting scenarios. The medium scenario represents expansion of existing capacity while the high scenario would represent the development of new mills. The impacts are presented in terms of direct, indirect, induced, and total effects as determined from an input-output model. Direct impacts are the increased employment, income, and output attributable to the expansion of activity. Indirect impacts are due to increases in purchase of raw materials and other goods and services required for the expansion. Induced effects are those due to the consumer purchases that result from the increased employment generated by the original expansion.

The medium and high scenarios would also require substantial staffing and funding increases to handle the increase in workload for planning and administration of timber sales.

Table I.6. Summary of statewide changes: direct, indirect, and total effect of increase in employment, additional employee compensation, and increase in total industrial output by harvest scenario.*

	Medium Scenario			High Scenario		
Impact	Direct Effect	Indirect Effect	Total Effect	Direct Effect	Indirect Effect	Total Effect
Employment (jobs)	352	3,788	6,752	3,059	18,424	35,094
Additional employee compensation (millions of $)	16.9	84.4	146.4	133.2	418.9	790.4
Total industrial output (millions of $)	611.2	297.0	1,059.5	3,084.0	1.451.2	5,324.1

Note: Induced effects may be estimated by subtracting direct and indirect effects from total effect.

Impacts on the Tourism and Travel-based Industries

A lack of information on relationships between the level of harvest and its consequences for the tourism and travel industry precluded the quantification of impacts. However, some general observations are possible. Resorts and other tourism-based facilities depend on the visual amenity of the surrounding forest for their setting. It is thus likely that individual resort operations will be adversely impacted by visually obtrusive harvesting operations within their viewshed or along access routes. The consequences for the use levels of the facility or the recreational experience of the users would depend on the expectations of the clientele attracted to the resort. The overall result is complicated by the fact that increased access to forest areas provided by harvesting often increases the level of recreational activity, however, the type of activity (primitive versus motorized) may change. Use of VMGs can reduce the area adversely impacted and the duration of impacts.

Base Scenario Review

The base scenario was modelled using the existing levels of roundwood consumption as the basis for demand over the modelled period of 50 years. This assumes that no further forest-based industrial developments take place within this period.

The base level of harvesting is well below the level of tree and forest growth potential if timber production was the only objective. It also appears sustainable from a biological standpoint as it would allow retention of other forest characteristics and values of concern in this study. As with any modelling effort, this conclusion is valid within a range of error and to the degree that the assumptions employed are representative of actual conditions. In this context, based on long-term (modelled) sustained yield analyses, a timberland area of approximately 7.4 million acres could sustain close to a 4 million cord annual harvest level. This would leave over 7.5 million potentially harvestable acres of timberland unharvested over the long-term. This analysis suggests that large areas of timberland could potentially be shifted towards other nontimber management objectives, such as wildlife habitat, without severely impacting timber production at the 4 million cord level in the long-term.

This situation applies to aspen, but with an important caveat. Given significant increases of demand coupled with an unbalanced age class distribution, there will likely be constraints in the supplies of this species during the middle of the modelled period. In order to meet the prespecified statewide timber demand levels, the base, medium, and high scenario projections assumed that 25 percent of the demand for this species would be transferred to the northern hardwood species.

The projected harvesting patterns indicate that harvesting is projected to occur in virtually all forested regions of the state. This pattern reflects the well-developed road network in Minnesota and the decentralized nature of the timber industry. In essence, few stands in Minnesota are ruled out for harvesting because of their location.

Base Scenario Significant Impacts Summary
Analysis considered impacts statewide and by seven ecoregions. The base scenario identified the following significant impacts:

1. projected significant loss of forest area in ecoregions 1, 2, 3, and 4 due to land use change (also includes consideration of the loss of timberland in the north);
2. projected harvesting affecting patterns of forest cover in areas of mixed land use (considers amount, type, and fragmentation of cover important to wildlife habitat);

3. projected changes to tree species mix (important to maintaining biodiversity and wildlife habitat; four tree species show significant declines in stem number);
4. projected changes in the age class structure of paper birch (important to community replacement capability for this species; the young age classes appear deficient in acreage for replacing the older age classes);
5. projected harvesting affecting genetic variability of plant or animal species (important to maintaining biodiversity; critically endangered, endangered or threatened communities are identified);
6. projected harvesting affecting federal- or state-listed plant species of special concern, threatened, or endangered or their habitats (statewide 9, 7, and 37 species listed as endangered, threatened, or of special concern are projected to be adversely impacted by harvesting);
7. changes in the susceptibility and vulnerability of covertypes to forest health risks (important to community stability and productivity; largely dependent on age class structure and the amount and type of harvesting activity);
8. projected harvesting affecting site nutrient capital, i.e., nutrient supplies present and/or actually available (important to sustainability of forest growth and yield; results indicate nutrient losses with certain types of harvesting on various types of soils; approximately 5 million acres are at risk for calcium loss);
9. projected harvesting affecting soil physical structure (important to maintenance of forest growth; the actual area where significance criteria for compaction are exceeded is estimated at 330,000 acres plus haul road area);
10. projected harvesting causing accelerated erosion from forest roads (important to site productivity and water quality; about 25,000 acres plus haul roads are estimated to be impacted with major concern in ecoregion 6);
11. projected changes in the populations of forest dependent wildlife (by changes in amounts of habitat available; 46 species, about 25 percent of all wildlife species studied, were projected to be significantly impacted). Negative impacts are projected for the ringneck snake, beaver, northern flying squirrel, gray and fox squirrels, bobcat, lynx, as well as 39 bird species, for example, Cooper's Hawk, Great Gray Owl, Pileated Woodpecker, Eastern Bluebird, Ovenbird, Song Sparrow, Yellow Warbler and Hooded Warbler;
12. projected harvesting affecting populations of endangered, threatened, or special concern species of animals (two such species, Louisiana Waterthrush and Red-shouldered Hawk are projected to be negatively impacted);

13. projected harvesting affecting patterns of mature lowland conifer stands (important to wildlife habitat; many important patches of lowland conifer habitat may be lost with harvesting);
14. projected harvesting affecting the availability of food producing trees (important to wildlife; particularly oaks and other mast producing species);
15. projected harvesting in the absence of VMGs on visually sensitive areas (important to aesthetics and recreational use; visual aspects of landscapes and recreational settings are impaired);
16. projected development of permanent forest roads in primitive (undeveloped) and semiprimitive nonmotorized areas (important to maintaining primitive or undeveloped recreational opportunities; harvesting leads to a loss of such areas); and
17. projected harvesting affecting unique cultural and historical resources (important to the protection and integrity of these resources; disturbance from harvesting can effectively destroy these resources).

Base Scenario Recommended Strategies

Numerous strategies were identified to mitigate the significant impacts projected to occur at the base level of harvest. These recommended mitigations are presented under three categories which reflect their main focus:

1. site-level responses;
2. landscape-level responses; and
3. forest resources research.

Site-level Responses: Strategies in this category are intended to modify operational procedures used in the planning and execution of timber harvesting and forest management activities on an individual site or local scale. The responses considered are:

- ***Modifications to harvesting practices and equipment.*** Modifications to the practices and equipment used in Minnesota can be used to mitigate significant impacts projected to occur as a consequence of timber harvesting and forest management activities. Such modifications include:
  - *Retain Slash* (including bark where appropriate). This strategy is intended to modify harvesting systems and techniques in order to reduce the loss of nutrients from harvested sites and to maximize habitat values for small animals in the resulting cutovers. This must also encompass logger safety considerations.
  - *Equipment and practices for use in multiple entry harvesting operations.* The projected increase in the use of multiple entry, i.e., thinning, or uneven-aged silviculture will require modifications to existing safe equipment and practices to avoid excessive damage to retained stems during harvesting operations.

- *Modify season of equipment operation to minimize compaction.* This strategy is intended to reduce compaction by identifying susceptible sites and limiting operations on those sites to periods when the risk of compaction is lowest.

- ***Modifications to silvicultural practices.*** These specify the circumstances where modifications to normal silvicultural practices are required to maintain wildlife habitat and aesthetic values. Typically, the modifications represent a shift from clearcutting to techniques that retain a proportion of the stand following harvesting.
  - *Patterns of forest cover in areas of mixed land use.* A strategy to mitigate the negative impacts of changing patterns of forest land in the southern parts of the state requires modifications to the silvicultural practices used and specification of the size of individual cuts. Thinning or uneven-aged management should be used where feasible.
  - *Retention of key habitat requirements in clearcut areas.* Certain key habitat can be retained within clearcuts by retaining snag trees, trees with cavities; and retention of conifer patches and isolated trees when harvesting in predominantly deciduous forests.
  - *Retention of cavity trees* or mature trees that are likely to produce cavities in stands that are clearcut, will provide nesting and hiding places for a wide range of birds as well as some mammals in postharvest forests.

- ***Protection of sensitive sites.*** Sensitive nest sites, habitats, and rookeries should be identified and protected by appropriate buffers.

- ***Increasing the wood fiber productivity of timberlands.*** There are two elements to the strategy. The first provides short- to long-term benefits, and the second provides medium- to long-term benefits.
  - *Increasing Utilization.* This element is intended to increase utilization by making maximum use of the volume of wood available for harvest in any particular stand, as well as optimizing use at mills.
  - *Increasing Productivity.* Regeneration to full stocking levels and species-site matching are two of the most readily implemented and effective ways to increase the productivity of timberlands on a statewide scale. Thinning and management to reduce pest damage can also provide important gains.

Landscape-level Responses: These are typically long-term or broad-based solutions that require extensive analysis and/or planning to identify and achieve the intended objectives of developing regional or statewide responses. These responses also provide direction and coordination across ownerships. The strategic responses considered here are:

- ***Measures to reduce the area of forests converted to other land uses.*** This strategy seeks to develop policy instruments to discourage conversion of forested land to other, nonforest, land uses.
- ***Balancing age class and covertype structure.*** This strategy seeks to develop statewide objectives that cross ownership boundaries that addresses future age and/or size class and covertype structure goals.
- ***Riparian corridors.*** This strategy identifies environmentally sensitive areas near waterbodies. Harvesting can be carried out within these buffers; however, uneven-aged management or thinning rather than clearcutting are the most appropriate silvicultural systems. Riparian corridors are a special case of a broader strategy referred to as *connected landscapes*, which are wide corridors of mature or selectively cut forest between core areas such as patches of old growth, research natural areas, and scientific and natural areas. Connected landscapes are considered a potentially important tool. However, more research is needed to determine its effectiveness and approaches for implementation.
- ***Extended Rotation Forests (ERF).*** This strategy provides one means to manipulate age class distributions. ERF can be described as any forest managed on a rotation length that is longer than that recommended for the covertype for timber production. Management as ERF does not preclude harvesting and therefore does not remove lands from the timberland base; yet it helps provide many of the biodiversity features of older forests over large areas.
- ***Protection of sensitive sites for plant species.*** This strategy would exclude or modify harvesting in the known locations of rare plant species and rare plant communities that are likely to be sensitive to harvesting impacts and should be excluded from harvesting.
- ***Landscape-based road and trail plan.*** This strategy would involve planning and coordination between ownerships to develop landscape-based road and trail plans, and would cover the development of new roads (particularly in primitive and semiprimitive nonmotorized areas); long-term access needs; and closure policies.
- ***Develop VMGs.*** This strategy requires development and widespread application of VMGs. VMGs, especially if used in conjunction with nonpermanent roads, give attention to the important social attributes and long-term benefits of primitive recreation opportunities and reduce the likelihood of adverse visual impacts.
- ***Integrated Pest Management (IPM) strategies.*** The state should initiate and oversee development of IPM strategies for the major pests likely to increase as a consequence of timber harvesting.

Forest Resources Research: Strategies in this category are intended to: obtain the information needed to undertake strategic and operational planning; monitor changes at the landscape- and site-level; and provide the basis for developing management direction and planning tools. The responses considered here are:

- ***Monitor the age class and covertype structure of the state's forests and their pattern across the landscape.*** This strategy would develop monitoring of the age class and covertype structure of the state's forests and information on landscape patterns. This information is important to planning and analysis in a wide range of subject areas.
- ***Undertake an inventory of the state's biodiversity features.*** This strategy will speed up the identification of the occurrences of rare plant and animal species and communities, and key habitat features for wildlife species.
- ***Conduct an inventory of old growth forests across all ownerships.*** This strategy, in conjunction with the above inventory of biodiversity features, will speed up the identification of important sites and ensure their protection.
- ***Develop and fund a research program to investigate the effects of timber harvesting and forest management activities on the tourism and travel industry in Minnesota.*** This strategy is intended to identify and quantify the relationship between changes in the forest resource and induced changes in recreational/tourism user patterns in forested areas in the northern part of the state.
- ***Upgrade and maintain a listing of known heritage resource use sites in the state.*** These resources include cultural landscapes, standing structures, archaeological sites, cemeteries, and traditional use sites. This strategy will upgrade the quality, extent and utility of the database on the state listing of known sites and their locations and aid their protection.

Base Scenario Cumulative Unmitigated Significant Impacts

The mitigation strategies described in the previous section will likely mitigate many of the significant impacts projected to occur under the base level of harvesting. However, some unmitigated impacts such as loss of forest area and timberland in the north, loss of soil nutrients on some sites, and disturbance of archaeological resources will remain, despite implementation of the mitigation strategies. These impacts will likely be concentrated on NIPF lands as a consequence of likely lower standards of planning and supervision of field operations, compared to large ownerships with professional staffing. However, the mitigations proposed would reduce the likelihood of significant impacts that might degrade the long-term sustainability of the state's forest resources. The only exception is the projected reductions in the nutrient capital of some low productivity sites. These reductions will need to be carefully monitored. The relationship between changes in nutrient capital and changes in site productivity also needs to be closely observed.

The harvesting projected to occur at the base level (4 million cords) will likely be sustainable in a broad sense. That means this timber harvest level can be continued indefinitely and other forest resource characteristics such as soil productivity, water quality, wildlife habitat, and aesthetic values can be maintained *providing recommended mitigation strategies are implemented within the next few years.* There will be changes to the forest; however, the most profound of these will be a consequence of the natural forest aging process.

Medium and High Scenarios Overview

The previous section describes the changes projected to occur under the base scenario and the associated significant impacts and mitigation strategies. The differences in identified impacts projected to occur at the medium and high scenarios, compared to the base scenario, lie in the *degree* of impacts rather than the *types* of impacts. Similarly, the unmitigated impacts of the medium and high scenarios are the same type as those for the base scenario, but they differ in degree. As an example, the medium scenario impacts certain wildlife habitat availability to a greater extent than the base scenario, but the type of impact (say habitat loss) is the same. For any significant impact criteria, there is also only one threshold for significance. Beyond that threshold, impacts can assume increased importance, but that does not change the type of impact as defined here or its significance. In particular, the high scenario suggests many impacts are large and would be left unmitigated.

For most covertypes, the differences between the three scenarios are related to the intensity of timber harvesting and related forest management activities at the landscape-level. The types of site-level impacts will remain the same under the medium and high scenarios, although would typically apply to more area than under the base scenario. For example, 900,000 acres were projected to be significantly affected by compaction under the base scenario; while 1,025,000 acres were projected to be affected under the medium scenario. Other area-based impacts include the remaining impacts on soils (nutrient loss and erosion), impacts on cultural and historic resources, and impacts on primitive and semiprimitive areas.

In addition, the number of animal species affected (increases and decreases in populations) increased from the base to the medium, and medium to the high levels of harvesting (see tables I.4 and I.5). These changes were a consequence of changes in areas of particular forest types affected, and the projected intensity of harvesting reflected in changes in the age class distributions. Similarly, the increased intensity at the higher levels of harvesting also affected other nontimber values including aesthetics and recreation values, covertype species composition, and rare plants and plant communities.

The level of economic benefits evaluated in this study as accruing from the medium and high scenarios increased relative to the base level scenario.

Recall that these economic benefits were previously noted to be limited to only those for which data were available, primarily forest industry employment and financial flows. The studied increases in the forest industry sector were accompanied by flow on benefits to other sectors that service these industries or are otherwise likely to benefit from increased levels of economic activity. The increased levels of harvesting will increase direct and indirect employment.

The impacts of the increased levels of harvesting on the tourism and travel industry are unclear. These impacts are likely to be linked to the intensity of harvesting with increasing harvesting having an adverse impact, but in ways that are difficult to quantify.

The most important differences between the scenarios are those related to the long-term sustainability of the levels of harvesting. An analysis of long-term sustainability indicates that, with some modifications, the levels of demand specified under the base and medium scenarios are sustainable in the long-term. *However, harvest at these levels would need to implement the recommended mitigations relatively soon to avoid or mitigate the significant impacts described under these scenarios.* In contrast, the levels of harvesting specified under the high scenario could not be sustained for timber assuming the levels of productivity investments and net increments (forest growth) used in the GEIS analysis. Additionally, there is concern that some significant impacts to forest resources at that level of harvest could not be fully mitigated.

The results, as based on the modelling techniques and assumptions used, indicate that a level of approximately 5.5 million cords is the maximum that could be sustained. *However, these conclusions also assume the site-specific or other mitigations below the modelled level of resolution are implemented within the next few years and do mitigate otherwise significant impacts.* This assumption is critical since the 5.5 million cord harvest level was not explicitly examined for impacts as was done for the base, medium, and high scenarios. Also, at this level of harvesting there is little flexibility available to meet timber supply demands while making provision for nontimber values. Importantly, if some of the significant impacts cannot be effectively mitigated, then the 5.5 million cord level would not be sustainable as described for this study.

The high level of harvesting is still below the level of tree and forest growth potential if timber production was the only objective. However, harvest levels above 5.5 million cords appear sustainable only if, in addition to effective mitigation of significant impacts, the loss of forest land projected in the north was halted, and substantial investments in forest management are made to improve productivity. Clearly, such harvest levels would require long-term investment. Additionally, such harvest levels might require the USDA Forest Service allowable sale quantities on the two national forests in Minnesota to be increased.

The high level scenario was not analyzed with a view to examining it as a feasible goal for the statewide level of harvest. The level was specified as the estimated maximum level of harvesting that could be sustained from a timber production standpoint. As such, it served a useful analytical purpose. The analysis has shown that, with the assumptions and constraints applied, this level is not achievable on a sustainable basis.

Suggested Strategic Programmatic Responses

The GEIS presents a variety of mitigation recommendations at each of the three alternative levels of statewide timber harvest that are required of each level of harvesting to assure mitigation of the identified significant impacts. While such tactical mitigations are extremely important and useful study outcomes, the GEIS also serves the broader purpose of providing direction on the types of policy (programmatic) strategies the state should consider to help verify and effectively address and implement these recommended mitigations. The various mitigation options can be integrated into a comprehensive set of policy strategies that can serve as the focus for an implementation program. This will require a well-coordinated statewide policy formulation effort aimed at establishment of the following:

Forest Resources Practices Program

The GEIS study team recommends that the most coordinated way to collectively consider the site-level recommendations is through a *state comprehensive Forest Resources Practices Program* (FRPP). Such a program would serve as an umbrella structure for the implementation of a wide range of specific management prescriptions. These management prescriptions could include guidelines that address the following activities associated with timber harvesting, and that are recognized in the GEIS as desirable approaches to mitigating adverse impacts:

- timber sale design and layout to incorporate nontimber concerns (e.g., visual BMPs, wildlife habitat, protection of rare plant occurrences, and archeological sites);
- methods for the disposal/redistribution of slash and other woody biomass;
- establishment and management of riparian corridors;
- BMPs for water quality;
- biomass retention (e.g., inclusion of snags);
- postharvest reforestation practices;
- style and methods of road construction;
- managing for visual/aesthetic objectives;

- managing for protection of unique historical/cultural resources; and
- traffic control/site amelioration to minimize compaction.

The following implementation steps are associated with adoption of the new FRPP:

- The FRPP should initially be voluntary to help avoid costly public and private steps. However, the FRPP must also clearly define the following elements:
  - logger, forest operator, and forester certification or licensing programs;
  - statistically sound monitoring and evaluation of compliance activities, wherein if compliance falls below a specified threshold for two consecutive years, mandatory compliance rules become effective automatically for the area out of compliance, and stay mandatory until three consecutive years of successful compliance are once again achieved;
  - wood purchasing industries will be encouraged to adopt a forest operators/loggers code of practices (COP) that is congruent with forest practices guidelines. This COP would then be introduced into all forest operators/loggers contracts to ensure statewide standard compliance; and
  - the state should work with its own agencies and departments, the counties and especially the USDA Forest Service to develop financial assistance and incentives programs for private landowners, operators, and loggers.

Sustainable Forest Resources Program

The GEIS study team recommends that to successfully mitigate, in advance, unacceptable *landscape-level* impacts from timber harvesting and forest management activities, a statewide *Sustainable Forest Resources Program* (SFRP) should be adopted. This initiative would provide a broad, landscape-level focus on managing Minnesota's forest resources for a variety of outputs and objectives. The basic objective of this SFRP would be to establish a statewide structure for: systematically identifying existing resource conditions; evaluating these conditions in light of past forest resource trends; determining desired future forest conditions; identifying and developing specific strategies necessary to achieve those desired future forest conditions; and providing feedback to assess the success in achieving those objectives.

In contrast to forest or land use planning efforts conducted by federal, state, and county agencies, the SFRP would identify and set goals for desired future forest conditions that *transcend ownership boundaries*. In addition, the temporal requirements associated with achieving these goals could be longer-term than existing individual planning efforts. Achieving desired statewide forest covertype and age class goals along with developing coordinated plans to protect especially sensitive plant and animal species are examples of mitigations that would be administered through a SFRP. The steps in developing and enhancing such goals are:

- identify present and past resource conditions;
- identify future forest condition goals;
- formulation of management alternatives to achieve these goals; and
- monitoring and evaluation (feedback).

Forest Resources Research Considerations
In addition to recognizing specific gaps in the existing information relating to Minnesota's forest resources, the GEIS study process underscored the need to focus future forest resources research efforts to address the following information needs:

- multidiscipinary considerations;
- broadening spatial and temporal dimensions;
- linkages to resource management; and
- investment and response linkages.

As well as identifying information gaps, the GEIS study process also noted areas where additional research will be needed to fully mitigate projected timber harvesting and forest management significant impacts. Examples of research initiatives that could be included as foundation steps for this program are:

- to develop a better understanding of timber harvesting and forest management impacts on ecosystem functions and processes;
- to identify the full role of forest soils and their various conditions in forest resources productivity in Minnesota;
- to provide the scientific basis for setting and refining desired age class and covertype goals to meet biological diversity objectives;
- to determine the interaction between the level of timber harvesting and forest management activities and the tourism/outdoor recreation industry;
- to determine management techniques and impact assessments for forest pests;
- to identify and evaluate low impact timber harvesting techniques and technologies applicable to Minnesota;
- to identify potentially complementary forest industries for Minnesota; and
- to fulfill some of the monitoring functions identified under the harvesting practices and SFRP.

In order to meet previously identified research program goals and objectives, and effectively deal with the other issues raised here, the GEIS study team recommends the state assume the central role for the development of a comprehensive cross-landowner, statewide *Forest Resources Research Program* (FRRP). The statewide FRRP should also become the driving force for extension, technology transfer, and continuing education activities. This applies to current programs and those to be developed in cooperation with the Minnesota Extension Service (MES).

The GEIS study team recommends the establishment of a Minnesota Applied Forestry and Harvesting Program within the statewide FRRP and in coordination with the MES. The program would be jointly administered by the MNDNR and the MES and would:

- be the basis of certification/licensing for employment and subcontract work in forest areas for all landowners and agencies in Minnesota as required by the COP;
- integrate forest management, harvesting, and other forest multiresource subjects into a comprehensive extension education program; and
- be supportive of the needs of the FRPP and SFRP.

Minnesota Board of Forest Resources

The study considered a range of possible administrative and organizational structures to carry out the major strategic program recommendations (FRPP, SFRP, and FRRP). These included the identification of the advantages and disadvantages of the EQB, MNDNR, and the Minnesota Forestry Coordinating Committee (MFCC) and a forestry board in this role. Important attributes considered for the organization included the need to:

- provide opportunities for representative stakeholders of Minnesota's forest resources to provide input;
- provide an environment that fosters interagency coordination;
- have defined opportunities and procedures for providing public input to decision making;
- be recognized as the focal point that can provide input to legislative and executive branches on statewide forest resource policy matters;
- be recognized as the organizational entity with the authority to implement the strategic program recommendations;
- have adequate staff and financial resources to fully accomplish program objectives; and
- have the authority and responsibility without being in conflict with other existing agency policies or programs.

Implementation of the broad, strategic programmatic recommendations developed here will need to be carried out through means that involve executive and legislative branch participation. While the FRPP, SFRP, and FRRP efforts *could* be developed independently, the GEIS study team analysis concluded that a forest resources board is the most appropriate administrative structure for implementing these initiatives. As such, the team views the creation of a forest resources board as crucial to effectively develop these three major policy initiatives. Functional responsibilities of the board should include the following:

- to coordinate all forest resource issues, policies, plans, and programs;
- to serve as the primary advisory body on forest resource issues to the executive and legislative branches of the Minnesota state government;
- to design, implement, administer, and assume responsibility for the FRPP, SFRP and FRRP; and
- to work with both the executive and legislative branches of government to secure funding, and to implement the organizational structures required to meet its mission.

As a means of implementing the strategic policy responses presented in this section, the GEIS study team recommends the initial focus should be on *establishing* a state board of forest resources. As the recommended umbrella structure under which the site- and landscape-level strategic policy and forest research initiatives are largely carried out, it is essential that this organizational structure be created in advance of the other policy initiatives. Only after a forest resources board is created can these other strategic policy responses be fully implemented. As an initial step in the development of this board, the GEIS study team suggests the creation of an ad hoc task force with broad representation that includes both legislative and executive branches. This task force could decide upon the key mission, authority, functions, and structure of such a board. The intended outcome of this task force would be draft legislation to create a Minnesota Board of Forest Resources.

Conclusions

Two broad issues are paramount: biodiversity and the social and economic health of our society. Analyses in this study indicate that few aspects of either issue are in peril at this time in Minnesota. However, the actions taken now can do much to minimize resource problems and provide opportunities for society in the long-term.

Follow-up efforts need to ensure that, to the extent desirable and practical, the recommendations put forward in this assessment are fully implemented. The model runs used to project future forest conditions for the three harvest scenarios employed mitigation strategies, such as for 20 percent ERF on state and federal lands, reservation of old growth, and buffer strips along certain waterways for wildlife. The model runs necessitated employment of these strategies to reduce the cumulative negative impacts of harvesting during the 1990-2040 timeframe. Therefore, actions are also necessary to implement these and other recommendations of the GEIS in the field as soon as possible. The GEIS study team also suggests that efforts should be undertaken to disseminate the information and findings of the GEIS to the state's land management organizations. In addition, educational efforts should be directed at disseminating the findings and recommendations of the GEIS to the 130,000 NIPF owners, as they are collectively responsible for managing nearly one-half of the state's forest land base. Workshops, seminars, and other similar forums are suggested as appropriate ways to disseminate the GEIS findings and recommendations.

The GEIS study team strongly recommends that processes to implement these recommendations should begin immediately. Public interest in the management and protection of Minnesota's forest resources has grown tremendously in the last few years. The GEIS study process has characterized many of the important forestry issues, providing a focus for the debate about the extent of problems or concerns, as well as how to effectively deal with them. Given this momentum, the study team believes successful implementation of the study's recommendations will be enhanced by their prompt consideration by the appropriate policymakers.

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LIST OF PREPARERS

Contractor
The contractor hired by the Minnesota Environmental Quality Board (EQB) to prepare a Generic Environmental Impact Statement (GEIS) on timber harvesting and forest management in Minnesota is Jaakko Pöyry Consulting Inc. of Tarrytown, New York.

Qualifications
Jaakko Pöyry Consulting, Inc. is a member of the Jaakko Pöyry Group, the world's leading independent consulting and engineering organization specializing in forestry and forest industry development. Jaakko Pöyry was established in 1958, and has its world headquarters in Helsinki, Finland. It employs nearly 6,000 people in over twenty countries.

Since the 1960s, the Jaakko Pöyry Group has focused on the environmentally sound development and sustainable management of forest resources, based on progressive forestry practices. The Group has a worldwide reputation as advisor to forest industries, national governments, and international agencies. Jaakko Pöyry companies have carried out forest resource management and utilization planning assignments in more than 100 countries, acquiring extensive expertise in all aspects of natural resource and ecosystem management. Much of this experience is related to the forest sector Master Plans and forest industry projects, and the Group has carried out approximately 60 forest-based/related projects over the last five years. In particular, the Jaakko Pöyry Group has considerable experience in conducting environmental impact assessments and environmentally-based development plans for a region, based on an objective, analytical, and comprehensive approach that includes estimating the economic impact of the recommendations.

Personnel
For the Minnesota GEIS project, Jaakko Pöyry has created a multidisciplinary team led by senior consultants from the USA, Australia, Canada and the United Kingdom. Jaakko Pöyry personnel were provided through the Jaakko Pöyry consulting network, and directed by the Jaakko Pöyry Consulting, Inc. office in Tarrytown, New York.

Because a detailed local perspective was an essential element of the project, Jaakko Pöyry subcontracted with a select group of scientists drawn largely from the University of Minnesota (UofM). In addition to their technical abilities, these experts were hired because of their thorough understanding of the practices and issues associated with managing, using, and protecting Minnesota's forest resources. Collectively, these scientists contributed expertise in: forest growth modelling, forest ecology, biometrics, forest economics, timber supply analysis, water quality, fisheries, entomology, watershed management, wildlife, soils, forest health, remote sensing, aesthetics, landscape architecture, forest recreation, cultural resources, forest policy, wood utilization and harvesting, and database management. A complete listing of all GEIS study participants is provided in section 2.1 of the main report.

1
INTRODUCTION

1.1
Minnesota Environmental Quality Board

1.1.1
Authorization

The Minnesota Environmental Quality Board (EQB) was established by the Minnesota Legislature in 1973 to serve as an interdepartmental forum for addressing and resolving environmental problems and issues.

1.1.2
Responsibilities

Legislated responsibilities of the EQB are to: (1) initiate interdepartmental investigations into state environmental problems; (2) review and coordinate the environmental programs of state agencies to ensure compliance with state environmental policy; (3) review the rules and criteria of state agencies for granting and denying environmental permits; and (4) coordinate the development of legislative proposals submitted by state agencies (MS 116C.04, Subd. 2, 1990).

In practice, the EQB accomplishes these responsibilities through the administration of specific programs and activities such as the state's Environmental Review Program, Power Plant Siting and Pipeline Routing, and Water Resource Planning. Staff support for EQB activities are provided by the Minnesota Planning Office, although member agencies may also assign their own staff to work on specific projects.

1.1.3
Membership

The EQB is a 15-member executive branch board, consisting of both state agency administrators and citizens. The chair of the EQB is appointed by the governor and is considered a representative of the governor's office. The nine agency administrators represented on the EQB include the commissioners of Natural Resources, Pollution Control, Public Service, Agriculture, Health, and Transportation; the directors of the Office of Waste Management and Strategic and Long-Range Planning; and the chair of the Board of Water and Soil Resources. The five citizen members are appointed by the governor at staggered, four-year terms. Current membership of the EQB is as follows:

- Robert Dunn, chair (governor's representative)
- Rod Sando, Department of Natural Resources
- Charles Williams, Pollution Control Agency
- Kris Sanda, Department of Public Service
- Elton Redalen, Department of Agriculture
- Mary Jo O'Brien, Department of Health
- James Denn, Department of Transportation
- John Chell, Office of Waste Management
- Linda Kohl, Minnesota Planning Office
- D. James Nielson, Board of Water and Soil Resources
- Bruce Bomier, citizen member
- Carolyn Engebretson, citizen member
- Deanna Fairbanks, citizen member
- Douglas Magnus, citizen member
- Paul Toren, citizen member

1.2
Generic Environmental Impact Statements

1.2.1
Authorization

A Generic Environmental Impact Statement (GEIS) is a specific form of environmental review that can be used to study certain types of projects not adequately reviewed on a case-by-case basis. The authorization for conducting alternative forms of environmental review, such as a GEIS, is found in Minnesota's Environmental Policy Act, MS 116D.04, Subd. 4a. Specific criteria for determining the need for a GEIS and the unit of government most appropriate to oversee its preparation, and the general process and content of a GEIS are identified in Minnesota Rules, part 4410.3800. Although only the EQB is authorized to order a GEIS, any person or government body may request the EQB to consider the preparation of a GEIS.

1.2.2
Unique Attributes

A GEIS differs from project-specific environmental impact statements (EIS) in the following four major ways:

1. **Cumulative Impacts Focus**. While a project-specific EIS typically examines environmental impacts within a limited geographic area, a GEIS analyzes the cumulative impacts associated with a number of separate, yet related activities. In the case of the GEIS on timber harvesting and forest management, cumulative impacts are those resulting from the hundreds of individual logging activities occurring in the state

each year—in effect, the collective impacts of these individual operations on the state's overall environmental quality.

2. **Discretionary Nature**. The administrative rules governing the state's Environmental Review Program establish general criteria for determining when it would be in the state's best interest to prepare a GEIS. However, these criteria do not specify explicit thresholds which, if exceeded, mandate the EQB to order such a study. The decision by the EQB to prepare a GEIS is voluntary. Additionally, because a GEIS is considered an alternative form of environmental review, projects under consideration by a GEIS are still subject to normal environmental review procedures and requirements, as well as environmental permit procurement procedures. In essence, a GEIS is considered a long-range planning document that can provide useful information regarding geographically broad and long-term consequences that are unlikely to be identified in project-specific environmental review processes. Therefore, a GEIS provides the context within which future project-specific EISs can be assessed.

3. **Recommendation Development**. A third distinction between project-specific EISs and GEISs is the focus of the GEIS on developing recommendations. Traditional environmental review documents assess the likely consequences of feasible and prudent alternatives to a proposed action (e.g., changes in process technology, proposal size or site location), but do not state which of the analyzed alternatives is preferred. These decisions are left to the government agencies responsible for issuing the necessary development and/or environmental permits. However, a GEIS is not limited to strictly the analysis of impacts, but can advocate strategic policy and program direction through the development of recommendations to address the identified impacts.

4. **Funding Mechanism**. Unlike project-specific development proposals where the costs associated with preparing environmental review documents are borne by the project proposer, no mechanism exists for assessing the costs of preparing a GEIS. Funding for a GEIS is typically via special legislative appropriations, contributions of EQB member agencies, or outside funding sources. The EQB does not have the authority to establish rules relating to assessing the costs of preparing a GEIS.

1.2.3 GEIS Need Criteria

Although Minnesota's Environmental Review Program does not recognize circumstances in which preparation of a GEIS is mandatory, certain factors are considered by the EQB in determining the need for a GEIS. These factors are:

- whether reviewing the proposed action can be better accomplished by a GEIS than by project-specific review;
- whether the possible effects on the human environment are highly uncertain and involve unique or unknown risks;
- whether a GEIS can be used in a subsequent project-specific EIS to provide a context in which the individual project can be assessed;
- the amount of basic research needed to understand the impacts of such projects;
- the degree to which decisionmakers or the public have a need to be informed of the potential impacts of such projects;
- the degree to which information to be presented in the GEIS is needed for governmental or public planning;
- the potential for significant environmental effects as a result of the cumulative impacts of such projects;
- the regional and statewide significance of the impacts and the degree to which they can be addressed on a project-by-project basis; and
- the degree to which governmental policies affect the number or location of such projects or the potential for significant environmental effects.

1.3
EQB Decision: GEIS on Timber Harvesting and Forest Management

In July 1989, a citizen petition was brought before the Minnesota EQB. This petition cited a number of environmental and economic issues that could be directly impacted as a result of accelerated timber harvesting in Minnesota, and requested that the EQB prepare a GEIS to examine the cumulative impacts resulting from timber harvesting and forest management activities. The major concern of the petitioners was that no formal environmental review process currently existed to provide an analysis of the collective impacts that expanded timber harvesting activities might have on Minnesota's environment.

Support for the study was given by several individuals and groups involved in the management and use of the state's forests. After lengthy deliberation, the EQB unanimously passed a resolution to authorize the preparation of a GEIS on timber harvesting and forest management activities in December 1989. The EQB designated itself as the governmental unit responsible for the study's preparation.

1.3.1 Advisory Committee

A central component of the EQB's resolution ordering preparation of the GEIS on timber harvesting and forest management was the establishment of an advisory committee. This ten-person committee was created to provide direction and oversight of the GEIS study process through their recommendations to the EQB. Committee membership includes economic development, environmental, conservation, tourism, and public land management interests, reflecting a broad cross-section of stakeholders in the management and use of Minnesota's forest resources.

Membership. Members of the GEIS Advisory Committee are as follows:

- Don Arnosti
- Janet Green
- Dennis Kmit
- Roy Linder
- Tom Sawle
- Wayne Brandt
- Butch Eggen
- Darrell Lauber
- Gerald Rose
- Jim Woehrle

Doug Jackson and Bob Raufs also served on this committee.

Charge. The EQB asked the Advisory Committee to assist in the preparation of the GEIS by assuming the following major responsibilities:

- to advise the EQB on the scope of the GEIS, including the issues to be examined, the type and level of detail of studies to gather and analyze information, and the schedule for preparation of the GEIS;
- to advise the EQB on the selection of a consultant to assist in preparation of the GEIS;
- to review and provide comment to the EQB on reports prepared by the consultants, and on the proposed draft and final GEIS documents; and
- to make recommendations on the alternatives presented for the mitigation of impacts where analysis has indicated the potential for significant impacts.

To enhance the Advisory Committee's ability to develop consensus advice on these four areas, the EQB secured the services of Howard S. Bellman, Madison, Wisconsin, to serve as facilitator to this committee.

1.4 GEIS Funding Sources

Funding for the GEIS, which totals $875,000, comes from the following public and private sources: Minnesota Environment and Natural Resources Trust Fund ($400,000), state legislative appropriations ($300,000), Crow

Wing County via the Iron Range Resources and Rehabilitation Board ($100,000), and the Cuyuna Range Economic Development Corporation ($75,000). In addition, the Northwest Area Foundation provided a grant of $47,000 to the EQB for facilitation services associated with operation of the GEIS Advisory Committee.

1.5 GEIS Process

This section of the document sets out the key aspects of the study process from the initial scoping process to the completion of the draft and final GEIS documents.

1.5.1 Scoping Process

The first step in conducting a GEIS is to identify and define the issues to be addressed in the study. This is accomplished through a scoping process. The main purpose of scoping is to focus the study by clearly defining the critical issues in need of examination. In addition, the scoping process establishes other important GEIS study parameters such as study objectives, assumptions, and alternatives to be analyzed.

The scoping process for the GEIS was initiated by the EQB in early 1990. Over the course of four meetings, the GEIS Advisory Committee worked to develop a draft scoping document that would specify the study's general format and issue content. Upon receiving this document from the Advisory Committee, along with the recommendation that it be used as the basis for public review, the EQB issued the committee's report as the draft scoping document in July 1990. Shortly after the draft scoping document was released, the EQB established a 40-day comment period in which the public could comment and suggest modifications to the draft document. During that public comment period, the EQB held three public meetings (Rochester, Twin Cities, Grand Rapids) to discuss the proposed format and content of the GEIS, and to solicit public input on that draft.

In total, 94 individuals or organizations submitted written comments during the scoping period, and 84 individuals or organizations provided testimony at the three public meetings. Upon completion of the scoping period, the Advisory Committee reviewed the public comments. After three meetings, the committee reached consensus on the recommended content of the final scoping document. In December 1990, the EQB approved the Final Scoping Decision (FSD) for the GEIS as recommended by the Advisory Committee. The final scoped issues are repeated from the FSD in section 1.5.5.

1.5.2 Study Objectives

The FSD calls for a GEIS study to be based on three overarching objectives:

1. to develop a basic understanding of the status of timber harvesting and related forest management activities in Minnesota, and how this level of statewide activity relates to long-term sustainable levels of timber removals;
2. to identify and assess the environmental and related (i.e., economic and social) impacts associated with current and potential elevated levels of statewide timber harvesting and forest management activity; and
3. to develop strategies to mitigate the existing or potential significant adverse impacts that are identified.

1.5.3 Major Assumptions

The following are major assumptions used in defining the scope of the GEIS on timber harvesting and forest management in Minnesota:

Geographic Coverage
The GEIS examines the impacts of timber harvesting and forest management on Minnesota's environment and on relevant sectors of the state and regional economies. To the extent possible, all forest lands and resources within the state's boundaries have been considered in this study. Issues and data have been gathered and analyzed at appropriate levels of resolution in order to determine the statewide cumulative impacts.

Forest Lands Under Consideration
The GEIS examines the cumulative impacts of timber harvesting and forest management activities occurring on all forest lands in Minnesota. This includes, to the extent possible, all public forest lands owned and/or managed by federal, state, county, or municipal governments as well as forest land owned by industrial and nonindustrial private interests. Both commercial and noncommercial forest lands are the subject of this study.

Relationship to Timber Harvesting and Forest Management
The GEIS analyzes only those impacts associated with timber harvesting and associated forest management activities in Minnesota. Timber harvesting and forest management is defined to include a broad range of human-induced activities related or incidental to altering forest environments. Although not inclusive, typical activities include logging, site preparation, reforestation (through both artificial and natural means), forest road design, density and construction, chemical applications, and thinning operations.

1.5.4
Alternative Statewide Timber Harvesting Scenarios Analyzed

The purpose of discussing alternatives in an EIS is to compare the environmental impacts of the proposed project with other reasonable alternatives to the project, including the alternative of no action. In the case of this GEIS, the proposed project was defined in terms of the state's cumulative timber harvesting and related forest management activities. Therefore, alternatives addressed in the GEIS are defined as different levels of statewide timber harvesting activity. In addition to examining the existing levels of harvesting, potential future timber harvesting levels are also analyzed to identify impacts that would result if such levels of statewide activity were actually achieved.

The FSD specifies that, to the extent possible, all issues are to be reviewed from the following three levels of statewide timber harvesting and associated forest management activity:

4.0 million cords. This was the level of statewide timber harvesting activity that occurred in 1990, the most recent year for which data was available at the time the document was drafted.

4.9 million cords. This is the level of statewide timber harvesting activity estimated to occur by 1995 if all announced or considered forest products industry expansions fully materialize. (This also approximates a 50 percent increase in timber harvesting and associated forest management activity over 1988 statewide harvest levels.)

7 million cords. This is the estimated maximum annual volume of timber available for harvest statewide for all tree species in the year 2000. (This also approximates a 100 percent increase in timber harvesting and associated forest management activity over 1988 statewide harvest levels.)

These alternatives provide for analysis under three different perspectives:

1. the current level of timber harvesting and forest management activity;
2. a level of statewide timber harvesting activity that is estimated to occur within the next five years if proposed expansions occur; and
3. estimated long-term maximum sustainable annual statewide timber harvest levels.

As is discussed more fully in section 2.3, the first alternative (4.0 million cords) was adjusted upward from the 3.2 million cord level specified in the FSD to reflect up-to-date information on existing statewide timber harvesting activity.

1.5.5 Scoped Issues

The following are the *issues of concern* identified in the FSD as those needing investigation in the GEIS. Under each major issue is a series of questions intended to more clearly define the significant aspects of each issue.

Maintaining Productivity of Forests for Timber Production. Making sure that forests are able to sustain (over long periods of time) the production of ample supplies of timber in an environmentally sensitive manner is of major importance to society. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *Based on most recent statewide forest inventory information, what allowable timber harvest rates are sustainable for major Minnesota forest types? What rates are possible for sustaining economic activity based on pulp, fuelwood and quality sawtimber products? What methods are used (or could be used) to estimate allowable harvest rates (considering structural and taxonomic diversity, specific geographic areas, and various landowner classes)?*
2. *What is the relationship between current and future estimates of sustainable timber supplies and the demands expected for the supply of such timber? Are there seasonal differences in timber demand and supply?*
3. *Are there classes of landowners, geographic regions or forest types where timber harvest rates may be expected to exceed allowable timber harvest rates or biological growth? If needed, what strategies can be implemented to assure the perpetuation of a renewable forest resource? What are the impacts of these strategies and what forest conditions will result from their implementation.*

Forest Resource Base. Forests are dynamic ecosystems which change naturally and in response to human intervention (e.g., timber harvesting). Understanding the nature and extent of such change is important to the making of wise management and land use decisions. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *To what extent have changes occurred in the size and composition of Minnesota's forest land base (using reliable statewide information)? What were the major factors contributing to this change?*
2. *To what extent do timber harvesting and management activities impact the abundance, composition, spatial distribution, age class structure, genetic variability and tree species mixture (for example, in creating forest monocultures) of Minnesota's forests (based on reliable*

information)? To what extent are changes in these characteristics specifically attributable to timber harvesting and management of certain forest landowner categories?

Forest Health. *The management of forests should be undertaken so as to ensure that they are sustained in a healthy condition over long periods of time, recognizing that endemic pest conditions will be present. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:*

1. *What impact does timber harvesting and management have on the change in risk of disease and insect infestations to Minnesota's forests?*
2. *To what extent are changes in the risks of insect and disease infestations specific to a particular forest landowner class, geographic region, tree species or forest type?*

Plant and Animal Diversity in Forest Ecosystems. *A diverse range of plants and animals are associated with forest ecosystems. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:*

1. *What impact does timber harvesting and management have on the biological diversity of forests at the genetic, species and ecosystem levels? What spatial patterns of forest cover does timber harvesting create, and how do these patterns impact wildlife and native plant communities (for example, fragmentation of forests)?*
2. *To what extent are federal and state-listed species of special concern, threatened, or endangered species or their habitats impacted by timber harvesting and management?*
3. *Based on the DNR's final definition of "old growth" forests and "old" forests, to what extent do these forests exist in Minnesota; how are they identified and managed; and how are they impacted by timber harvesting and management?*

Forest Wildlife and Fish. *Forest wildlife and fish are an integral part of forest ecosystems. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:*

1. *What are the forest dependent wildlife and fish species, their specific habitat requirements, and their current status and distribution?*
2. *To what extent does timber harvesting and management impact populations and habitats of each of the ten groups of wildlife as defined in Appendix B to the FSD.*

Water Quality. Forests are capable of influencing the flow of significant quantities of water of various qualities. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *To what extend does timber harvesting and management result in changes in the level of sedimentation, nutrient loading and runoff in lakes, rivers, streams and wetlands?*
2. *To what extent are fertilizers, compost, sludge and pesticides used in timber management, and what are their impacts on the quality of surface and groundwater?*
3. *To what extent does timber harvesting and management impact aquatic ecosystems, wetlands and peatlands?*

Forest Soils. Forest soils are a fundamental resource on which rests the ability of forests to provide a wide variety of benefits. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *To what extent does soil erosion occur as a result of timber harvesting, and how does this rate of erosion compare with forest soil erosion rates in undisturbed forests? What specific timber harvesting and management activities are major contributors to the erosion of forest soils?*
2. *To what extent do timber harvesting and management (e.g., short cycle rotations) activities impact nutrient cycling and the productivity of forest soils? To what extent do specific management and timber harvesting practices impact the productivity of forest soils?*
3. *To what extent do timber harvesting and management activities impact the compaction of forest soils? To what extent does soil compaction impact forest productivity and the growth of forest plants?*
4. *To what extent does the time of year in which timber harvesting occurs impact forest soil productivity and the success of forest regeneration?*

Forest Recreation. Forests provide significant opportunity for a wide variety of outdoor recreational experiences. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *To what extent are forest recreation opportunities, both quantitatively and qualitatively, impacted by timber harvesting and management? Do such impacts vary by type of recreation (e.g., day use, overnight use, dispersed, nondispersed, on-site, off-site, consumptive, nonconsumptive)?*

Economics and Management. Forests provide a variety of benefits which are critical to the economic and social health of regional and statewide *economies. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:*

1. a) *To what extent does timber harvesting and management impact regional and state economies?*
   b) *Which and to what extent do specific economic sectors benefit from timber harvesting and management?*
   c) *Which and to what extent are specific economic sectors adversely impacted by timber harvesting and management?*
2. a) *To what extent is the state's recreation and tourism industry impacted by timber harvesting and management?*
   b) *Which and to what extent do specific segments of the recreation and tourism industry benefit from timber harvesting and management?*
   c) *Which and to what extent are specific segments of the recreation and tourism industry adversely affected by timber harvesting and management?*
   d) *To what extent will an increase or decrease in timber harvest affect the habitats of deer and ruffed grouse, other game species and other recreational use of wildlife; and how will these changes affect state and regional economies?*
3. *What is the current distribution of timber stumpage among various users? What laws, policies and procedures influence this distribution?*

Aesthetics and Unique Cultural Resources. *Forests provide a variety of scenic vistas and often are the setting for important cultural and historic resources. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:*

1. *To what extent are unique historical and cultural resources (e.g., Native American cultural, religious and spiritual resources) in forested areas impacted by timber harvesting and management.*
2. *To what extent does timber harvesting and management impact the visual quality of Minnesota's forests?*

As discussed in subsequent sections of the document, data availability limited the extent to which impacts could be quantitatively assessed for certain issues. The GEIS study does identify areas where future research is needed to collect data that are currently unavailable but needed to more completely address all GEIS-scoped issues. The primary vehicle for addressing these FSD-scoped issues is the collection of nine technical papers, *Maintaining Productivity and the Forest Resource Base, Forest Soils, Forest Health, Water Quality and Fisheries, Biodiversity, Wildlife, Unique Historical and Cultural Resources, Economics and Management Issues,* and *Recreation and Aesthetics* (Jaakko Pöyry Consulting, Inc. 1992a,b,c,d,e,f,g,h; 1993), outlined in section 2.3.

1.5.6 Other Analyses

In addition to the previously mentioned scoped issues, two other issues were identified for analysis. These issues were related to, but not dependent on, levels of timber harvesting and forest management being examined. The first issue was the assessment of opportunities for using recycled fiber to meet additional wood fiber demand, including an assessment of any consequent impacts on the environment and the economy. The second issue required the identification and description of studies that address global warming and its possible effects on Minnesota's forests.

1.5.7 Study Timeframe

The FSD specified a schedule for study preparation that envisioned the preparation of the feasibility assessment and study workplan by June 1991. The GEIS study was to be started in June, and a draft GEIS, including input from the Advisory Committee, was to be completed in January 1992 and released for public comment in February or March 1992. The final document was to be completed in June 1992.

This schedule constrained the time available for the study and was a fundamental and critical factor shaping the study methodology. The proposed methodology was unconstrained by cost but constrained by a final reporting date of July 1992 (Jaakko Pöyry Consulting, Inc. 1991a).

The manner in which the GEIS process ultimately evolved extended the study timeframe to the middle of 1993. The major factors responsible for this extension included: (1) initial delays in securing funding for the approved GEIS Workplan (Jaakko Pöyry Consulting, Inc. 1991b); (2) difficulties associated with critical data sets required to conduct the analysis; (3) a more extensive oversight role for the GEIS Advisory Committee than originally envisioned; and (4) additions to the EQB-approved study process as set out in the Workplan, such as conducting a consultant-initiated external review of all technical papers prior to their submission to the EQB.

2
GEIS STUDY COMPONENTS

This section provides an overview of the general structure and methodology used to conduct the GEIS study, as well as its principle outputs. A description of the study's main elements is included, as well as a chart that illustrates the organization of the study. The overall study structure was originally developed in the Feasibility Study and the methodology was developed in the Workplan. The study methodology was specifically developed to meet the study's three objectives, major assumptions, and original work schedule, and structured in a way that explicitly addresses the ten major issue areas identified in the FSD.

2.1
Study Participants

The study team of Jaakko Pöyry international consultants and local experts was organized into a core group, six specialist study groups, the preparers of five background papers, and other specialist staff. In total, more than 60 individuals were utilized by Jaakko Pöyry to help prepare the GEIS. An organizational chart identifying the subdivision of the study into the six study groups and core group is set out in figure 2.1. A brief description of the major responsibilities of the key groups is described below.

Core Group
The group was comprised of Jaakko Pöyry consultants and the local study group coordinator. It was responsible for the overall analysis, writing, and preparation of the study workproducts; preparation of the draft and final GEIS documents; presentations to the EQB, the Advisory Committee, and the public; and ongoing liaison with the state and contract administration matters.

Individuals in this group include:

- Dr. James A. McNutt, Project Manager;
- Doug G. Parsonson, Project Coordinator;
- Dr. Alan R. Ek, Study Group Coordinator; and
- Dr. Lee E. Frelich, Associate Project Coordinator.

Specialist Group
The specialist group was subdivided into six study groups to provide in-depth technical analysis of the ten issues specified in the FSD. In addition, individuals were brought to the project to develop the background papers or provide GIS and pattern analysis. The specialist study groups and their participants are as follows:

Principal Local Study Team Members

Maintaining Productivity and the Forest Resource Base
Dr. Dietmar W. Rose, Dr. Thomas E. Burk, Dr. Alan R. Ek, Dr. Howard M. Hoganson, Dr. Marc E. McDill, David K. Walters, Douglas C. Kapple

Forest Soils and Forest Health
Dr. David F. Grigal, Dr. Peter C. Bates, Jane Cummings Carlson, Dr. Deborah G. McCullough, Dr. James C. Balogh

Water Quality and Fisheries
Dr. James A. Perry, Dr. Raymond M. Newman, Dr. Kenneth N. Brooks, Dr. Nels H. Troelstrup, Jr.

Biodiversity and Wildlife
Dr. Peter Jordan, Dr. Lee E. Frelich, Dr. Gerald J. Niemi, Dr. Donald P. Christian, Joann M. Hanowski, Calvin J. Harth, Dr. Edward J. Cushing, Paul H. Glasser, Will Pitt, Kristina Miller

Recreation, Aesthetics and Cultural Resources
Dr. Dorothy H. Anderson, Dr. David W. Lime, Dr. Leo H. McAvoy, Dr. David G. Pitt, Dr. Christy A. Hohman-Caine, Wayne A. Freimund, Jerrilyn L. Thompson, Grant E. Goltz, Doug G. Parsonson

Economics and Management Issues
Dr. Allen L. Lundgren, Dr. Marc E. McDill, Donald G. MacKay, Dr. Benedict Arias

Several of the specialist study groups addressed more than one issue area. The senior members of these groups are identified in figure 2.1 and the Workplan. A number of other people also provided specific inputs to the study process.

In preparing these papers, each study group carried out the following activities: data collection, technical literature review, evaluation of the existing conditions, background analysis, and the development and evaluation of significant impacts and related mitigation measures. The methodology used for each of these components is outlined in section 2.3.3 of this document, and is set out in detail in the various technical papers.

Each study group was responsible for the preparation of one or more technical papers which, together with the background papers, address all questions stated in the ten issue areas.

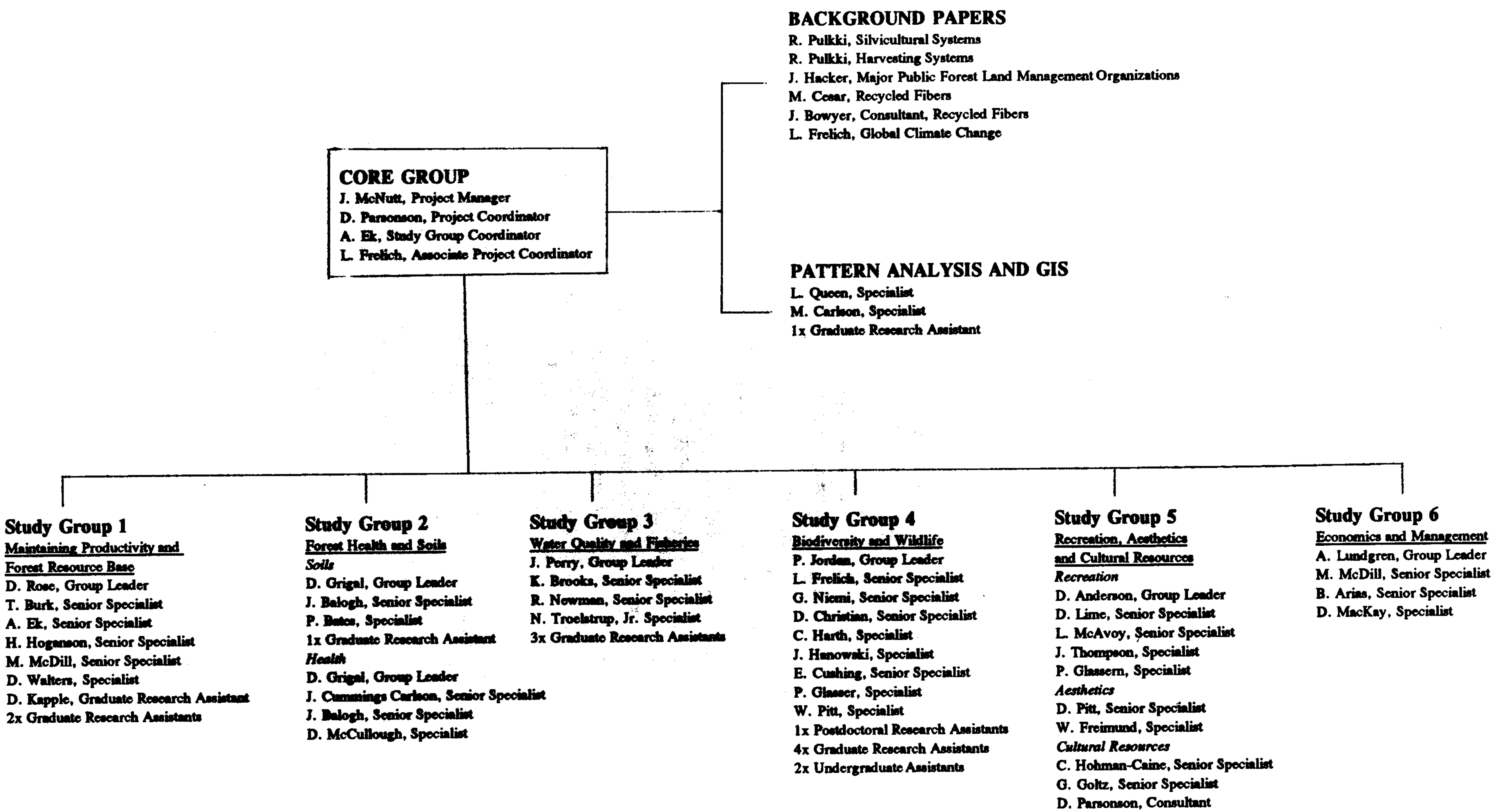

Figure 2.1. Study team organization.

Other individuals involved in preparing the technical and background papers and other workproducts used to develop the GEIS document are identified below. This list does not include the many people who undertook data analysis and other background work.

Jaakko Pöyry Personnel
Louis Carbonnier, Mary Cesar, Dr. Reino Pulkki, Ben Airas, Doug Gill, Scott Estey, Jan Rushing, and Sheila Parsonson

Others
Dr. James L. Bowyer, Dr. LLoyd Queen, Jan J. Hacker, and Clara M. Schreiber

2.1.1 Other Study Participants

In addition to the contractor's study team, the following groups of individuals and organizations also contributed to the study process.

Jaakko Pöyry Network Support Group: This group included Jaakko Pöyry senior management members and specialists who were available for consultation and special analyses relating to issues of policy, industry, and technology.

Minnesota Planning Office: The Minnesota Planning Office was the state's agent for administering the GEIS study. As project manager, the Minnesota Planning Office was responsible for the overall management of the study and was actively involved in all aspects of planning and preparing the GEIS. The Minnesota Planning Office assigned Dr. Michael Kilgore as the state's GEIS project coordinator and to serve as the liaison between the contractor, Jaakko Pöyry Consulting Inc., and the EQB. Dr. Kilgore also administered the GEIS Advisory Committee.

GEIS Advisory Committee: The GEIS Advisory Committee provided inputs and advice to the EQB at various stages of the study process, as discussed in section 1.3.2. The Advisory Committee played an important role in formulating the final significance criteria and selecting mitigation alternatives to be considered in the technical papers and this document. In addition, some Advisory Committee members secured technical advice in the review of draft documents by soliciting comment from independent outside experts and/or agency personnel.

Environmental Quality Board: The EQB role in the study process was to provide overall study direction as necessary and to approve workproducts. The major work of the EQB was conducted through the Board's GEIS

Committee, chaired by Dr. Paul Toren. Other committee members were Rod Sando and Robert Dunn.

Consultant-initiated Ad hoc Peer Review Group: Selected technical experts reviewed the final draft technical papers prior to their submission for approval by the EQB.

Maintaining Productivity and the Forest Resource Base
Dr. Charles Scott, USDA Forest Sciences Laboratory
Dr. Doug Brodie, Oregon State University
Dr. John Pastor, Natural Resources Research Institute

Forest Soils
Dr. Jim Bockheim, University of Wisconsin-Madison
Dr. Bill Atkinson, Dr. Hank Froehlich, and Brian Kramer, Oregon State University

Forest Health
Dr. Bill Miller and Dr. Bob Blanchette, University of Minnesota

Water Quality and Fisheries
Dr. Sandy Verry, USDA North Central Forest Experiment Station
Dr. John Clauson, University of Connecticut

Biodiversity
Dr. Malcolm Hunter, University of Maine
Dr. Thomas R. Crow, USDA Forest Sciences Laboratory
Dr. Steve Chaplin, Nature Conservancy

Wildlife
Dr. Robert Giles, Virginia Polytech Institute
Dr. Robert W. Howe, University of Wisconsin-Green Bay
Keith McCaffery, Wisconsin Department of Natural Resources

Recreation and Aesthetics
Dr. Wayne Tlusty, University of Wisconsin
Dr. John Schomaker, U.S. Fish and Wildlife Service
Dr. Herb Schroeder, USDA Forest Service

Unique Historical and Cultural Resources
Dr. Bill Lovis, Michigan State University
Gordon Peters, USDA Forest Service

Economics and Management Issues
Dr. Robin Gregory, Decision Research
Dr. Randall O'Toole, Cascade Holistic Economic Consult.

Dr. Richard Alston, Weber State University
Dr. Rebecca Judge, St. Olaf College

Independent Peer Review Group: An independent peer review of the draft GEIS was provided by a panel of objective experts prior to the public release of the draft document:

Review Coordinators
- Dr. Roger Sedjo, Resources for the Future
- Dr. Harold Burkhart, Virginia Polytech School of Forestry and Wildlife Resources
- Dr. Bill Lange, USDA Forest Service

2.2 Study Structure

The study flow chart (figure 2.2) shows how the study process was structured to integrate the work products from the various study teams. It also illustrates how opportunities were provided for input from other participants. The steps followed in the study are numbered from 1 to 19 in this figure. The figure identifies some of the preliminary documents which were instrumental in shaping the study approach. Other important factors in shaping the study included the provision of opportunities for the EQB, Advisory Committee, and the public to provide input; the internal relationships between elements of the study team; and the EQB-defined key study workproducts.

Although the major tasks of the study shared several common elements, many of these tasks were undertaken independently and combined later to create the GEIS document. This approach was adopted primarily because of the time constraints originally imposed on the study (refer to section 1.5.7). The short time frame meant that a more desirable linear study format was not possible; therefore, the parallel format was adopted, with six study groups and background paper authors working concurrently on steps 3 to 14, as shown on the study flow chart.

Aside from sharing common objectives stemming from the FSD, the common elements referred to above included using:

- the Forest Inventory and Analysis (FIA) data set from the USDA Forest Service as primary data inputs;
- ecoregions to provide uniform subdivisions of the state for analyzing/reporting impacts at a level of resolution below statewide level;
- the model run outputs from three timber harvesting scenarios as a common basis for data with which to quantitatively assess impacts;

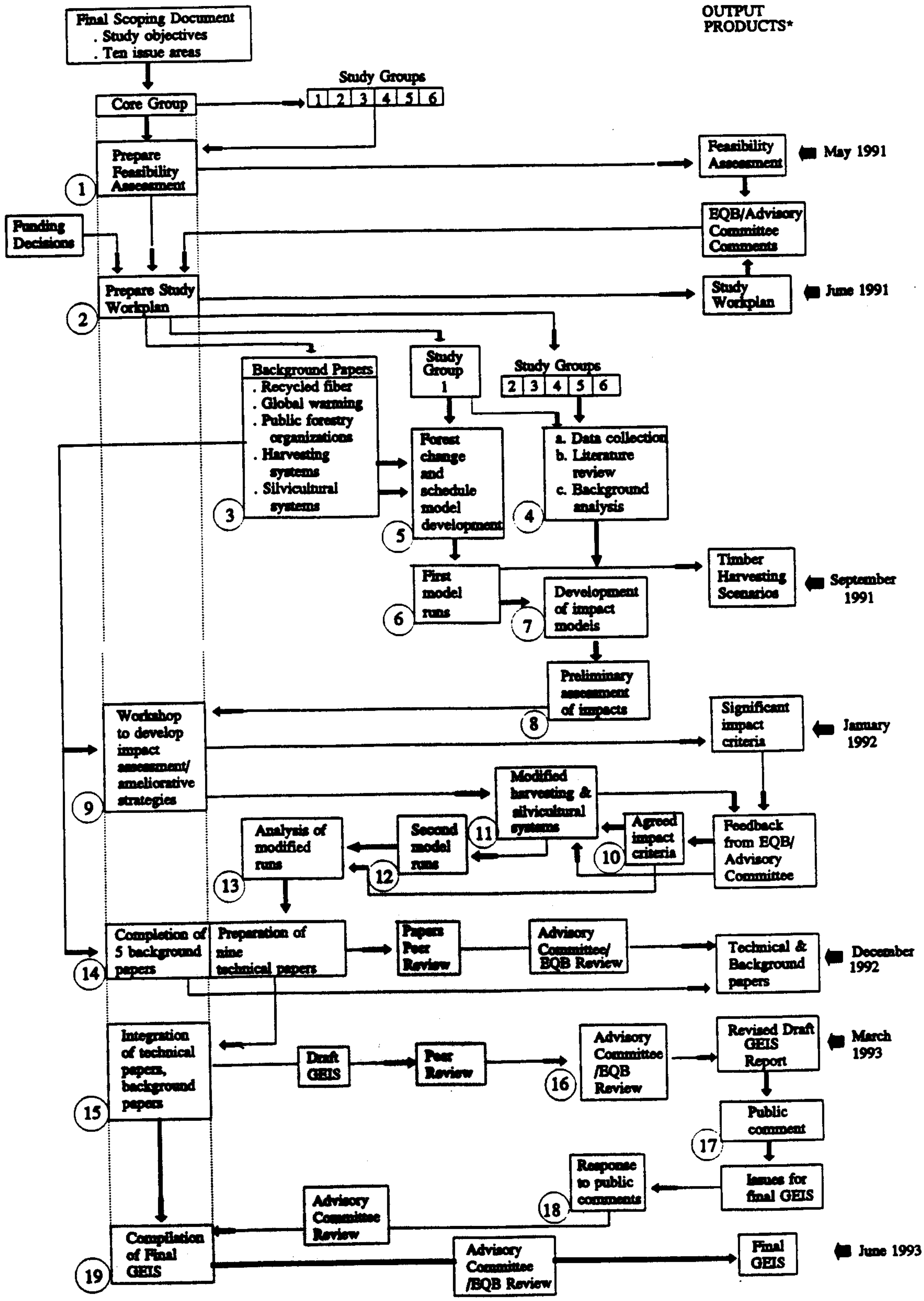

Figure 2.2. Study flow chart.

- approved criteria to identify significant impacts, mitigation alternatives, and preferred mitigation actions;
- information on predominant silvicultural and harvesting systems and techniques used in Minnesota and the current policies, programs, and practices of Minnesota's public forestry organizations; and
- a common structure and format.

2.2.1 Data Inputs

The USDA Forest Service 1990 FIA unit data formed the basis for the harvest scenario modelling and was used by the other study groups to develop characterizations of the forests and forested areas of Minnesota. A comprehensive description of the FIA data can be found in section 4.2.1 of the *Maintaining Productivity and the Forest Resource Base* technical paper. Generally speaking, the FIA data provides the following:

- statewide coverage, reinventoried every 10 to 15 years;
- on-the-ground measurements augmented with aerial photographic interpretation;
- a statistical sample to represent existing forest conditions; and
- estimates for
  - types of tree species and covertypes present,
  - area,
  - volume,
  - growth and mortality, and
  - average annual removals.

The preliminary 1990 FIA test data set was made available to the study team by the USDA Forest Service under the terms specified in a memorandum of understanding between the USDA Forest Service and the EQB. The FIA data were structured into a relational database to facilitate retrieval of user-defined information. Where appropriate, other data were linked to the FIA plot locations to provide a consistent basis for subsequent analysis. The FIA data were examined by each study group to identify data attributes that could be used in subsequent analyses.

2.2.2 Ecoregions

The FSD called for a study that would enable the EQB to assess the cumulative impacts of timber harvesting and related forest management issues at a statewide level, over time, for the specified range of harvesting levels. In order to achieve the stated objectives, the study had to be conducted at a scale of resolution that provided this broad perspective, while still including sufficient detail to substantiate the analysis and to enable development of appropriate strategies to avoid and/or ameliorate identified impacts. A uniform format for the presentation of information was also needed. These requirements were met by subdividing the state into 7 **ecoregions** shown by figure 2.3.

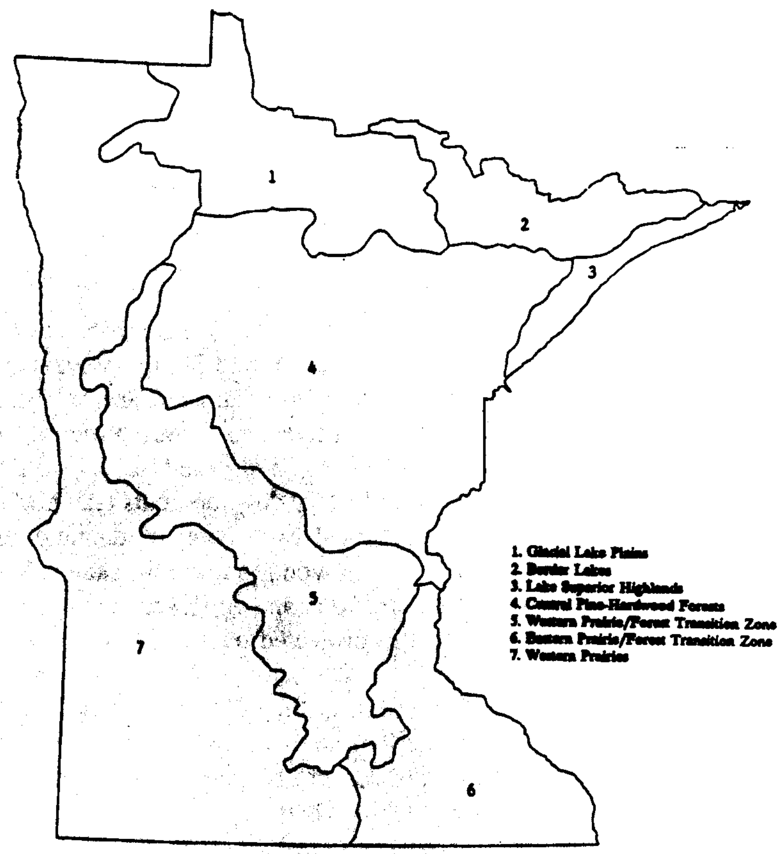

Figure 2.3 Ecoregions used in the GEIS study. (Source: Jaakko Pöyry Consulting, Inc. 1992a.)

These ecoregions are geographic regions with similar physical and biophysical characteristics, and were derived from the ecoregions defined by the Upper Great Lakes Biodiversity Committee (UGLBC). Some of the analysis was performed using smaller units than the above ecoregion subdivisions. Where possible, results from analyses undertaken at these levels of detail are aggregated and reported at the ecoregion scale.

In the technical papers, the reporting of economic, social, and other impacts was sometimes best handled using other types of regional subdivisions. The choice of the subdivisions used was governed by the form of data available and its ability to provide meaningful interpretations.

2.3 GEIS Workproducts

The following sections describe the major workproducts produced as part of the GEIS study process.

2.3.1 Statewide Timber Harvesting Scenarios

The initial harvesting scenarios were produced as the third workproduct from the study process and are shown as step 6 in the study flow chart (figure 2.2).

Three harvesting scenarios were produced in accordance with the explicit requirement set out in the FSD to analyze environmental and related impacts at three distinct levels of timber harvest intensity. These scenarios model the timber supplies needed to meet (1) the existing levels of demand (4 million cords/ annum), (2) a demand level projected to occur if all planned or announced industrial developments take place (4.9 million cords/annum); and (3) a hypothetical high level of demand that would require harvesting 7 million cords of wood per annum statewide. These three are referred to as the *base, medium,* and *high* scenarios, respectively. All three harvesting scenarios are projected over a 50-year planning horizon.

The base scenario for the statewide timber demand is 800,000 cords higher than the 3.2 million cord level specified in the FSD. These differences reflect more recent estimates of contemporary wood consumption levels than were available when the FSD was issued. Details of demand levels for industrial wood and fuelwood used to compile the three scenarios are provided in section 3.5.

Harvesting Scenarios Preparation Process

Harvesting Scenarios as Alternatives: The GEIS uses an analysis of the three EQB-specified levels of harvesting as a surrogate for an analysis of project-specific alternatives when assessing impacts. The base and medium levels are derived by summing demand for wood from existing or planned industry facilities. The locations of these industry facilities and the volumes and types of wood they require is known. The high level of harvesting specified additional harvesting activity needed to reach a level of harvest estimated to be equal to the long-term maximum sustainable level of harvest from the state's forests.

By structuring the study alternatives in this way, the FSD required development of a methodology to allocate or schedule harvests across Minnesota's forests, and over time, to meet the specified levels of demand. The harvesting scenarios were developed to match the demands from specific industries with the capacity of the forests to meet that demand. Harvesting operations and associated forest management activities were scheduled for individual stands in a way that made the most economic sense, i.e., least cost overall within the framework of mitigations and constraints. Constraints were imposed by market demand and the availability of particular categories of forest land for harvesting.

Data yielded from the scenarios formed the basis for most of the subsequent impact analysis undertaken by the study groups. Therefore, the scenarios were a critical element to being able to assess impacts for those issues of concern identified in the FSD.

The scenarios had to be prepared at a scale that would yield the following categories of information for each harvesting level:

- where and how timber harvesting and forest management activities would need to occur to meet the specified demand;
- a plausible schedule for harvesting over the 50-year study period;
- consequent likely changes to the age class, species composition, and structure of the state's forests during, and at the end of, the period being assessed; and
- projections of the proportion of the specified level of harvest that would be yielded by the various ownerships.

Data Requirements and Model Development: The scope of the study and the need to address the issues of concern required the collection of data describing the existing forest condition and existing and future industry demands and related factors. This information was used in the generation of scenarios that depict how, when, and where harvesting would have to take place. It was also used to depict the type of changes that would occur to the forests under the various levels of harvesting.

The previously described FIA database was selected as the most useful characterization of the state's forested lands and the starting condition of the state's forests. The FIA database contains enormous detail derived from an intensive sampling of the state's forest. Statewide this database for 1990 provided records from 13,536 field checked plots classified as forest. Additionally, the database contained 760 plots classified as nonforest land with trees. The forested plots were further classified into three categories: *timberlands* (productive forests potentially available for harvest); *reserved forest* (productive and unproductive forest unavailable for harvesting); and *unproductive forest*. Subsequently, only the timberlands were assumed to be available for harvest.

The plots provided a spatial approximation of the total resource and were used as the basic *units* from which the scenarios allocated timber harvesting activity. Each plot from the FIA database has an *expansion factor* that is used to convert plot characteristics to the stand scale the plot represents. As an example, most timberland plots represented 900 to 1,500 acres.

Development of computer models to generate the three scenarios was necessary to handle the amount of information required and to project the scenarios far enough into the future to insure that long-term, as well as short-term, impacts could be detected. Models were adapted and/or specifically developed to generate realistic harvesting scenarios by incorporating the most recent available data covering the following:

- the volume (by size and species), location, and ownership of wood potentially available;
- existing, planned, or potential wood-based industries and their locations;
- current costs associated with timber harvesting, transport, and forest management activities;
- the regional transport network to link the wood supplies with the processing facilities;
- forest management practices and the implications of these on the structure and species composition of the forests and yields of timber in the short- and long-term (see below);
- criteria used by industries to select stands when making purchases of timber; and
- existing land management policies that influence the availability of timber for harvest.

Specific estimated timberland availability by ownership is shown in table 2.1.

Table 2.1. Availability of timberland by ownership assumed for second runs.

Ownership	Percent Available
National forests	
Chippewa	87
Superior	53
State	95
County	95
Other public	64
Forest industry	98
Other private	90

Source: Jaakko Pöyry Consulting Inc. (1992a).

In addition to these data, other important inputs were used in the modelling process. These were:

- the ability to simulate tree growth and the forest development, including forest area and land use change, that would occur during the planning period to reflect the regeneration after harvest, growth (including volume and size increments) changes in the mix of species occupying a site over time (termed *succession*); and
- the ability to alter *utilization levels*, (defined as the minimum and maximum diameters that are used to determine if a log is suitable for a particular use), on a per tree or per acre basis.

Recent and assumed forest area changes are shown in table 2.2. See section 6.12 in the Maintaining Productivity and the Forest Resource Base technical paper for more detail on actual implementation.

Table 2.2. **Recent and assumed forest land area change by survey unit, 1990–2040.**

FIA Unit	1977–90 (percent)	1990–2040 (percent)
Aspen-birch	-1.47	-5.7
Northern pine	-2.70	-10.7
Central hardwood	9.96	34.9
Prairie	13.57	46.0
All units	0.03	0.2

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Two timber harvest and forest management planning models were also incorporated in the development of the statewide timber harvesting scenarios. These models were:

1. RxWRITE: a set of programs used to develop options for how each area of forest or stand (as represented by the plots) might be managed at each of the 10-year planning decision points used in the study, and
2. DTRAN: a forest management scheduling model that *optimizes* harvesting and management activities by selecting from the options available.

Examples of the types of options produced for a stand old enough for harvesting might include: clearcutting; thinning a certain proportion of the stand; selective harvesting; or no harvesting. For a stand that has just been harvested, the choices might be to allow the stand to naturally regenerate, or to plant it and develop a forest consisting of different species than those occupying the site prior to harvest. Thus, the range of options changed either as the stand aged, or in response to changes brought about by choices made in earlier periods. The range of options available branches out over time and is referred to as a *decision tree,* illustrated by figure 2.4.

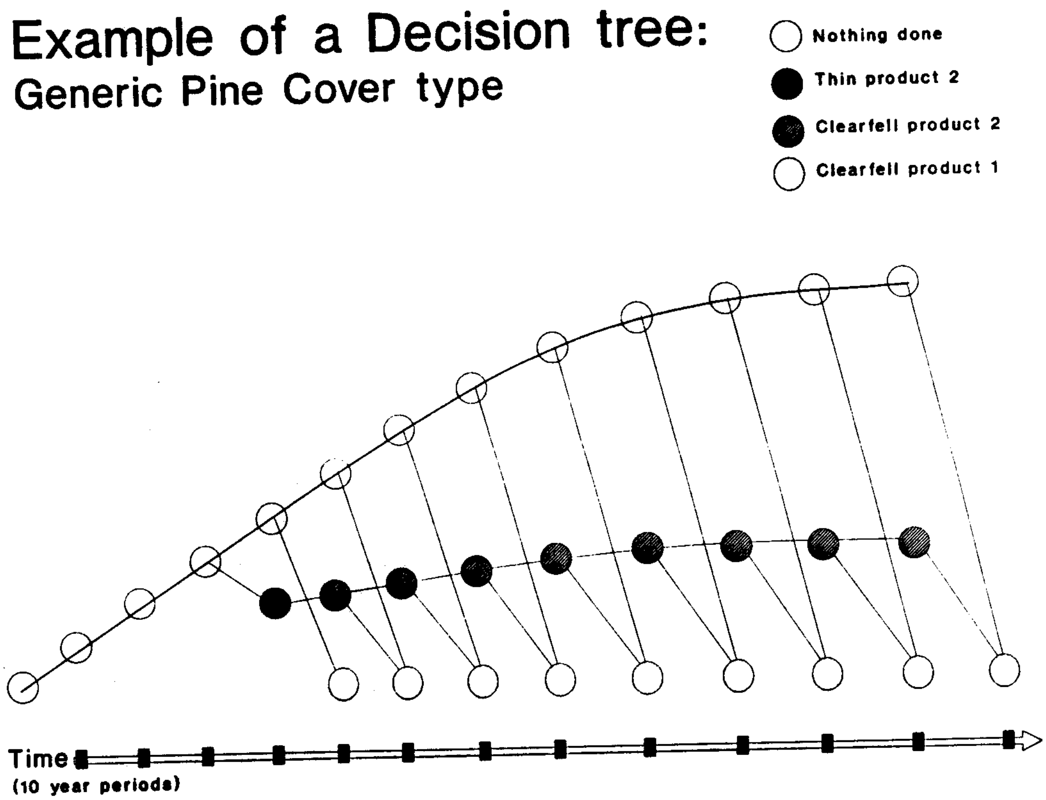

Figure 2.4 Example of a Decision Tree. (Source: Jaakko Pöyry Consulting, Inc. 1992a.)

The most appropriate option for each stand at each ten-year decision point was selected by the forest management scheduling model, as it matched demand for a product with the stand or forest best able to supply that product. Demand was aggregated into six *market centers* to simplify the analysis. These are shown by figure 2.5. No market centers were defined in the south of the state because demand was assumed to be comprised of many smaller enterprises.

The rotation ages for various covertypes and the covertypes themselves that were assumed in the GEIS are shown in table 2.3.

Other models were incorporated within this framework as necessary to generate data, and to modify and interpret inputs and outputs: (1) a tree growth model (GROW) was used to grow trees as part of the model that develops prescription options; (2) a regeneration model was developed to portray new stand development following harvesting; and (3) a basic geographic information system type model (GISTRAN) was incorporated into the management scheduling model to generate transport information and to allow graphic depiction of outputs from the model.

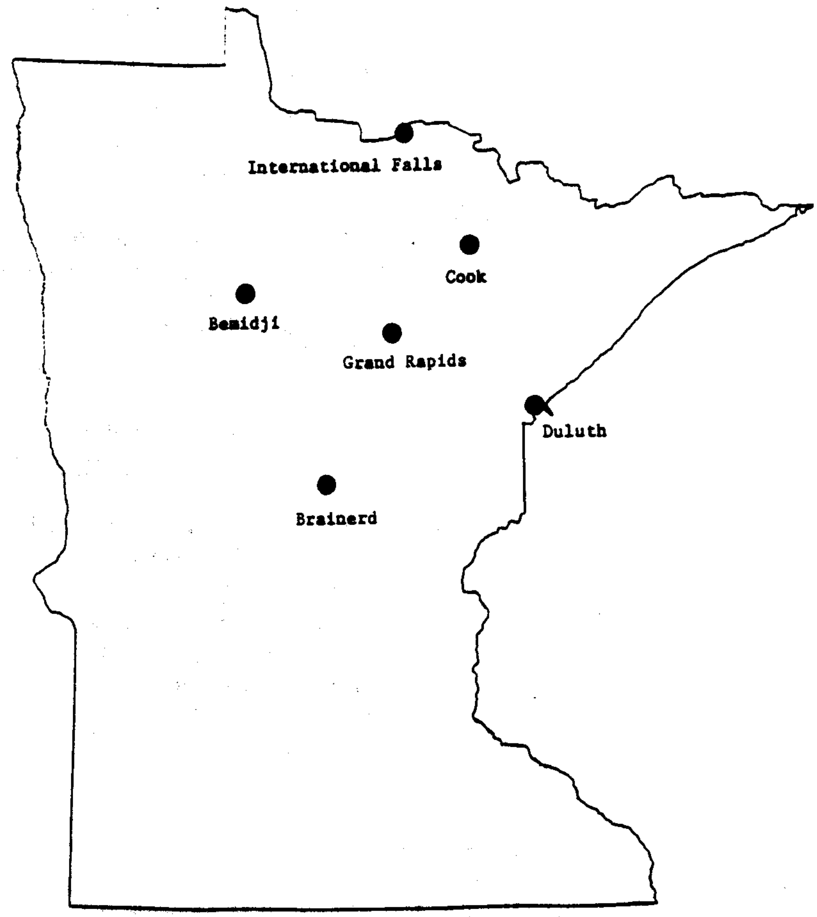

Figure 2.5. Market Centers. (Source: Jaakko Pöyry Consulting, Inc. 1992a.)

All together, the above collection and linkage of models was termed the *Forest Change and Scheduling Model*.

Table 2.3. FIA covertypes and minimum nominal rotation ages assumed in the GEIS.

FIA Code	Description	Nominal minimum rotation age*
1	*Jack pine.*—Forests in which jack pine comprises a plurality of the stocking. (Common associates include eastern white pine, red pine, aspen, birch, and maple.)	50
2	*Red pine.*—Forests in which red pine comprises a plurality of the stocking. (Common associates include eastern white pine, jack pine, aspen, birch, and maple.)	60
3	*White pine.*—Forests in which eastern white pine comprises a plurality of the stocking. (Common associates include red pine, jack pine, aspen, birch, and maple.)	60
12	*Black spruce.*—Forests in which swamp conifers comprise a plurality of the stocking with black spruce in the most common. (Common associates include tamarack and northern white-cedar.)	60
13	*Balsam fir.*—Forests in which balsam fir and white spruce comprise a plurality of stocking with balsam fir the most common. (Common associates include aspen, maple, birch, northern white-cedar, and tamarack.)	50
14	*Northern white-cedar.*—Forests in which swamp conifers comprise a plurality of the stocking with northern white-cedar the most common. (Common associates include tamarack and black spruce.)	70
15	*Tamarack.*—Forests in which swamp conifers comprise a plurality of the stocking with tamarack the most common. (Common associates include black spruce and northern white-cedar.)	60
16	*White spruce.*—Forests in which white spruce and balsam fir comprise a plurality of the stocking with white spruce the most common. (Common associates include aspen, maple, birch, northern white-cedar, and tamarack.)	60
50	*Oak-hickory.*—Forests in which northern red oak, white oak, bur oak, or hickories singly or in combination, comprise a plurality of the stocking. (Common associates include jack pine, elm, and maple.)	60
70	*Elm-ash-soft maple.*—Forests in which lowland elm, ash, red maple, silver maple, and cottonwood, singly or in combination, comprise a plurality of the stocking. (Common associates include birches, spruce, and balsam fir.)	60

Table 2.3. continued.

FIA Code	Description	Nominal minimum rotation age*
80	*Maple-basswood.*—Forests in which sugar maple, basswood, yellow birch, upland American elm, and red maple, singly or in combination, comprise a plurality of the stocking. (Common associates include white pine, elm, and basswood.)	70
91	*Aspen.*—Forests in which quaking aspen or bigtooth aspen, singly or in combination, comprise a plurality of the stocking. (Common associates include balsam poplar, balsam fir, and paper birch.)	40
92	*Paper birch.*—Forests in which paper birch comprises a plurality of the stocking. (Common associates include maple, aspen, and balsam fir.)	50
94	*Balsam poplar.*—Forests in which balsam poplar comprises a plurality of the stocking. (Common associates include maple, aspen, and balsam fir.)	40

* The full set of harvest and treatment options and ages are considerably more complex than indicated by this column. For example, ERF rotations are longer than those specified here. See appendix 1, Jaakko Pöyry Consulting, Inc. (1992a), for details.

Assumptions

Development and application of the models generating the three timber harvesting scenarios required certain assumptions generally relating to:

- the use of FIA plots and their associated expansion factors as an adequate approximation of the state's forest resource;
- growth of trees and changes in forests over time and regeneration of trees after harvesting;
- costs of timber harvesting and forest management activities; and
- availability of timberlands for harvest, and applicability of management practices for the different ownerships.

With respect to forest growth, the model used (GROW) is an individual tree-based model that projects individual tree growth and mortality on each FIA plot. The rates of growth and mortality are developed from submodels which themselves were calibrated by USDA Forest Service NCFES researchers and others using data from remeasured and other field plots. The growth and mortality estimated by the model are a function of tree species, size, crown development, site quality, stand density, and to some extent stand treatment. These calibrations and hence the precision and accuracy of estimates reflect the level of disturbance in the calibration data itself. Given that catastrophic disturbances such as fires, windstorms, and insect and disease outbreaks are difficult to incorporate in such databases, we suspect that overestimates of growth are still possible for some forest types. Consequently, for the second model runs, adjustments developed by FIA researchers were also employed with the net effect being to reduce forest growth estimates (see section 4.10.1 of Jaakko Pöyry Consulting, Inc. 1992a). The model also assumed site quality (site index) would remain stable over the 50-year projection period.

For the second runs, covertype changes were developed on an individual plot basis in two ways, that due to harvest and that due to succession or stand dynamics. The first type of change occurred at harvest (clearcut) and was developed from (1) decision trees for planting and (2) in the case of natural regeneration from covertype change matrices developed separately by FIA unit from changes in harvested plots over the period 1977–90 (see section 4.10.1 and appendix 2 of Jaakko Pöyry Consulting, Inc. 1992a). The second type of covertype change was developed from the GROW model results at ten-year intervals over the study period. Covertype change or succession was evaluated by applying the covertype algorithm to the projected FIA plot tree list (the list of trees on the plot and their associated characteristics) at that time and reclassifying the plot by covertype as appropriate. Thus the differing projected tree size, mortality and thinning by species determined the covertype and thus any change. Preliminary comparisons of this approach to actual FIA plot covertype changes over the period 1977–90 suggested this rather direct approach seemed to capture the direction of covertype change.

More specific assumptions for each of the three harvesting levels are discussed in sections 5, 6, and 7. A detailed discussion of all such assumptions can be found in the Maintaining Productivity and the Forest Resource Base technical paper.

Information on predominant harvesting and silvicultural systems, along with the policies of the state's public forestry organizations, were used to develop a detailed profile of the current methods of forest management, silviculture, and timber harvesting practices in Minnesota. Methods with potential application in Minnesota were also considered. Using this information, profiles of typical operations were developed for a range of operations, covertypes, and ownerships and incorporated into the management alternatives used in the forest change and scheduling model. These alternatives describe the silvicultural and harvesting systems that are assumed to apply to each category of operation, covertype, and ownership. This included assessments of the availability of timberlands over time (see below).

Model Runs

Two model runs were made for each of the three timber harvesting scenarios, creating two sets of harvesting scenarios. The major differences between the model runs was the incorporation of covertype dynamics and the assumed availability of timberlands for harvest.

The first model runs assumed that stands retained their original covertype designation throughout the study period, regardless of harvesting or other factors. The second runs incorporated model refinements to include (1) possible covertype change with harvesting, and (2) succession to other covertypes associated with aging and stand dynamics.

In the first model runs, an important assumption was that all timberlands in the state were available for harvesting. The only exceptions were those within legislatively designated reserve areas and those designated as unproductive. The first model runs also assumed that management objectives for all available lands included the possibility of timber harvesting, therefore ignoring and/or simplifying some of the constraints imposed by the various ownerships. The second model runs introduced ownership constraints and mitigations. These constraints and mitigations reflect current and prospective management procedures and policies applied by the major forest land managers. Examples include:

- extended rotation forests (ERF), i.e., rotation for a given forest covertype lengthened, usually by 50 percent, compared to minimum rotation ages. Approximately 20 percent of the timberland on state and USDA Forest Service ownerships to be managed under an ERF prescription (note that the Superior National Forest does not currently have an ERF program);
- greater use of uneven-aged management;
- designation and reservation of old growth and old growth replacement acreage;
- best management practices (BMPs), i.e., thinning or ERF within 100 feet of water; and
- wildlife buffers (thinning only within 200 feet of water) on the national forests and in the southeastern part of the state.

Old growth forest designation was implemented by identifying approximately one to two plots over 120 years old in each covertype (younger when necessary, but no less than 90 years old) and one replacement plot from an adjacent younger age class. Such plots comprised 57,500 acres of old growth and a similar acreage of replacement forest. These plots were then reserved from harvest for the duration of the study period. Much of this acreage was located on state and federal lands.

In addition, estimates of the actual availability of timberlands for harvest or management, developed separately by ownership, were used to set aside a portion of the timberland as *not available* for various economic, environmental and social concerns.

Other model changes for the second runs included refinement of thinning options, notably to reflect desired practice within buffers and for approximating and encouraging uneven-aged management. Forest and timberland area change from 1990 to 2040 was also implemented gradually throughout the 50-year period using estimates of annual change rates (see section 5.2.1 for a description of those rates). The second runs also applied the USDA Forest Service allowable cut limits for yields from national forest timberlands for the base and medium scenarios. National forest cut limits were relaxed for the high scenario. Additionally, a technological change assumption was that northern hardwoods could be substituted for aspen. Section 4.10 of the Maintaining Productivity and the Forest Resource Base technical paper provides a detailed discussion of the second model runs formulation and constraints.

Inclusion of the model refinements described here including stand dynamics, ownership constraints, and mitigations means that the second runs are a reasonable depiction of current and future timber availability.

More runs and more detailed alternatives might have been developed. However, it must be noted that the GEIS is not an agency-specific planning exercise, rather it is an attempt to assess impacts of specified levels of harvesting at an ecoregion and state level across ownerships.

The outputs from the model runs were in the form of plots harvested by planning period; the type of harvesting (clearcutting and thinning); the products harvested; products delivered and their cost; and assumed management activities (aside from harvesting). These outputs were used as an input into the forest change model which generated depictions of the forest condition on each plot over time. Depictions of changes on each plot were created at an individual tree level of resolution. The tree and plot expansion factors and stand acreage were then used to convert this to stand level and ecoregion changes.

The study groups used various parts of this output, depending on their specific requirements for conducting environmental impact assessments. For example, the forest soils study group required information on the volume of timber removed by covertype and the frequency of harvests; whereas the wildlife group required data including the presence or absence of certain key tree species, the age and size class structure of stands, and any changes in covertype.

The forest changes projected under the scenarios were then used to develop and characterize impacts affecting the issues of concern for each of the three harvesting scenarios.

Descriptions of the study group analyses using the model outputs are set out in more detail in subsequent sections of this document.

2.3.2 Study Criteria Development

There are three types of criteria developed for the GEIS:

1. *significant impacts* criteria;
2. *mitigation alternatives* criteria; and
3. *mitigation strategies* criteria.

These criteria were prepared as the major component of the fourth work product of the study process, which corresponds to step 10 in the study flow chart (figure 2.2).

The criteria were developed to facilitate input from the Advisory Committee and EQB into the study process. The first category was developed to assess the significance of each of the impacts identified in the study process. For those impacts identified as significantly adverse, a second set of criteria was developed to identify potentially suitable mitigation alternatives. Finally, the third set of criteria was developed (to select between mitigation alternatives) to identify appropriate strategies for policy development.

The criteria developed were critical work tools that ensured the study remained focused on the process needed to develop the best set of mitigation strategies to address cumulative, statewide impacts. Key issues and objectives in this process were:

- to comprehensively identify all potential impacts;
- to develop a systematic approach for assessing impacts in order to identify those which are considered significant;
- to develop intellectually sound/objective alternatives to minimize those impacts identified as significant;
- to facilitate two-way feedback between the GEIS study team and the EQB Advisory Committee on development of these criteria; and
- to develop a framework for identifying practical mitigation strategies that have the uniform support of all parties involved.

Criteria Development Process
A sequential process was used to develop the criteria. The initial or first run timber harvesting scenarios were analyzed to identify impacts, by issue area,

that could occur at the three levels of timber harvesting. Technical criteria were developed that identify (in most cases) threshold levels that indicate when impacts were considered to be significant. These levels were developed using existing standards where appropriate, and from the literature or based on expert judgement where standards do not exist. In practice, very few standards had been previously developed to address the issues examined in the GEIS. Consequently, expert opinion and judgements were dominant factors in shaping the significance criteria.

The criteria, which have been approved by the EQB, reflect input from the EQB, based partly on advice from the GEIS Advisory Committee. The GEIS study team provided draft, technically-based criteria, and the Advisory Committee added a social dimension. This two-stage approach to criteria development reflects the identified role of the Advisory Committee and EQB (and its staff) (FSD section IV.C) to determine those issues where significant impacts could result from timber harvesting.

The sequence of how the criteria were applied, and the points where Advisory Committee and EQB input were required as part of the criteria development process are illustrated in figure 2.6.

Significant Impacts Criteria

Impacts identified in the course of this study varied in their significance and therefore in the need to develop a specific mitigation response. This was a critical stage of the study process, as these tests of significance ultimately defined the scope of mitigation responses developed by the GEIS.

Identification of an impact as being significant does not automatically prescribe a specific mitigation response. The significance criteria were developed to be inclusive rather than exclusive. Their purpose was to identify the issues and circumstances where policy initiatives were required. The range of possible policy responses, the factors used to choose between them, and the implications of selecting a particular response were all evaluated by subsequent criteria.

Criteria were developed to evaluate each of the issues of concern in the FSD. The categories of impacts to be considered are set out in the FSD within the Issues of Concern (section viii, page 8). Eighteen *categories* of impacts were identified, based on the ten issue areas in the FSD. The categories are set out in the left hand column of table 2.4.

For each significance criterion developed, several background factors were used to determine levels or thresholds when impacts are likely to be considered significant. These background factors were provided to support the significance assessment and/or to provide insight as to the basis for the specified threshold. They include:

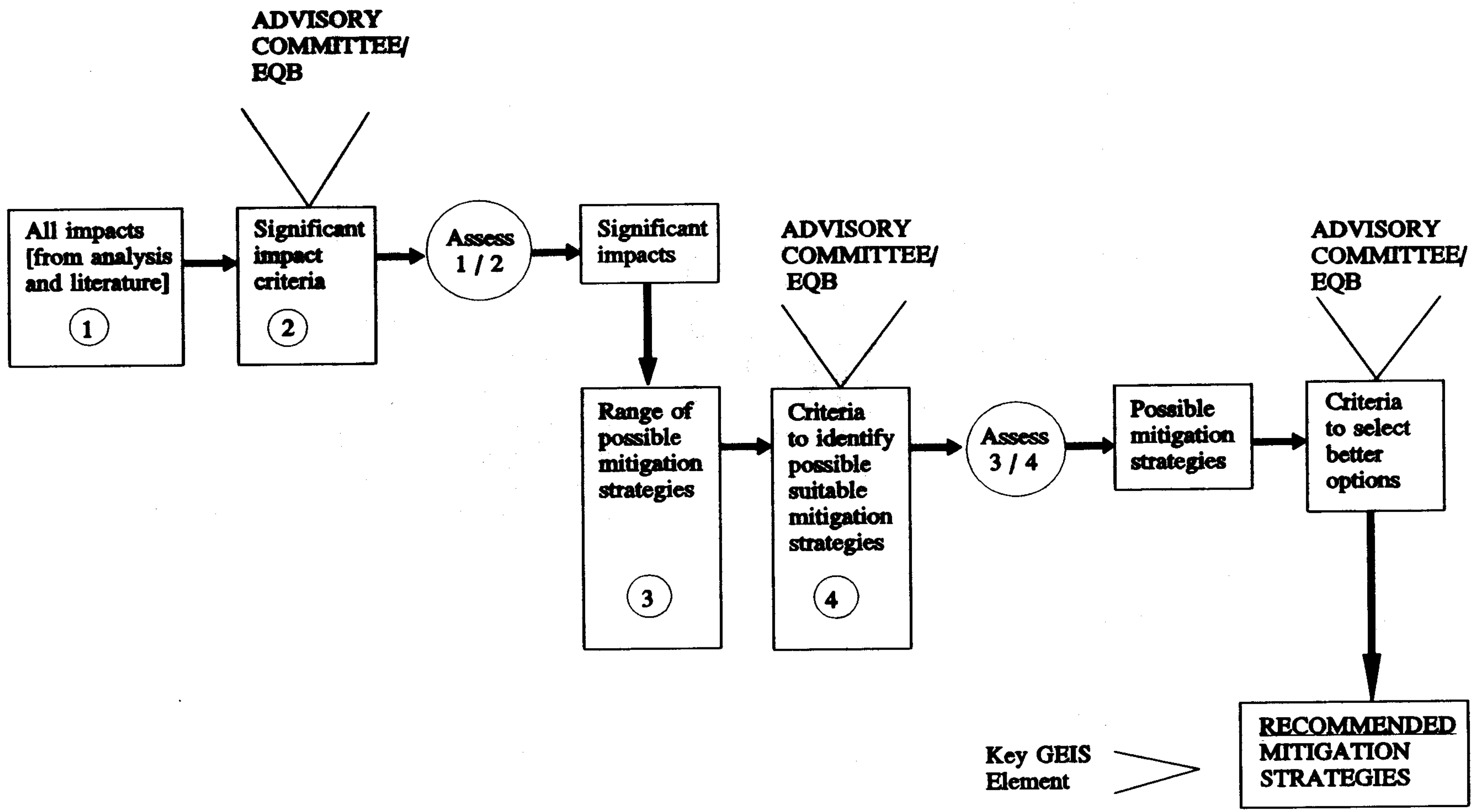

Figure 2.6. Process for criteria and mitigation strategy development. (Source: Jaakko Pöyry Consulting, Inc. 1991c.)

- severity and spatial extent of impact;
- certainty of impacts;
- duration of impact (irreversibility);
- consideration of existing guidelines and standards; and
- biological and economic implications.

The first factor identified the likely extent and severity of an impact. Impact extent varies from very localized site-specific impacts to those impacting a watershed, physiographic region, soil type, covertype, ecoregion, or the entire state. The second factor identified the degree of certainty that a predicted impact would occur. The key factors influencing certainty are identified for each criterion. The third factor incorporated the anticipated duration of the impact, and whether or not it is reversible. Duration was defined as very short-term—less than 2 years; short-term—2 to 10 years; medium-term—10 to 50 years; long-term—greater than 50 years; and irreversible. The fourth factor incorporated those existing standards and guidelines that are applicable to the respective issue areas. The fifth factor identified the key biological and economic implications of the impact.

Most of the criteria were applied to assess both positive and negative changes to the specified variable. Changes were assessed cumulatively over the 50-year study period, and in most cases, assessments were made at ten-year intervals. Most criteria were applied statewide, although some were applied to smaller geographic units, usually ecoregions.

Table 2.4 lists the significant impact criteria and the issue areas they were intended to address.

Mitigation Alternatives Criteria

These criteria were used to identify mitigation actions with the potential to address the identified significant impacts. The purpose behind this stage of the process was to identify mitigation actions which are effective and practical in a physical context, as well as in terms of the political, financial, and administrative environments in Minnesota.

Input from technical experts, the Advisory Committee, and the EQB are reflected in the final criteria. Unlike the significance criteria, the criteria to identify potential mitigation alternatives were applied uniformly across all issue areas documented in the FSD.

Major considerations used in the development of criteria to identify potential mitigation alternatives included:

- financial considerations;
- administrative considerations;

Table 2.4. Coverage of FSD issues of concern by significance criterion.

Final Scoping Decision issues of concern		Significance Criterion																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
A1	*Descriptive**																					
2	*Descriptive*																					
3	Unsustainable harvest					X																
B1	Changes to forest area	X																				
2	Abundance, composition, spatial distribution, age class structure, genetic variability, and tree species mixture	X	X	X	X	X				X		X	X									
C1	Risk of disease and insect infestations					X	X															
D1	Biological diversity at genetic, species, and ecosystem levels-patterns of forest		X	X	X	X				X	X	X										
2	Federal and state species of special concern, threatened, or endangered species or habitats								X		X	X										
3	Old growth and old forests					X		X														
E1	*Descriptive*																					
2	Populations and habitats of ten groups of wildlife and fish		X	X	X	X					X	X	X			X						
F1	Sedimentation, nutrient and runoff													X	X		X					
2	Fertilizers, compost and sludge													X								
3	Aquatic ecosystem, wetlands and peatlands													X		X						
G1	Erosion																X					
2	Nutrient cycling, productivity																		X			
3	Compaction																	X				
4	Seasonality of harvest																	X				
H1	Recreation			X																X		
I1	. Regional and state economies . Sectors benefitting . Sectors disadvantaged																				X	
2	. Recreation and tourism industry . Segments that benefit . Segments that are disadvantages . populations and habitat of game species consumptive uses																			X	X	
3	*Descriptive*																					
4	*Descriptive*																					
J1	Cultural, historical resources																					X
2	Visual quality																			X		

Source: Jaakko Pöyry Consulting, Inc. (1991c).

*Some issues in the FSD require description of existing conditions rather than change.

Significance Criterion and corresponding number (key to table 2.4)

KEY

1 Changes to MN forests - size and composition of forest land base
2 Changes to MN forests - patterns of forest cover in areas of mixed land use
3 Changes to MN forests - patterns of forest cover in predominantly forested areas
4 Changes to MN forests - tree species mix
5 Changes to MN forests - age class structure
6 Forest health - change in susceptibility or vulnerability
7 Old growth forests
8 Federal- or state-listed species of special concern, threatened, or endangered species or their habitats
9 Forest species - genetic variability
10 Forest dependent wildlife - habitats (lowland conifers)
11 Forest dependent wildlife - habitats
12 Forest dependent wildlife - food species
13 Lakes, rivers, streams, and wetlands - level of sedimentation/nutrient loading
14 Lakes, rivers, streams, and wetlands - runoff
15 Lakes, rivers, streams, and wetlands - aquatic ecosystems
16 Forest soil productivity - soil erosion
17 Forest soil productivity - compaction/puddling
18 Forest soil productivity - nutrient removals
19 Forest recreation and aesthetics - visual impacts
20 Regional economics - changes in economic parameters
21 Historical and cultural resources - forestwide impacts

- certainty of effectiveness; and
- social implications.

Mitigation Strategies Criteria
The criteria developed for this aspect of the process were used to identify the preferred mitigation strategies that form the basis of the tactical GEIS recommendations set forth in sections 5 to 7. Selection of preferred mitigation strategies depended on consideration of the following characteristics of each mitigation alternative:

- effectiveness—Can the mitigation alternative accomplish its intended objectives?
- feasibility—Can the mitigation be implemented?
- concomitant effects—What effects, beneficial and adverse, would the mitigation measure have on other resources values?
- implementation success—What is the likelihood that the mitigation will be successfully implemented?

As with the criteria used to identify mitigation alternatives, these criteria were applied uniformly to all mitigation actions identified in the previous stage of the process. The objective was to develop workable mitigation strategies that collectively addressed the significant impacts in an integrated fashion, thus insuring strong, workable policy options.

2.3.3 Technical Papers

The following describes the subject matter and role of the technical papers in the GEIS process. The subject matter of each paper is related to the issues of concern identified in the FSD. All the technical papers shared some common elements, and these are described here, followed by a brief synopsis of each of the papers' objectives and methodology.

Role in the GEIS Study Process
The technical papers were developed to provide an in-depth analysis wherever possible of each issue of concern identified in the FSD. Information sources are identified, and the methods used to conduct the impact analysis are explained.

The impact analyses identified cumulative impacts that could be linked to the statewide levels of timber harvesting and forest management activities developed in the three harvesting scenarios. The impacts were assessed for significance, and mitigations were identified and assessed using the EQB-approved criteria and the processes previously discussed.

Each technical paper describes the application of this process to the relevant issue area(s). The outcome of the process is an assessment of significant impacts, the range of mitigation options available (if any), and the preferred alternatives. The criteria referred to previously were used for decision making. The analysis required to apply the criteria also provides results that justify the conclusions and recommendations of each technical paper. The technical papers represent a comprehensive record of the way each issue area was addressed, why it was addressed in this way and the outcome of the analysis.

Conclusions from the technical papers are integrated into the GEIS document, together with information from the background papers, primarily in sections 3 to 7.

Common Elements
Some common elements in the technical papers were necessary in order to integrate the papers into the GEIS. These were described in section 2.2. In addition to a common structure, the technical papers used similar approaches to the literature review and background analysis.

The key elements of the technical papers and a proforma for their structure were specified in the contract for consultant services between the state and Jaakko Pöyry Consulting, Inc. This format was acknowledged in the Workplan. The specified format has been modified slightly to aid in presentation.

Literature Review
Comprehensive literature reviews were carried out by the study groups. The literature reviews were used to identify the ecological, biological, and physical processes of relevance to the study area. They were also used to identify the cause and effect relationships between these processes and timber harvesting and forest management activities. Reviews typically involved a tiered approach, focusing on ecoregions and USDA Forest Service FIA units in Minnesota, then subsequently the Great Lakes region, the United States, and where appropriate, the world.

Background Analysis
The information and data collected during the literature review were used to augment existing information held by the experts in the study groups. Data and information were used as follows:

1. to describe the types of timber harvesting and forest management activities that could be applied under the various scenarios;
2. to describe existing conditions in the natural, social, and economic environments of relevance to the ten issue areas including an analysis of the current level of industry and related harvesting activity;

3. to analyze the relevant processes and changes that have shaped present conditions, including the rate and direction of changes; and
4. to identify how timber harvesting and forest management activities interact with the forest environment in terms that reflect the ten issue areas.

Where appropriate, models that simulate the processes of change, particularly those caused by timber harvesting and forest management activities, were examined and tested by the study groups to determine their suitability for use in the study.

A separate analysis was conducted to identify and characterize the patterns in forest cover, particularly changes resulting from timber harvesting and forest management activities. Patterns in forest cover were examined, with thirty sample sites randomly selected from the list of FIA ground plots where timber harvesting has occurred recently. Aerial photo interpretation was then used to map patterns of forest cover for the section surrounding these plots. The patterns were interpreted and mapped by land use, forest covertype, stand size, and density classes, as per FIA procedures. A ground check was made to verify this interpretation and mapping. Based on these data, profiles of the typical patterns created by the range of timber harvesting and forest management activities were generated. This information was subsequently used by various study groups to interpret the impact spatial harvesting patterns might have on specific resources. Section 4.3.3 provides a good example of how this information was used in interpreting timber harvesting impacts on riparian corridors.

Objectives and Methodology

The following section provides an overview of the objectives and methodology used by each of the study groups to address the issues of concern from the FSD, identified in section 1.5.5. Unless otherwise noted, study methods and analysis pertain to the second model runs.

Maintaining Productivity and the Forest Resource Base

Objectives: This study group had three primary objectives, which collectively were of key importance to the entire GEIS process:

1. to develop the three FSD-required timber harvesting scenarios, which describe projected future forest conditions up to 50 years based on assumed levels of timber harvesting (as described in section 2.3);
2. to assess the current productive potential and long-run sustainable yield potential of Minnesota forests; and
3. to describe the key attributes of the forest resource base, including identification of historical changes, factors affecting change, and description of the current statewide forest resource base.

Methodology: The work of this study group was of fundamental importance to the GEIS. The study group analyzed the current resource status and used this analysis to develop the harvesting scenarios discussed in section 2.3. Considerable interaction with the other study groups was required for this component of the GEIS study, and the results served as the basis for estimating the potential of the forest resource to produce various levels of timber outputs and the associated costs of producing these outputs.

The productive potential and the long-term sustainable yield potential of Minnesota forests were examined for different time periods under different levels of investments in forest management practices and for different ownerships and regions. This part of the study was carried out after the study group developed a clear understanding of the existing resource base, as well as an understanding of how it has been shaped by past actions.

Forest management schedules were simulated using the forest change and scheduling model. The specific model formulations were constructed to examine specific issues, including the impact of assumptions about forest growth and yield on predicting the productive potential of Minnesota's forests.

The analysis also examined aspects of resources management, identifying potential inefficiencies and constraints in the supply of timber by regions over time. Recommendations for improved integration and the delineation of *sustained yield* units are made, based on identified opportunities and potential cost savings. The cost of producing various levels of forest products over time is an important byproduct of the scheduling model. These production cost estimates reflect required production levels, initial inventory, and changes in the inventory over time as a result of harvest and management activities. The impacts of intensifying forest management, imposing management constraints such as buffers, and excluding certain lands for timber production is measured by the change in the production costs. This serves as an indicator of the potential tradeoffs among various management options. Management problems such as those associated with overmature aspen, low quality northern hardwood stands, stocking control, and appropriate choice of species are also discussed.

The forest management schedules for each scenario were examined to identify their impact on nontimber resources. The schedules also provided data for an economic impact assessment by identifying when, where, at what level, and at what costs certain management activities will take place under each simulated scenario. The study group provided other study groups with detailed descriptions of the harvest schedules and management for each scenario, including the timing and location of all major forest management activities. Feedback received from experts in other study groups was in the form of management constraints or mitigations to protect or enhance nontimber values of the forests. These constraints and mitigations were incorporated into the forest management scenarios used for the second runs of the forest change and scheduling model.

The Maintaining Productivity and the Forest Resource Base study group was also responsible for the evaluation of potential impacts on the timber harvesting scenarios brought about by increased uses of recycled fiber in Minnesota. Input from a background paper on recycled fiber (section 2.3.4) was used to assist in this.

Forest Soils and Health

Forest Soils

Objectives: The study group's objective was to assess the impacts of the three levels of statewide timber harvesting and forest management activities on forest soil's erosion, nutrient cycling, compaction, and overall productivity. The importance of this objective is that maintenance of site productivity is a key factor in sustainable forest management. Therefore, identifying and reducing impacts on forest soils is an essential part of any strategy to achieve sustainable forest management. Adverse impacts on soil resources are strongly linked to the other issue areas. Eroded soil can impact water quality, aquatic ecosystems, and water-based recreational and tourist uses. A decrease in site productivity could affect wildlife populations and ultimately, the level of harvesting the forest can sustain.

Methodology: To this end, this study group reviewed and summarized the current state of knowledge on the effects of timber harvesting and forest management activities on forest soil properties. This information was applied to Minnesota conditions by using a Geographic Information System (GIS) to assess the impacts of the three levels of timber harvesting on soil erosion, soil compaction, nutrient cycling, and forest productivity, as outlined in the objectives statement.

A review of the available literature, input from core group experts, and information from the harvesting systems and silviculture systems background papers were used to identify:

- timber harvesting and forest management impacts on soil properties;
- specific soil properties that are important for evaluating these impacts; and
- the spatial distribution of forest soil properties in Minnesota.

Based on the results of this review, a series of decision rules and impact assessment matrices was developed to evaluate the effects of forest management activities on Minnesota's forest soils.

The overall impact assessment was facilitated by subdividing the state into seven ecoregions, as discussed in section 2.2.1. Soil, vegetation, and climatic characteristics for each ecoregion were quantified, based on thematic layers available in the GIS.

Impacts were evaluated by running different timber harvesting and forest management scenarios through the assessment matrices. The resulting spatial and temporal distribution of harvests indicated the extent or acreage of various soils impacted, according to the type of harvesting. Each scenario was evaluated within each ecoregion. Ecoregions were aggregated in order to estimate statewide impacts. Where adverse impacts were identified, the study group worked with other study groups to develop strategies to mitigate those impacts.

Emphasis in the technical review was on Minnesota conditions; information was drawn from work done in Minnesota, states adjacent to Minnesota and neighboring Canadian provinces. The review considered timber harvesting and forest management as agents of change in forests, and compared changes due to these activities with more *natural* changes, such as those from natural plant succession and windstorms to *seminatural* changes, such as those from forest fires, and to other changes caused by human activity, such as roads, air pollution, global climate change, and increased recreational populations in forested areas.

Forest Health

Objectives: This study group's basic objective involved an assessment of the risk of insect damage and disease, as related to current and projected harvest levels, by ownership class, geographic region, tree species, and forest type. The importance of this objective is that the management of Minnesota's forests should insure the forests are sustained in a healthy condition over long periods of time and that the negative impacts of epidemic disease and insect infestations are minimized. Although endemic populations of both insects and pathogens are important components of forest ecosystems, outbreaks of pests can result in substantial ecological and silvicultural losses. Plant stress induced by moisture and nutrient depletion, climatic conditions, and timber harvesting and forest management practices contribute to insect and pathogenic infestation. In addition, elements of global atmospheric change such as air pollution and global warming may affect forest health.

Methodology: The study group assessed effects of timber harvesting and forest management on risk of pest infestation and identified factors that may contribute to, or mitigate pest damage. A review of technical and scientific literature aided in the identification of primary insect and pathogen pests associated with specific species and covertypes in Minnesota forests. Ecological and management-related factors were also surveyed to determine their influence on pest population buildup and damage. Treatments or management options for minimizing pest impact have been provided.

Effects of timber harvesting levels and forest management intensity on pest impacts were assessed by combining information derived from the technical literature review with information available in GIS form. Matrices were developed relating specific pests with important site or stand-related attributes. A hierarchical approach to database and matrix development allowed information to be aggregated on varied scales. Potential impacts of pests were subsequently evaluated on an ecoregion or statewide basis. Pest information was integrated with the timber harvest and forest management scenarios developed by other study groups using an iterative feedback, review and revision process. The potential impacts of harvesting scenarios on pest damage, practices to alleviate damage, and data or knowledge gaps that limit development of conclusions were also analyzed.

This study group focused on the following key items:

- primary insect pests and diseases for each ecoregion, covertype, and dominant forest species in Minnesota, with focus on diseases and insects currently regarded as significant problems. Where appropriate, insects and diseases were identified for specific stages of forest development; e.g., seedling establishment, seedling-sapling, sapling-mature, mature-overmature, for dominant forest species and covertypes;
- infrequent or historical outbreaks of other forest health problems and their potential future significance;
- pests not currently established in Minnesota but with potential for significant impact (e.g., gypsy moth);
- ecophysiological traits associated with epidemic and/or damaging populations of forest pests. Traits were divided into:
  - ecological variables not directly related to forest management activities, including soil, topography, and climatic variables; and
  - site or stand variables directly influenced by forest management activities including stocking, stand size, or species composition.

  Potential impacts of landowner class on risk of pest infestation were included in the analysis;
- forest management activities that may increase risk of pest infestation or damage. Forest management activities to avoid or mitigate damage from insects and pathogens were also identified for pests noted above;
- scientific literature pertaining to effects of global climate change, acid rain, and ozone on forests and associated insects and diseases. Where possible, the possible impacts of these factors on forest pests in Minnesota were considered; and
- gaps in the knowledge base. Following the literature review, gaps were noted and priority research needs have been identified.

Emphasis in the technical review was on Minnesota conditions. Information was drawn from work done in Minnesota and adjacent states and Canadian provinces. The review considered forest management as an agent of change in forests, wherein changes due to natural plant succession were compared with changes caused by management and other human activities. Examples of changes brought about by human activities include air pollution, global climate change, and increased recreational populations in forested areas.

Water Quality and Fisheries

Objectives: This study group's basic objectives included assessing the impacts of the three timber harvesting scenarios and forest management activities on:

- sedimentation, nutrient loading and runoff in lakes, rivers, streams, and wetlands;
- surface and groundwater quality as related to uses of fertilizers, compost, sludge, and pesticides; and
- forest dependent fish species, their habitat requirements, and their current status and distribution.

Methodology: This analysis of the effects of increased timber harvest was developed from literature reviews and professional experience. The analysis was conducted by a seven-member study group representing water quality, hydrology, fisheries, and ecological disciplines. The work is presented in an ecoregional framework (i.e., changes are presented for each of three harvest scenarios, by ecoregion), based on the seven ecoregions of Minnesota. This analysis focuses on the two largest and most forested ecoregions, but it also includes comments on the other ecoregions. While all lakes, streams, and wetlands were considered within an ecoregion framework, the analysis focused on first through third order streams and 10- to 50-acre lakes as these were the most likely to be impacted by harvesting.

The study focusses on the potential impacts of the three harvesting scenarios on more than 15 water resource variables. The impact of each scenario on each variable is described with the following four qualifiers:

1. indications of direction of change;
2. indications of magnitude or severity of change;
3. indications of uncertainty due to variability in time and space; and
4. indications of uncertainty due to data considerations.

The fish community has been divided into coldwater species (e.g., salmonids, sculpins) and coolwater-plus-warmwater species (e.g., percids, centrarchids, cyprinids). Impacts on those communities are stratified by lake and stream strata because of variations in the type and degree of impact. Waterbodies are stratified by size and location in the basin. Impacts from timber harvesting and forest management activities vary with waterbody size strata. The small and low order systems receive more direct impact, while larger lakes and higher order streams receive more indirect impact. Background data on water quality, the fish community, and fish habitat vary predictably with ecoregion, thus facilitating the identification and predictability of impacts.

The forest change and scheduling model via changes in FIA plot characteristics produced the spatial and temporal distributions for the various harvest intensity scenarios. These change data, in turn, served as driving variables for water resources and fisheries analyses. Significant impact assessment criteria and appropriate strategies to mitigate impacts were developed in conjunction with the other study groups.

Biodiversity and Wildlife

Biodiversity

Objectives: This study group's objectives focused on assessing the impacts of timber harvesting and forest management on biodiversity, and the resulting technical paper complements the Forest Wildlife technical paper. Specifically, the objectives were to assess impacts on:

- biological diversity in forests at genetic, species, and ecosystem levels;
- forest dependent federal and state species of special concern, threatened, or endangered species or habitats; and
- old growth and old forests.

Methodology: In considering how timber harvesting and forest management may impact forest plants and endangered, threatened, or special concern animal species the emphasis was on the habitats of species, rather than the populations themselves. The forest management practices analyzed in the GEIS affect species primarily through altering forest type and age class. This in turn comprises the substrate, and cover required by the animals and smaller plants. Habitat matrices, based on research by study group members, were applied to the endangered, threatened, or special concern animal species in the state. However, there is not sufficient data to construct habitat matrices for understory plant species in Minnesota. Consequently, given the lack of data for analysis of individual plant species habitat, it was assumed that small plant diversity—as well as moss, fungi, and insect diversity—is dependent on structure at the community and ecosystem level. Further, it was assumed that the best way to maintain regional biodiversity and prevent species extinction, is to maintain *examples* of all natural community types recognized by the Minnesota Natural Heritage Program in the context of a fairly natural landscape pattern.

The technical assessment of timber harvesting and forest management impacts on biodiversity was undertaken using a variety of information sources and synthesis processes. Initially, each study group member thoroughly examined the technical literature on relationships between forest land animals or plants and the forest communities that are their habitats, particularly as these are affected by forest management changes. This review was used together with input from the background papers on harvesting systems and silvicultural systems to identify: (1) known habitat attributes for plant species that would be impacted by changes in age, composition, and spatial patterns of forest stands; (2) case studies in which timber harvesting and forest management activities have led to changes in plant communities; and (3) specific information on rare or endangered species associated with any forest system within the state.

Because information summarized from the USDA Forest Service's FIA plots was the only systematic, statewide source on forest habitat data available, this study group attempted to tie the analyses of old forests and abundance of plant species of interest to the extent of specific forest types and age classes, as designated within the FIA system.

The potential impact of timber harvesting and forest management on wildlife and plant species of interest was evaluated for the three levels of harvest—base, medium, and high. The Maintaining Productivity and the Forest Resource Base study group supplied projections of Minnesota's forest resource base for each of the next five decades under each of these three harvesting levels. These projections included postcutting acreages and age class distributions of each FIA covertype, in each of the seven ecoregions.

These data were used to estimate the amount of habitat available for communities, old forests, and species of interest.

This input was then used to assess significance of projected impacts and appropriate mitigation strategies against the EQB-approved criteria. The Biodiversity study group worked very closely with the Wildlife study group to assure the best possible technical results in achieving both groups' goals.

Wildlife

Objectives: The group's objectives were to:

- identify the forest dependent species of wildlife, their specific habitat requirements, and their current status and distribution; and
- determine to what extent timber harvesting and forest management will impact populations and habitats of eight broad groupings of wildlife as outlined in the FSD.

Methodology: This study group assessed the potential impacts of base, medium, and high levels of timber harvesting and related forest management activities on Minnesota's forest wildlife over a 50-year planning period.

Impact analyses were done by four separate subgroups—small- and medium-sized mammals, large mammals, birds, and herptofauana (amphibians and reptiles). For each of these four subgroups, species of interest (those species that depend on forested habitat or survival) were selected for analyses. Species of interest included 22 small- and medium-sized mammals, 5 large mammals, 138 birds, and 12 herptofauana. Analyses of wildlife populations were performed statewide and for each ecoregion within Minnesota for virtually all species. These analyses were closely coordinated with work of the Biodiversity study group, which assessed the impact of timber harvesting and forest management on all plant species and wildlife or plant species that are endangered, threatened, or of special concern.

As specified in section 2.3.2, the three timber harvesting scenarios incorporated various ownership constraints, notably constraints on availability, and mitigations including ERF, uneven-aged management, reservation of old growth, BMPs, wildlife buffers, and modelling refinements that estimated forest area and covertype change for 1990–2040.

The eight broad wildlife groupings identified by the FSD were all analyzed: forest ungulates, forest grouse, forest furbearers (carnivores and rodents), forest interior birds, conifer-dependent birds, hardwood-dependent birds, forest raptors, and species that require old or mature forest. Two additional categories were added by the Wildlife study group: cavity-dependent birds and riparian birds.

The three harvesting scenarios provided one major type of data that can be linked to wildlife populations. These data were the acreage and approximate location of forest by USDA Forest Service FIA forest covertype, and stand age or size class. Thus, the strategy employed by the study group to assess impacts of timber harvesting and forest management activities on wildlife populations was to link abundance of each species to specific FIA forest covertypes, and age or size classes in the existing forests of Minnesota. For each species of mammal and bird, an index of relative abundance was constructed. The indices weighted acreage of each combination of forest type/size class by its value as habitat for the species. The direction and magnitude of future population change was then estimated by examining projected acreage of forest types and size classes under each of the three harvesting scenarios. Data were more limited for herp species; consequently, the total acreage of potential habitat, both existing and in the future, was used as an index of population change for this species.

After identifying the direction and magnitude of the population changes, the study group applied the EQB-approved criteria mechanism to identify the likely significant impacts and generate the appropriate mitigation strategies.

Recreation, Aesthetics and Cultural Resources
Recreation and Aesthetics

Objectives: This section sets out the methodology used to assess impacts relating to recreation and aesthetics issues. The objective of the study group was to assess the impacts of three levels of timber harvesting and related forest management on each issue area noted here:

- to what extent are forest recreation opportunities both quantitatively and qualitatively impacted by timber harvesting and forest management;
- do such impacts vary by type of recreation; and
- to what extent does timber harvesting and forest management impact the visual quality of the state's forests?

The overall approach taken was first to assess impacts on recreation opportunity classes and the recreational activities that take place within those classes. Then the group assessed aesthetic values within each recreation opportunity class. This was followed by characterizing the visual sensitivity of sites. Subsequently, this led to an assessment of aesthetic impacts due to harvesting. The methodology has been outlined separately for recreation and aesthetics.

Recreation Methodology: Forests provide significant opportunities for a wide variety of recreational experiences. Timber harvesting operations and related forest management practices can affect the quality of the recreationist's experience and the kinds of opportunities provided. Changes in recreation opportunities as a result of harvesting are not well known or documented. Little research has been conducted to examine the relationships between timber harvesting and recreational use patterns in Minnesota.

Furthermore, on a statewide basis, little is known about how or why different landscapes appeal to different kinds of recreationists. The types of recreation opportunities provided on some public lands within the state are known, and in some cases, why visitors go to those places is also known. For example, various divisions of the MNDNR have conducted recreation surveys to find out where recreationists go, what activities they engage in, what their motives are, and what kinds of facilities/resource areas are needed to meet current and future recreation needs statewide. There is also an extensive annotated bibliography of social science research conducted in the Boundary Waters Canoe Area Wilderness (BWCAW). Findings from these and other studies were compiled to assess the range and diversity of opportunities statewide.

Since the location, number, and type of recreation opportunities existing statewide are not well defined, it is unclear whether or how timber harvesting practices diminish or enhance opportunities on the whole. Despite these limitations, the study group made a concerted effort to estimate changes in outdoor recreation opportunities expected to occur as a result of the three timber harvest level scenarios. Specifically, the group has:

- identified the range and diversity of outdoor recreation opportunities existing within the state;
- assessed the impact of timber harvesting levels on various types of recreation, recreation users, and specific recreation activities;
- identified and assessed possible changes in recreation use patterns and recreation users as a result of increased timber harvesting and forest management activities;
- assessed recreation users' attitudes toward timber harvesting and forest management practices and how these attitudes affect user behaviors; and
- assessed the quality of recreation opportunities and experiences resulting from different timber harvesting and forest management activities scenarios.

The Recreation Opportunity Spectrum (ROS) was used as the guiding framework to describe recreation opportunities within the state. Briefly, ROS describes six levels of recreation opportunities—primitive, semiprimitive nonmotorized, semiprimitive motorized, roaded natural, rural, and urban. Generally, opportunities described in the primitive range are less developed, less accessible, and less abundant. They also tend to occur in more natural areas than nonprimitive opportunities.

For each harvest level, each of the six opportunity classes identified within the ROS framework was examined to identify and assess changes in activities, setting attributes, and the value of the recreation opportunity. Changes in recreation opportunities as a result of timber harvesting activities were defined as movement of a forest area from one ROS class to another. By definition, any change in the recreation opportunity results in a change in the kinds of recreation experiences possible.

The forest recreation experience is highly dependent upon visual and other sensory stimuli. Research indicates that the quality of that experience and the ability of a forest resource to attract visitors/tourists/recreationists is closely related to the perceived quality of the view. Consequently, the recreation and aesthetics specialists worked together to coordinate the literature review in common topic areas, and to share data and conclusions in developing impact matrices. The primary areas covered included:

- resource setting attributes relevant to recreation opportunities;
- recreation activities arrayed from high visibility/high resource impact to low visibility/minimal resource impact as related to specific setting classes; and
- direct and indirect values of various recreation activities.

In addition, emphasis was given to the study of nonroaded areas and the implications of developing permanent forest roads in such areas.

Aesthetics Methodology: Conceptually, the methods used to assess visual sensitivity were similar to those used by the National Forest System. The ROS, a key component of recreation value, is used as a recreation planning and management tool on national forests. The visual management objectives that serve as the core of the USDA Forest Service Visual Management System (VMS) are analogous to visual sensitivity ranks.

The data needs and assessment procedures used in setting visual management objectives are similar to those used in assessing sensitivity rank.

Two constructs, relative forest attractiveness value and recreation value, combine to define the visual sensitivity ranks of the timberland plots. An area of high visual sensitivity possesses a high level of relative forest attractiveness, and would also be a place where many people pursue a variety of outdoor recreational activities. In contrast, an area of low visual sensitivity would have a comparatively low level of relative forest attractiveness, and few people would use the area as a recreational activity setting.

It follows that the most visually sensitive areas are where more stringent visual management prescriptions would be appropriate. The study group assumed for this exercise that failure to implement such prescriptions would produce significant adverse impacts on the recreational and aesthetic values of the harvested forest and of surrounding areas. In contrast, timber harvesting and forest management activities occurring on less sensitive plots need to conform to only the most basic visual management prescriptions. These less sensitive areas were assumed not to be particularly attractive nor would they be likely to sustain high levels of recreational use.

In summary, a total of five visual sensitivity ranks were identified:

Visual Sensitivity Rank I.—Plots or areas of this rank are a special case for lands adjacent to designated recreational areas such as state parks, national parks, wilderness areas, wild and scenic rivers, and long-distance trails. They are highly sensitive lands because of their proximity to designated recreational areas.

Visual Sensitivity Ranks II to V.—Areas in these ranks are defined by ROS class, attractiveness value, and recreation value combinations. Visual sensitivity rank V includes the lowest recreation and attractiveness values.

Once this ranking was developed for the FIA plots, the likely impacts of the three harvesting scenarios was evaluated. Subsequently, this led to the assessment of significant impacts and development of the ultimate mitigation strategies.

Cultural and Historical Resources

Objectives: Timber harvesting and some forest management activities can have direct and irreversible impacts on historical and cultural resources. The objective of this study group was to examine the extent to which such resources can be impacted by timber harvesting and forest management.

Methodology: The resources considered by the study group included cultural landscapes, standing structures, archaeological sites, cemeteries, and traditional use sites. Examples of these are Native American traditional use sites and sacred/religious sites. These resources, collectively referred to as Heritage Sites, are protected by a variety of state and federal laws. They are nonrenewable resources.

Impacts to Heritage Sites affect not only the physical Heritage Sites themselves, but also the cultural lifestyle of Native American peoples. The nature of these effects were delineated and mitigation measures suggested. Specifically, the cultural resource specialists:

- characterized the maximum impacts that could occur under the three harvest intensities identified in the FSD;
- assessed the constraints involved in compliance with relevant law and regulation under each of the harvest intensities;
- recommended management procedures based on a model of site location; and
- defined work needed to generate site locational information for a GIS and to increase accuracy of the site locational model.

The cultural resource specialists summarized potential impacts of the three management scenarios according to type of Heritage Site and ecoregion. Uncertainty due to data considerations was also addressed.

Economics and Management

Objectives: The Economics and Management Issues study group's objectives were to assess expected impacts from timber harvesting and forest management as noted here:

- to what extent are state and regional economies impacted;
- which and to what extent are specific economic sectors benefitted or adversely impacted;
- to what extent is the state's recreation and tourism industry impacted;
- which and to what extent are specific segments of the recreation and tourism industry benefitted or adversely impacted;

- how will habitats of deer and ruffed grouse, other game species, and other recreational use wildlife be affected; and how will these changes affect state and regional economies; and
- what is the current distribution of stumpage among various users; what laws, policies, and procedures influence this distribution?

Methodology: Increased levels of timber harvesting result in increased purchases and sales by timber harvesting operations, and changes in economic activity for some forest products industries and other sectors. These changes in economic activity are likely to change levels of income, sales, employment, and other measures of the economy. Increased harvest levels also result in changes to the forest resource and to forest management practices and activities by various forest landowner groups. These changes to the forest resource affect timber inventories, growth, and yield, and may also alter soil productivity, water quality, wildlife habitat, the aesthetics of forested areas, and other forest characteristics. These, in turn, may affect forest uses (e.g., various recreation opportunities) and users (e.g., hunters, hikers, cross-country skiers). Such changes in forest uses have impacts on recreation, tourism, and other economic activities in the state.

In response to increased levels of timber harvesting, forest management activities of landowners often have to be increased. Additional funding and personnel is required to: prepare and administer the timber sales required to meet the levels of timber harvest proposed; intensify silvicultural and forest management activities (site preparation, regeneration, thinning, etc.); coordinate land use planning; forest road construction and/or maintenance; and meet other land management needs. These increased management activities have economic impacts within land management organizations (e.g., budget and staffing implications), and have economic impacts outside the organization (e.g., increased purchasing of supplies and equipment, contracting for services).

The major objectives of the Economics and Management Issues study were addressed in the following three distinct steps.

1 Determine economic impacts of increased timber harvesting and management. Analyses to determine economic impacts of increased timber harvesting and forest management activities were conducted as two separate tasks: (a) to determine economic impacts of increased timber harvesting, and (b) to determine economic impacts of increased forest management activities.

The first task, determining the economic impacts of increased levels of timber harvesting and forest management activities, estimated the economic impact of three levels of timber harvesting. Economic impacts were estimated for specific sectors of the economy, for groupings of counties that represent the various ecoregions and economic regions of Minnesota using an input-output economic modelling technique (IMPLAN and IPASS models). Wherever possible the study also identified sectors that benefit and sectors that are adversely affected by the increased levels of timber harvesting and forest management activities. The base level of harvest was used as the baseline from which to estimate changes due to increased levels of timber harvesting. Measures of economic impact included expected changes in income, output, and employment over time that result from the increased timber harvests, by economic sector. Impacts were estimated as changes in regional and state economies from the base level timber harvest.

The second task, determining the economic impacts of increased timber management activities, estimated the impacts of the three levels of timber harvesting on management activities of county, state, and federal land management agencies in Minnesota over time. The impacts of these changes in management activities were also considered, specifically as they affected budgets and personnel requirements within these agencies, and employment and income for various economic sectors and regions in the state. Impacts were estimated as changes in budgets and personnel of the various public land management agencies, and resulting changes in regional and state economies, by economic sector, from what would have occurred with the base timber harvest level. Only public forest land management agencies were included in the analysis. Of federal lands, only those managed by the USDA Forest Service, were included. Of state-owned lands, only those managed by the MNDNR Division of Forestry were included. To provide a county focus, a few key sample counties in the northern part of the state were also addressed.

2 Determine timber harvesting impacts on the recreation and tourism industry, including recreational use of wildlife. The Economics and Management Issues study group found poorly documented linkages between timber harvesting levels, changes in forest composition and characteristics (e.g., timber stands, soils, water, wildlife habitat), changes in recreation activities and other nontimber uses and activities, and changes in economic impacts on the tourism industry and other related economic sectors. Unfortunately, specific quantitative data on the linkages between timber harvesting and levels of participation in various outdoor recreation activities are lacking, and could not be developed in sufficient detail for economic analysis for this study. Information to quantify how changes in recreation opportunities would affect visitor days for various types of recreation activities was unavailable, so it was not possible to directly quantify the impacts of increased timber harvesting on the recreation and tourism industry. However, it was possible to explore how various levels of assumed changes in recreation activities would affect economic sectors that are related to the recreation and tourism industry. This was done using information gathered by the state about participation and expenditure patterns for different classes of recreation and tourism. Such information was helpful in analyzing the potential importance to the economy of various levels of changes in the recreation activities that are likely to be affected by increased levels of timber harvesting, even though the exact impacts could not be determined.

3 Determine timber sale stumpage distribution among various users, and what laws, policies, and procedures influence this distribution. This issue was interpreted to mean: Who gets how much of what stumpage from where in timber sales from various land management agencies and owner groups, and what influences this distribution? That is, how much of what kinds of stumpage from various landowner groups is currently allocated or distributed through timber sales to various users of timber stumpage? Also, what laws, policies and procedures influence how this distribution takes place?

In determining stumpage distribution, consideration was given to how stumpage distribution among users varies by timber species, land ownership, and economic regions. These data were related to an analysis of whether the stumpage is purchased directly or indirectly. Two types of timber sales purchases were considered in this analysis:

1. the various kinds of primary wood-using industries, such as pulp and paper mills, structural and other particleboard mills, sawmills, pole treating plants, and others that obtain the cutting rights and subsequently use roundwood harvested from the forest as a raw material in their industrial processes; and
2. independent logging contractors who purchase cutting rights and then sell harvested timber to one or more users.

In determining what laws, policies, and procedures influence how this distribution of stumpage takes place, primary attention was given to the laws, policies, and procedures of county, state, and federal land management agencies that affect how stumpage is distributed. However, in doing so, it was recognized that economic factors within the timber industry affect the distribution of timber sales. Where competitive bidding for stumpage is effective, economic factors within the forest products industry and among individual industries strongly influence stumpage prices for any particular timber sale, and thus determine (or at least influence) the distribution of stumpage among individual loggers and mills. A comprehensive analysis of the importance of prices and economic competition in the allocation of timber stumpage was not a focus for this study.

2.3.4 Background Papers

In addition to a detailed study of the issues mentioned above, specialists were contracted to provide five background papers under the supervision of the core group and independently of the study groups. These papers were prepared to meet two distinct requirements of the study process. Two background papers, *Global Atmospheric Change* and *Recycled Fiber Opportunities* (Jaakko Pöyry Consulting, Inc. 1992i,j), were prepared to address the additional factors, outside of the issues of concern, identified in the FSD (see 1.5.5). The other three papers, *Public Forestry Organizations and Policies, Harvesting Systems,* and *Silvicultural Systems* (Jaakko Pöyry Consulting, Inc. 1992k,l,m), provided the detailed information needed to guide the study groups through a full understanding of how timber harvesting and forest management is practiced in Minnesota.

The following sections briefly describe the content of each background paper.

Global Atmospheric Change
A survey of the general nature and conclusions of the research on possible impacts of global atmospheric change on Minnesota's forest, including changes in:

- the extent of forests;
- species that comprise them; and
- costs of management.

Recycled Fiber Opportunities
An examination of the existing and potential opportunities for utilizing recycled fiber in the wood products manufacturing process in Minnesota including:

- implications of paper and associated products currently produced in Minnesota;
- current technology;
- availability of recycled fibers to Minnesota paper industries;
- opportunities for using current technology to substitute recycled fiber for virgin wood fiber in papermaking and allied products;
- possibilities for short- and long-term use of recycled fiber by Minnesota's wood products manufacturing industries and potential environmental; and
- economic impacts of using recycled fiber in the production of paper and allied products by Minnesota's wood fiber industries.

Public Forestry Organizations and Policies
A description of public forest land management organizations in Minnesota including:

- organizational histories and structures;
- major forest management and timber harvesting policies;
- major forestry programs and activities;
- current planning and coordination efforts; and
- public participation in forest management and planning.

An examination of laws and policies for related land uses and development in order to assess the extent to which they apply to:

- timber harvesting;
- forest management; and
- nonindustrial private forest (NIPF) lands.

Additionally, this paper developed estimates of timberland availability by ownership.

Harvesting Systems
A description of harvesting systems currently used and those with potential for use in Minnesota, plus an assessment of the competitive aspects and physical impacts of possible harvesting systems through a detailed discussion of:

- harvesting systems and equipment currently used in Minnesota by forest covertype;
- harvesting systems and equipment employed elsewhere in similar conditions;
- transport systems currently used to move harvested wood from the forest to processing facilities;
- ground pressure indices for the different harvesting systems and equipment; and
- comparative productivity and cost data for the above harvesting and transport systems.

This paper also addresses one specific aspect of a major issue of concern (Economics and Management): *What level of road density, design, and construction is appropriate to provide access for all forest activities (e.g., timber harvesting and management, fire/insect/disease protection, and dispersed recreation on forest lands)?*

Silvicultural Systems
A discussion of existing and potential silvicultural systems, in terms of suitability for the range of forest covertypes and physical conditions in Minnesota including:

- a description of the types and extent of use of silvicultural systems being used in Minnesota;
- a discussion of other silvicultural systems potentially available for use in Minnesota;
- an assessment of the comparative indices of timber yields versus the yield of other forest values associated with each silvicultural system currently being used as well as those with potential for use; and
- operational costs of the various silvicultural systems.

2.4
GEIS Study Document Development

The last major activity in the GEIS process involved the development of the formal GEIS study document. The key steps for this activity were:

- preparation of the draft GEIS document;
- independent peer review of the draft GEIS document;
- submission of the revised draft GEIS document for public review and comment; and
- submission of the Final GEIS Study to the EQB.

2.4.1
Draft GEIS Document Development

Following completion and EQB approval of the nine technical and five background papers, the Core Group began the process of preparing the draft GEIS study document. The initial effort integrated information from these 14 papers. This is identified as step 15 in figure 2.2.

The Workplan and FSD both call for the draft GEIS to be "a high quality, professional document written in plain English...." This guidance was important as the Core Group's goal was to synthesize and integrate the substantially technical-type materials from the 14 papers into an easy to read, user-friendly document. In this regard, preparers of the GEIS document attempted to avoid the more complex, scientific context of the 14 papers described earlier. For a more rigorous and technical perspective, readers are referred to the 14 technical and background papers.

The draft GEIS document integrated the technical and background work, clearly identifying and describing the impacts associated with statewide timber harvesting and associated forest management activities. It also identified and described recommendations to address those impacts.

The FSD and Workplan call for the draft GEIS to include separate chapters, one for each alternative statewide timber harvesting scenario. As noted here, these chapters include the following:

- a complete description of each alternative statewide timber harvesting scenario including all assumptions;
- a clear and concise discussion of how statewide timber harvesting and associated forest management activities will impact the issues and subissues identified in section xiii of the FSD at each scenario-prescribed level of activity;
- a clear and concise description of *significant impacts* (existing or potential) identified in the analyses;

- a description of possible means (*mitigation alternatives*) of alleviating or minimizing the identified significant impacts; and
- recommendations for mitigating (*mitigation strategies*) those significant impacts including the rationale for such recommendations.

Sections 5 to 7 of the draft GEIS document were prepared in accordance with this guidance. Forest policy strategies suggested to help ensure that the collective set of mitigation recommendations identified in these sections are implemented over time are discussed in section 8.

2.4.2 Draft GEIS Document Peer Review

The FSD and Workplan call for peer review of the draft GEIS prior to its submission to the Advisory Committee and EQB. This is step 16 in figure 2.2. The goal of this technical peer review was to obtain an independent, objective, and critical review of the initial draft GEIS. The review panel selected by Jaakko Pöyry and endorsed by the EQB was identified in section 2.1.1. The guidelines used to select this review group stipulated that reviewers:

- have not substantially participated in the preparation of any work products prepared for the GEIS project;
- are knowledgeable and respected experts in the subject material addressed in the draft GEIS; and
- represent a balanced but diverse set of opinions on the subject matter addressed in the draft GEIS.

Once the peer reviews were completed, the Core Group provided the state written summaries of all comments submitted by all reviewers. Subsequently, the Advisory Committee and EQB reviewed the initial draft GEIS document and all peer reviews with the Core Group. Based on guidance from the Advisory Committee and the EQB, the Core Group then modified the draft GEIS in preparation for public review and comment.

2.4.3 Public Review and Comment

The FSD and Workplan call for a formal public review period to secure public comment and input on the draft GEIS. This is step 17 in figure 2.2. Included as part of this review are three public information meetings to explain the draft report's findings and conclusions, and to solicit public input on the draft. These meetings were originally scheduled for April 1992. However, due to the extended GEIS project timeframe (see section 1.5.7), these public meetings were subsequently rescheduled to June 1993.

Following the public meetings, the state assumed responsibility for organizing and summarizing all substantive comments provided by the public on the draft GEIS during the entire designated public comment period, which is set at a minimum of 40 consecutive days.

The state's GEIS project coordinator designated all substantive comments as either "technical" or "policy." The Core Group responded to technical matters, and the Advisory Committee and EQB responded to policy comments. The chair of the EQB has the final authority over the adequacy of responses to both technical and policy comments as reflected in the final GEIS document.

2.4.4
Final GEIS Compilation and Submission

The Core Group was responsible for incorporating all EQB approved public comment responses into the Final GEIS document. This is step 18 in figure 2.2. Once the draft GEIS was revised into the Final GEIS, it will be submitted to the Advisory Committee and EQB for final editing. This ensures that the Final GEIS document is identical in format to the draft GEIS, except for EQB-approved responses to the public comments. Approval for release of the Final GEIS study rests solely with the chair of the EQB.

2.5
Resource Information Issues

The GEIS process required an immense amount of resource-based information. Sources of information have been highly varied. They included:

- published research documents;
- public agency published documents and statistical data reports;
- Jaakko Pöyry network data base, studies, and reports;
- unpublished research materials;
- public agency files and interoffice studies and communications;
- internal UofM files, reports, models, and databases; and
- expert knowledge, etc.

The Core Group and the study groups invested a tremendous amount of time and energy scouring for information within Minnesota, the United States as a whole, and, where possible and appropriate, even globally. Yet in spite of this concerted effort, many important information needs fell short of the optimal or simply were not met.

An example of this was the type of database needed for generating the three harvesting scenarios and all of the related scenarios' outputs required by all the study groups to conduct their respective technical analyses. Key requirements were the need for an updated, pre-existing database that consistently covered all timberland on all ownerships statewide with a very wide array of data elements/variables. Unfortunately, no such database exists. The closest possibility is found in the USDA Forest Service FIA system and database. The FIA system was never designed for a GEIS-type process, but does allow for essentially statewide coverage and contains many of the data variables required by the study groups.

Another complicating factor was that the 1990 Minnesota FIA survey was not published when the GEIS process started in mid-1991. As a consequence, the GEIS work proceeded on the unpublished data. In addition, the study groups had to create new and novel techniques to meet information needs. For example, habitat typing by FIA plot for wildlife and biodiversity analyses required conducting separate technical analyses. Although inadequate in some ways, the FIA database and system were the best available, and the study groups were able to develop techniques that helped extend the database to meet most needs at this level. Without the FIA database, the GEIS process would have been severely constrained.

An example of data that was totally lacking in a form useful for the GEIS process was specific documented impacts of timber harvesting (physical site change) on the recreational experience by recreation activity. Much anecdotal information is available, as are numerous site-specific/focused studies that provide indications of relationships. However, a well-researched statewide database across all major timber harvesting and recreational issues was simply not available. As a consequence, the Recreation and Aesthetics technical paper's examination of these relationships was forced into a broad and qualitative analysis.

Another example of a major data deficiency was one which related to changes in timber harvesting levels and related forest management activities to changes in the economic aspects of the tourism (and recreation) industry. The GEIS study groups were unable to isolate a comprehensive useful database that would allow for a nonspeculative evolution of such relationships over time for various timber harvesting scenarios. The GEIS specialists know these issues are linked. However, with a charge to pursue fact-based analyses, a meaningful evaluation of these particular relationships was not possible.

One additional data deficient area involved that dealing with sites' nutrient capital. Although much data is available, good, concise knowledge on nutrient effects on forest productivity and growth are not readily available. Also, the extent to which nutrients versus other factors (temperature, moisture, etc.) are limiting factors is also not well known. As a consequence, some of the specificity desired in the soils research for the GEIS was not possible.

The key point of this discussion is to highlight two important resource information issues:

1. the GEIS process required and was based on a tremendous volume of resource related information; and
2. many information needs were either lacking in completeness or simply not available, and this affected the ability of the GEIS team to fully address all FSD-scoped issues.

These resource information deficiencies were expected and this was noted in the FSD. Where such deficiencies had a material effect on the GEIS process, the FSD and Workplan called for the Core Group to identify and outline future research needs. This topic is specifically covered in section 8 of the GEIS document.

3
MINNESOTA'S FOREST RESOURCES

3.1
Forest Resources

As used in this study, the term *forest resources* refers broadly to the range of values and outputs, both consumptive and nonconsumptive, commonly associated with forested environments. Such values include wildlife, water quality, timber production, recreation, aesthetics, and soil productivity. This is analogous to the meaning ascribed to forest resources by the Minnesota Forest Resources Management Act of 1982 (see section 4.1.1).

3.1.1
Historic Overview of Minnesota's Forests

History provides some perspective within which future Minnesota forest scenarios, and the assumptions underlying them, can be judged. Such perspective is important for policymakers in setting strategic direction and in trying to comprehend how current policy decisions and program directions may shape the future.

Land ownership patterns, forest types, and many other forest characteristics which exist in Minnesota today were strongly influenced by history. Prior to European settlement in the 19th century, the forests of Minnesota already had a long history of use by Native Americans. That use was as a source of food and shelter, and it also served to provide for a range of spiritual values. Additionally, fire was a common forest management tool employed by Native Americans.

In the early 19th century, Minnesota's forest acreage was extensively and largely dominated by conifers. White pine attracted the most attention and was essentially all logged between 1880 and 1910. Subsequently, attempts were made to settle these lands. The combination of heavy slash accumulations following logging and minimal fire protection resulted in catastrophic fires which destroyed property and took human lives. Soil productivity was also affected by the destruction of leaf and needle accumulations.

Following logging, speculators became interested in these low productivity, partially cleared areas and began selling them as agricultural lands to Easterners and immigrants looking to settle further West. Large transfers of public domain lands into private hands occurred in the late 1800s and in the early 1900s. However, this trend of transferring public forest land to private ownership began to change with the establishment of the national forests early in this century. By that time, however, vast acreages of the most productive land had passed into private ownership.

Of the federal land that remained, the majority was in what is now the BWCAW and land within the Chippewa National Forest specifically reserved by treaty. Subsequent land exchanges consolidated federal ownership of forest land, and the remaining land outside of consolidated ownerships was transferred to the fledgling state agency, the Department of Conservation, via various land grants. Since the late 1920s, the USDA Forest Service has continued to purchase land, primarily to increase national forest acreage within established forest boundaries, but not for the sole purpose of growing timber.

In the 1930s and 1940s, large-scale tax forfeiture occurred and the state Department of Conservation acquired privately owned lands that had been unable to support viable agriculture. The fact that these lands had been considered viable agricultural lands at one time distinguishes them (from a productivity standpoint) from the federal lands, as the majority of the latter never supported agriculture. Again, the private owners generally retained the most productive agricultural land (and timberland), which is concentrated in south, central, and northwestern Minnesota.

At the time when large-scale transfers of tax forfeited lands back to public ownership was occurring, the recipient state and county agencies did not have the personnel, money, or expertise at the time to actively manage these lands. Consequently, many of these acres gradually began to convert back to forest naturally. This new forest was largely hardwood with a large component of the pioneer species aspen. This species composition might have been different if state and county agencies had been better equipped to manage these lands. Reforestation by large-scale planting of conifers was a common practice on federal lands, and would probably have been practiced more extensively by state and county agencies if funding had been available.

3.1.2 Forest Land Area

Statewide Area of Forest Land

Forest lands currently occupy about 16.7 million acres in Minnesota, or about 33 percent of the state's 50.8 million acres of land. In Minnesota, the most comprehensive information on general characteristics of forest resources is the statewide forest survey conducted by the USDA Forest Service through its FIA project, based at the agency's North Central Forest Experiment Station in St. Paul. The first survey was conducted in 1934–36, and subsequent surveys or major updates were developed in 1953, 1962, 1977, and 1990. Three major categories of forest land recognized in the surveys are:

1. *Timberland or commercial forest.*—Forest land with trees that are growing fast enough so that they are potentially available for commercial use, and on lands not legislatively designated as an area where timber harvesting and other forest management prescriptions cannot occur.
2. *Unproductive forest or woodland.*—Forest land that, even though potentially available for harvesting, is not suited for growing trees that could be used for commercial purposes. Lands with poor soil, such as rocky areas on the Canadian shield in northern Minnesota and waterlogged peatlands are examples.
3. *Reserved Forest.*—Timberland and unproductive forest land legislatively withdrawn from timber utilization. Examples of reserved forest include state parks and the BWCAW.

Table 3.1 summarizes the survey results from 1936 to 1990. The area of all forest land has declined from 19.6 million acres to the current 16.7 million acres over the 54-year period. This is approximately half the area of forest prior to European settlement. The loss of forest area has occurred as a consequence of expanding agriculture and urbanization. The area of reserved forest land has risen from 400,000 acres in 1936 to 1.1 million acres today. Most of this increase came in the 1970s, when the BWCAW and Voyageurs National Park were legislatively established. Together these two areas of reserved forest land comprise over 80 percent of Minnesota's reserved forest acreage. The increase in reserved forest and the decline in total forest land over the last 50 years has led to a decline in timberland of about 3.4 million acres, or 19 percent. Caution should be used in interpretation of changes in unproductive forest land, as the definition of unproductive forest land differed between 1936 and 1953 and 1962 and again between the 1977 and 1990 FIA surveys. Today, most of the unproductive forest land in Minnesota consists of black spruce and tamarack forests growing on peatlands. Currently, timberland, reserved land, and unproductive or other forest lands make up about 88, 7, and 5 percent, respectively, of the state's total forest land base.

The 1990 FIA forest survey also shows an additional 953,600 acres of nonforest with trees (e.g., cropland or pasture with trees, windbreaks, marshland with trees, and urban areas with trees). These areas are important as tree cover itself and because they can represent land moving in or out of a forested classification or land use.

Table 3.1. Forest land area in Minnesota by major land class for 1953–90 (thousand acres).

Year	All Forest Land	Timberland	Reserved Forest Land	Unproductive or Other
1990	16,715[a]	14,773	1,113	828
1977	16,709	13,695	1,179	1,835
1962	18,445	15,412	470	2,563
1953	19,344	18,098	428	818
1936	19,615	18,215	400	1,000

Source: Jaakko Pöyry Consulting, Inc. (1992a).
Note: Portions of this and other inventory-related tables were drawn or derived from USDA Forest Service FIA documents and/or test data.
[a] Increases in all categories from 1977 to 1990 are more the result of a survey method correction than actual gain.

Distribution of Forest Land Area Within the State

A tabulation of forest land by ecoregion (table 3.2) shows that about half of total forest land occurs in heavily forested ecoregion 4 (Central Pine-Hardwood Forests). Extreme north and northeast Minnesota (ecoregions 1, 2 and 3) are also heavily forested and contain major acreages of the state's forest land. Ecoregions 5 and 6 cover the Prairie-Forest transition zone, where the largest area of former forest land has been converted to agriculture or other uses. Although the acreage of forest land in these two ecoregions is substantial, it represents a relatively small proportion of the land area within the ecoregion. Forest land in ecoregion 7—the Prairie region—consists mainly of scattered woodlots and stands of trees along streams and rivers.

Table 3.2. Forest land area in Minnesota by major land class and ecoregion, 1990 (thousand acres).

Ecoregion	All Forest Land	Timberland	Reserved	Unproductive
1	3,372.0	2,862.4	21.1	488.5
2	2,023.7	1,049.8	941.9	32.0
3	908.0	871.7	30.6	5.7
4	8,172.9	7,813.1	84.5	275.3
5	934.7	910.3	15.4	9.0
6	637.2	619.9	14.0	3.3
7	666.3	646.2	5.6	14.5
Total	16,714.8	14,773.4	1,113.1	828.3

Source: Jaakko Pöyry Consulting, Inc. (1992a).

More than half of all timberland occurs in ecoregion 4 (Central Pine-Hardwood Forests), and 85 percent of the reserved acreage is in the ecoregion 2 (Border Lakes), mostly in the BWCAW. Most of the unproductive forest is in the Red Lake Peatlands of ecoregion 1 (Glacial Lake Plains), with a substantial area also in various peatlands in ecoregion 4.

3.1.3 Description of Minnesota's Forest Resources

Forest Types

Minnesota's forest land can be classified into 14 *forest types* (sometimes also called *covertypes*), which is what was done for the GEIS, based on the proportion of various tree species that compose a given stand (an area of forest about 1 acre in size). Each forest type bears the name of one or two tree species that form a majority or plurality of wood volume in the stand. Although the types have simple, short names, most stands have a considerable mixture of species. Many stands contain five or six species of trees. As a result, a stand may be classified as aspen, when, for example, aspen comprises only 30 percent of the wood volume, and other species like balsam fir, white pine, white spruce, and red maple each comprise 15 to 20 percent of the total volume. Aspen stands may also vary greatly in species composition from place to place. For example, in ecoregion 5, an aspen stand may include substantial amounts of red oak and sugar maple, with few conifers. In ecoregion 2, an aspen stand may include substantial amounts of spruce and fir, with no maple or oak.

The forest types and their extent in Minnesota, as estimated in 1990, are described in table 3.3. Currently, the aspen forest type occupies the largest area, about one-third of the total. However, as mentioned above, many aspen stands have considerable components of either hardwoods or conifers, and so are more diverse than the name suggests. Black spruce occupies the largest area of any conifer type, due to its ability to grow on peatland soils. Minnesota has the largest area of these soils in the lower 48 states. Other major forest types include maple-basswood, oak-hickory, and elm-ash-soft maple, each comprising 7 to 8 percent of the total forest land area.

Table 3.3. Forest type acreage for timberland, reserved, and unproductive plots, statewide (thousand acres). Based on the 1990 FIA survey.

Forest Type	Forest Land Category			
	Timberland	Reserved	Unproductive	Total
Jack pine	447.5	131.5	0	579.0
Red pine	301.6	80.4	0	382.0
White pine	63.2	3.8	1.3	68.3
Black spruce	1,322.1	126.6	533.7	1,982.4
Balsam fir	734.3	93.1	12.5	839.9
Northern white cedar	680.5	25.1	38.3	743.9
Tamarack	705.1	8.9	110.7	824.7
White spruce	93.8	39.9	0	133.7
Oak-Hickory	1,190.4	9.5	13.4	1,213.3
Elm-Ash-Soft maple	1,291.5	42.8	33.1	1,367.4
Maple-Basswood	1,396.7	17.0	0	1,413.7
Aspen	5,115.4	422.1	30.3	5,567.8
Paper birch	834.7	94.9	2.1	931.7
Balsam poplar	427.7	7.1	8.4	443.2
Other	0	10.4	1.0	0
Nonstocked	169.9	0	43.5	222.8
Total	14,773.4	1,113.1	828.3	16,714.8

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Forest Stand-size and Age Class

Foresters categorize stand-size class by the diameter at breast height (dbh) of the dominant trees. Sapling-seedling stands are dominated by trees less than 5 inches dbh, poletimber stands by trees 5 to 9 inches dbh (11 inches for hardwoods), and sawtimber stands by trees 9 inches or more in dbh (11 inches for hardwoods). The stands composing Minnesota's timberland are aging and more of the acreage is stocked with trees than in the past. These trends are reflected in comparisons of stand size class data over time. The data in table 3.4 show a shift of acres from the seedling and sapling category to poletimber and sawtimber classes. Sawtimber as a class rose from 12.2 percent of timberland in 1953 to 33.1 percent in 1990.

There is a simple explanation for this trend. Much of Minnesota was cutover in the late nineteenth and early twentieth centuries. Forests have become established on many formerly cutover lands and, once established, timber volume growth has exceeded removals (harvesting) and mortality. Therefore, much timberland acreage has grown into the older, larger size classes. For many covertypes the forests are much older, on average, than they were in 1953. Even though harvesting has converted older stands to young ones over that period, covertypes with little harvesting now have extensive acres of maturing stands.

Table 3.4. Timberland area in Minnesota by stand-size class, 1953-90 (thousand acres). Nonstocked indicates forest land not occupied with trees (i.e. needs planting or seeding to reforest the area).

Year	All Size Classes	Sawtimber	Poletimber	Saplings & Seedlings	Nonstocked and Other
1990	14,774	4,895	5,261	4,449	169
1977	13,695	3,135	6,956	3,435	169
1962	15,412	2,387	7,520	4,294	1,211
1953	18,098	2,017	5,281	6,317	4,483

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Age class distributions are important to developing and maintaining a given forest structure and composition. When a forest has an equal number of acres in each age class, the age class distribution is considered *balanced.* Balanced age class distributions in turn assist in developing an even flow of timber yield and other forest values. Where age class distributions are unbalanced, management typically employs strategies that will replace existing stands upon harvest or natural mortality to achieve a more balanced age class structure. For example, a majority of the white pine forest area is 40 to 100 years old. There is relatively little area either older than 100 or younger than 40 years. This suggests the need for management to increase the acreage of young stands that will eventually replace the existing older stands.

The result of regrowth plus harvesting to date is reflected in the age class distributions for timberlands. A tabulation of such age class distributions for all covertypes is given in appendix 2. For reasons discussed in the next paragraph, only gross changes to age class distributions can be interpreted.

The stand age variable is difficult to accurately measure in the field for a variety of reasons: (1) difficulty in reading rings from increment cores for many species (particularly aspen), (2) variability in sample tree ages, (3) possible unintentional bias or error in choosing trees representative of stand age, (4) variability in years to reach Dbh (the usual point of measurement), (5) some stands may vary widely in age to the point of being uneven-aged, and (6) reserve stand ages were estimated from aerial photo interpretation. A stand may encompass trees with ages ranging over twenty years and still be considered even-aged. Figure 3.1 describes the age class distributions for two illustrative covertypes. Additional figures and commentary by covertype is given in section 2.3.3 of the Maintaining Productivity and the Forest Resource Base technical paper.

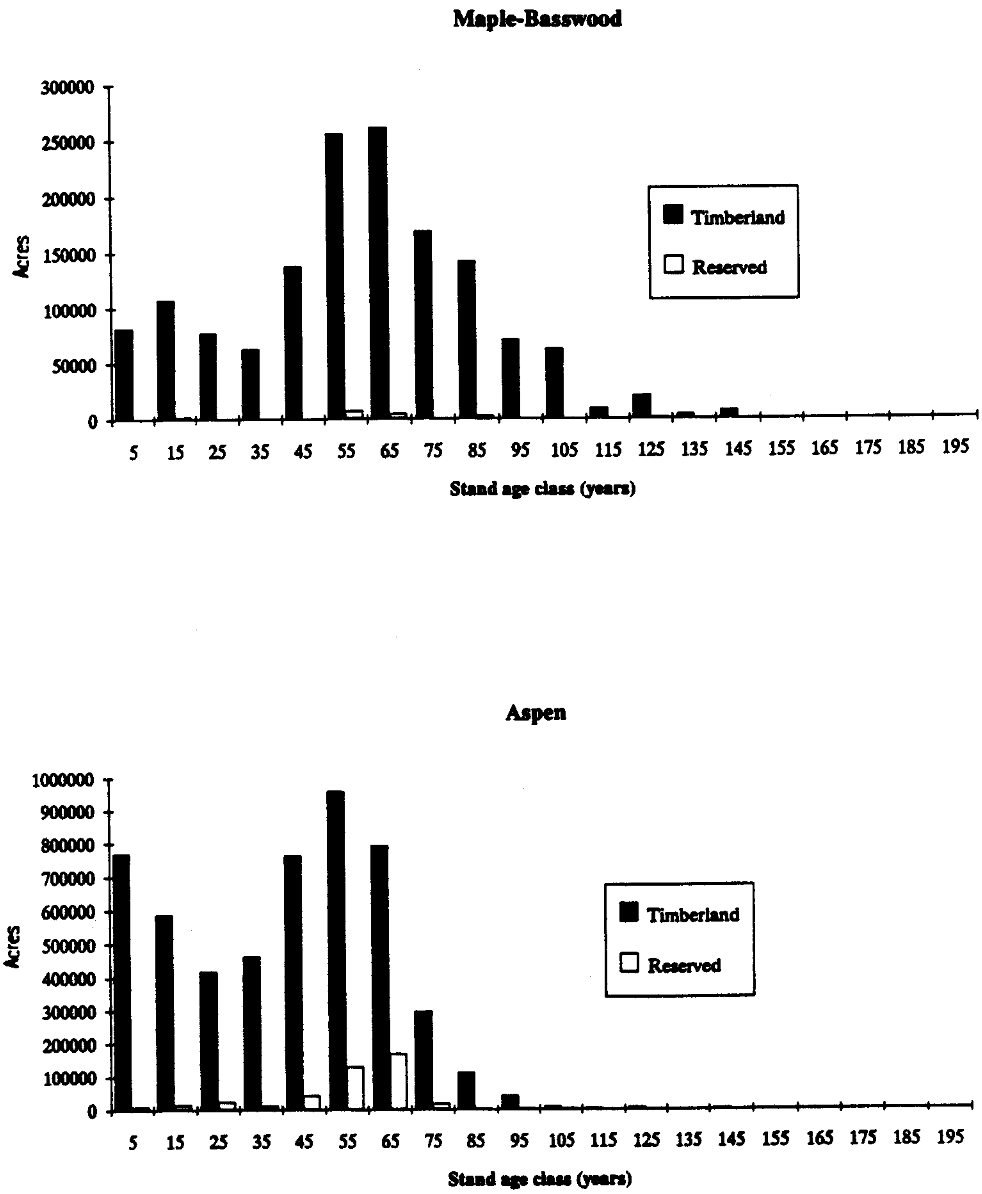

Figure 3.1. Age class distributions for FIA maple-basswood and aspen forest covertypes for timberland and reserved forest, 1990.

Maple-basswood

The maple-basswood forest type acreage on timberlands is dominated by stands from 50 to 70 years of age (see figure 3.1). This is typical of stands that developed in the early part of this century after logging and following the decline of agriculture. Like several other hardwood forest types, low demand has led to an unbalanced age class distribution with few younger stands present. The reserved forest acreage in this type is small and concentrated in the middle to older age classes in the central and southern portions of the state. The species comprising the covertype are generally shallow rooted, long-lived and respond to release or disturbance to advanced ages. Two site quality situations are recognized: (1) stands largely composed of sugar maple on well-drained sites, and (2) less well-drained or excessively drained sites with significant amounts of red maple and other hardwood species. Stands in the first category have the potential to grow sawtimber. Stands in the second category are typical of sites where tree form is poor and sawtimber quality is low. With time these stands can become uneven-aged. This covertype has a rich overall tree species composition compared to most pioneer covertypes.

Aspen
Aspen is a fast growing but short-lived tree species that typically reaches maximum timber volume production in the 25- to 50-year age range. Beyond that, growth diminishes and mortality and decay losses can reduce stand yields. However, in the northern part of the state, stands are capable of growing to more than 100 years of age. Individual trees may far exceed that. Like other types, most of the present stands originated in the first half of this century. Some observers have referred to this as a *wall of wood* moving to older age classes. However, harvesting over the last 20 years has led to a more balanced distribution of acres by age class, i.e., harvesting of older stands followed by prolific natural regeneration by suckering has led to development of substantial acreage of younger or replacement stand acreage. As shown by figure 3.1, there is a shortage of acreage in 25- and 35-year-old age classes, raising concerns about the adequacy of aspen timber supply in the period 2010–20. In managed stands, rotation ages are typically shorter than 50 or 60 years. The acreage of older stands suggests that these stands have not been utilized for one or more of the following reasons: lack of demand; inaccessibility or unavailability due to insufficient stumpage prices or constraints placed by owners. Silviculturally, this is also a concern because older stands on many sites do not sprout and regenerate well. Thus how these stands are managed and harvested over the next several decades will have a large impact on the continuity of timber supplies for major industries. The age class distribution of aspen is also considered important for wildlife, particularly game species that are favored by early successional stages of vegetation. The current large acreage of this type insures that it will be a major factor in both timber and nontimber management efforts for many decades.

Stand age is also important as a major factor in determining tree size, quality, and value. For some species, e.g., red oak, age may be deceptive as demand has been high for some time and the remaining quantity of high quality timber is a concern. Locally, quality is problematic and depends heavily on the grazing and other history of stands.

Growing Stock Dynamics

With or without harvesting, Minnesota's forests will change considerably in the coming decades. Such change will follow from aging, stand dynamics, or succession to different species, and natural forces such as fire, drought, windstorms, insect outbreaks, and disease. Harvesting can accelerate or slow such changes depending on the type and extent of the harvesting.

The stand aging and dynamics associated with the increase in acreage in the larger tree size classes in table 3.4 have also led to a dramatic accumulation of growing stock as shown in table 3.5. From 1936 to 1990 the net growth on Minnesota's forest land has exceeded the removals from harvesting to the extent that growing stock has more than doubled. Growing stock volume considers only those trees that satisfy typical size and quality standards for merchantability and then only the utilizable portion of those trees. The volume of dynamics (rate of resource change) is also informative. The rate of resource change has three components: *net growth, mortality*, and *removals*. Net annual growth of growing stock is defined as the annual change in volume of sound wood in live sawtimber and poletimber trees and the volume of trees entering these classes as ingrowth, less volume losses resulting from natural causes. Table 3.6 describes the trends in the rate of resource change since 1936.

Table 3.5. Growing stock volume and sawtimber volume on timberlands in Minnesota by softwoods and hardwoods (million cubic feet).

	Growing stock (million cubic feet)			Sawtimber (million board feet)		
Year	All Species	Hardwood	Softwood	All Species	Hardwood	Softwood
1990	15,091	10,460	4,631	34,657	22,489	12,168
1977	11,455	7,978	3,477	24,608	16,077	8,531
1962	9,444	6,060	3,384	14,875	8,742	6,133
1953	7,235	4,406	2,829	12,538	7,499	5,039
1936	6,903	3,652	3,251	12,455	5,867	6,588

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 3.6. Comparison of average net annual volume growth, mortality and removals from 1936, 1953, 1962, 1977 and 1990 from original survey reports (million cubic feet) for growing stock.[a]

		All		Hardwoods		Softwoods	
	Year		Percent[b]		Percent		Percent
Net growth	1990	367.1	2.4	254.9	2.4	112.2	2.4
	1977	348.9	3.0	229.1	2.9	119.8	3.4
	1962	364.2	3.7	257.4	4.2	106.8	3.0
	1953	384.6	5.3	267.0	6.1	117.6	4.2
	1936	373.1	5.4	229.1	6.3	144.0	4.4
Mortality	1990	219.6	1.4	153.1	1.5	66.5	1.5
	1977	141.5	1.2	107.8	1.4	33.7	1.0
	1962	111.0	1.1	55.6	0.9	56.4	1.6
	1953	173.0	2.4	105.0	2.4	68.0	2.4
	1936	95.4	1.4	57.2	1.6	38.2	1.2
Removals	1990	207.6	1.4	154.2	1.5	53.4	1.2
	1977	193.6	1.7	124.8	1.6	68.8	2.0
	1962	125.6	1.3	63.1	1.0	62.5	1.7
	1953	154.2	2.1	76.2	1.7	78.0	2.8
	1936	161.3	2.3	82.9	2.3	78.4	2.4

Source: Jaakko Pöyry Consulting, Inc. (1992a).
[a] Estimates vary by procedure and assumptions for each survey area thus these values are only approximately comparable.
[b] Percent of survey report growing stocking volume.

3.1.4 Nontimber Resource Contributions of Forests

Minnesota's forest resources provide a variety of nontimber values important to addressing environmental, economic, and amenity interests and objectives. Key among these are the following:

Outdoor Recreation

Hiking, fishing, hunting, and camping are just a few of the outdoor recreation activities that take place in a forested setting. With over 12,000 lakes, 90,000 miles of streams and rivers, and 16.7 million acres of forest land, together with the fish and animals that these water and forest resources support, Minnesota is endowed with abundance of recreational opportunities.

Minnesotans actively engage in many outdoor recreation activities, with an average participation of 225 hours per year. A survey conducted in 1985 indicated that the most popular activities, in terms of hours spent annually per capita, were walking/hiking (18 percent of the hours), fishing (12 percent), biking (12 percent), and driving (8 percent) (figure 3.2). Together they accounted for 50 percent of reported outdoor recreation hours. Next in importance were swimming (6 percent), boating (5 percent), hunting (4 percent), and nature observing (4 percent), which together accounted for another 19 percent of reported outdoor recreation hours. Sightseeing, camping, and golfing accounted for an additional 9 percent.

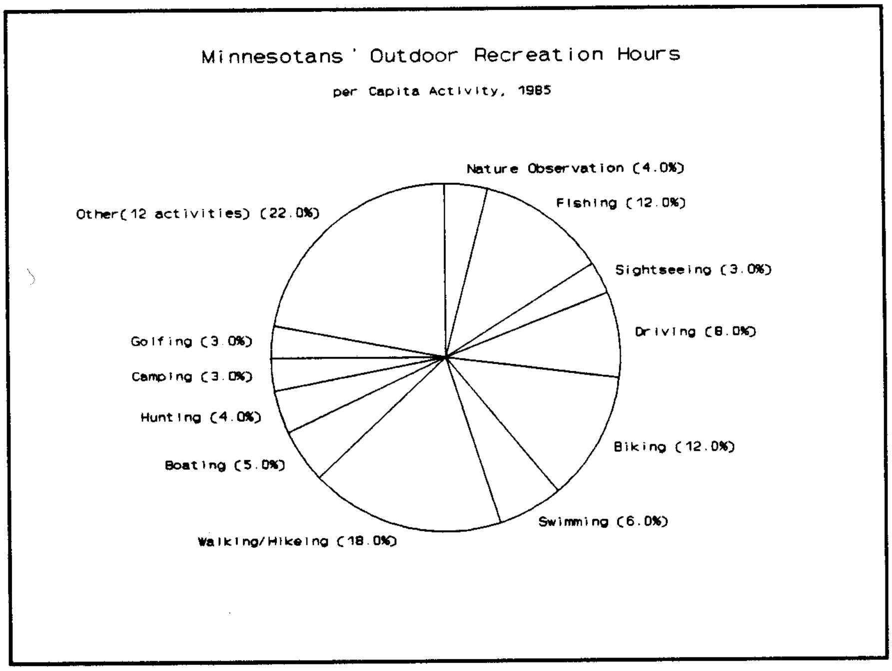

Figure 3.2. Hours spent annually in outdoor recreation by Minnesotans, 1985. (Source: Jaakko Pöyry Consulting, Inc. 1992h.)

Eighty percent of all outdoor recreation activities occur in northeastern Minnesota, in ecoregions 2, 3, and 4. The Central Pine-Hardwood Forest (ecoregion 4) accounts for at least half of all outdoor activities, except for canoeing, 40 percent of which occurs in the Border Lakes (ecoregion 2) and 19 percent in the Superior Highlands (ecoregion 3).

Economic Importance of Outdoor Recreation

The MNDNR conducted a 1985–86 outdoor recreation and expenditure survey of residents, and a 1978 summer outdoor recreation and expenditure survey of visitors to Minnesota. These surveys were used to develop estimates of statewide outdoor recreation travel-related and equipment expenditures in 1985 dollars. Annual travel-related expenditures in the state for outdoor recreation amounted to $1.2 billion in 1985 dollars. Of this, Minnesota residents accounted for $854 million (69 percent) and nonresidents

$386 million (31 percent). Transportation, groceries, restaurants, and lodging accounted for 77 percent of the expenditures for outdoor recreation travel (figure 3.3). Expenditures for travel-related equipment amounted to an additional 8 percent of the total.

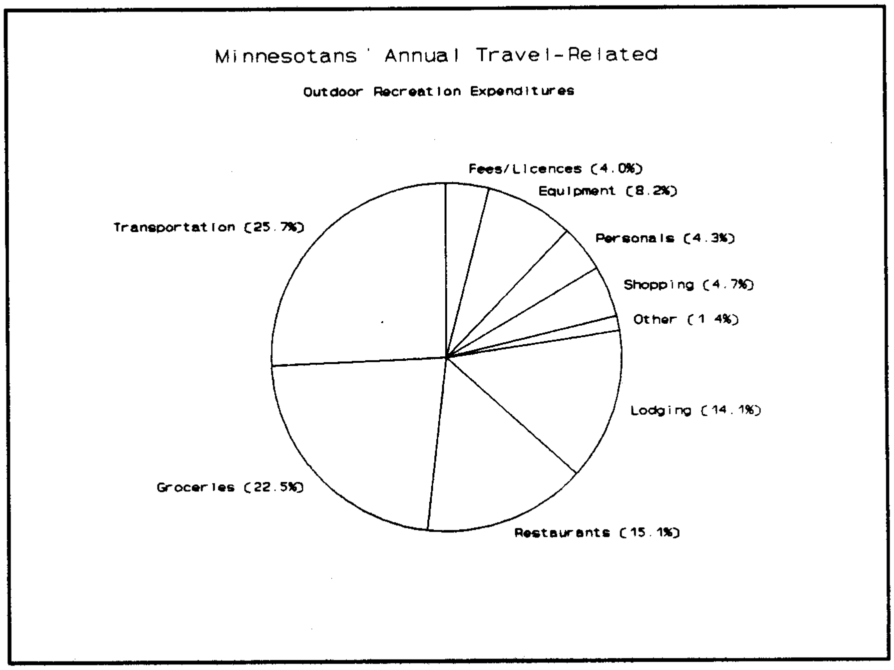

Figure 3.3. Annual travel-related expenditures for outdoor recreation by Minnesotans, 1985. (Source: Jaakko Pöyry Consulting, Inc. 1992h.)

Equipment purchases by Minnesotans were dominated by boats (including motors and accessories), which accounted for 41 percent of the total (figure 3.4). Large recreational vehicles (RVs) accounted for an additional 10 percent of equipment expenditures. Bikes, hunting (equipment and clothes), clothing and footwear (except for fishing and hunting), and sports (equipment not listed elsewhere) each accounted for approximately 8 percent of equipment expenditures. Recreational transportation (snowmobiles, 3-wheelers, and 4x4 trucks), fishing (equipment and clothing exclusively for fishing), and other (camping and nonconsumptive use equipment) accounted for the remaining 18 percent.

The direct and indirect impacts of outdoor recreation expenditures in Minnesota generated 58,000 jobs, primarily in the wholesale/retail sector and the services sector. These jobs amounted to 3.3 percent of the total number of jobs in the state. Outdoor recreation and tourism was most important to the regional economy of the northeast, accounting for over 10 percent of total economic output in that region.

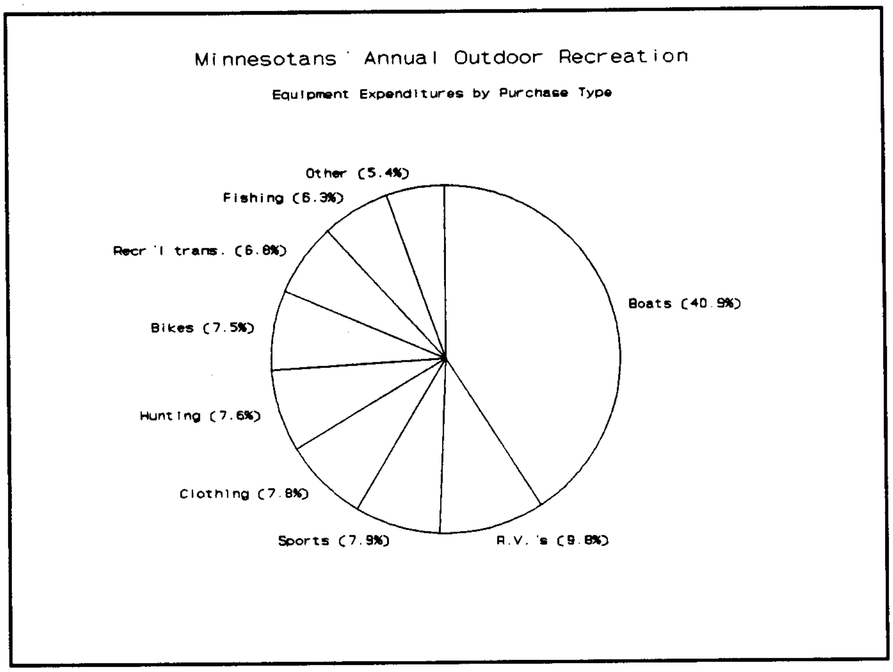

Figure 3.4. Annual expenditures on equipment purchased for outdoor recreation, by type of purchase, by Minnesotans, 1985. (Source: Jaakko Pöyry Consulting, Inc. 1992h.)

Aesthetic Values-Attractiveness of the Forest

Several factors related to landform and landcover contribute to the attractiveness of a forested landscape to outdoor recreationists and tourists. Landform dimensions generally considered attractive include steep slopes, diversity of slope steepness, ability to see water, and diversity of water features such as lakes and streams of different sizes in one landscape. People also seem to derive aesthetic enjoyment from "outdoor rooms," which provide visually bounded spaces, such as a small lake surrounded by tall trees, or a sense of canopied space within a forest with vertical walls and ceiling provided by trees. Landcover dimensions associated with high aesthetic value include species diversity within stands; diversity of vegetation types on the landscape; presence of large old trees; vegetative distinctiveness, such as fall color of maple trees or the white bark of paper birch; the condition of the forest floor with respect to amount of dead wood; and the extent of ground-cover vegetation.

Cultural and Historical Values of the Forest

Forests are often the setting for important cultural and historic resources. Minnesota's heritage resources represent values that are important to Minnesotans. Heritage resources reflect the history, contributions, and ongoing cultures of the ethnic groups that created this state. The following types of heritage sites are recognized in Minnesota:

Cultural Landscapes are a collection of features which represent interaction between humans and the environment. People may assign cultural meaning to natural features or features which have been made or modified by humans.

Standing Structures include buildings and structures made and used by people, generally in the recent past. Standing structures are rare within the timberlands.

Archaeological Sites are located on or below the surface of the ground or under water. They include two major categories: Native American sites such as the remains of large and small villages, camps, and processing sites; and Euro-American sites such as fur trade posts, homesteads, and logging camps. Most of these sites are not visible at the ground surface and require special techniques to locate.

Cemeteries may contain the remains of one or more human beings and are common on forested lands in Minnesota. These include Native American and Euro-American cemeteries.

Traditional Use Sites are locations which have been historically used by one or more groups of people for some type of activity. They may lack the physical evidence of artifacts or structures, and are often characterized by plants, animals, and/or topography which are of cultural and religious significance to Native Americans.

Biological Values of the Forest

The biological diversity of forests is of immense ecological, social, and economic importance to the world. Ultimately, the sustainability of forest resources, both economically and ecologically, depends on the maintenance of biodiversity, for the following reasons:

Forests contain genetic strains of forest trees and other plants which are adapted to local climate and site conditions. Minnesota has many species which reach either the northern or southwestern edge of their geographic range in the state. Currently, these species may be rare at the edge of their range, but they may become dominant in the future. If global warming occurs, local genetic races of trees from near the edge of the species range that are adapted to climatic extremes may help maintain forest productivity. For example, sugar maple has several isolated populations beyond the northern edge of the contiguous range of the species along the North Shore of Lake Superior (ecoregion 3). If the climate of northeastern Minnesota becomes warmer, these isolated sugar maple stands would serve as nuclei for new northern hardwood forests that would be more productive than the current birch-spruce-fir forests, which would be under heat and drought stress.

Forests often contain local populations with natural resistance to disease. Scientists who develop disease resistant varieties of crops and forest trees often search wild populations for individuals which appear to have genetically conferred disease resistance. The disease resistance can often be transferred through breeding to other populations which may have superior growth rates or form. Using this technique, varieties of white pine resistant to blister rust and varieties of American elm resistant to dutch elm disease have been developed.

Forests often contain species which may produce new economically valuable products. It is impossible to predict when an apparently unusable plant may, at some future date, produce a necessary product or allow a new local industry to develop. An example of an unexpected product is ginseng (*Panax quinqefolium*), a small herb of old growth sugar maple forests, that is now listed as of special concern in Minnesota. Ginseng is in demand for medicinal use in oriental countries. Farmers in north central Wisconsin, a region where ginseng was once abundant in the wild, used local wild stocks to start up ginseng farms, and these expanded rapidly in the 1970s and 1980s. Today, ginseng farming is a significant portion of the agricultural economy of north central Wisconsin.

Biological diversity of forests is essential for aesthetic and recreational values in Minnesota. Landscapes managed to enhance biodiversity include a large variety of forest types which have important implications for tourism, a major industry in Minnesota. Many people visit Minnesota to see forest wildlife such as Bald Eagles, owls, hawks, gray wolf, white-tailed deer, and black bear. These species range widely and use a variety of special habitats, such as isolated stands of oaks or large pines. Many songbirds and wildflowers occur mainly in mature or old growth forests. Patches of oaks and maples provide fall colors. Management of Minnesota's forest landscape to enhance biodiversity will maintain all of these recreational resources into the future.

An important aspect of Minnesota's 19th century history was the cutting of the great forests of white and red pine. Ensuring that stands of these species are able to reestablish in representative sites throughout their original ranges is as much a cultural responsibility as it is an environmental one.

Forests exhibit ecological processes useful for management and educational purposes. Many original vegetation types were maintained in a sustainable, productive state on the landscape by natural disturbances, and forest soils developed slowly over thousands of years. The sustainability of current forest management practices can be assessed by comparing the natural rate of nutrient addition and removal from the soil by disturbances and successional processes with similar rates for managed forests. Natural disturbances of various types can hold forests at one successional stage or speed the development of a desired late successional stage. However, disturbance must be studied in its natural context before it can be applied to forest management. Ultimately, forest management will be sustainable if natural processes are used as guidelines.

Forests sequester large amounts of carbon. Trees use carbon dioxide as a major building block to make cellulose, which is incorporated into wood. An acre of red pine or oak forest on a good quality site in Minnesota can sequester 50 to 100 tons of carbon as it grows from a seedling stand to an old sawtimber stand. Since 1977 or earlier, about 2 to 4.5 million tons of carbon have been added each year to existing Minnesota forest lands (MNDNR 1991). This is because in the last several decades most Minnesota forests each year have added more wood volume than has been removed. Sequestration of carbon by forests is important because it can help counterbalance the addition of carbon dioxide to the atmosphere that is now occurring due to burning of fossil fuels.

Forests provide water resource protection. Forest resources provide important cover and mechanisms to maintain and protect water resources. As continuous vegetative cover, forests can affect the amount, timing, and quality of water yield. Forest stand density, for example, can influence the timing of runoff peak discharges, thereby lessening the impact on stormflow and flooding. Even though much of Minnesota's topography is fairly flat, forests also serve as stabilizing forces to protect against soil erosion and sedimentation problems in waterbodies. The forest floor and soils are also important in filtering and modifying chemical inputs from nearby agricultural or developed areas. Forest canopies in riparian areas also reduce the input of organic matter in adjacent waterbodies and the amount of light reaching the water surface, factors which affect species composition, growth, and production of the animals that inhabit the water resource.

3.2 Forest Ownership and Management

3.2.1 Forest Ownership

Private individuals and corporations, other than the forest industry, own the largest area of Minnesota timberland—about 6.4 million acres or 43 percent of all timberland (table 3.7). The state is the largest public landowner with over 3 million acres of timberland, followed by counties and the national forests. The forest industry owns about 5 percent of all timberland in the state.

The ownership pattern of timberland in Minnesota has changed only slightly since 1953 (table 3.7). Much of the change is the result of decreases in the amount of timberland due to reservation (BWCAW and Voyageurs National Park) and reclassification of land from timberland to unproductive and then back to timberland status.

Table 3.7. Timberland area in Minnesota by ownership class 1953-90 (thousand acres).

Year	All Classes	National Forest	State	County	Other Public	Forest Industry	Other Private
1990	14,774	1,821	3,078	2,506	198	751	6,420
1977	13,695	1,715	2,651	2,342	155	772	6,060
1962	15,412	2,142	2,639	2,732	126	716	7,057
1953	18,098	2,195	3,484	3,619	143	509	8,148

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Reclassification of timberland into the reserved land use category accounts for most of the reduction in timberland for federal ownership. The decrease on other lands is more difficult to explain. Past large-scale shifts in timberland acreage have been closely linked to demand for agricultural land. During periods of higher commodity prices for agricultural goods, timberlands have been cleared and used for cropland. Also, other private includes Native American lands. Because these lands contain a substantial portion of unproductive forests, shifts in the amount of timberland may be the result of changes in definitions shifting forest land between unproductive and timberland categories. Also, the other private class in some areas is being increasingly fragmented as it is being handed down to estate heirs over time.

Use of marginal agriculture lands for cropping has long been a concern among federal and state governments. In response, new federal and state programs have been developed in the past decade to convert these acreages back to tree or shrub cover, much of which would eventually result in its reclassification to timberland. However, these are new programs while the conversion of woodlots to cropland has been consistent for many years. Note that the state has a long history of programs to reclaim marginal farmland, dating back to the soil bank conservation programs of the 1930s.

Urban expansion is also a significant factor in timberland loss on private ownerships, at least around major metropolitan centers such as the Twin Cities, and in the St. Cloud/Rochester corridor—areas where a high percentage (higher than the state average) of forest land is likely to be classified as timberland due to the generally more productive soils.

Studies to determine the cause of timberland area change suggest the cases vary in a complex manner over time and by region of the state. Table 3.8 indicates the ownership of Minnesota timberlands by ecoregion. National forest timberlands are the most concentrated, with 45 percent of all USDA Forest Service lands occurring in ecoregion 4 and the remainder in ecoregions 1 through 3. Industry lands are only slightly less concentrated—49 percent occur in ecoregion 4 and 36 percent in ecoregion 1.

Approximately 73 percent of county timberland is in ecoregion 4 and 14 percent in ecoregion 1. Approximately 46 percent of state lands are in ecoregion 1 and 36 percent in ecoregion 4.

Table 3.8. Timberland by ownership class and ecoregion 1990 (thousand acres).

Ecoregion	Total	National Forest	State	County	Other Public	Industry	Other Private
1	2,862	125	1,414	347	63	273	640
2	1,050	590	151	119	4	49	137
3	872	289	114	182	2	61	224
4	7,813	817	1,204	1,819	63	367	3,543
5	910	0	51	22	32	0	805
6	620	0	67	6	20	1	526
7	647	0	77	11	14	0	545
Total	14,774	1,821	3,078	2,506	198	751	6,420

Source: Jaakko Pöyry Consulting, Inc. (1992a).

3.2.2 Management Structure

National Forests

The USDA Forest Service is the largest agency of the U.S. Department of Agriculture. It administers two national forests in Minnesota, the Superior National Forest (located in ecoregions 2, 3, and northeastern part of 4) and the Chippewa National Forest (located in the northwestern part of ecoregion 4). Each national forest has a forest supervisor who oversees forest staff, helps formulate regional and forest-level policies, and helps disseminate research information. The forest supervisor also works to accomplish state and private forestry program objectives, and meets regionally allocated production targets for goods and services on the forest.

Each of Minnesota's two national forests is divided into five districts. Each district is headed by a district ranger whose primary responsibility is on-the-ground management of national forest programs, which is carried out by field personnel. This level of the national forest system generally has the most direct contact with local government officials, forest users, and other segments of the public.

The grouping of Minnesota's national forest lands into two large blocks allows management for multiple use objectives that can only be achieved at the landscape-level. Diverse goals, such as maintaining large nonmotorized recreational areas with appropriate buffer zones, riparian management zones, large areas of old uneven-aged forest management, and areas of even-aged forest management, can be accomplished simultaneously on the national forests while still producing enough timber to enhance the local timber industry and practicing sustained yield forestry. Such management is more difficult to effectively practice where ownership patterns are fragmented, as is often experienced on state administered forest lands and, to a greater degree, county managed forest lands.

In terms of the degree to which large areas of contiguous forest land occurs across the landscape, national forests are the most aggregated, followed by state and then county forest land. These differences in management are also reflected in availability of timberland for harvest. Availability is estimated at 87 and 53 percent on the Chippewa and Superior national forests, respectively, but 95 percent on state and county forest lands.

MNDNR Division of Forestry

The Division of Forestry is headed by a director located in St. Paul, with field offices organized into five regions: Bemidji, Grand Rapids, Brainerd, Rochester, and Metro. The regions are in turn divided into areas (16 total) and field stations (69 total). The division follows a multiple use management plan with responsibility for timber production, enhancement of outdoor recreation, biodiversity, and other uses of state forest lands.

The regional administrative level provides centralized services, specialist services, policy implementation, and supervision for the areas within the region. The area administrative level has similar duties for the field stations within the area. The field station administrative level carries out the on-the-ground management activities of the Division of Forestry.

In contrast to the USDA Forest Service whose entire ownership is essentially contiguous, the MNDNR Division of Forestry is less able to carry out the landscape-scale multiple use objectives—such as simultaneous primitive areas and timber production on the same forest. This is due to the smaller size of individual state forest holdings. For example, MNDNR has an old growth program whereby *old growth stands* of 20 to several hundred acres in size are reserved from harvest. This is in contrast to the national forests, which are capable of creating an *old growth landscape*, such as the BWCAW in Superior National Forest. The state forests have emphasized timber production more than the national forests, but less than the county forests, as described below.

County Management System
Minnesota is one of only two states in the U.S. with an extensive county managed land base. Counties manage 2.5 million acres of forest land. St. Louis County has the largest county land system at 744,800 acres, followed by Koochiching (278,000 acres), Itasca (255,700), and Cass (232,900). Four additional counties manage at least 100,000 acres, and four more manage 50,000 to 100,000 acres. Technically, these lands are owned by the state, but there is a statutory trust in each county where such lands exist. All lands that now compose the county land base became county land through tax forfeiture. The state makes annual payments to counties in lieu of taxes that would otherwise be generated by these lands.

Each county's land base is managed by a land commissioner, county auditor, or, for counties with small amounts of forest land, the MNDNR. The vast majority of county forest land is concentrated in a few counties with land commissioners and a county land department. Land commissioners are appointed by county boards and function as the administrators of the county land system. In counties with large land areas, lands are often divided into districts or areas, with management of each area under a resources manager.

The primary focus of management on county forest lands in Minnesota has been generation of revenue from timber sales, which in turn also helps support the local forest industry job base. Although the county lands technically belong to the state, their management was specifically excluded from the Forest Management Act of 1982, which provides for multiple use management of all state owned forest resources. For counties with significant forest land, the tracts are generally large and contiguous, second only to the national forests. Where counties have smaller holdings, they are mostly in small, scattered parcels, so that management for fish and wildlife and recreation and aesthetics, which often require large contiguous areas of forest, have been difficult, and consequently of secondary importance in county forests. Also important, the primary reason some counties do not manage for resources other than timber is because they have no legal mandate to do so.

However, to a certain degree, county managers cooperate with state and national forest wildlife and recreation management programs, as these lands often surround county forest lands. Where practiced, this cooperation also allows counties to take advantage of state and national forest expertise and personnel, which the counties could not afford on their own. One difficulty in fully assessing this aspect is the lack of specific data regarding actual cooperative management acres by county and by resource use.

3.3 Minnesota's Primary Forest Products Industries

Primary forest products industries utilize roundwood (logs or other round sections cut from trees for industrial or consumer use) to produce output, much of which is used as a raw material by other economic sectors. Industries that utilize wood-based products, but not roundwood, are referred to as secondary forest product industries. The major forest products industries in Minnesota include: (1) pulp and paper, (2) hardboard, (3) waferboard (also known as flakeboard) and oriented strand board (OSB), (4) lumber, (5) veneer, and (6) treated wood. The following section discusses the facilities, type of product, and employment generated for these major categories in Minnesota.

3.3.1 Pulp, Paper, and Hardboard

Minnesota has 13 mills that produce pulp, paper, and/or hardboard (table 3.9). Of these, ten produce pulp and purchase roundwood on the open market. There are seven pulp and paper mills in Minnesota. Six of these mills purchase roundwood; the Potlatch paper mill in Brainerd obtains the processed pulp it uses from the Cloquet mill and on the open market. In total, the six pulp and paper mills, other than Potlatch-Brainerd, purchase about 1.4 million cords of roundwood each year.[1] From this, they produce about a million tons of pulp each year. They also purchase about 425,000 tons of pulp each year from outside the state. Most of the purchased pulp is softwood kraft pulp obtained from Canada. These seven mills produce about 1.9 million tons of paper each year.

Many products other than paper are produced with wood pulp. In Minnesota, these include hardboard, boxboard, roofing felt, sheathing, ceiling panels, and decorative tiles (table 3.9). Superwood Corporation operates two hardboard plants in Minnesota that use about 150,000 cords of roundwood each year to produce 60,000 million square feet (3/8 in. basis) of hardboard annually. Two other companies, International Biltrite Inc. and CertainTeed Corporation, also purchase roundwood. Together, they use about 45,000 cords per year to produce sheathing and roofing dry felt. The Waldorf Corporation in St. Paul makes cardboard and corrugated boxes using primarily recycled paper.

In 1985, about 4,962 people were employed in the pulp and paper industries of Minnesota.

[1] The numbers in table 3.7 are cords per day. To obtain cords per year, multiply by 365 days per year.

Table 3.9. The pulp and paper and hardboard industries in Minnesota, 1990.

Company	Location	Hardwood Roundwood Purchases (CPD)[a]	Softwood Roundwood Purchases (CPD)[a]	Pulp Produced (TPD)[b]	Type of Pulp	Final Product	Quantity	Units (per day)
Superwood Corp.	Bemidji	82	27	100	GW[c]	hardboard	37	mmsf[d](3/8)
Potlatch Corp.	Brainerd	0	0	0	--	coated offset text and cover	329	tons
Potlatch Corp.	Cloquet	699	164	534	Kraft	coated offset text and cover	504	tons
USG Interiors Inc. Co.	Cloquet	0	0	0	--	misc.: ceiling panels, decor. tiles	--	--
Lake Superior Paper Ind.	Duluth	0	438	438	GW	SC[e] groundwood printing papers	685	tons
Superwood Corp.	Duluth	274	27	350	GW	hardboard	128	mmsf (3/8)
Blandin Paper Co.	Grand Rapids	329	315	521	GW/TM[f]	coated and uncoated printing	1,370	tons
Boise Cascade Corp.	Intn'l Falls	1,260	247	890	Kraft	business papers	1,397	tons
International Biltrite Inc.	Intn'l Falls	68	0	110	GW	sheathing	--	--
Hennepin Paper Co.	Little Falls	14	41	68	GW	bleached & unbleached printing	82	tons
Champion International	Sartell	178	164	493	GW	SC groundwood printing papers	233	tons
Champion (Cont')						lightweight coated pub. papers	548	tons
CertainTeed Corp.	Shakopee	60	0	80	GW	roofing dry felt	185	tons
Waldorf Corp.	St. Paul	0	0	0	--	clay coated boxboard	850	mmsf
Totals		2,964	1,425	3,585				

Source: Jaakko Pöyry Consulting, Inc. (1992h).

[a] CPD - cords per day.
[b] TPD - tons per day.
[c] GW - groundwood pulp.
[d] mmsf - million square feet (3/8 indicates 3/8 inch basis).
[e] SC - supercalendared paper.
[f] TM - thermomechanical pulp.

3.3.2
Oriented Strand Board (OSB) and Flakeboard

The waferboard, flakeboard, and OSB industry is relatively new. Minnesota has been at the forefront of this rapidly expanding industry. The first commercial waferboard mill in the United States was built in Grand Rapids, Minnesota, in 1974. That mill is now owned and operated by the Potlatch Corporation and produces OSB. The first commercial OSB mill in the United States is also located in Minnesota. It was built by Potlatch in Bemidji in 1981. Between 1981 and 1985, four new mills began operations in Minnesota. Two of these were waferboard mills and two were OSB mills. Recently, Trus Joist MacMillan began operating a new mill in Crosby, Minnesota, which makes parallel strand lumber, a new variant of the oriented strand technology. In total, these mills require 1.06 million cords of roundwood per year and produce 1,315 million square feet of board (3/8 in. basis) per year (table 3.10). In 1985, about 1,000 people were employed in the waferboard and OSB industries of Minnesota.

Table 3.10. The OSB and flakeboard mills of Minnesota, 1991.

Company	Location	Est. Date	Type of Board	Wood Use (K Cd/yr)[a]	Output (mmsf[b]/yr)
Potlatch Corp.	Grand Rapids	1974	OSB	265	275
Potlatch Corp.	Bemidji	1981	OSB	175[c]	220[c]
Northwood	Solway	1981	Wafer	210	300
Potlatch Corp.	Cook	1982	OSB	175	210
Louisiana Pacific	Two Harbors	1985	Wafer	100	130
MacMillan	Crosby	1991	PSL[d]	135	180
Totals				1060	1315

Source: Jaakko Pöyry Consulting, Inc. (1992h)

[a] K cd/yr - 1000 cords per year.
[b] mmsf - million square feet, 3/8 in. basis.
[c] This mill is in the midst of an expansion. Consumption is expected to increase in 1992 to as much as 315,000 cords of roundwood per year. Production will increase accordingly.
[d] PSL - parallel strand lumber.

3.3.3
Sawmills

There are an estimated 892 sawmills in Minnesota, scattered throughout the state. All of these are small by national standards. They vary in size from 1 to 100 employees. Aspen is the primary species used for sawlogs, with 82 million board feet cut and delivered in 1988. Red oak (47 million board feet cut in 1988), red pine (43 million board feet), jack pine (35 million board feet), and white pine (20 million board feet) are the next most important sawlog species. Altogether, 307 million board feet, or about 615,000 cords, of sawlogs were cut in Minnesota in 1988. Although sawlog volumes are small, sawlog values are relatively high. Thus, in value terms, the roundwood purchased by sawmills is as least as important as the roundwood purchased by either the pulp and paper industry or the waferboard and OSB industries. In 1985, about 1,495 people were employed in sawmills in Minnesota.

3.3.4 Other Primary Forest Products Industries

Other primary forest products industries include logging, veneer production, and treated wood products. The logging industry plays a unique role among primary forest products industries, serving as the supplier of roundwood to all other primary forest products industries. Thus, the logging industry could be viewed as a *preprimary* forest products industry. Data compiled by Minnesota Forest Industries indicates that there were 4,390 full- and part-time loggers in the state as of 1992. Relatively little of the roundwood produced in Minnesota is used for veneer production. However, due to the high value of veneer quality roundwood, this cannot be viewed as an insignificant industry. Veneer is more commonly produced in southern Minnesota than in northern Minnesota. Similarly, wood preservation is a small, but significant, primary wood products industry in Minnesota. Wood treatment may be classified as a secondary industry, depending on the degree of integration of the wood treatment facility. That is, if a treatment facility purchases only lumber for treatment, it would be considered a secondary wood processor. Facilities that purchase roundwood are considered primary producers.

Fuelwood may be considered another industry, but much of it is dispersed or local usage, and activity and employment is difficult to track in total. However, fuelwood consumption has recently been estimated by the MNDNR at 530,000 cords per year. Table 3.11 describes recent wood consumption in Minnesota, which with fuelwood removals totals nearly four million cords.

Table 3.11. Wood consumption from Minnesota's forests, 1991 (thousand cords).

Use	Consumption
Pulpwood, paper and paperboard	1,210
OSB and other pulpwood	1,505
Subtotal	**2,715**
Lumber	581
Fuelwood	530
Other	152
Total	**3,978**

Source: Jaakko Pöyry Consulting, Inc. (1992a).

3.4 Wood Fiber Consumption

The Minnesota forest products industry is in the midst of a significant expansion of output and wood use. Total industrial roundwood receipts increased from 91 million cubic feet in 1960 to 121 million cubic feet in 1975 and 218 million cubic feet in 1988 (table 3.12). The greatest expansion

Table 3.12 Industrial roundwood receipts by type of mill in Minnesota, 1960, 1975, and 1988 (in million cubic feet).[a]

Kind of mill	All Species		
	1960	1975	1988
Pulpmills[b]	61.9	83.8	156.4
Sawmills	26.4	30.9	55.7
Other mills[c]	2.7	6.6	6.4
Total	91.0	121.3	218.5
	Softwoods		
Pulpmills[b]	29.1	28.8	33.3
Sawmills	11.5	9.7	22.4
Other mills[c]	0.1	0.3	0.9
Total	40.7	38.8	56.6
	Hardwoods		
Pulpmills[b]	32.8	55.0	123.1
Sawmills	14.9	21.2	33.3
Other mills[c]	2.6	6.3	5.5
Total	50.3	82.5	161.9

Source: Jaakko Pöyry Consulting, Inc. (1992h)
[a] Table values can be converted to cords by the approximation of 80 cubic feet per cord.
[b] Includes flakeboard plants after 1978, formerly reported in other mills category.
[c] Does not include treating plants or fuelwood receipts.

has taken place in pulpmills, where roundwood receipts almost doubled from 1975 to 1988, increasing from 84 million cubic feet in 1975 to 156 million cubic feet in 1988. This data is somewhat misleading, however, as receipts at flakeboard and OSB mills were included with "other mills" for 1975 and with pulpmills in 1988. (In 1960, there were no flakeboard or OSB mills.)

Much of the increase in the reported receipts for pulpmills reflects the tremendous growth of the waferboard and OSB industries in Minnesota during the 1980s. Prior to the 1980s, receipts at these mills were not significant. Sawmill roundwood receipts also increased significantly between 1960 and 1988, rising from 31 million cubic feet to 56 million cubic feet. In percentage terms, both pulpmill (including flakeboard and OSB mill receipts) and sawmill receipts have increased by about the same proportion. Pulpmill receipts increased about 86 percent, and sawmill receipts increased 81 percent between 1975 and 1988. There was little overall change in receipts for other mills from 1975 to 1988.

A more detailed look at the expansion in pulpwood receipts (figure 3.5, table 3.13) indicates there was a slow but steady rise from 1960 to the early 1970s, followed by a decade of fairly stable receipts. Rapid growth in pulpwood receipts again occurred in the early 1980s, rising from 1.1 million cords in 1980 to 1.96 million cords in 1984. Receipts have since risen to

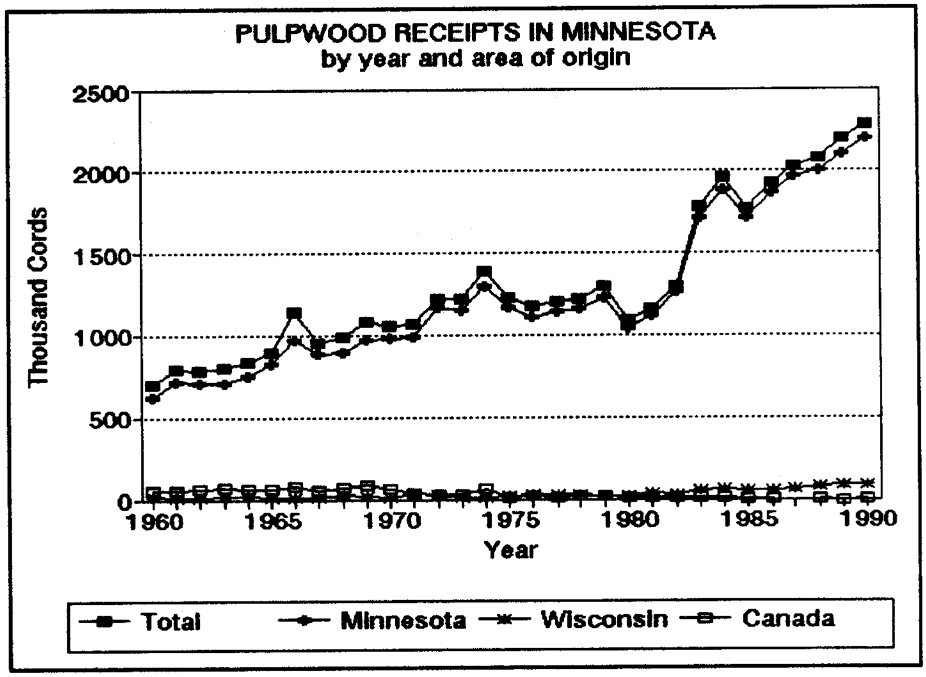

Figure 3.5. Pulpwood receipts in Minnesota, all species, by area of origin, 1960–90. (Source: Jaakko Pöyry Consulting, Inc. 1992h.)

2.29 million cords in 1990. As figure 3.5 and table 3.13 show, almost all of the pulpwood received by mills in Minnesota is produced within the state (approximately 96 percent in 1990). Only from 3 to 4 percent comes from outside the state, mostly from Wisconsin.

Table 3.13. Pulpwood receipts in Minnesota, by area of origin, 1960–90.

Year	Area of Origin				All Areas
	Minnesota	Wisconsin	Other States	Canada	
	(thousands of cords)				
1960	626	19		57	702
1961	721	14		58	793
1962	711	15		60	786
1963	712	20		73	805
1964	753	19		63	835
1965	828	8	1	61	898
1966	970	13	78	79	1,140
1967	884	15	1	58	958
1968	900	22	1	69	992
1969	977	17	2	86	1,082
1970	981	11	1	65	1,058
1971	992	35	1	36	1,064
1972	1,168	28	2	26	1,224
1973	1,152	14	29	27	1,222
1974	1,297	14	16	65	1,392
1975	1,173	20	18	15	1,226
1976	1,109	23	26	19	1,177
1977	1,149	26	19	15	1,209
1978	1,155	26	20	17	1,218
1979	1,226	21	29	19	1,295
1980	1,044	18	20	15	1,097
1981	1,119	34		11	1,164
1982	1,264	26		8	1,298
1983	1,720	53		9	1,782
1984	1,888	65		8	1,961
1985	1,714	59		2	1,775
1986	1,873	56		1	1,930
1987	1,967	62			2,029
1988	2,003	80		1	2,083
1989	2,110	89	2	0	2,201
1990	2,200	83	2	2	2,286

Source: Jaakko Pöyry Consulting, Inc. (1992h).

Figure 3.6 shows the overall trend in pulpwood receipts in Minnesota between 1979 and 1988. Clearly, there has been a steady, increasing trend. This increasing trend reflects an expansion in the number and capacity of Minnesota pulp and paper mills and waferboard and OSB mills. However, 1983 and 1984 also stand out as years when roundwood consumption was relatively high, reflecting the generally buoyant U.S. economy at that time. In addition, receipts were relatively low between 1980 and 1982, due to the recession in the early part of the decade. These numbers illustrate how receipts vary in response to current national forest products market conditions and do not reflect solely the state's industrial capacity.

Figure 3.6 also shows the breakdown of pulpwood receipts by species groups. The figure shows that the increases in pulpwood receipts are almost entirely due to increasing utilization of aspen. Figure 3.7 shows the distribution of roundwood receipts by species varied during the period from 1979 to 1988. The graph shows the trend of increasing reliance on aspen as the primary pulpwood species. However, the graph also shows that this trend appears to have been reversed, at least temporarily, beginning in 1988. The graph also shows that the proportion made up of pine receipts has been declining. Spruce and balsam fir show declining proportions between 1979 and 1987, but an increase in importance since 1988.

The expansion of the wood industry in Minnesota is likely to continue for at least the next half of a decade. Current forest industry expansion plans include $1.6 billion in investments in new plants and equipment. These new mills, if built, will consume an estimated 790,000 cords of pulpwood per year in addition to the 2,377,000 cords currently consumed.

The type of roundwood required by this growing forest products industry depends upon the manufacturing processes used, developments in the markets for their final products, and the availability of alternative raw materials. In the short run, these industries exhibit fairly specific demands for raw materials. For example, pulpmills have specific requirements regarding species mix when procuring wood. Sawmills generally require much larger diameter trees to produce dimension lumber and boards than pulpmills. Timber is not a uniform undifferentiated raw material. It varies considerably in many ways including specific gravity, pulp yield, resin content, and bark retention. Although some species may be close substitutes, others are not. Thus, the species composition and size of the available wood supply can greatly affect the amount of suitable roundwood available for any particular mill.

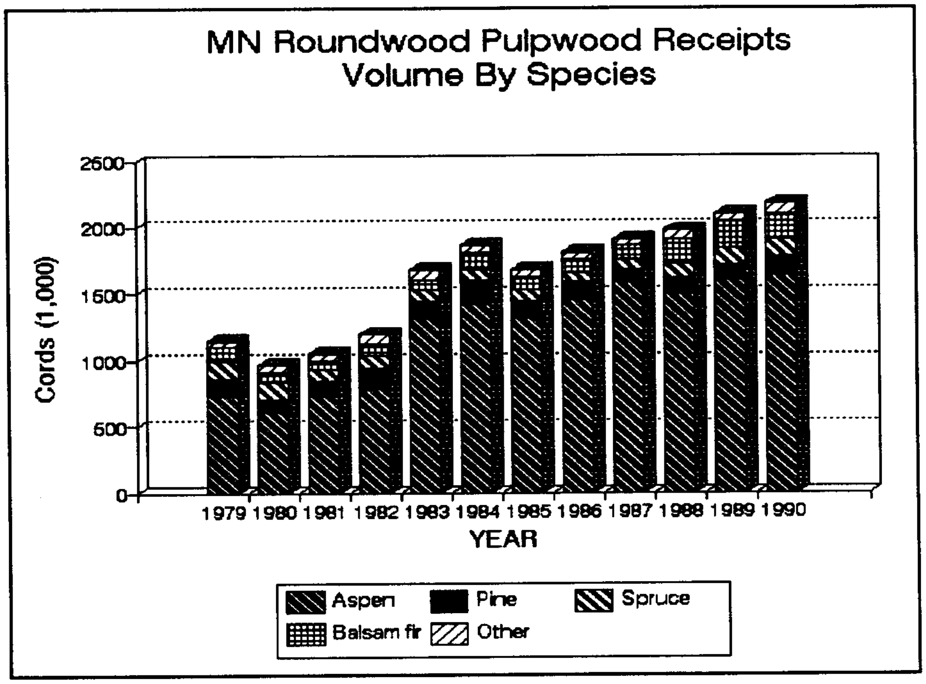

Figure 3.6. Minnesota pulpwood receipts from roundwood, volume by species, 1979–90. (Source: Jaakko Pöyry Consulting, Inc. 1992h.)

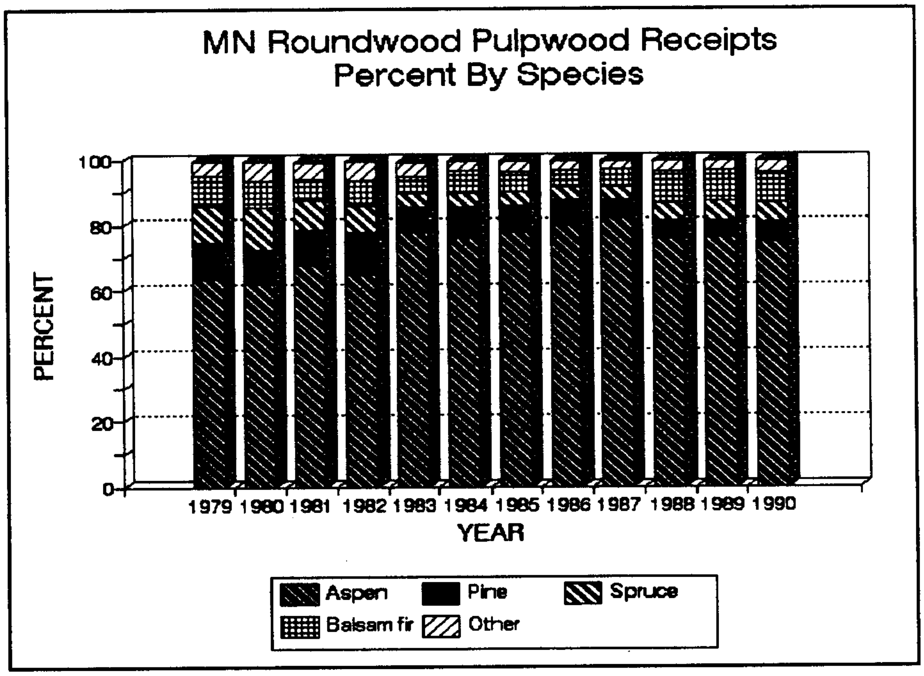

Figure 3.7. Minnesota pulpwood receipts from roundwood, percent by species, 1979–90. (Source: Jaakko Pöyry Consulting, Inc. 1992h.)

On the other hand, when increased use or declining supply of a particular type, size, and quality of wood cause the price for that raw material to go up, the incentive to find ways to use cheaper substitutes is increased. The development of the reconstituted wood panel industry—waferboard, OSB, and now parallel strand lumber (PSL)—is an example of the ability of industry to respond to changing resource availability. These industries owe their success, and possibly their existence, to the increasing scarcity of the large timber that has been traditionally used in making plywood and lumber.

3.5 Silvicultural and Harvesting Systems Used in Minnesota

3.5.1 Silvicultural Systems

A *silvicultural system* is defined as a management process, following accepted silvicultural principles, whereby stands are tended, harvested, and replaced, resulting in a forest of distinctive form. Included in the silvicultural system are the type of harvest method (clearcutting or individual tree selection, etc.), site preparation (mechanical scarification, prescribed burning, etc.), and regeneration (planting, seeding, or natural regeneration) practices. The two major management methods in forests are even-aged and uneven-aged management.

Even-aged Management
Even-aged management is the application of a combination of actions that results in the creation of stands in which trees of essentially the same age grow together.

Clearfelling
To avoid confusion, clearfelling is used instead of clearcutting as the general term depicting the removal of all trees from an area in one cut to produce an even-aged stand. Clearfelling usually yields the highest merchantable volume growth per acre, and has the lowest per unit volume harvesting cost. It is also the most feasible silvicultural system for most shade intolerant species (i.e., unable to regenerate and grow under the shade of others). There are a number of forms of clearfelling:

Clearcutting.—Any clearfelled area which is greater than or equal to 5 acres.
Clearcutting with standing residuals.—Any clearfelled area which is greater than or equal to 5 acres with 6 to 9 live and/or dead residuals left standing per acre.
Block cutting.—Any clearfelled area less than 5 acres which is regular (usually square) in shape.

Patch cutting.—Any clearfelled area less than 5 acres which is irregular in shape. Patch cuts are generally more aesthetically pleasing than block cuts.

Alternate strip cutting.—A clearfelled area generally at least the width equal to the tree height, and as long as the effective off-road transport distance for the conditions present (generally less than 1,200 feet), with leave strips left between cut strips.

Shelterwood

The shelterwood system requires two (i.e., two-stage shelterwood) or more cuts before the final harvest. The initial cuts are used to stimulate reproduction through increasing seed production, stimulating stump and/or root sprouting, and supplying increased light to the new seedlings, sprouts, or advanced regeneration. The remaining stems provide shelter from excessive fluctuations in temperature (e.g., frost) and moisture (e.g., water stress) and, in some cases, insect pests. Once the stand is regenerated, the sheltering trees are removed. In the shelterwood system more than 20 dominant trees per acre are left after the initial cut.

Seed Tree

Seed tree cutting is similar to shelterwood cutting, except fewer trees are left per acre. Seed trees can be left evenly distributed over the cutover or in groups. The number of seed trees left depends on the species and can vary from 10 to 20 dominant, good quality trees per acre. Once sufficient seedling stocking is reached, the seed trees are removed.

Thinning

Thinning is not a silvicultural system, but an intermediate cutting in an even-aged stand used to increase diameter growth on the remaining stems, salvage natural mortality, reduce the rotation age, increase stand quality and hygiene, increase the content of more desirable species within a stand, and, in some cases, allow the more successful use of shelterwood and seed tree methods (e.g., trees become more *wind-firm*). Thinning may be from below (favor dominant trees) or above (favor most promising trees, not necessarily dominant trees). Thinning may be selective, in which individual trees, usually poor quality or suppressed trees, are removed from throughout a stand, and row thinning where every second or third row of a plantation is removed.

Uneven-aged Management

Uneven-aged management is the application of a combination of actions needed to simultaneously maintain continuous high forest cover, recurring regeneration of desirable species, and the orderly growth and development of trees though a wide range of diameter and age classes, preferably in all age and diameter classes within a rotation. This is the silvicultural system which requires the most planning, tree selection, and harvesting skill. This silvicultural system is most applicable to shade tolerant species (i.e., can grow under the shade of other trees). Two methods of logging can be used in uneven-aged logging:

Individual (single) tree selection logging.—Individual trees are selected for removal uniformly throughout the stand due to overmaturity, poor hygiene, poor form, or some other selection criterion.

Group selection logging.—Groups of 3 to 4 overstory trees, as well as any understory trees beneath them, are removed throughout a stand to produce a patchwork pattern. Depending on the size of the opening, this system could also be classed as patch cutting.

Uneven-aged management is likely to be used more in the future as harvesting and management become more sensitive to broad social and ecosystem values, especially aesthetics and biodiversity. However, it is easily misused to become just high grading (i.e., selecting mainly the best trees for removal), thus reducing the quality of the local genetic pool and the overall quality of the stand. It also limits genetic improvement opportunities. Further, if not done with great care, damage to residual stems can lead to a decline in stand health. The system also involves frequent access (typically removals are spaced at 10- to 20-year intervals).

3.5.2 Harvesting Systems and Methods

A *harvesting system* is the tools, equipment, and machines used to harvest an area. This includes some machinery to fell trees, delimb them if necessary, and off-road transport to a road where the logs can be trucked to a mill. Felling is commonly by chainsaw or feller-buncher, a machine resembling a construction crane with a boom capable of cutting trees at the base, picking them up, and laying them on the ground in small bunches. Common transport methods are by grapple skidder and cable skidder, both tractor-like vehicles that grab a bunch of logs with a plier-like mechanical arm or with a cable to be dragged to a pick up location.

A *harvesting method* is the form in which wood is delivered to the logging access road. Common harvesting methods in Minnesota include: (1) cut-to-length, in which trees are felled, delimbed, and bucked to the desired length in the stump area; (2) tree length, in which trees are felled, delimbed, and topped in the stump area or a point before roadside; (3) full tree, in which trees are felled and transported to roadside with branches and top intact.

3.5.3
Silvicultural and Harvesting System Use in Minnesota

Of the total timber harvested in Minnesota during 1991, 39 percent of the volume is estimated to have come from clearcuts and 42 percent from clearcuts with standing residuals. Clearcutting with standing residuals is the practice of leaving 6 to 9 live or dead standing stems per acre. The two categories in turn accounted for 71 percent of the area with logging operations. The percent area subject to clearcutting or clearcutting with residuals ranged from 56 percent on private and other lands, to 91 percent of forest industry lands (table 3.14). Patch, strip, and other modified clearcutting accounted for 8 percent of the volume and area logged. Selection cutting accounted for 5 percent of the volume and 8 percent of the area logged. The volume removed in thinnings was 4 percent, and this occurred on 10 percent of the areas with logging operations.

The total area with logging operations in 1991 was estimated to be 199,828 acres. Regeneration by planting occurred on 32,603 acres, seeding on 5,963 acres, and natural regeneration on 142,275 acres. Approximately 10 percent was thinned and required no regeneration or site preparation. Therefore, virtually all harvested areas are retained in or will be regenerated to a forested condition. On 28,509 acres where site preparation did take place, 63 percent was mechanical preparation, 29 percent involved chemical herbicide treatment, and 8 percent was by prescribed burning. Of the nearly 200,000 acres harvested, 55 percent was on private and other lands; 8 to 15 percent on each of state, county, and national forests; and 6 percent on private industry lands (table 3.14).

Statewide, the average logging site area was 32 acres. However, since logging operations commonly consist of several cutting units, individual cuts are probably smaller in size. Most logging occurred during the winter (December-February, 43 percent), while the least occurred during the spring (March-May, 9 percent). Logging during the summer (June–August) accounted for 22.5 percent of the volume harvested, while 25.3 percent of the volume was harvested during the fall (September–November).

In northern Minnesota, ecoregions 1 through 4, the majority of the felling (69 to 81 percent, depending on the region) was by feller-buncher. In the Central Pine-Hardwood area of Minnesota (ecoregions 5 and 6), all of the felling reported in the survey was by chain saw. For the state on average, 73 percent of the felling was by feller buncher, 27 percent by chain saw, and less than 0.5 percent by mechanized harvester.

Table 3.14. Summary of estimated annual silviculture operations on timberlands by ownership over the period 1990-91.

DATA SOURCE	Survey					Estimate	Total estimate
OWNERSHIP	State	County	National Forests	Forest industry	Native American	Private & other	
Area of ownership, ac	2,584,000	2,226,506	1,705,000	834,479	498,046	6,023,800	13,871,831
Total volume harvested, cord	685,900	553,071	344,000	214,635	86,692	1,959,002	3,843,300
Area with logging operations, ac	30,861	26,395	17,296	11,148	4,428	109,700	199,828
Natural regeneration area, ac	19,760	20,594	13,113	7,559	3,402	77,847	142,275
Artificial regeneration area, ac	9,465	5,128	2,724	2,765	481	18,003	38,566
SILVICULTURAL SYSTEMS AND THINNING, % by volume							
- clearcutting (area >5ac)	55	60	0	95	93	26	39
- clearcutting with standing residuals	38	29	97	1	0	42	42
- patch cutting (0.25-5ac)	3	5	0	0	0	7	5
- strip or other modified clearcut	1	2	0	0	2	6	3
- seed tree cutting	0	0	0	0	0	1	1
- shelterwood cutting	0	0	0	0	0	3	1
- selective logging	1	3	0	0	0	9	5
- thinning	2	1	3	4	5	6	4
SILVICULTURAL SYSTEMS AND THINNING, %by area							
- clearcutting (area >5ac)	52	56	0	91	83	21	34
- clearcutting with standing residuals	36	30	91	1	0	35	37
- patch cutting (0.25-5ac)	2	5	0	0	0	6	5
- strip or other modified clearcut	1	2	0	0	1	5	3
- seed tree cutting	0	0	0	0	0	1	1
- shelterwood cutting	1	0	0	1	1	5	3
- selective logging	2	5	0	0	0	13	8
- thinning	5	3	8	7	15	13	10
REGENERATION AREAS, acres							
- planting	4,750	4,948	1,979	2,442	481	18,003	32,603
- seeding	4,715	180	745	323	0	0	5,963
- natural regeneration	19,760	20,594	13,113	7,559	3,402	77,847	142,275
- TOTAL	29,225	25,722	15,837	10,324	3,883	95,850	180,841
SITE PREPARATION AREAS, acres							
- chemi-aerial	402	0	0	54	0	399	855
- chemi-ground	1,402	1,369	0	191	0	2,593	5,555
- prescribed burning	825	120	192	100	0	1,083	2,320
- mechanical	3,553	1,360	2,431	1,831	444	8,421	18,040
- mechanical with band spraying	0	0	0	932	0	816	1,748
- TOTAL	6,182	2,849	2,623	3,108	444	13,313	28,519
TIMBER STAND IMPROVEMENTS, acres							
- chemical release - aerial	535	2,715	0	2,002	0	366	5,618
- chemical release - ground	675	1,877	0	1,362	0	273	4,187
- hack and squirt	20	0	0	0	0	1	21
- mechanical/manual release	808	455	3,782	53	408	383	5,889
- noncommercial thinning	427	164	60	203	590	172	1,616
- residual stem felling	570	271	7,686	474	0	1,071	10,072
- pruning	150	28	13	10	0	24	224
- slash disposal (burn brush piles)	50	41	0	0	0	11	102
- TOTAL	3,235	5,550	11,541	4,104	998	2,301	27,729

Source: Jaakko Pöyry Consulting, Inc. (1992m).

The majority of the delimbing was done manually using a chain saw (66 percent), while 33 percent was delimbed using mechanized equipment. In addition, 68 percent of the delimbing and topping was in the cutover, while less than 32 percent was at roadside. Less than 1 percent of the volume was full tree chipped. In general, chain saws are used to delimb hardwoods in the cutover, while mechanical delimbing is used more in softwoods and occurs mainly at roadside. There was also a minor amount of mechanical delimbing in the cutover.

Off-road transport of wood was mainly by grapple skidder (69 percent of the volume harvested). Off-road transport by cable skidders accounted for 30 percent. Grapple skidders were most widely used in northern Minnesota, while cable skidders were most used in the Central Hardwood portion of the state. The average age of logging equipment in Minnesota is high with the majority (64 percent) of all equipment being greater than six years old.

The majority of the bucking occurred at roadside (76 percent). Only 7 percent of the wood was bucked in the cutover. Almost 17 percent of the wood was not bucked and was transported to the mills as tree lengths. Less than 1 percent of the volume harvested was full tree chipped. The majority of the full tree chipping was of hardwood residuals destined for hog fuel.

Transport of wood from roadside to the mills is by truck. Less than 1 percent of the volume transported was in chip form. Approximately 82 percent of the volume was transported in pulpwood or log lengths, while 17 percent was as tree lengths. Almost all wood was transported by tractor-semitrailer units, with an average load capacity of about 10 to 11 cords Tandem axle trucks with pup trailers are also used to some extent.

3.6
Utilization of Recycled Fiber

3.6.1
Current and Projected Future Supply of Recovered Paper

Approximately 1.7 million tons of various grades of paper were generated and 0.6 million tons were recovered in Minnesota in 1990, yielding an overall recovery rate of 36 percent. This was slightly higher than the average for the Midwest for most grades.

Approximately 115 thousand tons of old newspaper (ONP) were recovered in 1990 in Minnesota. This recovery is expected to rise to 140 thousand tons by 1995, and 160 thousand tons (or 72 percent of the ONP available) by the end of the decade. Higher future recovery of ONP will mainly be due to new Canadian demand for ONP, good access to supplies in Minnesota, and by mandatory recycling which is monitored and enforced in the U.S. The

U.S. recycling programs calling for increased recycled paper content in U.S. newsprint are providing recovered material (e.g., ONP) for Canada to meet U.S. demand for newspaper. However, most of the current ONP collected in Minnesota (e.g., in 1990) was used by Minnesota mills; and the net surplus demand totaled only 20 thousand tons (which went primarily to Canada). The net state surplus is expected to rise to 40 thousand tons by 2000.

About 30 thousand tons of old magazines (OMG) were collected in Minnesota in 1990. The majority of the OMG collected in Minnesota was overissue or newsstand returns. Recovery is expected to rise 40 thousand tons by 1995 and 55 thousand tons by 2000. None of the OMG collected in Minnesota is used in Minnesota mills. This is not expected to change throughout the decade.

An estimated 50 thousand tons of office wastepaper (OWP) in Minnesota were recovered in 1990. By 1995, recovery is expected to rise to 100 thousand tons and to 120 thousand tons by 2000.

3.6.2 Demand and Use of Recovered Paper Now and in the Future

Overall, mills in Minnesota consumed 15 thousand tons more OWP than was collected in the state in 1990. Because of the various subgrades (i.e., computer printout, white grades, mixed), some grades are likely to be shipped out of Minnesota, while other grades are imported. The net deficit, however, is expected to increase as two planned deinked pulpmills come online in Minnesota in the 1990s. By 2000, mill consumption will likely exceed collection by about 130 thousand tons.

Increased collection and use of recovered paper in Minnesota and surrounding states could reduce demand for wood by the state's forest products industry, but supplies of some grades are limited. The state's paper industry is mainly comprised of printing and writing paper mills. Most of the pulp consumed is bleached kraft (chemical) and groundwood pulps.

The alternative recovered papers for bleached virgin kraft pulp include high-grade deinking, pulp substitutes, or OWP. Planned use of OWP by two new market deinked pulpmills in Minnesota would yield a net shortfall of this grade within the state. Note that market pulpmills are those that manufacture pulp for sale in the open market.

Recovered papers that represent the most realistic alternatives to bleached virgin groundwood pulp are ONP and OMG. Users of these grades compete with Canadian newsprint mills for limited supplies. Canadian mills have already established long-term contracts for ONP collected in Minnesota.

Supply contracts for these grades from Canadian newsprint mills would limit the availability of ONP and OMG to new users. The inconsistent quality of mixed paper currently precludes its use in significant quantities to make printing and writing papers.

3.6.3 Potential Expansion of Recycled Fiber Utilization and Effects on the Wood Products Industry

The effect increased collection and use of recovered paper will have on the wood products industry will depend on the type of pulp it replaces. Economics favor the substitution of recovered paper for purchased pulp rather than integrated pulp, if substitution for integrated pulp means idling existing facilities. Integrated pulp is that manufactured at a facility where the pulping operations are colocated (integrated) with the papermaking, such as the Potlatch Corporation mill at Cloquet. If recycled pulp made from recovered paper replaces purchased pulp, there would be little or no effect on the wood harvest in the state since the purchased pulp being replaced is not a product of the Minnesota's forests. Recycled pulp could replace planned virgin pulp capacity. Planned increases in virgin pulping capacity at Minnesota paper mills by 1995 total almost 600 thousand tons, which will require an additional 1.1 million cords/year. Some Minnesota paper mills purchase kraft pulps to augment integrated kraft pulp production or as an exclusive kraft source. All groundwood consuming mills in the state are integrated to groundwood pulp.

Under the following specific conditions, use of market deinked pulp produced in Minnesota could replace up to 400 thousand cords of wood harvested in the state annually:

- if the recycled pulp produced by Superior Recycled Fiber Industries (a mill now under construction) offsets planned virgin chemical pulp capacity of Minnesota mills, it could reduce demand for wood by up to 150 to 200 thousand cords per year; and
- if the planned recycled pulp produced by Minnesota Pacific Pulp and Paper Corporation is built and then offsets planned chemical pulp capacity of Minnesota mills, it could reduce annual demand for wood by up to 150 to 200 thousand cords.

Given the configuration of the state's pulp and paper mills, it is unlikely that market deinked pulp will replace *existing* virgin pulp production in Minnesota. The factors supporting this conclusion include the composition of the state's paper industry, the economics of replacing existing pulp production, the physical characteristics of deinked pulp versus currently used pulps, and the supply and demand for OWP. The most likely scenario is for market deinked pulp to substitute for additional virgin pulp capacity first, and then to replace purchased kraft pulp. However, these two scenarios are not exclusive, and a combination of the two could exist simultaneously.

3.7 Impacts of Global Climate Change on Minnesota's Forests

Emissions of CO_2, caused mainly by fossil fuel burning, and other greenhouse gases, are likely to enhance the earth's natural greenhouse effect, causing significant warming over the next century. Global circulation models (GCMs) are computer models of the earth's atmosphere capable of simulating the earth's current climate, including seasonal changes. Several GCMs produced by independent teams of scientists agree that an increase in the mean air temperature at the earth's surface of 1.5° to 4.5°C will result if the concentration in the atmosphere of CO_2 doubles ($2xCO_2$ scenario). The length of time required for atmospheric CO_2 concentrations to double will depend on the rate at which people reduce the use of fossil fuels, but may occur sometime between the years 2030 and 2100. Current versions of GCMs have poor spatial resolution. However, preliminary results suggest that interior continental areas such as Minnesota may warm more than the global average. Although estimates of precipitation are still very uncertain, a majority of the five GCMs surveyed for this report predict that Minnesota will have decreased summer soil moisture under $2xCO_2$ scenarios. On the other hand, a majority also predict increased winter soil moisture, which could partially compensate for drier summers.

Should significant warming occur in Minnesota, a northward shift in vegetation types such as the prairie-forest border is likely, so that the state will have less forest acreage in the future. The warm period, 7,000 years before the present (ybp), when temperatures of the current interglacial period reached their peak in the Midwest, provide a reasonable analog for future warming. Summer temperatures at that time were 1 to 2°C warmer than at the present time, and the prairie-forest border was located about 100 miles to the northeast of its current location.

Several different speculative simulations of response of forests to warming agree in general with the altithermal analog. Empirical models that look at the climate at the edge of the current range of a species or vegetation type and project where the same limiting climate variables would occur under $2xCO_2$ scenarios, predict significant displacements in species ranges. The predicted geographical displacements vary with the GCM used. For example, the western edge of the sugar maple range would only move a few tens of miles eastward under the GISS GCM $2xCO_2$ scenario, which predicts increased rainfall in Minnesota. The increased rainfall would compensate for the warmer temperatures. However, under the GFDL $2xCO_2$ scenario, the southwestern edge of the sugar maple range would move north of Lake Nipigon, Ontario. Forest stand dynamic models predict that under a $2xCO_2$

scenario, spruce-aspen-birch forests in northern Minnesota will change to sugar maple forest on deep loamy soils, or pine/oak savanna on shallow and/or sandy soils. If significant warming occurs, the overall predicted patterns are for southern Minnesota forest types to displace northern types, and southern forest types to be displaced by grassland.

Depletion of ozone in the earth's stratosphere is another factor that may exacerbate the effects of global warming. With a thinned ozone layer, more ultraviolet light than usual may impinge on forest canopies, possibly causing physiological damage to trees and reducing productivity.

Air pollution is unlikely to cause significant damage other than very locally near point sources of pollution. Although eastern Minnesota has rainfall slightly more acidic than natural rainfall, the state is outside the area with rainfall pH low enough to cause long-term significant forest damage. Levels of ozone, nitrogen oxides and sulfur dioxide are not high enough to cause widespread forest damage in Minnesota.

There are several factors that will influence the rate and magnitude of change in forests that are difficult to simulate. Theoretically, increased concentrations of CO_2 should have direct effects on plant growth, making them more efficient in water use, thereby compensating for drought stress brought on by warmer temperatures. Research on direct CO_2 effects is in early stages, and there are conflicting results among studies as to whether there will actually be a significant compensatory effect. Warmer summer weather could increase the frequency of severe wildfires and windstorms, accelerating the rate of change in forest species composition. Climatic warming will probably not proceed evenly over time, but instead will follow the natural tendency towards periods of several very warm years in a row, alternating with periods of less warm years (serial correlation). This could lead to periods with extremely severe fire weather and high heat or drought induced mortality. Other factors that could modify the response of forests to global change include changes in pest-host relationships, changes in seasonal distribution of precipitation, the currently unknown ability of individual trees to tolerate changes in climate, and the ability of trees to shift their range northward at rates much faster than those that have occurred due to natural climate change over the last 20,000 years. No one simulation of forest response to climatic change takes all of these factors into account, but there are models that take some into account individually.

Forest management activities add another unknown element to global change. The movement of vegetation now depends on both natural and human vectors. Extensive tree planting, fire control, and development of drought-tolerant varieties can lead to establishment of forests outside a species' current or future natural range. In addition, the Minnesota forest products industry and public land managers could respond to global warming by altering spatial and temporal patterns of harvest. For example, stands with high heat-induced mortality could be harvested and reforested with species adapted to a warmer climate. These activities could compensate—to an unknown degree—for the effects of global change on Minnesota forests.

4
NATURAL RESOURCES REGULATORY AND POLICY FRAMEWORK

The previous section described the physical status of Minnesota's forest resource base. This companion section discusses the regulatory and policy-making framework that impacts management of the state's natural resources base. Together, these two sections establish a framework for evaluating the extent to which impacts are likely to occur, given the current level of harvesting activity:

existing resources + existing management = likely results and impacts

4.1
Framework Overview

The following section describes this decision-making environment, discussing the state's regulatory and management framework; the state, county, and federal (USDA Forest Service) systems; the state's research and extension programs; the policies and programs to encourage management on NIPF lands; and background information on the management of Native American forest lands.

4.1.1
Policy Principles and Guidelines

The Minnesota Forest Resources Management Act (MFRMA) of 1982 defines *forest resources* as meaning:

> "...those natural assets of forest lands, including timber and other forest crops, recreation, fish, wildlife habitat, wilderness, rare and distinctive flora and fauna, air, water, soil and educational, aesthetic and historic values."

Given this definition, the following describes fundamental policy principles and related developments.

Although policies of each public ownership class may differ in specific details, they are generally based on three fundamental principles or concepts. Except where directed differently by laws and regulations, lands should be managed under a *multiple use* philosophy, the amount of each product produced should not exceed the *sustained yield*, and production activities should be designed and carried out so the resource base is preserved, called *nondegradation*. The following principles guide land management policies and regulations, including those that impact private lands. These principles are often embodied in Minnesota and federal law and policies that exist in a wide range from formal to defacto:

- *Multiple Use.*—Lands should be managed to provide a wide variety of products and services. This does not mean providing for every use on every acre, but rather providing for the variety of products and uses desired by the public over the entire land area. In fact, certain uses can dominate in some areas. Neither county nor private owners have a legislative mandate to manage for multiple use, and in some or many cases, these owners' management is directed primarily towards timber production (e.g., many county lands, most forest industry lands, and some NIPF lands). On the other hand, some NIPF owners are concerned exclusively with amenity values and conduct no forest management or harvesting activities.
- *Sustained Yield.*—The level of products and services produced should not exceed the biological productivity of the land or its ability to accommodate the desired services. For timber production, this most commonly takes the form of calculation of an allowable cut. For recreation production, this most commonly means allowing recreation activities up to the capacity of the land to provide the desired experience. For wildlife production, sustained yield can mean adjusting hunting and fishing regulations to keep species within the carrying capacity or at viable population levels. Habitat management is also used as a way of increasing the carrying capacity of land for various wildlife species. In practice, however, allowable cut levels and carrying capacity are dynamic and depend on a variety of factors, including the level and intensity of management.
- *Nondegradation.*—Production activities should not result in long-term degradation of the land base upon which those activities depend. Maintaining soil productivity and water quality are the most frequent goals of management regulations and policies designed to adhere to this principle.

Two recent policy developments in Minnesota that embody these three principles apply to all ownership classes—increased interest in the application of BMPs and a proposed forest practices act. A review of these developments and other relevant background will help illustrate how fundamental policy principles can be embodied in the state's natural resources decisionmaking framework.

BMPs

In 1990, Minnesota established voluntary guidelines called Best Management Practices (BMPs) to protect and maintain water quality for activities related to timber harvesting, mechanical site preparation, pesticide use, forest roads, prescribed burning, and fire lane construction on all ownerships. These voluntary guidelines are similar to those established in other states and are the primary vehicle for prescribing preferred harvesting and associated practices.

The driving force behind the establishment of these guidelines was the 1972 amendments to the Federal Water Pollution Control Act which, for the first time, dealt seriously with the control of nonpoint sources of pollution. As stated in the guidelines, Section 208 of the act required each state to develop plans and procedures for controlling nonpoint source pollution to the *extent feasible*. In 1987, Congress passed amendments to the Clean Water Act requiring the development of a specific nonpoint source control program. Section 319 of the act mandates the development of BMPs to reduce nonpoint source pollution to the *maximum extent practicable*.

Water quality protection is the primary goal of most BMPs guidelines. Minnesota's guidelines cover recommended practices with respect to road construction and maintenance, timber harvest planning and layout, mechanical site preparation, pesticide use, and prescribed burning—all oriented toward protecting water quality.

An important mechanism used by most public and some private landowners to ensure compliance with BMPs is the specific language included in logging contracts. Specific contractual obligations frequently go beyond BMPs guidelines to include a range of cutting and cultural practices, such as methods of slash disposal or retention of certain species of trees. Although many of the conditions included in logging contracts are not specified by statute, these contractual conditions are enforceable under contract law. As such, logging contract conditions can serve as a powerful tool in influencing how harvesting is carried out.

Additional regulations exist in Minnesota to control water pollution and to preserve scenic vistas along waterways, and some of these apply to private lands. Regulations are contained in local water plans, upper Mississippi Headwaters Board ordinances, local zoning controls or ordinances, shoreland management ordinances, Wild, Scenic and Recreation River Rules, the National Environmental Policy Act (NEPA), MNDNR Division of Water permits as required by law where construction activities impact public waters, the National Forest Management Act (NFMA), the Minnesota Pesticide Control Law, and the Minnesota Groundwater Protection Act of 1989.

Proposed Forest Practices Act

As previously stated, Minnesota's BMPs guidelines are currently voluntary. In a step toward making them (or similar guidelines) mandatory and uniformly applied statewide, a Minnesota Forest Practices Act was introduced in the legislature in 1991. This bill promoted timber growth and reforestation and adopted a policy of no-net-loss of commercial forest land. NIPF lands consisting of less than 40 acres, Native American lands, or growers of decorative trees would not be affected. The bill addressed many of the activities covered under the BMPs guidelines, as well as the establishment of a board for rule and policymaking. Although never enacted, the bill did attract widespread attention across Minnesota's forestry community and as such is indicative of existing intentions by some to move beyond the current BMPs system.

4.1.2 Planning and Coordination Role

With the exception of some counties, all public landowners in Minnesota do natural resources planning that cover collectively a wide range of forest resource planned for, acreages, and ownerships. On the county level, this often results in formal county plans or annual activity reports. State planning is three-tiered and involves completion of a comprehensive statewide forest plan, which provides resource assessment and program direction as well as regional and unit plans for the state forest system. Although similar to state-level forest planning initiatives in terms of product output, the USDA Forest Service has the most detailed and analytically complex system of planning.

Coordination among public landowners is achieved in various ways, such as with financial resources or shared technical expertise. Historically, the federal level took most of the responsibility for coordination among the various landownership categories, but this has changed as state and county agencies expanded and acquired more professional resources management expertise. However, of importance is that coordination at the forest resource management level is much less than optimal, which in turn does interfere with effective landscape management concepts, programs, and actions.

The Minnesota Forestry Coordinating Committee (MFCC) also plays a role in program coordination in Minnesota. The director of the MNDNR Division of Forestry serves as chair of the MFCC. The committee is composed of representatives of many public landowners and natural resources research organizations in the state as well as representatives of various Minnesota natural resources associations, industries, councils, and committees. The coordinating committee's mission is to enhance through coordination the effectiveness of forestry programs to increase benefits for the people of Minnesota and the nation. Objectives include:

- identifying major issues affecting the forestry community;
- improving coordination among members of the forestry community;
- proposing initiatives/projects to the forestry community; and
- strengthening the voice of the forestry community with the executive and legislative branches of government and with the public.

Coordination (or more accurately, cooperation) also takes the form of provision of federal monies for various programs operated by state agencies or through which money is passed on to local governments or private individuals. Such coordination is most often with respect to activities undertaken by programs, not on the objectives of programs.

Minnesota agencies are also involved in many regional or multistate cooperative efforts. These efforts often involve federal, state, and county interests and promote both inter- and intrastate coordination that extends beyond state lines. Examples of such coordination include the:

- *Lake States Forest Fire Compact.*—This compact includes Minnesota, Wisconsin, and Michigan and the province of Ontario. It provides for cooperative efforts in fire training, research, and during emergency fire situations.
- *Lake States Forestry Alliance.*—This alliance of Minnesota, Wisconsin, and Michigan serves as a regional body whereby the three states can cooperatively address forestry problems and issues of mutual interest. Primary responsibilities of the alliance are:
  - identification of the Lake States as an important forestry entity;
  - encouragement of interstate cooperation for agencies;
  - issuing Congress joint representation on important regional matters;
  - analyzing regional forest resource trends and opportunities jointly; and
  - developing a major regional resources assessment, which is currently underway.
- *Upper Great Lakes Biodiversity Committee.*—This committee is a joint effort of federal and state agencies, university faculty, Native Americans, environmental groups, and the forest industry to encourage appropriate consideration of biological diversity in management of forest resources in the Lake States region.
- *Research cooperatives (based at the UofM, College of Natural Resources).*—These cooperatives typically involve a dozen or more supporting members from industry and government agencies (federal, state, and county). The objective is to support and encourage highly focused applied research and technology transfer that addresses important common problems in forest management. Minnesota-based regional cooperatives include the:
  - Minnesota Tree Improvement Cooperative;
  - Forest Vegetation Management Cooperative;
  - Great Lakes Forest Growth and Yield Cooperative; and
  - UofM/Institute of Paper Science and Technology Aspen/Larch Genetics Cooperative.

4.1.3 Overview of Programs

State and federal forest landowners operate programs directed toward the major biological components and uses of the forested environment, such as timber, water, fisheries, wildlife, and recreation. These programs are most administratively distinct in the state forest system and least administratively distinct on the national forests. The emphasis placed on each program varies by ownership. Counties are oriented toward programs of timber production and on-the-ground management. Considerations in overall resources management vary widely from county to county. Additionally, separate programs organized along functional lines (e.g., for fisheries, wildlife, etc., separately) are not common.

Conversely, national forests' timber programs are a much smaller percentage of the total USDA Forest Service program. In the National Forest System, programs involving planning and noncommodity uses of resources appear to be the major thrust. In addition, the Research and State and Private Forestry branches of the USDA Forest Service operate the largest programs directed at research (including academic institutional support) and cooperative assistance of any public land management agency based in Minnesota. Note that the MNDNR is the delivery agent for Minnesota's State and Private Forestry program. The net effect is that the state forest management programs stimulated by the USDA Forest Service have elements of both commodity and noncommodity orientations.

Many programs also exist to assist NIPF landowners. These programs often differ in their objectives. The most emphasized objective shared among them is to improve the standard of land management on NIPF-owned forests, irrespective of the primary management objectives.

4.1.4 Public Participation Needs

Public participation undertaken by public land management agencies is generally concentrated around their major planning activities. There are two types of public participation, informal and formal. Informal public participation is usually one on one between resource professionals and citizens and is not required or governed by law or policy. In contrast, formal public participation is required by law or policy. Informal public participation occurs almost continuously as state residents interact with state, county, and federal agency personnel. Because of their grassroots orientation, counties use informal public participation almost exclusively. Formal processes are pervasive in the public participation activities of the national forests, and to a lesser extent, the state forests. These formal processes are legally specified and often detailed and complex.

4.2 State Management System

The organizational history of the state forest system began in 1895 with the legislative appointment of the state auditor as the forest commissioner. The primary responsibility of the forest commissioner was the appointment of fire wardens to enforce recently passed laws regarding fire suppression and prevention. Four years later, a Forestry Board was created to manage state lands obtained through grant or gift. This led to the establishment of the first state forest, Pillsbury State Forest, the following year on land donated to the state by John S. Pillsbury.

Over the years, several organizational and charter changes have taken place. By 1948, the Department of Conservation consisted of five divisions in addition to the commissioner's office: Forestry, Game and Fish, Lands and Minerals, State Parks, and Water Resources. Several divisions and bureaus have since been added, and the Department of Natural Resources (the name change occurred in 1971) consists of 14 divisions or bureaus in addition to the commissioner's office.

Just as the structure of MNDNR has evolved and grown to encompass many resource issues over the years, so have the agency's policy and program directions.

Policies generally expanded from an almost exclusive early 1890s focus on fire prevention to encompass planting, forest management, and timber sales. The era of multiple use ushered in a variety of policies that focused on the production of goods and services other than timber. An example of this and a major policy event in Minnesota's forest history was passage of the MFRMA of 1982. Many provisions of the act grew out of the recommendations of a large study of forest management in Minnesota conducted for the Legislative Commission on Minnesota Resources (LCMR) by the Banzhaff Company (Banzhaff 1980). Key provisions and required actions of the MFRMA include:

- an inventory and map of all existing state forest roads and classification by use standard and condition. This state forest road plan was produced by the Division of Forestry in the early 1980s;
- a report on current and anticipated reforestation needs. The significant backlog of state lands needing planting in 1982 has since been eliminated;
- the direction for forestry research and extension and direction for continuing education;
- a statewide forest resource assessment every ten years. The first assessment was completed by the Division of Forestry in 1983;

- a program document every four years. The first program document was completed by the Division of Forestry in 1983. Two more were completed in 1987 and 1991;
- a requirement to follow a multiple use/sustained yield policy in managing state forest lands. Within this context, forest resources were broadly defined. This was the first time the MNDNR was legally directed to follow this policy; and
- the creation of a forest management fund—dedicated receipts from certain forestry activities. This was lost in 1989 as a result of fund consolidation in state government.

The trend toward a broadening of policy to encompass production of goods and services other than timber is continuing. State policymakers today are becoming more focused on issues such as protection of old growth (draft guidelines not yet finalized and approved were first established in 1990), global warming, loss of timberland, and the sustainability of projected future timber harvest levels.

4.2.1 MNDNR Policy Focus

The Division of Forestry of the MNDNR is the primary agency charged with management of state owned forest resources and programs to assist in the management of county and NIPF lands. As noted in the previous section, the general management philosophy is guided by the MFRMA, which directs the commissioner of natural resources to manage state forest resources based on the principles of multiple use and sustained yield management. The following current management policy directions were summarized from the Minnesota Forest Resources Plan (MFRP), Program Direction: Fiscal Years 1991-95:

- increase the health and productivity of forest lands for higher balanced levels of commodities and amenities aimed at strengthening Minnesota's forest products and tourism economies;
- improve the ability to protect from wildfire damage;
- enhance coordination of public/private forestry programs for shared goals;
- maintain communications with forest user groups to improve sensitivity to the broad range of public needs and expectations;
- improve state forest land biological diversity;
- encourage wood products industries to use available raw materials, promote value added expansion and new development of secondary wood products manufacturing, and ensure a sustainable supply of wood products industry raw materials;
- intensify efforts to manage for nontimber goods and values;

- improve forest management practices to acceptable levels to enhance forest resources and reduce resource losses such as those from insects, diseases, and soil erosion;
- manage trust fund lands in a consistent manner based on sound natural resources management principles to maximize long-term economic returns;
- employ the regional planning process to promote interdisciplinary planning. Promote biological diversity and integrated resources management by adopting an ecological classification system and landscape management techniques;
- support a policy of no net loss of timberland and no net loss of total forest land on all ownerships as outlined in the report of the Governor's Blue-Ribbon Commission on Forestry and Forest Products; and
- develop a forestry/wildlife coordination policy (completed in 1980).

Intra-agency Coordination Policy Relationships
As a result of the last policy listed above, Forestry/Wildlife Guidelines for habitat management for all state owned lands were written and approved. These Guidelines for Habitat Management may affect *how much* land is available for timber harvesting and forest management, and *what kind* of harvesting and management activities are practiced on MNDNR lands. These guidelines are used by wildlife and forestry field personnel throughout the state for MNDNR lands on both forestry- and wildlife-administered lands. Modified harvesting and management practices to accommodate wildlife needs are used extensively on state lands.

These guidelines are one example of how the policies of other MNDNR divisions impact management of Division of Forestry administered lands. The MNDNR has major fisheries, wildlife, recreation, minerals, and waters programs that directly affect forest land management and timber harvesting policies, and to effectively implement these requires sound intra-agency coordination. In particular, the agency is considering various ways to achieve greater integration of its efforts at natural resources management. These issues are addressed in more detail in the materials that follow.

Other State Policies
The state has a myriad of other policies that help create the current resources management framework. For example, they include coverage of the following:

- land exchanges;
- mineral exploration opportunities;
- land reclamation;
- herbicide use;

- wetlands; and
- timber sales.

In addition, the MNDNR is developing policies on the following:

- old growth;
- ERF; and
- old forest.

Overall, the state has many policies and related regulations and laws that collectively create a broad and sometimes complex range of implications for resources management.

4.2.2 State Planning

The Division of Forestry of the MNDNR is responsible for statewide forest resources planning. The statewide forest resources plan considers all ownerships and serves as the base for long-range program and budget development for the state agency. This plan has often been required for states cooperating in federally sponsored forestry planning programs.

Widespread state forest resources planning began in earnest in 1978, when the Cooperative Forestry Assistance Act (P.L. 95-313) was passed. This act authorized financial and technical assistance for states engaged in planning efforts. State authorization is based on directives in Minnesota Statutes, Sections 89.011 and 89.012; which respectively:

- direct the MNDNR to prepare and maintain a *statewide* forest resources management plan with an assessment and a program; and
- development of *unit* forest resources management plans which set out specific goals and objectives for management, protection, development, and production of forest resources.

The second level of state planning is more geographically specific. The MFRMA requires preparation of plans for each geographic administrative unit identified as an appropriate unit for planning purposes by the Division of Forestry. The Division of Forestry initially used the area administrative level as the unit for these forest plans. Currently, plans are developed at the regional level. These plans reflect the general policy and program direction as specified in the MFRP as well as specific objectives, program, and budget targets. The primary focus of the program portion of these plans is on Division of Forestry programs and lands, and ensures that operational activities of the division reflect existing policy. Other portions of these plans address forest land management on all lands—especially, those in the southern third of Minnesota.

The Division of Forestry has always done some type of statewide forest planning. Historically, this revolved around fire control, planting, and timber management. Minnesota's first statewide plan was completed in 1977. A second, more comprehensive plan was completed in 1983, based on legislation enacted in 1982. An update of the program direction section of the 1983 plan was completed in 1987 and July 1991. As with all planning efforts undertaken by public agencies, the process is a continuing one as modifications are made in response to changing forest and state conditions. The 1993 statewide assessment will be the basis for developing a 1995 program plan, which is intended to be broad and strategic and address *all forestry programs in the state, not just MNDNR programs.* The purpose of the assessment and program plan is to describe Minnesota forest resources, project forest-related goods and services, supply and demand, and provide management policies and programs for the benefit of all interests and ownerships.

The steps in state forest resources planning are similar to those in the USDA Forest Service planning process, as specified in the Resources Planning Act (RPA). Both begin with identification of issues and goals and require a broad master plan with more specific subordinate units' plans. The 1983 MFRP (the broad master plan) consisted of seven volumes:

1. Planning Concept;
2. Issues Document;
3. Assessment;
4. Goals and Strategies;
5. Objectives and Recommendations;
6. Program and Budget; and
7. Annual Budget Implementation.

Each of these are updated as needed on an approximately five- or ten-year cycle. The 1983 documents will be superseded by the 1993 assessment and 1995 program updates.

4.2.3 State Coordination

In planning, coordination is often the responsibility of many groups. This holds true for forest resources planning. For example, the State and Private Forestry Branch of the USDA Forest Service is responsible for coordinating planning efforts undertaken by the state and federal levels of government. Planning coordination also occurs directly between the MNDNR and the two national forests, especially for forestry, fish, and wildlife. Within the MNDNR, the Office of Planning is responsible for integrating the MFRP with the department's comprehensive plans.

A great deal of informal *coordination* occurs among the state and county land management agencies. Formal *cooperation* also occurs within a number of programs. State/county coordination and cooperation often centers around transfers or pass-through monies which flow from the state level to the county level. Aside from this type of financial transfer, no specific mechanisms exist to coordinate decisions regarding the spending of this money.

Coordination among the departments' planning efforts, and review and input by the legislature is undertaken through various legislative committees and the LCMR. In the past, the Minnesota State Planning Agency was responsible for coordination with other state agencies and local units of government in ongoing state natural resources planning efforts. This agency was abolished in 1991, and this responsibility was shifted to the newly created Office of Strategic and Long-range Planning.

Coordination of environmental policy is dealt with by the Minnesota EQB. The EQB was established by the Minnesota Legislature in 1973 to serve as an interdepartmental forum for addressing and resolving environmental problems and issues. Primary responsibilities of the EQB are to: (1) initiate interdepartmental investigations into state environmental problems; (2) review and coordinate the environmental programs of state agencies to ensure compliance with state environmental policy; (3) review the rules and criteria of state agencies for granting and denying environmental permits; and (4) coordinate the development of legislative proposals submitted by state agencies.

4.2.4 State Programs

Major forestry programs and activities are conducted through the Division of Forestry of the MNDNR. This division has management responsibility for approximately 4.4 million acres, or 85 percent of all state owned land in Minnesota. The Division of Forestry has 21 different programs grouped into six general categories. These categories are listed below with a brief description of their programs and functions.

1 State Forest Land Management Program

Land Administration.—Administers state land leasing, sales, acquisition, and exchanges.

State Forest Recreation.—Administers 46 campgrounds, 44 day use areas, 1,200 miles of trail, 142 water accesses, and 17 canoe and boating route campsites. Conducts recreation planning, develops and maintains recreational facilities, enforces rules and regulations, distributes maps and other interpretive materials, and produces brochures on state forest recreation areas and state trail systems.

State Forest Roads.—Inventories, maintains, reconstructs, and manages the forest transportation system. Plan for the construction of new roads as needed.

Timber Management.—Manages state-owned forest lands primarily through timber stand regeneration, timber stand improvement, and regulation of harvest following standard silvicultural principals.

Timber Sales.—Appraises, sells, and supervises the harvest of timber on state lands.

Fish and Wildlife Habitat Management.—Implements old growth guidelines and Forestry/Wildlife Coordination Policy and Guidelines in all areas of the state. This often takes the form of modification of reforestation, timber stand improvement or timber harvest, or separate wildlife enhancing projects.

2 Cooperative Forest Management Program

Private Forest Management.—Promotes forest management on NIPF lands by developing multiple use management plans for landowners and providing landowner education, technical assistance, and marketing assistance. This is the lead program which coordinates state and federal assistance monies for NIPF owners.

Urban and Community Forestry.—Provides training and technical assistance to managers of Minnesota's urban and community forests. Increases interagency coordination of programs operated by these managers and public awareness of the values of urban and community forests.

Cooperative County Forest Management.—Provides technical and financial support to county land departments; channeling technical services and finances through ongoing division programs rather than with direct staff support. Continues the historic role in providing tree seedling production, pest protection, and forest inventory information. De-emphasizes statutory oversight and regulatory responsibilities in favor of an advisory approach for ensuring sound resources management.

Forest Pest Management.—Develops effective control programs for Minnesota pests with emphasis on nonchemical management approaches. Provides technical assistance and education services to private forestry-based industries and all managers of forest land in the state on insect and disease prevention and control.

Forest Soils.—Maintains site productivity and enhances forest resources management through the use of landform, soil, and vegetation technical information.

3 Nursery and Tree Improvement Program

Nursery and Tree Improvement.—Produces forest regeneration material of the highest genetic and biological quality in the quantities needed for use by state agencies and sale to other forest landowners.

4 Resource Protection Program

Wildfire Protection and Management.—Conducts activities to aid in the prevention, presuppression, and suppression of wildfires on 45.5 million acres of public and private lands in Minnesota.

Law Enforcement.—Provides compliance with state statutes for preventing wildfires, protecting the public's interest in state land and its assets, and ensuring the division's recreational facilities can be enjoyed safely by the public.

5 Forest Resource Information and Planning Program

Forest Resource Assessment and Analysis.—Collects and processes forest resource information utilizing forest inventory, remote sensing, and biometrics techniques and technology.

Forest Products Utilization and Marketing.—Increases the economic benefits from production of forest products within the state; increases wood-using efficiency of the state's forest products industry; and provides forest resource and forest products information for the forest products community and general public.

Forest Information Systems.—Coordinates, develops, and maintains the division's computer information system.

Forest Resource Planning.—Provides the Division of Forestry with strategic and land management planning services. This includes updating of the MFRP.

Public Affairs.—Provides information and education to the public on division programs, products, and services.

6 Administration and Technical Support Services

Human Resources Development.—Oversees division recruitment, selection, orientation, training, education, and development of all division personnel.

Maintenance and Administration.—Administers fiscal matters, property and equipment maintenance, and overall supervision of the division.

4.2.5 Public Participation in State-level Forest Resource Planning

Informal public participation is used frequently at the state level. For example, for the state's planning process, the public is involved with the MNDNR Division of Forestry on specific issues via various types of informal roundtables or committees. Examples include the recently held Old Growth Roundtable and Forest Practices Regulation forum. In addition, from time to time, the governor or MNDNR commissioner create special committees or commissions on forestry that include public representatives. The MNDNR also pursues other formal and informal public participation processes initiated at the department level that directly involve the Division of Forestry. Examples include the forest roads committee and annual logger/timber sale meetings. Importantly, legally mandated state public participation activities are centered in the planning process, just as they are in the federal management system.

When possible, the planning team within the Division of Forestry utilizes existing communications channels to solicit public participation in planning activities. Draft planning documents are distributed to interested parties for review directly by the planning team through established MNDNR communications channels, through other state planning agencies communications channels, and through various commissions and councils.

Important here is the new state planning process being employed by the MNDNR administrative regions 1, 4, and 5. This new process is based on landscape planning, utilizes interdisciplinary teams to set desired future conditions, has developed innovative public participation processes, and is a departure from past MNDNR planning efforts.

As with the USDA Forest Service planning process, public involvement in state forest resource planning activities is most concentrated at the beginning and end of the process. Comments and suggestions are solicited in the initial scoping process when issues are selected. Following completion of draft documents, meetings are held throughout the state to explain the documents and to compile oral comments on their content. Submission of written comments is also encouraged.

At the unit planning level, public participation consists of information meetings held before plan development, so comments received can be used to help prepare the plan. More informal meetings are also held with various interest groups during the plan development stage to solicit comments or suggestions. Public information meetings are also held on the draft unit plan.

Similar to rights of appeal on the federal level, participants who are not satisfied with the resulting state forest plans can file suit in the state court system. This right exists in Minnesota but not in every state.

4.2.6
State System Overall Assessment

Although not specifically identified as a FSD-scoped issue, this brief overall assessment is provided to address some considerations that may help focus future decisions.

The statewide system for natural resources decisionmaking is diverse and wide ranging, both geographically and topically. Although it primarily involves the MNDNR, numerous other agencies, departments, boards, committees, and citizen interest groups have significant roles. The following points are important considerations:

- the state has a comprehensive array of laws, regulations, guidelines, etc., intended to help ensure wise management of natural resources;
- within this comprehensive array, however, there is *the potential* for overlapping interests and authority, shared decisionmaking, and lack of clear responsibility (for example, are the roles of the LCMR, MNDNR, and EQB, with respect to resources management, clear and noncompetitive?);
- with careful coordination, consistency, and a sound awareness of the mix of tools available to decisionmakers, the current system can work effectively;
- the difficulty can arise when these needs are not met, and *the potential* for that to occur seems high;
- the quality of the state's natural resources decisionmaking can suffer without streamlining and application of clear policies with straightforward responsibilities and corresponding authority; and
- this *potential* has been compounded by the state's budget situation and the MNDNR's loss of staffing since 1985.

4.3 County Management System

Minnesota is one of only two states in the U.S. with an extensive county managed land base (technically, these lands are owned by the state, see section 3.2.2). Each county's land base is managed by a land commissioner, county auditor, or the MNDNR (for counties with small amounts of forest land). Counties with extensive county-administered forest land holdings have land commissioners who administer lands through a county land department. These land commissioners are appointed by their respective county boards and function as the administrators of the county land system. As of 1990, fourteen counties had land commissioners.

All land commissioners are members of the Minnesota Association of County Land Commissioners (MACLC). The MACLC became a formal nonprofit organization in 1984 in order to better coordinate county activities; and to facilitate the sharing of problems, solutions, and opportunities at a grassroots level. The MACLC also became involved in the legislative process and public education programs. This increased the visibility of the county land system in the policy community and established it as a major public landowner on a par with the older, more visible state and federal systems.

State law, MN Stat. 282.01, requires county boards to classify county managed land as either conservation or nonconservation. Legislation requiring this classification and authorizing the appointment of county land commissioners was first passed in 1935. In general, conservation lands are more suitable for public ownership and management while nonconservation lands are more suitable for private ownership and use.

Conservation lands can be reclassified by county boards in several ways. They can be transferred to the state for management, designated as nonconservation, transferred to other parties (public or private) or designated as memorial forests. Since 1945 when legislation authorized establishment of memorial forests, designation of conservation lands as memorial forests has been common, indicating the increasing forestry expertise of the county land departments.

Memorial forests are actively managed by county land departments, primarily for timber production. In fact, to be designated as memorial forest, the land must be "...more suitable for forest purposes than for any other purpose..." (MN Stat. 459.06 [2]). Proceeds from timber sales or any other revenue generating activity in memorial forests may be, and nearly always is, placed into a separate permanent fund within the trust to be used for the management and development of that forest. After the expenses of the managing land department are paid and an elective set-aside distribution of funds is made to special accounts, such as Memorial Forest Account, Timber Development Fund, Recreation Account, or others provided in statute, the remaining funds must be distributed by statutory formula to school districts, the general revenue fund, and townships or municipalities in which they were generated. Income from the sale of products on other types of county owned land *not* classified as memorial forest is distributed in a similar manner.

What this means is that unlike the MNDNR current policy focus on multiple use concepts, the counties' are more heavily oriented toward generating revenues for public services (e.g., emphasize timber production and harvesting).

4.3.1 County Policy Focus

Counties in Minnesota have very similar policies due to their self-supporting funding structure, local constituencies, and similar resource bases and timber and recreation markets. All counties have policies heavily oriented toward forest management for the production of wood products.

In addition to providing direct revenue to the county, it is clear to county managers that additional benefits in the form of employment are generated as the wood is harvested and processed by local wood products firms. Both direct and indirect economic benefits contribute to the focus on wood production as the major management objective.

Yet counties also have become more active and sophisticated in taking a broader view of the forest resources beyond timber. Eight counties are currently developing a biophysical land classification and mapping system. Information regarding climate, geology, land forms, landscape positions, soils, and vegetation are being organized into a hierarchical arrangement of the biological and physical resources that characterize the forest environment. This will provide resources managers with an ecological framework for strengthening prescriptive forest management through more comprehensive resource evaluations. However, caution is important. Some of the county inventory/mapping systems being developed are not fully compatible with each other or with existing state and federal systems. This lack of coordination could lead to future planning constraints and coordination problems.

Some counties also cooperate with state and federal land managers regarding fish and wildlife habitat management. Policies regarding fish and wildlife habitat management involve modification of management and silvicultural practices as a means of taking wildlife considerations into account. Such modification varies by species and focuses primarily on habitat improvement for game species, which is viewed as important for much of the county lands statewide. Some county timber harvest and forest management plans are done in an integrated manner with site-specific policies directed toward deer yards and grouse habitat.

Federal and state law govern county actions regarding endangered species. Less commonly, a county will have specific policies regarding endangered and nongame species. Hubbard County, for instance, has site-specific policies regarding management of habitat for endangered, threatened, and special concern species.

Other County Policies

Like the state, individual counties also have a wide variety of other policies that affect resources management. Such policies cover the following:

- recreation and aesthetics;
- special use lands (for public and environmental education);
- roads;
- land acquisition and disposal; and
- timber sales.

Overall, the county resources management policy framework is broad, but differs from state management policy in two basic ways:

1. it is more oriented toward commercial timber production, and
2. it is not as complex.

4.3.2 County Planning

County forest management planning is very autonomous compared to state (and federal) efforts and systems. Each county land department represents the policy and management focus under the control of each county board. Counties are not required by law to prepare formal land management plans. Consequently, county efforts exhibit differing patterns of planning. Nine of the 14 counties with land commissioners have specially developed written plans. Four of these were completed in the 1990s, three in the 1980s, and two in the 1970s. Several are in the process of being updated.

Other counties use different planning methods or are in the process of conducting some type of planning effort. One county is developing a new planning approach that incorporates many of the elements of traditional planning with state-of-the-art data processing and GIS capability, which will permit extensive modeling and frequent updates when fully operational.

Many existing county plans are comprehensive and cover such categories as an overview of the land base, fish and wildlife policies, fire policies, outdoor recreation policies, the economic importance of roads, and current timber sale and pricing procedures. They are also very similar to state level regional resources management plans in a gross sense. This consistency is in part the result of state technical and financial assistance provided to certain counties, specifically for planning activities.

4.3.3 County Coordination

Counties, especially the 15 with land commissioners, coordinate with federal, state, regional, and local agencies and landowners in many ways. The MACLC plays a key role in many cooperative efforts with members assigned to coordinate various activities such as developing standards, as in BMPs, and participating in working groups or policy task forces. Counties participate in and help fund various formal cooperatives such as the Forest Vegetation Management Cooperative, the Great Lakes Forest Growth and Yield Cooperative, the Minnesota Tree Improvement Cooperative, and the Aspen/Larch Genetics Cooperative. Counties also coordinate activities through participation in the Minnesota Forestry Coordinating Committee, forest inventory efforts, sharing data and information, and occasionally by sharing costs and contributing lands for special projects. Additional coordination takes place through special County Road Committees to deal with multi-agency road and access issues.

Considering all of these activities, perhaps the most important is the coordination and cooperation that occurs among counties. By creating a forum that encourages periodic dialogue among county land commissioners, the MACLC provides a vehicle for cooperation and support among counties as well as with state, industry, and private landowner or user organizations.

4.3.4 County Programs

Unlike the MNDNR, county land departments are not arranged into separate programs based on function. Furthermore, there is great disparity across county land departments in terms of funding and personnel support, and this affects the array of what can be offered (e.g., Carlton versus St. Louis counties). However, overall resources management decisions take into account a variety of resource values. Some of the management activities undertaken by the counties in this way are:

- road construction, reconstruction, and maintenance;
- reforestation;
- timber stand improvement;
- forest inventory;
- remonumentation (land surveys, etc.);
- wildlife;
- recreation;
- timber management;
- land management; and
- forfeited tax sales apportionment.

4.3.5 Public Participation in County-level Forest Resource Planning

Public participation on the county level is largely informal. Where planning efforts include public participation, counties may employ processes similar to those used by the MNDNR and the USDA Forest Service. They are not, however, legally required to do so. Many counties also have advisory committees, composed of county residents and elected officials. These advise the land commissioner and the county board on the direction the forestry programs should take.

4.3.6 County System Overall Assessment

Again, though not specifically addressed as an FSD-scoped issue, comments here are intended to help focus on key future considerations. The county system for natural resources decisionmaking is narrowly focused relative to counterpart state and federal processes. Its goals are straightforward, for the most part, which allows for this less complex approach. Difficulties probably lie in the number of separate county jurisdictions, the variety of interests, and the increased likelihood of intercounty conflicts. However, the MACLC has done much to minimize potential difficulties. The following points are important considerations:

- those counties with highly fragmented land bases will likely have more problems with natural resources decisionmaking, especially that aimed at multiple use management and landscape-level objectives;
- the counties are not under the auspices of the MFRMA, which can lead to less legal accountability for multiple-use management;
- the county land departments are not sufficiently staffed or funded for adequate multiple resources-based forest policy and program decisionmaking;
- an emphasis on optimizing revenues from public land holdings can create public perception problems in the present environmentally oriented climate;
- the counties have historically relied, to a certain degree, on state resources and technical expertise regarding county forest planning matters, and this reliance *can* lead to strong influence from the MNDNR; and
- given their basic charter and available resources, the counties appear to have a system that is well tailored and scoped to their own needs, but as indicated, the county management of state lands is conducted without formal multiple use management guidelines, and without the formality in planning, public input, or coordination with other public landowners that is evident for the MNDNR and the USDA Forest Service.

4.4 Federal Management System

The USDA Forest Service is the largest agency of the U.S. Department of Agriculture and is headed by the chief of the USDA Forest Service. Six deputy chiefs are assigned to oversee each of the six distinct branches. These branches are the first level in the administrative structure. The six branches are:

- Programs and Legislation;
- Administration;
- Research;
- State and Private Forestry;
- National Forests; and
- International Forestry.

In addition to these branches, an Office of Information is located in Washington, D.C., to assist in public information and public involvement activities.

The Programs and Legislation Branch handles budgeting, policy analysis, and legislative affairs. The Administration Branch handles personnel, procurement and property, and information systems. The International Forestry Branch was recently added to the agency's structure and is oriented toward international forest management and assistance. The Research Branch conducts natural resources research at seven regional experiment stations and at the Forest Products Laboratory in Wisconsin. The State and Private Forestry Branch provides and coordinates technical and financial assistance to state forestry agencies for use in various programs (generally cooperative forestry, fire management, forest pest management, and private forest landowner assistance). The National Forest Branch of the USDA Forest Service is the only branch with land management responsibilities. It is also the largest branch, both in terms of budget and personnel, and the most visible to the public. There are eleven program areas that national forests are responsible for: engineering; lands; land management planning; minerals and geology management; range management; recreation management; timber management; watershed and air management; wildlife and fisheries; public affairs; and administrative resources.

Each of the two national forests in Minnesota is headed by a forest supervisor who reports to the regional forester located in Milwaukee, Wisconsin. The forest headquarters of the Chippewa is located in Cass Lake and the forest headquarters of the Superior is located in Duluth. Forest supervisors have the following responsibilities:

- to provide leadership and supervision to forest staff;
- to participate in the formulation of regional and forest level policies, programs, and objectives;
- to work toward the accomplishment of State and Private Forestry program objectives and the dissemination of research information; and
- to meet regionally allocated production targets for goods and services produced on the forest and planning objectives.

Of all public owners of forest land in Minnesota, the federal government was the first to adopt policies emphasizing management for both commodity and noncommodity production. The national forests, in fact, were the first public landowner to adopt the concept of multiple use management and to undertake extensive resources management planning.

4.4.1 Federal Policy

The federal agency primarily responsible for forest resources and programs in Minnesota is the USDA Forest Service. The general management philosophy is guided heavily by the NFMA and its associated range of regulations and guidelines. This philosophy creates a far more complex and wide reaching resources policymaking framework than exists for either the state or the county systems. The USDA Forest Service Manual, a key component of the policymaking framework, provides guidelines that illustrate this concept of breadth and diversity:

- *Human and Community Development.*
  Help individuals and local communities enhance their self-sufficiency and maintain community stability by identifying supportive forest and range related opportunities;
- *Environmental Management, Subsection—Pesticide and Herbicide Use.*
  Use pesticides only after analysis demonstrates that pesticide use is essential and use only Environmental Protection Agency (EPA) registered pesticides. Herbicides will not be applied directly into water or wetlands. All lakes, streams, ponds, and ditches which contain water at the time of treatment will have untreated buffer zones.
- *Recreation Management, Subsection—Recreation Opportunities.*
  The five ROS classes will be used to guide management within each management area and to ensure road management and development conform to ROS needs.
- *Timber Management, Subsections—Rotation Ages and Culmination of Mean Annual Increment, Management Intensity and Utilization, and Silvicultural Practices.*
  An individual timber sale will usually be designed to harvest a number of stands in an area of about 1,000 acres, which is served by a common transportation network. Such areas are called compartments. A stand of timber, at rotation age, may be offered for sale if it has operable timber, meets market conditions, is accessible, and its sale would be consistent with other resource objectives. The stand should be harvested at culmination of mean annual increment (MAI) to yield the most growth (rotation age). Harvesting of timber prior to MAI culmination is prohibited by NFMA.

  Although not stated separately as a distinct policy, land and timber management are clearly influenced by the issues of retention of old growth and maintenance of biodiversity. Each management area is assigned a biodiversity index with management guided by habitat requirements of various wildlife indicator species. Management plans also contain standards for retention of old growth. For example, the Chippewa National Forest Plan calls for 90,000 acres of ERF designated over the 150-year planning horizon. There will not be 90,000 acres designated at any one time; acres will move in and out of old growth status. As of 1992, 24,700 acres were designated as old growth.

- *Timber Management, Subsection—Soils Productivity, Wetland and Riparian Areas, and Timber Stocking Levels.*
  Silvicultural practices are to be conducted in a manner so as not to adversely affect soil productivity. Various activities associated with logging such as log landings or yarding areas, disposal of residual logging debris, soil disturbance, and felling of trees are prohibited in specified types of wetlands and restricted to certain times of the year in others. Riparian resource values will be optimized by establishing an area at least 100 feet wide along the shores of perennial streams and lakes.
- *Wildlife Management, Subsections—Threatened and Endangered Species, Sensitive Species, Other Species of Concern, Viability Indicator Species, Management Indicator Species, Moose and Deer Population Guides, and Fisheries.*
  Endangered and threatened species and their habitats conservation or recovery receive special priority in national forest management (FSM 2670.3). The gray wolf, American Peregrine Falcon, and the Bald Eagle are the threatened and endangered species occurring on Minnesota's national forests. Each species is governed by detailed management standards.
- *Forest Pest Management.*
  A system of integrated pest management (IPM) method is used on the national forests. These methods emphasize techniques such as selection of rotation ages, species mix, stand densities, suitable sites, and stand acreages that are least conducive to pest outbreaks.

Other Federal Policies

Several other forestwide policies are found in manuals, guidelines, and miscellaneous USDA Forest Service regulations. These policies address such resource issues as:

- visual quality;
- air quality;
- range management;
- cultural resources;
- minerals;
- fire management;
- pollution control; and
- land ownership adjustments.

Generally speaking, the federal system is based on a comprehensive and quite complex mix of policy directions that are collectively aimed at a very broad-based philosophy of resources management. In a sense, the USDA Forest Service resources management framework has evolved to where timber management directives are utilized to foster development and enhancement of all the other forest-based resources. This conceptual framework is significantly different than those that exist for the state and county systems.

4.4.2 Federal Planning

In brief, forest management planning on the federal level is:

- legally specified;
- multilayered, complex, and time consuming; and
- driven by detailed economic and demand analyses.

It is the most complex and detailed type of natural resources planning done by public agency landowners in Minnesota. USDA Forest Service planning (and planning conducted by all federal land management agencies) is governed by a number of statutes and regulations. Planning, as conducted today, was mandated for the USDA Forest Service with the passage of the RPA in 1974. As noted in the preface of the Final EIS of the Land and Resource Management Plan for the Superior National Forest:

> The 1974 RPA, as amended by the 1976 NFMA, requires the preparation of a forest plan for each national forest. The forest plan must be prepared following federal regulations in National Forest System Land and Resource Management Planning. Also required is an EIS for each forest plan.
>
> This EIS follows procedures established by the USDA Forest Service regulations for implementing the NEPA and others by the Council on Environmental Quality (CEQ). The forest plan is a companion document to the EIS. For purposes of NEPA disclosures, the EIS and the forest plan are treated as combined documents. A Record of Decision approving the forest plan needs to be available for public review.

The RPA and NFMA formally specify the planning process, but in fact a great deal of planning was carried out before these laws were established. The Chippewa National Forest first adopted a *multiple use* forest management plan in 1938, followed soon after by the Superior National Forest. Prior to that, planning was less comprehensive and individual planning efforts concentrated on single resource issues. For instance, there might have been a timber plan, a planting plan, etc., each of which were separate stand alone planning exercises.

The RPA requires an assessment every ten years and programs every five years. NFMA requires forest plans at least every 15 years. Consequently, the USDA Forest Service planning process occurs in three stages at 5- to 15-year intervals. Key components of this process are:

- An RPA *assessment* of the natural resources situation is prepared. From this assessment, a national direction is formulated which encompasses all forest resources and all demands on those resources. This is summarized in a document called the *program*. The first assessment and program documents were completed in 1975 and 1976, respectively, the most recent in 1989 and 1990, respectively. These documents establish long-term planning policies.
- Planning then proceeds to the area or regional level. A region or subregion is one in which the national forests are similar. The Lake States Area Guide (the physical product of this level) establishes management policy for the national forests in Minnesota, Wisconsin, and Michigan.
- Each national forest prepares its own forest plan at least every 15 years which details management direction, goals, alternatives, and costs and benefits of each alternative. Each plan also includes an environmental impact statement for each alternative. The forest plan needs to provide for goods and services in an environmentally sound manner to provide the public the greatest long-term net benefits. The Superior's and Chippewa's most recent forest plans were completed in 1986.
- Detailed plans are completed for the various units within each national forest.
- A key product is the establishment of *standards and guidelines* and *desired future conditions*, which together have major impacts on plan implementation and field level practices.

4.4.3 Federal Coordination

The USDA Forest Service coordinates planning for the national forests with other public agencies largely on an informal basis. For example, other federal, state, and county agencies are sent draft planning documents for comment as a regular part of the public participation phase of the planning process. In this way, personnel from other agencies function in a role similar to any other individual or group who makes comments about and suggested revisions to the forest plan.

The USDA Forest Service is legally obligated to coordinate its planning with other agencies and states. However, it is not legally obligated to coordinate its efforts or the final adopted plans to the statewide forest plan developed by the MNDNR. In fact, other agencies are simply asked to comment during public review where their comments carry no more weight than general citizen inputs. Earlier incorporation of other public agencies' inputs prior to public review would appear to be needed to enhance the end product and stimulate more effective resources management cooperation. There are recent improvements in such coordination at the statewide level, but field level coordination is still minimal in some subject areas.

During the development of forest plans for the Superior and Chippewa national forests, for which updated plans are due in 1994–96, the regional forester delegates authority to coordinate with state agencies directly to the individual forests. The governor also designates a state representative to oversee coordination, but the field level still lacks any formal coordination mechanisms.

At the regional plan level, coordination with state agencies is more formalized. As previously stated, each state is responsible for forest planning on a statewide basis. The USDA Forest Service cooperates in this effort by providing the base data used to formulate the state plan, including Forest Survey, supply and demand projections for various forest outputs, and other information generated by the Research Branch of the USDA Forest Service. The state reciprocates by providing similar data to the USDA Forest Service. State forest resource plans also provide input data for the regional and national RPA plans. The State and Private Forestry Branch of the USDA Forest Service is responsible for coordinating federal and state planning at the federal regional plan level.

The project that generates the greatest cooperation between the USDA Forest Service and other land management agencies is the statewide forest survey. The reasons for this close cooperation are very pragmatic and include efficiency, need for data consistency, and the desire to avoid public conflicts over databases and common needs. Other agencies with vested interests frequently provide additional money or in-kind support for intensification of the survey to increase its accuracy at substate analysis levels.

4.4.4 Federal Programs

The USDA Forest Service operates a broad range of programs at various levels throughout the natural resources community. These can be categorized into three broad areas:

1. national forests;
2. research; and
3. state and private forestry.

Those directly relating to the USDA national forests are discussed here, while the research programs are reviewed in section 4.5 and NIPF assistance programs are outlined in section 4.6.2.

National Forests' Programs
Each national forest is responsible for 11 broad program areas: engineering, lands, land management planning, minerals and geology management, range management, recreation management, timber management, watershed and air

management, wildlife and fisheries, public affairs, and administrative resources. The extent of each program on a national forest depends on the characteristics of the forest. For example, range programs on eastern forests are very small or nonexistent, while those on many western forests are large. Forests near major population centers often have large recreation programs in comparison to more remote forests. The specific programs on each forest may also have different names and include groupings of subprograms under each major program. On the Chippewa and Superior national forests, seven program areas are prominent:

Recreation Program: The recreation program provides and protects facilities and natural resources to accommodate the public's needs for outdoor recreation, emphasizing opportunities for experiencing nature. Recreation management is directed also toward maintaining, repairing, and restoring the existing facilities necessary to meet these demands.

Engineering Program: The engineering program constructs, maintains and improves roads, recreation facilities, utilities, dams, trails, land line locations, buildings, and other physical structures to meet national forest program needs.

Fire Program: The purposes of the fire program are twofold: first, to carry out prescribed burning as needed to meet silvicultural needs; and second, to protect national forest lands and adjacent state and private lands covered by reciprocal agreement from wildfire. The USDA Forest Service fire program is strongly oriented toward fire suppression on national forest system lands despite the existence of reciprocal agreements. State fire forces are more directly concerned with suppression on private lands. Protection from wildfire can include education and training activities, presuppression, fuels management, actual suppression activities, and rehabilitation of burned areas. Firefighting in Minnesota is a strongly cooperative effort between all public land agencies. Activities are coordinated through various committees and the Minnesota Interagency Fire Control Center. The acres burned on the national forests are usually quite small, and predominately caused by humans.

Timber Program: The timber program is intended to produce in perpetuity continuous flows of timber harvests while ensuring protection of environmental values and other land uses. The timber program is very complex and contains several subprograms. Resource inventory is literally an inventory of forest stands—their ages, species composition, productivity, nearness to water, location, importance for wildlife, etc. Timber resource inventory planning and silvicultural examination develop necessary base information for the orderly management of the timber resource. Sales preparation involves the layout and marking of a harvest area, drafting of contracts, auction procedures, etc. Harvest administration assures that timber is cut in accordance with the contract, which includes not only the price of the timber and when it must be paid but also such things as specifications for road construction, cutting methods to be employed, and penalties for adverse environmental impacts caused by negligence. Reforestation and stand improvement is aimed at obtaining adequate forest land stocking and maintaining a timber productivity level sufficient for sustained yield management.

Wildlife and Fish Program: The wildlife and fish program is intended to maintain self-sustaining healthy populations of desired nonnative and existing native vertebrate species and to improve the habitat productivity for those species highly desired by the public, such as deer, elk, wild turkey, trout, bass, and salmon. In addition, the USDA Forest Service has special responsibilities to identify and adjust management to ensure the perpetuation of threatened and endangered species of plants and animals. Like the fire program, the wildlife and fish program is highly cooperative, especially with the MNDNR, which regulates the harvesting of all game species in Minnesota, regardless of location.

Land Management Program**:** Supervision and management of a wide range of activities is carried out within the land management program. On the Chippewa and Superior national forests, this program is actually a multitude of relatively small scale activities. Included are such things as rights-of-way management, land exchange and acquisition, special use permits, water monitoring, mineral permits, and grazing permits.

Human Resources Program: The human resources program administers programs in work, training and education for the underemployed, unemployed, elderly, young, and others with special needs. On the national forests of Minnesota, these programs are of two types: employment for target clientele and volunteer programs such as the Youth Conservation Corps, the Senior Community Service Employment Program, and the programs for College Work Study and Cooperative Employment and Training Act (CETA).

4.4.5
Public Participation in Federal-level Forest Resource Planning

Informal public participation in federal forest management and planning is similar to that for other public owners. Organizations and individuals communicate their views to individual land managers or USDA Forest Service offices. They may form coalitions to more effectively influence USDA Forest Service officials to act on their issue of concern. This type of public participation is often local in nature, but can expand and impact management on a state, regional, or national level. The Monongahela and

Bitterroot controversies are the best known examples, but the USDA Forest Service history contains many instances of such expansions from local issues.

Formal federal public participation activities are legally defined and prescribed in detail. They are extremely pervasive, making it very difficult for a federal agency to escape public scrutiny or appeal through administrative process or legal means. As a consequence, the USDA Forest Service planning efforts can become difficult and protracted as the interested members of the public fully exercise their rights to participate in the process.

Of all the public forest management agencies in Minnesota, the USDA Forest Service is probably the most acutely aware of the possible consequences of *not* being responsive. One only has to log the long list of court cases the USDA Forest Service has faced in the past decade as a consequence of both dissatisfaction with outcomes as well as perceived poor public participation inputs. There are many legal remedies available to individuals or organizations who feel their concerns are not being addressed by USDA Forest Service management or planning activities.

The national forests have attempted a process more akin to a representative model on the Lolo and Kootenai national forests in Montana. Initiated in response to numerous appeals to the forest plans, the "Accords" process, which attempts to reach mutual agreement on key issues and assumptions in advance of the actual plan development, has been more successful in resolving (or at least minimizing) conflict.

The Planning Process

The form and level of public participation in planning is clearly outlined in the RPA and therefore it is legally binding. Public participation in the planning process is concentrated in the first step of the process (identification of issues, concerns, and opportunities) and in the period leading up to plan approval. This public participation occurs at all three levels of USDA Forest Service planning (national, regional, and forest). The following describes public participation activities on individual forests.

Public participation on individual forests begins with a *notice of intent to prepare an EIS for the forest plan*, published in the Federal Register. This starts the scoping process which identifies the primary issues and concerns the EIS will address. National forests generally send similar notices to other governmental agencies, organizations, and individuals that have shown an interest in USDA Forest Service operations.

Following notice, the USDA Forest Service asks interested parties to comment on a preliminary list of issues and concerns, which the USDA Forest Service develops internally, and/or to add issues or concerns the public participants would like to see addressed. After reviewing these comments, the USDA Forest Service establishes the final list of issues and concerns. Justification for the selection of these final issues is carefully documented as it relates to the comments received.

No further public participation occurs until a draft EIS and proposed Forest Plan are developed. Once the drafts are completed, public participation resumes.

Public participation in national forest planning then moves forward with a notice of availability of the Draft EIS and proposed Plan published in the Federal Register. Individuals and groups on the USDA Forest Service mailing list and any other interested parties that request copies are then sent the drafts and solicited for comments. The comment period lasts approximately three months and includes several meetings organized by the USDA Forest Service. These meetings are used to assist people in interpreting the documents and to receive comments orally. The public is also encouraged to submit comments in writing to the USDA Forest Service.

At the close of the comment period, the USDA Forest Service modifies the drafts and publishes a final EIS and proposed Plan. The modifications can be minor or major, technical or general. For example, two changes made to the Chippewa National Forest Plan were the inclusions of intermediate harvests in the younger age classes of long-lived conifers and changes in the significance of some issues and concerns identified during scoping.

These final drafts must then be approved at the regional level. This is done through issuance of a Record of Decision. This decision is subject to appeal by any organization or individual. The appeal notice needs to be in writing and submitted to the regional forester with a statement of reasons to support the appeal and any request for oral presentation, within 45 days from the date of the decision.

The chief of the USDA Forest Service is responsible for a decision on the appeals. Rather than arbitrarily making a decision, an appeal usually starts another round of informal bargaining and negotiation between the USDA Forest Service and the appellants. This negotiation represents an attempt to settle out of court since the next step in the appeal process for those still dissatisfied with the outcome (the decision of the chief the USDA Forest Service) is to take legal action the USDA Forest Service in federal court.

The appeal process described above occurs on Forest Plan and EIS details. These details are often not site-specific at this stage. Final decisions on site-specific projects are made as the Plan is implemented. The public participation and appeal process as described above also applies to site-specific activities as implementation proceeds. This process can also result in court action. One additional key step before implementation is found in the Opportunity Area Analysis, which is governed by both the Plan and NEPA, which has a major impact on field level implementation decisions.

The Courts
Following this lengthy public participation process, parties still dissatisfied with USDA Forest Service activities have the option of suing the USDA Forest Service in federal court. The appellants must have *standing to sue* which means: a *case or controversy* exists; they have suffered personal *injury in fact, economic or otherwise*; and the interest sought to be protected or regulated will have court standing. Administrative action is also open to judicial review, as specified in the Administrative Procedures Act of 1967. Standing to sue is broadly and liberally interpreted in the United States, and few cases involving suits against the USDA Forest Service have been dismissed due to lack of standing.

The basis of these suits vary depending on which federal regulation the challenge is being brought under. The most common bases are:

- The USDA Forest Service acted in an arbitrary and capricious manner (i.e., did not properly consider all available information) which is not allowed under the NEPA;
- The USDA Forest Service violated one or more of the detailed procedural requirements in (usually) the NFMA or the RPA; and
- The USDA Forest Service did not act when they should have, as specified in NEPA, in undertaking an environmental assessment or drafting an EIS for some specific project.

A court judgement in favor of the USDA Forest Service can be appealed to higher courts. A judgement against the USDA Forest Service can result in certain parts of planning process being redone, even back to the very beginning in an extreme case. A suit brought concerning a management practice or site-specific project can result in modification or restriction of those practices or projects. Recent court decisions on spotted owl habitat management are examples of this type.

4.4.6 Federal System Overall Assessment

Here again, although not specifically identified as a FSD issue, this brief overall assessment is provided to help focus on key future considerations. The USDA Forest Service system for natural resources decisionmaking is extremely diverse and complex. The system is based on a myriad of federal legislation and numerous federal agencies' regulations and guidelines, as well as the USDA Forest Service's own voluminous standards, regulations, and guidelines. Thus the USDA Forest Service is faced with a very difficult task in natural resources decisionmaking. This has been enormously compounded by the scope of the *open process* since the inception of the NFMA in the 1970s.

With 12 percent of Minnesota's timberland (17 percent of forest land) concentrated into two large blocks (the Superior and Chippewa national forests), the USDA Forest Service can have substantial influence on how Minnesota's forest resources are managed. The following points are important considerations:

- nationally, the USDA Forest Service is well staffed with many technically sound specialists who cover most resources;
- the agency is usually funded to meet its basic goals;
- the agency's complex nationwide organizational nature and processes have at times raised perceptions of slowed and/or confused decisionmaking on both its own lands and those of other landholders; and
- to the degree that the above point is accurate, without improving its processes, resources management decisionmaking in Minnesota may be slowed over the long-term.

Overall, the USDA Forest Service has good resources, quality management, and a broad enough set of responsibilities to truly effect comprehensive multiple use management. The key problems appear to be that:

- *perceived* past focus toward timber production may adversely affect the agencies' credibility with some audiences;
- the agency has at times appeared to vacillate between addressing state and local interests versus federal interests;
- the RPA and NFMA do not appear to have worked as conceived in all their aspects; they are based on good intentions, but the public review and legal processes have sometimes made the agency appear indecisive;
- the USDA Forest Service's resources management decisions have at times been made in courts of law or in public forums; which
- have appeared to limit the agencies' authority to fulfill its responsibilities.

4.5 Research Programs

Although not aimed at any specific ownership class in Minnesota, the long-standing availability of formal research programs have had a material impact on the state's resources management framework and practice. There is a long history of cooperative agreements between the USDA Forest Service North Central Forest Experiment Station (NCFES) and the UofM College of Natural Resources. The Natural Resources Research Institute (NRRI) is the newest of the research organizations and linkages are less well developed. Also important is the research done by the MNDNR Division of Fish and

Wildlife. That research addresses various population management questions of an applied nature. Additionally, scientists from all five organizations have professional linkages to the Minnesota Section of the Society of American Foresters, the Wildlife Society, the Upper Mississippi Valley Section of the Forest Products Research Society, and various technical specialty groups.

4.5.1
College of Natural Resources

The UofM's College of Natural Resources houses the departments of Forest Resources, Forest Products, and Fisheries and Wildlife. The college and these units are in turn part of the UofM Agricultural Experiment Station (MAES). The Department of Forest Resources is primarily concerned with basic and applied research directed at meeting the needs of forest land management. Subject matter encompasses forest biology, ecology, genetics, silviculture, protection, water resources, recreation, management, economics, policy, and resource assessment and analysis. The Department of Forest Products focuses on basic and applied research on utilization from the standpoint of primary and secondary manufacturing. Emphasis is on the areas of structural design with wood, composite products, paper and fiber science and technology, biotechnology, wood preservation, recycling, wood chemistry, energy conservation, and more efficient uses of wood. The Department of Fisheries and Wildlife focuses on basic and applied research central to the management of fisheries and wildlife and their habitats. Emphasis germane to forests is on forest-wildlife interactions, maintenance of wildlife biodiversity, and ecosystem analysis.

These departments also have several faculty members with joint appointments in the UofM's Minnesota Extension Service (MES). These extension faculty members conduct applied research and convey research-based knowledge to the individuals, industry, public agencies, and interest groups in Minnesota through programs and continuing education. These departments also draw on faculty talent from other university units.

Direction for the research program comes from many sources, including priorities established through the USDA Cooperative State Research Service and the MAES. The college also derives a portion of its research and extension direction from the 1982 MFRMA. Funding is provided by state and federal appropriation and a wide variety of grants and contracts.

4.5.2
Natural Resources Research Institute

The NRRI was established in 1983 at the UofM-Duluth to assist in efforts to bolster Minnesota's economy through commercial development of natural resources in an environmentally acceptable manner. Organizationally, NRRI consists of the Center for Applied Research and Technology Development (CARTD), the Center for Economic Development (CED), and the Center for Water and Environment (CWE). NRRI provides technical and business assistance to economic development efforts, emphasizing applied research and development technology intended to assist informed decisionmaking. In CARTD, a major emphasis is directed towards forest products research, development and technology transfer on value-added composite and solid wood products. In CWE emphasis is placed on ecosystem management and climate change influences on the productivity and diversity of northern ecosystems.

The NRRI is funded by state appropriation and various federal and state granting agencies, Minnesota Technology, Inc., foundations, and industry. Overall direction is provided by the NRRI Advisory Board, and the direction of forestry research is provided by internal committees which seek input from various groups.

4.5.3
USDA Forest Service, North Central Forest Experiment Station

The NCFES conducts research in forestry and related fields through a seven-state area in the north central United States. It is also responsible for FIA in an eleven-state area. This includes the seven-state North Central area and the states of Kansas, Nebraska, South Dakota, and North Dakota. The station has nineteen research projects at nine forestry sciences laboratories throughout the region. Research encompasses forest silviculture and ecology, forest modeling, biotechnology, genetics, forest regeneration processes, landscape ecology, forest economics, resource evaluation, research evaluation, urban and high-use recreation, forest engineering, wood utilization, fire, insects and disease, water quality, and wildlife and fish habitat management.

About 100 of the support staff are located in Minnesota. The station takes its direction from the RPA of 1974, the NFMA of 1976, the Forest and Rangeland Renewable Resources Research Act of 1978, and other federal policies as administered through the USDA. The NCFES has its main offices on the UofM St. Paul Campus. The station also maintains a Forestry Science Laboratory in Grand Rapids, Minnesota, and fourteen experimental forests and watersheds, five of which are located in Minnesota.

4.5.4
Research System Overall Assessment

Though not specifically addressed as a FSD-scoped issue, the material in this section is offered to help focus on key future considerations. The combined efforts of federal and state research programs have provided important scientific understanding and technical information support to forest management in Minnesota. In doing so, it is acknowledged that researchers and extension or technology staff draw extensively on research conducted elsewhere in the U.S. and beyond. The following points are important considerations:

- the above research and extension or technology transfer units have access to substantial scientific talent and have been responsive to state needs given available personnel and financial resources;
- forestry research funding is not commensurate with the value of Minnesota's forests. Staffing levels to date have resulted in important contributions, but substantial information gaps remain. Further, these efforts will not be adequate to address the complex social and ecological questions the state will face as demand continues to increase for the many benefits the state's forests are capable of providing;
- extension and technology transfer seem to be the weakest links in this system due to very limited staffing. Investments in extension and technology transfer in forestry are considerably below that needed to deliver the products of research to forest landowners, managers, loggers, manufacturers, decisionmakers, special interest groups, and the general public. The result is limited understanding of the issues and opportunities and a large gap between practice and capability;
- forestry research programs in Minnesota appear to suffer from a lack of coordinated program planning and implementation. This can limit the research community's ability to focus limited resources on implementation that recognizes the strengths of the various research agencies. The result can materialize as unnecessary duplication of effort; and
- funding for state-based forestry research and extension programs is not always well articulated in the agency budgets and not necessarily well linked to forest management. Given current research program structures, it is not clear how the research needs articulated by the GEIS will be addressed with commensurate funding.

4.6
NIPF Landowner Considerations

Public policies directed toward NIPF landowners emphasize getting their acres into a managed state. What the landowner chooses to manage for is less important. The propensity of NIPF landowners to manage land and harvest timber is affected by many factors, including owner objectives, the size of the land holding, current and expected return on investments, tax policies, availability of public assistance, and statewide regulation. In fact, numerous state and national studies have documented that nontimber resource values/goals tend to motivate NIPF landowners, not timber production. However, some NIPF landowners are interested in timber production, and when contacted directly by forestry professionals, participate in initial and intermediate management activities, such as the Tree Farm and Forest Stewardship programs.

For the NIPF landowners, only a few public policies affect the framework in which this group approaches resources management. These include compliance with federal wetland regulations and shoreland management regulations in counties where they have been adopted and public tax policies.

4.6.1 Tax Policies

Tax policies which impact NIPF land include property and income tax policies. Property taxes in Minnesota which apply to privately owned timberland are of two types: ad valorem and tree growth.

Under the ad valorem tax system, the property's market value, its property classification, and the local tax rate are the bases for taxation. The county assessor determines an estimated market value and a property classification. Of the various classifications used, timberland is usually placed in one of four categories.

An alternative to the ad valorem tax system is the Minnesota tree growth tax system where property taxes are based on the value of annual timber growth on the property. Individual counties have the option whether or not to adopt this law. To date, approximately 90 percent of land enrolled under the Minnesota Tree Growth Tax Law is in forest products industry ownership.

The requirement that enrolled lands be open for public use appears to be a significant deterrent to NIPF landowners.

Income and inheritance tax policies which impact NIPF owners are much more complicated and can have major impacts on a landowner's attitude toward land management. One anecdote that has merit here is that the average rotation age for NIPF landowners who cut trees is approximately equal to the time period between the reading of two wills—implying that the levying of inheritance taxes can have significant influence on management decisions.

4.6.2 NIPF Assistance Programs

Public programs to assist NIPF owners have existed in Minnesota since the 1940s. The creation of public programs to assist NIPF owners began on the federal level in the USDA Forest Service and the Agricultural Stabilization and Conservation Service (ASCS). Private forest lands were widely acknowledged to be critical components of the forest resource base and also the least likely to be professionally and efficiently managed for timber or other products. Concerns about future timber shortages and loss of productive agricultural land due to wind and water erosion prompted the creation of the earliest programs. In the early 1970s, program expansions occurred as the result of concern for water quality, ecological aspects of the forest environment, and excess farm production.

NIPF assistance programs are of two general and mutually reinforcing types: those providing technical assistance and those providing financial assistance. Many forestry assistance programs have, at one time or another, been quite controversial, but the financial assistance programs generally draw the most attention. Except for short, select periods of time or specific programs, to increase or even maintain NIPF program funding nationally has been notoriously difficult. This is especially true for programs aimed at increasing timber supply. In Minnesota, state funding for assistance programs has contributed to program consistency when federal program funding has fluctuated.

The following are examples of current NIPF programs available that are aimed at improving the level of management on NIPF lands. These programs often target owners whose objectives are not solely timber production, but recognize other nontimber values such as wildlife production or recreational opportunities. Management, however, is important from a productivity and environmental protection perspective.

Forestry Incentives Program (FIP): The FIP is a cost-share and technical assistance program intended to encourage an increase in future timber harvests from NIPF lands. It was created in 1973 (P.L. 93-86, [4]) and is funded through the State and Private Forestry branch of the USDA Forest Service. The Minnesota FIP utilizes state general fund monies for practices not cost-shared through the federal FIP. The funds are distributed through soil and water conservation districts.

Agricultural Conservation Program (ACP): The ACP is a cost-share program intended to encourage the planting of plantations and the improvement of existing stands on NIPF lands. Established by the Soil Conservation and Domestic Allotment Act of 1936, ACP is the oldest cost-share program for NIPF owners. Funding for this program comes from the ASCS in the U.S. Department of Agriculture.

Conservation Reserve Program (CRP): The CRP is a voluntary land retirement program that assists the agricultural economy by converting farmland to forest land. The program retires marginal farmland for ten years. The program also helps reduce soil erosion, enhance wildlife habitat, improve water quality, and increase timber production. The CRP was created in the Farm Bill of 1985 and is administered through the ASCS. Technical assistance is provided for tree or shrub planting on areas larger than two acres and for the development of conservation plans.

Stewardship Technical Assistance: This component of the stewardship initiative provides technical assistance to NIPF owners. Focus is on working one-on-one with landowners in the development of a woodland stewardship plan for the landowner. These plans blend professional standards for management with landowner objectives and include considerable educational material.

Stewardship Incentives Program (SIP): This component of the stewardship initiative is a cost-share program intended to assist NIPF owners in implementing their woodland stewardship plan. SIP provides funds for activities intended to enhance wildlife habitat, intensify management for timber production, control erosion, etc.

America the Beautiful: This is the most recent NIPF program discussed here, having started in 1989. Program goals include enhancing existing natural and recreational resources and addressing the buildup of atmospheric carbon dioxide by planting trees. Funding for this program is provided by the USDA Forest Service through the SIP and urban cost-share programs. Cost-share assistance is available for tree planting and forest improvement. Funds can also be used to strengthen a variety of activities such as education and technical assistance. This program is unique because it has a community or urban component. Under this component, the program encourages the solicitation of private, public, and corporate funds to assist with the costs of urban tree planting.

Reinvest in Minnesota (RIM): The state sponsored RIM program has many components designed to protect soil and water resources in the state and to improve wildlife habitat. Only part of the money is used to assist NIPF owners. RIM was created in 1986 and receives its funding through the sale of State General Obligation bonds. Funds are for wetland restoration, purchase of easements, land retirement, wildlife habitat improvement, critical habitat, etc. Although improved management for timber is not its primary goal, much of the work done under the program does improve management for other primary purposes. One component of RIM important to NIPF owners is the Forest Wildlife Habitat Improvement Program which funds certain wildlife practices not normally cost-shared by traditional programs such as ACP, FIP, and FIP.

In addition to these public programs, the Minnesota Tree Farm Program and industry-led private forest management programs are also important to NIPF landowners. The Tree Farm Program currently has nearly 2,800 members covering almost a million acres of timberland. The private forest management programs serve 1,500 landowners who manage approximately 150,000 acres statewide.

4.6.3 NIPF Landowners Overall Assessment

In brief, the NIPF resources management framework is directly affected by the availability of a broad array of public assistance programs. These programs are aimed at providing incentives to manage these forest lands in a way that ensures the public interest. The alternative to these programs is to employ zoning and other forms of guidelines (voluntary BMPs) or regulations (mandatory BMPs and/or a forest practices act). The voluntary BMPs mechanism currently exists in Minnesota, along with various other regulations and guidelines.

The implications of the NIPF landowner group, with nearly 45 percent of Minnesota's timberland (more than twice the MNDNR holdings), being basically unregulated are considerable. For example, as long as they *collectively* follow-up sound, voluntary BMPs, their implied policy direction will be good and constructive for Minnesota. However, should the opposite occur, then the impacts of timber harvesting and forest management to be documented in sections 5 to 7 of this study would be significantly more severe.

In Minnesota, it is ironic that of the three largest landowners, the smallest (USDA Forest Service) is the most legislated and regulated and the largest (NIPF) is the least. This imbalance may not be a problem in the future, but it certainly should be cause for concern and review. However, the generally positive level of compliance with still new BMPs concepts and the very modest extension and other education efforts employed so far suggest a high level of forestry practice can be achieved and maintained at modest cost through various educational programs.

4.7 Native American Forest Lands Background

Forest land on reservations is considered private forest land because it is owned by Native Americans and held in trust by the United States. Forest land on reservations is managed cooperatively by the USDI Bureau of Indian Affairs (BIA) and the Native American owners. Native Americans have exercised an increasing amount of responsibility over the management of their forest land.

The role of the BIA in timber management on Native American lands held in trust has changed during the past several decades. One major force has been a trend toward more self-determination for Native American tribes.

Self-determination gained acceptance in matters of federal Native American policy during the late 1960s and early 1970s. The objective of the policy was to increase and strengthen the Native Americans' morale, individualism, and tribal government by supporting tribal assumption of reservation services and programs, including forestry-related programs. The concept of self-determination was written into federal policy in the Indian Self-Determination and Education Act of 1975 wherein Congress made important policy statements regarding Native Americans. These statements laid a strong foundation for the successful implementation of the concept of *self-determination*.

The Indian Self-Determination and Education Act of 1975 contains provisions important to forest management on Native American lands, including giving tribal governments authority to contract directly with the USDI for services that the tribes desired. The rationale for this was that as tribal contracts increased, the BIA's contracting role would decrease. Nonetheless, the secretary of the interior has retained the right to decline to enter into any contract if the tribal organization is deficient in certain resources and would not be able to perform the service (P.L. 93-638, sec. 102 (a)). The authority of the secretary of the interior to contract directly with tribes for forest management activities was explicitly addressed in P.L. 101-630 where:

> "The Secretary shall undertake forest land management activities on Indian forest land, either directly or through contracts, cooperative agreements, or grants under the Indian Self-Determination Act..." (P.L. 101-630, sec. 305 (a)).

The secretary of the interior has other management objectives that specifically relate to forestry. The objectives are also described in Public Law 101-630. Among the objectives are:

> "...the development, maintenance, and enhancement of Indian forest land in a perpetually productive state in accordance with the principles of sustained yield and with the standards and objectives set forth in forest management plans by providing effective management and protection through the application of sound silvicultural and economic principles..." (P.L. 101-630, sec. 305 (b) (1)).

> "...the regulation of Indian forest lands through the development and implementation, with the full and active consultation and participation of the appropriate Indian tribe, of forest management plans which are supported by written tribal objectives and forest marketing programs." (P.L. 101-630, sec. 305 (b) (2)).

> "...the retention of Indian forest land in its natural state when an Indian tribe determines that the recreational, cultural, aesthetic, or traditional values of the Indian forest land represents the highest and best use of the land." (P.L. 101-630, sec. 305 (b) (5)).

While the level of direct BIA involvement varies from reservation to reservation in Minnesota, tribes must approve timber sales from their lands. At the same time, because the BIA manages land held in trust by the United States government, the tribes that contract must meet the same standards as the BIA. For instance, these standards include hiring professional foresters and accepting silvicultural prescriptions. Further, the BIA must approve all actions on the lands held in trust.

Although there is sometimes still significant BIA involvement for standards aimed at hiring professional foresters and accepting sound silvicultural prescriptions, Native American lands are now managed in a manner more similar to NIPF lands than those of the USDA Forest Service.

Another area affecting the Native American's resource decisionmaking is the myriad of state, county and federal programs that are directed at their own land bases. Examples are programs directed at forest roads, timber management, land administration, cooperative county forest management, wildfire protection and management, pest management, wildlife management, recreation management, and public affairs. These provide opportunities, but also add complexity to planning and management.

4.8 Summary and Implications

Natural resources management decisionmaking in Minnesota is based on a wide range of policies, programs, regulations, planning, coordination, and public participation. The primary parties involved are:

- the counties;
- the state, mainly through the MNDNR;
- the federal government, mainly through the USDA Forest Service;
- the forest industry landowners; and
- the NIPF group.

These four groups embody almost all of the decisionmaking mechanisms that influence the direction of natural resources management in Minnesota.

Some key considerations that can impact the status of forest land management are as follows:

- Minnesota has a substantial forest resource base today;
- the complexity of the decisionmaking mechanisms and their perceived overlapping nature, both organizationally and functionally, can create the potential for duplicative and inefficient resource program delivery; and
- the decisionmaking process seems to have grown inherently more complex in the past decade—the state could experience escalating difficulties in the statewide resources management decisionmaking area over time.

Some important considerations for more effective management of the state's forest resource base may lie in the following areas:

- common visions and goals for the statewide forest resources and related issues do not seem to exist;
- the NIPF forest lands could be more effectively managed, particularly with respect to goals, objectives, base investments, commitment to using expert advice, and commitment to voluntary BMPs. At present, on-the-ground timber harvesting and forest management standards and practices are highly variable;
- the potential difficulty of the USDA Forest Service to fully implement RPA/NFMA, which can lead to a significant amount of decisionmaking being made from outside the agency that in turn diminishes the agency's authority; and
- the state appears to have a complex set of overlapping mechanisms for resource decisionmaking and organizing support of management, which can interfere with the evolution of common visions and goals for statewide forest resources and related issues.

This last point could be the most critical in the long-run. Minnesota's forest resources need to function in a coordinated manner to optimize benefits to society. To the degree that the USDA Forest Service, the NIPF group, the counties, the MNDNR, and other interested parties, such as the forest products industry, conservation groups, the tourism and resort industry, etc., cannot go forward under well-articulated and common visions and goals, guidelines, and directions, the state's forest resources run the risk of inadequately providing for the values and services needed by society.

5
STATEWIDE IMPLICATIONS: 4 MILLION CORD ANNUAL HARVEST

This section of the study describes the modelling assumptions used and the outputs from the lowest level of harvesting modelled, termed the *base* level of harvest. The section is intended to provide an understanding of what was harvested and why; what effects this had on the forests and their associated resources and values as defined in the FSD issues of concern; what mitigations should be used to ameliorate the significant adverse impacts that result from this level of timber harvesting and forest management activity; and the effectiveness of those strategies at mitigating impacts as well as those impacts that will likely not be mitigated.

Background information is provided here which is not repeated in the sections that examine the two higher levels of timber harvesting and forest management activities. Those sections focus on the impacts projected to occur at the higher levels of timber harvesting and forest management in addition to those projected to occur at the current or base level.

This section draws heavily on information and analyses presented in the GEIS technical and background papers. Those papers set out in greater detail the methodology used and also identify the limitations of the methodology and the data used to undertake the analyses. Section 2.3 of this document discusses how the three statewide scenarios were generated. Unless stated otherwise, this section refers to the second model run results.

One final point—although already stated, it is important for the reader to understand that all three timber harvest scenarios were specified by the EQB as those levels of harvest to be explicitly examined in the GEIS. Therefore, this and the two subsequent sections discuss the likely harvesting activity, future forest conditions, and impacts on various forest and related characteristics that are projected to occur if these levels of timber demand were, in fact, achieved.

5.1
Description of Harvesting Activities

5.1.1
Underlying Assumptions

The base scenario was modelled using the existing levels of roundwood consumption as the basis for demand over the modelled period of 50 years. This assumes that no further forest-based industrial developments take place within this period. This further assumes that total demand from existing mills will be constant throughout the entire planning period; and that statewide logging intensity will remain static.

However, initial results indicated that the assumptions used to develop the second runs, which are described in detail in the Maintaining Productivity and Forest Resource Base technical paper (Jaakko Pöyry Consulting, Inc. 1992a), would make it infeasible to sustainably harvest the current level of aspen demand over the 50-year planning period and beyond. Therefore, an assumption was made that other species could be substituted for a proportion of the current aspen demand. It is likely that decreasing aspen supplies together with associated increases in aspen prices relative to other species will stimulate such substitutions in the real market. Predicting the extent of the shift is difficult, due to the long time horizon involved. Significant changes in demand for a species can occur over relatively short periods, as demonstrated by the case of aspen, which only twenty years ago was considered a weed species and experienced little demand.

It was assumed that hardwoods would be substituted for aspen as the output from the initial model runs indicated the state had a surplus of these species under current levels of harvest and the additional demand could be readily met. It was further assumed that 25 percent of aspen demand would be shifted to hardwood species even though feasible schedules could be developed with somewhat smaller shifts. Table 5.1 summarizes the assumed harvest levels by period and market. Note that the state was modelled in two parts, a northern and southern region.

There also was concern about the availability of high quality oak. This question was treated by the specification of red oak sawlog harvest levels for the southern region shown in table 5.1. However, continued availability of high quality red oak will depend heavily on silvicultural and harvesting practices that encourage the development of high quality logs.

5.1.2
Covertypes and Species Harvested

Table 5.2 summarizes the base scenario output that describes the total acres, acres uncut, acres clearcut once in 50 years, acres clearcut twice, acres thinned but never clearcut, acres thinned and clearcut for both the southern and the northern study regions, and the state as a whole. These data indicate that approximately 7.2 million acres of timberland would be harvested under the base scenario over the next 50 years. Conversely, adding the area of productive land *not* cut (1990–2040) to the productive land *not considered* in the scheduling model shows that a total of 7.6 million acres of timberland *would not* be harvested over this same period modelled under this scenario. Note that acres *not* cut would contain those young stands recently harvested and some that might be harvested beyond the 50-year study period. In addition, the 1.9 million acres of reserved and unproductive forest acreage (not included in table 5.2) would not be disturbed by harvesting. This means that under the base scenario 7.2 million acres of Minnesota's forest land would experience some harvesting and 9.5 million acres would not be harvested.

Table 5.3 shows the acreage harvested and not harvested by covertype. Most of the harvesting activity is concentrated in the aspen and other hardwood covertypes. Results for these two species groups show the effect of a shift in demand to the latter necessary to achieve long-term sustainability. The

Table 5.1. Assumed roundwood consumption levels by species group and market for the base harvest scenarios (thousands of cords per year).

Species Group Market	Period 1 (1990-99)	Period 2 (2000-2009)	Periods 3-6 (2010-49)
Aspen			
Bemidji	572	522	435
Brainerd	256	260.1	216.75
Cook	210	182.7	152.25
Duluth	506	454.5	378.75
Grand Rapids	433	390.6	325.5
I. Falls	415	412.2	343.5
subtotal	2,392	2,222.1	1,851.75
Spruce-fir			
Brainerd	70	70	70
Duluth	220.5	219.5	219.5
Grand Rapids	115.5	118.5	118.5
subtotal	406	408	408
Pine			
Bemidji	159	188	188
Duluth	151	153	153
I. Falls	111	98	98
subtotal	421	439	439
Northern Hdwds			
Bemidji	83	147	234
Brainerd	190	226.9	270.25
Cook	51	79.3	109.75
Duluth	93	145.5	221.25
Grand Rapids	61	112.4	177.5
I. Falls	48	94.8	163.5
subtotal	526	805.9	1,176.25
Total, North	3,745	3,875	3,875
Southern Region			
Red oak sawlogs	50	50	50
Other wood	250	250	250
Total, South	300	300	300
Total, Statewide	4,045	4,175	4,175

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 5.2. Summary of original timberland acres clearcut and/or thinned for the base scenario, 1990–2040.

Action Category*	North	South	Total
1 Total Timberland			14,773,400
2 Not Considered			1,356,500
3 Considered	12,409,900	1,007,000	13,416,900
4 Not cut	5,591,300	652,200	6,243,500
5 Clearcut once	5,775,300	320,700	6,096,000
6 Clearcut twice	846,000	0	846,000
7 Thinned but not clearcut	197,300	34,100	231,400
8 Thinned and clearcut	2,100	19,900	22,000
9 Total not cut, sum (2+4)			7,600,000
10 Total cut, sum (5-7)			7,173,400

Source: Jaakko Pöyry Consulting, Inc. (1992a).
**Not considered* are those plots representing young stands, old growth or areas assumed not available and therefore not considered for harvest in the period 1990-2040. *Considered* are those plots representing stands that are available and in terms of age, etc., feasible to consider for harvest during the 50-year study period. Action category 8, thinned and clearcut, is included in the clearcut once category.

acreages are displayed by the initial FIA covertype. A second clearcut was possible within the 50-year planning horizon only for aspen and balsam poplar, as only these covertypes had a minimum rotation (40 years) that would potentially allow two cuts within the 50-year planning period. Any other covertypes shown in table 5.3 as having a second clearcut are covertypes that were clearcut in the first planning period and then were regenerated in a way that assumed the covertype would change to aspen or balsam poplar.

Tables 5.2 and 5.3 probably underestimate the acreage likely to be cut because the model imposed selection harvests on only about 3 percent of the harvested acreage while the silvicultural survey conducted by Jaakko Pöyry Consulting, Inc. (1992m) found that these practices comprised approximately 8 percent of the harvest by area. Also, for interpretation, the model projects gradually improving per acre stocking levels over the study period and concentrates the harvest on the most economic (most accessible and productive) lands. Thus future per acre volumes for harvested stands are expected to increase in many cases over the study period. This implies that the acreage required to meet a particular harvest level may decline from the present. In comparing these projected harvests to the current harvest area—estimated at approximately 200,000 acres (Jaakko Pöyry Consulting, Inc. 1992m)—it is important to note that this estimate is also subject to important assumptions. In light of these factors, differences between present and projected harvest areas are to be expected.

Table 5.3. Projected acres of timberland (by initial covertype) that are harvested and not harvested in the base scenario, 1990-2040.

Forest Type	Clearcut Once	Clearcut Twice	Thinned	Total Acres Harvested	Total Acres	Acres Never Harvested	Harvest Acres as % of Total Acres	Harvest Acres as % of Total Harvest	Forest Type Acres as % of Acres
Jack pine	117,700	5,900	1,100	124,700	446,600	321,900	27.9	1.7	3.0
Red pine	188,900	6,700	11,600	207,200	354,700	147,500	58.4	2.9	2.4
White pine	37,900	1,700	0	39,600	68,600	29,000	57.7	0.6	0.5
Black spruce	281,900	15,500	5,200	302,600	1,349,900	1,047,300	22.4	4.2	9.1
Balsam fir	311,000	46,400	16,800	374,200	809,200	435,000	46.2	5.2	5.5
Northern white cedar	10,200	0	0	10,200	648,400	638,200	1.6	0.1	4.4
Tamarack	45,300	0	4,000	49,300	719,400	670,100	6.9	0.7	4.9
White spruce	23,700	1,300	2,900	27,900	91,700	63,800	30.4	0.4	0.6
Oak-Hickory	466,900	0	23,200	490,100	1,124,700	634,600	43.6	6.8	7.6
Elm-Ash-Soft maple	248,800	2,900	13,400	265,100	1,124,600	859,500	23.6	3.7	7.6
Maple-Basswood	314,400	3,100	17,900	335,400	1,470,200	1,134,800	22.8	4.7	10.0
Aspen	3,436,600	660,300	113,100	4,210,000	5,242,200	1,032,200	80.3	58.7	35.5
Paper birch	335,500	4,000	8,200	347,700	819,000	471,300	42.5	4.8	5.5
Balsam poplar	277,200	98,200	14,000	389,400	504,200	114,800	77.2	5.4	3.4
Total	6,096,000	846,000	231,400	7,173,400	14,773,400	7,600,000	48.6	100.0	100.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Breakdown of Harvest Volumes by Product Group

Table 5.4 summarizes the scheduled harvests for products within each group for the northern and southern regions of the state. In developing management schedules, target outputs were defined for product groups. Relative value differences were recognized for products within the pine group. In comparing sawlog volumes with pulp volumes it is important to note that the schedules do not necessarily imply that all of the sawlog quality

Table 5.4. Scheduling model harvest summary under the base scenario (thousands of cords per year).

Product Group	Component	Period					
		1990-99	2000-09	2010-19	2020-29	2030-39	2040-49
a) Northern region							
Aspen	Aspen pulp	1,297.7	1,281.2	1,276.80	1,379.1	1,334.6	1,375.4
	Aspen saw	1,083.8	956.5	587.70	475.3	532.2	481.4
	Total	2,381.8	2,237.6	1,864.70	1,854.4	1,866.7	1,856.6
	Target	2,392	2,222.1	1,851.75	1,851.75	1,851.75	1,851.75
Spruce-fir	S-fir pulp	240.2	204.3	176.10	156.9	159.5	144.5
	S-fir saw	165.1	204.3	229.60	244.4	252.5	264.4
	Total	405.3	408.5	405.60	401.3	412.1	408.8
	Target	406	408	408.00	408	408	408
Pine	Pine pulp	77.1	93	79.80	74	108.1	119.5
	R&W saw	303.1	258.7	283.90	311.5	243	212.9
	Other saw	34.6	89.5	71.50	52.3	91.1	109.9
	Total	414.8	441.1	435.30	437.9	442.1	442.2
	Target	421	439	439.00	439	439	439
N. Hardwoods	Pulp	406.5	552.1	746.40	698	695.5	676.7
	R Oak saw	45.7	74.3	136.70	133.3	102.9	59.5
	Other saw	78.4	175.3	293.80	343.7	373.1	438.9
	Total	530.8	801.4	1,176.80	1,175	1,171.4	1,174.9
	Target	526	805.9	1,176.25	1,176.25	1,176.25	1,176.25
All Groups	Total	3,732.7	3,888.6	3,882.4	3,868.6	3,892.3	3,882.5
	Target	3,745	3,875	3,875	3,875	3,875	3,875
b) Southern Region							
Red oak	Sawlogs	50.3	50.4	49.3	49.1	49.9	49.6
	Target	50	50	50	50	50	50
Other Wood	Various	246.2	249.9	255.4	253.8	246.7	244.5
	Target	250	250	250	250	250	250
All Groups	Total	296.5	300.3	304.7	303.9	296.6	293.6
	Target	300	300	300	300	300	300

Source: Jaakko Pöyry Consulting, Inc. (1992a).

material will be used as sawlogs. This was a major consideration in developing relative product values. Higher values were not assumed for aspen, spruce-fir, or northern hardwood sawlogs as at least some of this material will be used as pulpwood. Under the base scenario, the quantity of aspen sawlogs produced over time drops from over 1 million cords per year in period 1 to approximately 475,000 cords in period 4. Aspen is the only species to experience such a drop. However, even with the drop, production of aspen sawlog size material is still substantially above the estimated 210,000 cords consumed annually by Minnesota sawmills.

5.1.3 Harvesting by Ownership

As discussed in section 2.3.1, the second model runs assumed that allocation of timberlands to be harvested was constrained by assumed levels of availability by ownership category. These constraints reflect current and prospective agency policies and land management practices, as well as past trends in availability for ownerships with no articulated policies. Table 5.5 shows the total volume harvested from timberlands on each ownership under the base scenario.

Table 5.5. Original timberland acreage harvested by ownership under the base scenario, 1990-2040.

			Timberland	
Ownership	Acres Harvested	Percent	Acres	Percent
Chippewa National Forest	160,200	2.23	567,200	3.84
Superior National Forest	349,500	4.87	1,253,900	8.49
Miscellaneous federal	53,700	0.75	197,700	1.34
Native American	171,200	2.39	490,600	3.32
State	1,296,900	18.08	3,077,900	20.83
County and municipal	1,612,800	22.48	2,505,600	16.96
Forest industry	451,400	6.29	751,300	5.09
Other private	3,077,700	42.90	5,929,200	40.13
Total	7,173,400	100.00	14,773,400	100.00

Source: Jaakko Pöyry Consulting, Inc. (1992a).

The projected harvesting activities by ownership must be considered in the context that the GEIS is **not** a *planning* document and that the harvesting scenarios are not meant to predict that specific stands will or will not be harvested. The scenarios were developed as a tool to determine how much of the forest would have to be harvested statewide to meet the levels of demand specified in the FSD. The emphasis is on *statewide*, as this is the level of analysis that the GEIS is directed toward.

A substantial proportion of all forests were regarded as available for harvest (table 5.2). Certain categories of stands were excluded, including those in reserved and unproductive categories; those assumed to be unavailable because of age (too young); and those protected under existing policies, such as apply to areas of old growth and riparian corridors. Economic criteria were used to select the cutting sequence for available areas.

In modelling the distribution of timber harvesting activity across the state, the state's timberlands were treated as if the decisionmaking were controlled by a single entity, and as if meeting the specified wood demands economically subject to the assumed constraints was the only objective. With the exception of limiting the volume cut from the national forests to comply with existing allowable sale quantities (ASQs), the model did not recognize the ownership of a plot when allocating harvest. These are obviously simplifications of the real world with its diverse ownerships and even more diverse objectives of management.

Two main areas where differences exist between the modelled scenarios and actual or planned levels of harvest are:

1. the existing constraints for those ownerships that limit the area available for harvest to meet policy objectives; and
2. allocation of harvest levels to achieve a uniform flow of product on a sustainable basis for each ownership or even for certain blocks of timberland within an ownership.

The likely policy-based constraints on harvesting have been identified in the Public Forestry Organizations and Policy background paper (Jaakko Pöyry Consulting, Inc. 1992k) and were incorporated into the modelling process via assumptions of the percentage of total timberland that will be available for harvest. The level of cutting on national forests is also projected to be below existing allowable cut volumes, which is in line with existing harvest levels.

Averaged over the modelled period, the level of cutting on the state timberlands was similar to existing harvest levels.

However, several other important trends in the acreage harvested and the volume projected to be yielded from certain ownerships can be confidently interpreted from the model output. The volume of timber harvested would have to increase substantially over current levels of harvest occurring on county lands, forest industry lands, and private property. Consequently, even the present database for harvests on private lands lacks reliability, which underscores a risk in forecasting removals from such lands. On the whole, increased levels of cutting on these ownerships will have significant implications for the management of these lands.

In particular, substantial increases in the level of harvesting on private property lands will have statewide implications. The standard of management and planning on nonindustrial private forests is highly variable. Therefore, an increase in the amount of harvesting on this ownership will have implications for the overall standard of forest management, as well as the standard of site level operations. Increasing the level of harvesting on county lands will affect county land management organizations. Typically, these organizations have limited resources and the existing staff may have difficulty coping with additional responsibilities associated with increasing the level of cut.

5.1.4 Spatial Distribution

Table 5.6 describes the patterns of harvesting by ecoregion. Figure 5.1 shows the plots harvested during the first ten-year harvest period, and figure 5.2 shows the total number of plots harvested under the base scenario. The projected harvesting patterns indicate that harvesting is projected to occur in virtually all forested regions of the state. This pattern reflects the well-developed road network in Minnesota and the decentralized nature of the timber industry, meaning that few stands in Minnesota are ruled out for harvesting because of their location.

The area covered by dots in figures 5.1 and 5.2 is a rough approximation of the area harvested. The dots cover approximately 1,200 acres each, and most FIA plots represent about 900 to 1,500 acres.

Table 5.6. Original forest acreage and timberland acres cut and not cut by ecoregion under the base scenario, 1990-2040.

	Ecoregion							Total
	1	2	3	4	5	6	7	
Total forest land acres	3,372,000	2,023,700	903,000	8,172,900	934,700	637,200	666,300	16,714,800
Reserve/unproductive	509,600	973,900	36,300	359,800	24,400	17,300	20,100	1,941,400
Timberland acres (1-2)	2,862,400	1,049,800	871,700	7,813,100	910,300	619,900	646,200	14,773,400
Acres not cut, base	1,566,000	619,200	546,900	3,447,300	629,200	408,200	378,200	7,600,000
Acres cut, base	1,296,400	430,600	319,800	4,365,800	281,100	211,700	268,000	7,173,400

Source: Jaakko Pöyry Consulting, Inc. (1992a).

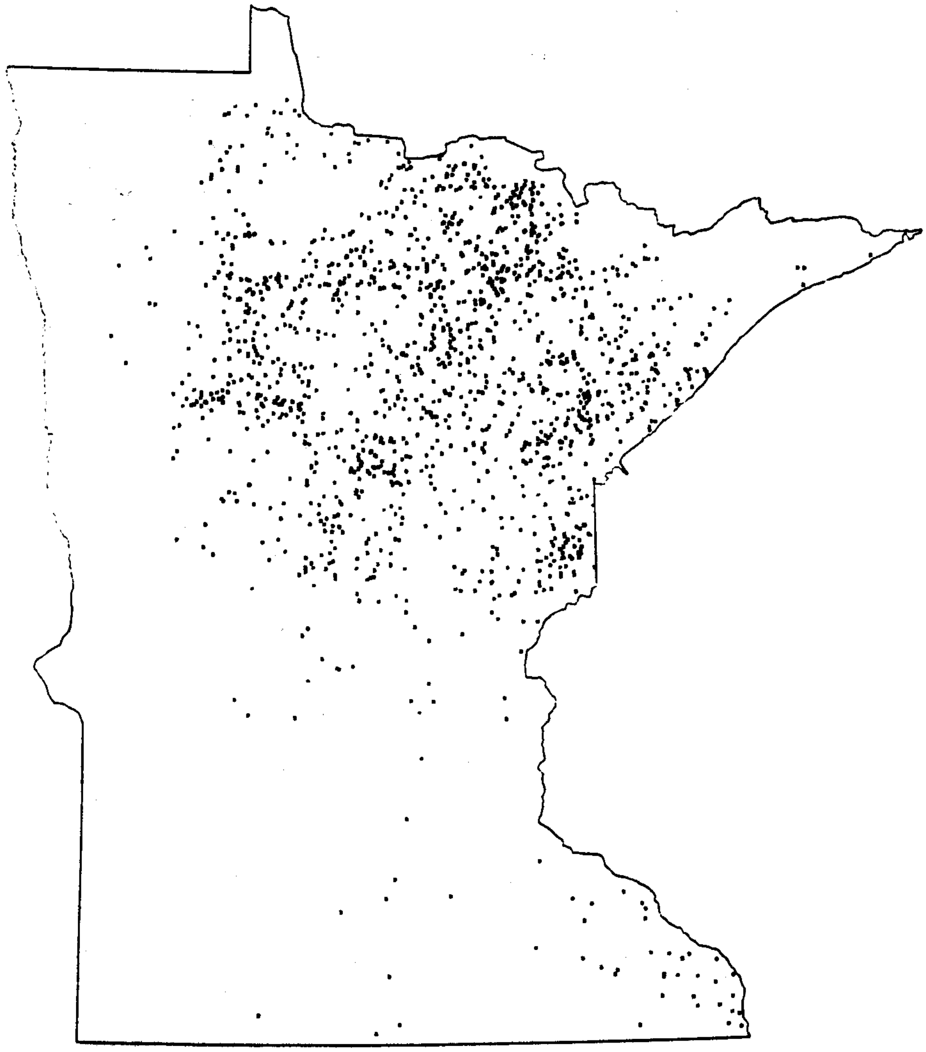

Figure 5.1. Location of harvested plots under the base scenario, 1990-2000.

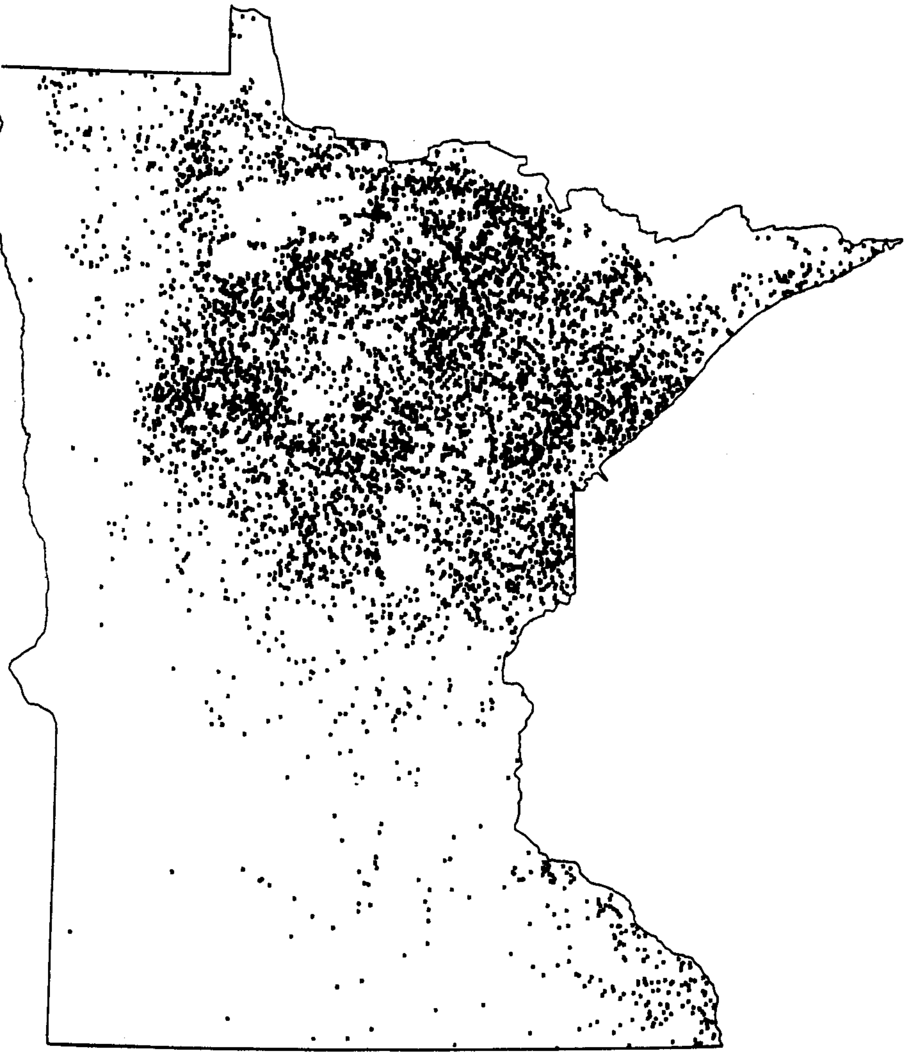

Figure 5.2. Location of harvested plots under the base scenario, 1990-2040.

5.1.5 Temporal Distribution

The pattern of harvesting showed no real trends at the ecoregion level of resolution, especially when assessed at ten-year intervals. However, such patterns would likely emerge at a local level. For example, harvesting in a particular area might be concentrated into a comparatively short span of time following upgrading of an access road. Subsequently, there would be a prolonged period when no harvesting would occur as the forests were regenerated.

5.1.6
Relationship to Long-term Sustainable Timber Removal

The modern concept of sustainability is concerned with the continuity of growth and yield of timber and also the continuity of nontimber goods and services from the forest. Managing a forest for sustained yield requires maintenance of the productive capacity of the forest to meet all these demands. *However, as requested in the FSD, the focus of the discussion in this section is on timber only. The importance of nontimber aspects of Minnesota's forests is introduced and discussed in subsequent sections.*

Definition of Allowable Cut and Sustained Yield
Forest regulation lies at the heart of forest management. It involves the consideration of site, stocking, structure, growth, and yield. It also involves the size and timing of timber cuts.

Forest regulation utilizes the concept of sustained yield. Sustained timber yield management is usually described as the management of a forest property for continuous production with the aim of achieving, at the earliest practicable time, an approximate balance between net growth and harvest, either by annual or somewhat longer periods.

Long-term Sustained Yield Analyses
Based on long-term sustained yield analyses similar to the analysis techniques used by the MNDNR, a timberland area of approximately 7.4 million acres could sustain close to a 4 million cord annual harvest level. This would leave over 7.5 million potentially harvestable acres unharvested over the long-term. This analysis was done twice; once using volume control, the tabular check method and the GIP model, and second, using GROW model simulation of the best economic stand management alternative until yields stabilized. Analyses were developed for at least 200 years in all cases. The effect of ownership constraints and mitigations such as extended rotations and buffer zones were considered by limiting the harvest and management alternatives for these areas or corresponding acreage (see sections 5.11 and 6.13 of Jaakko Pöyry Consulting, Inc. [1992a] for details of this analysis and models used). Comparisons showed the two approaches produced similar results. This analysis strongly suggests that it would be feasible, from a purely wood fiber production perspective, to sustain annual harvest levels higher than 4 million cords once the forest age class structure is regulated. This conclusion assumes appropriate site-specific or other mitigations below the modelled level of resolution are implemented and do mitigate otherwise significant impacts. It also suggests that large areas of timberland could potentially be shifted towards other nontimber management objectives, such as wildlife habitat, without severely impacting timber production at the 4 million cord level in the long-term. This result helps explain why forest industries see development opportunities in Minnesota.

5.2 Characterization of Future Forest Resource Conditions and Impacts

Forests, as with any living entity, change naturally over time, irrespective of human intervention. In addition to these natural changes, human activities such as harvesting can also change the forests. There are certain key characteristics of a forest that can be used to describe many other features. Among these key characteristics are age class, covertype, and species composition. The GEIS has been structured to identify the key characteristics that are likely to change; to project the extent of these changes under the three levels of harvesting; and to examine the implications of such changes for the identified issues of concern.

This section describes the projected changes to these key forest characteristics or descriptors that occur as a consequence of harvesting at the 4 million cord level, as well as those associated with the background levels of change that would occur over a 50-year period. The descriptors discussed include covertypes and their extent, age class distribution, abundance and diversity of tree species within covertypes and structural changes in the patterns of forest cover.

5.2.1 Forest Area and Covertype Abundance

Forest Area

Historical data from past surveys were used to generate predictions of likely changes to the *area* of forest in Minnesota over the period 1990 to 2040. The projected acreage changes are shown in table 5.7. Although these results are presented by FIA unit they need to be interpreted with caution at that level of resolution. The projected statewide gain of 0.8 percent for total forest area is probably the most reliable figure on which to base analysis. The trends show substantial (30 to 40 percent) increases in southern Minnesota, predominantly in agricultural or other nonforested land uses. Much of these gains are expected to come from reversion of marginal agricultural lands back to a forested condition. In the case of wooded pasture, this reversion to full forest cover can occur quickly. However, full recovery of such lands in terms of species composition and ecosystem functions may take much longer. Restoration of forest cover on bare land can take many decades. In the mostly forested northern part of the state, a decrease in total forest land area is predicted. This is because land use changes in that area, such as to urban uses or agriculture, are likely to occur in forest areas, hence the anticipated loss of forest land.

Covertype Acreages

Forest covertype classifications depend on a range of factors, and the relative numbers of trees from each species is an important parameter. For some stands, it is comparatively easy to decide on the appropriate covertype classification. For example, it is straightforward to classify a pure jack pine stand as *jack pine*. In contrast, many stands have mixtures of species which greatly complicate the process of covertype classification. Covertypes that fall into this category have been identified in the following analysis, because under these circumstances the classification can change as a consequence of a small change in the relative numbers of species present. These classification changes can mask more significant changes in species composition.

Table 5.7. Projections of total forest land area change by survey unit for the second runs, 1990–2040.

FIA Unit	1990	2040	Change	Percent Change
a) Timberland				
Aspen-birch	5,878,700	5,524,119	-354,581	-6.0
Northern pine	5,975,500	5,456,956	-518,544	-14.6
Central hardwood	2,275,400	2,988,059	+712,659	+31.3
Prairie	643,000	910,315	+266,515	+41.4
All units	14,773,400	14,879,449	+106,049	+0.7
b) Total Forest Area				
Aspen-birch	7,362,000	7,007,419	-354,581	-4.8
Northern pine	6,336,400	5,816,556	-519,844	-8.2
Central hardwood	2,357,200	3,098,307	+741,107	+31.5
Prairie	660,400	934,697	+274,297	+41.5
All units	16,714,800	16,856,979	+142,179	+0.8

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Following harvesting (or other natural disturbances), or as stands age, the proportions of species that make up a stand can change. When this occurs, the covertype classification may also change. Changing acreages in the various covertypes can be an important indicator of more fundamental changes in the state's forests.

Table 5.8 describes the projected covertype acreages for timberland, reserved and unproductive forest land.[1] The key projected changes for timberlands as a consequence of the level of harvesting projected under the base scenario are:

[1]In making projections, it was not possible to project forward the FIA covertype classification. Consequently, a simpler forest type classification was developed—one that approximated the FIA classification and could be projected. Background on that is described in appendix 2.

Table 5.8. Forest type acreage (as determined by GEIS covertype algorithm) for timberland, reserved and unproductive plots under the base scenario, 1990 and projected 2040, statewide (thousand acres).

Forest Type	1990				2040			
	Timberland	Reserved	Unproductive	Total	Timberland Base Scenario	Reserved	Unproductive	Total Base Scenario
Jack pine	487.1	125.9	1.2	614.2	329.6	56.2	1.2	387.0
Red pine	350.6	78.6	0.9	430.1	452.4	87.7	.9	541.0
White pine	137.3	9.7	1.3	148.3	141.0	32.6	1.3	174.9
Black spruce	1,320.8	129.6	527.5	1,997.9	1,001.2	88.3	547.5	1,637.0
Balsam fir	1,012.5	117.0	21.9	1,151.4	657.4	72.9	18.5	748.8
Northern white cedar	322.4	8.2	37.3	367.9	360.9	8.5	40.7	410.1
Tamarack	696.2	7.9	118.1	822.2	678.7	6.9	118.2	803.8
White spruce	137.1	43.9	0	181.0	227.9	106.7	0	334.6
Oak-Hickory	1,288.0	13.6	14.0	1,315.6	1,370.2	18.6	18.8	1,407.6
Elm-Ash-Soft maple	1,564.2	64.9	33.4	1,662.5	1,744.0	95.4	35.2	1,874.6
Maple-Basswood	1,301.8	30.6	2.1	1,334.5	1,460.2	34.8	2.1	1,497.1
Aspen	4,496.0	358.1	33.9	4,888.0	5,238.7	393.5	36.8	5,669.0
Paper birch	1,179.3	109.7	6.1	1,295.1	803.4	123.6	6.5	933.5
Balsam poplar	480.1	15.4	10.6	506.1	413.7	14.5	9.5	437.7
Nonstocked	0	0	0	0				
Other	0	0	0	0				
Total	14,773.4	1,113.1	828.3	16,714.8	14,879.4	1,140.2	837.3	16,857.0

- The jack pine type declines in acreage due to succession to other types and increased harvesting (from 487,100 to 329,600 acres for timberland in the base scenario).
- The red pine covertype increases by approximately 100,000 acres. That appears due to retention of this long-lived species, succession, planting and natural regeneration.
- The white pine covertype increases in acreage.
- The acreage in the black spruce covertype declines by 2040 with subsequent gains to the tamarack and aspen covertype acreages. (For timberland the decline in black spruce is from 1,320,800 to 1,001,200 acres.)
- The balsam fir acreage on timberland declines from 1990 to 2040 from 1,012,500 to 657,400 acres. The aspen covertype appears to be a major recipient of that acreage.
- The northern white cedar type acreage increases over the study period due largely to succession and harvesting of other lowland conifer covertypes.
- The acreage of tamarack decreases slightly over the study period.
- The white spruce covertype acreage, like that for white pine, is very sensitive to the covertype definition. The projections indicate a substantial increase in the area of this covertype.
- Oak-hickory covertype acreage increases from 1,288,000 to 1,370,200 acres for timberland in the base scenario or about 6 percent.
- Elm-ash-soft maple covertype acreage increases substantially over the study period, partly due to forest area increase in the southern portion of the state.
- Maple-basswood covertype acreage increases for the base scenario.
- Aspen covertype acreage increases 16.5 percent over its initial extent (4,496,000 acres). However, several other covertypes, notably paper birch and balsam fir, have stands with high proportions of aspen that could, by a slight change in species composition or the algorithm for determining that covertype, be called aspen. Likewise, much of the aspen acreage is mixed and with a slight change could be reclassified as paper birch, balsam fir, jack pine, etc.
- The paper birch covertype declines by several hundred thousand acres. However, as with aspen, many acres are composed of mixed species. Consequently, while the acreage classified as *paper birch covertype* has changed, the overall species composition change of the original areas was probably less than the covertype area change would suggest. Aging of this covertype is also a factor contributing to succession to other species.
- The balsam poplar covertype acreage declines.
- In the northern region of the state, large percentage declines in acreage in reserved areas are noted for jack pine, black spruce, and balsam fir. Large percentage increases are noted for white pine and white spruce. These changes are due to projected species succession as stands age.

Reserved acreage increases in the south are due to the assumptions incorporated into the model regarding forest area increases there.
- The acreage of the major unproductive forest types (black spruce, tamarack, northern white cedar, and aspen) appear stable over the study period.

These results are heavily dependent on the (1) extent of harvesting, (2) the probability of covertype retention or change at the time of harvest, and (3) postharvest succession. In the case of aspen, transition matrices associated with harvesting show that most upland covertypes, except oak and northern hardwoods, show an important percentage convert to aspen, especially if ten percent or more of the stand is already aspen. Conversely, existing aspen stands remain such about 90 percent of the time following harvesting. Postharvest succession, however, shows very little conversion to aspen and a long-term pattern of aspen being replaced by other covertypes and species. A summary of the transition patterns is presented in the Maintaining Productivity and the Forest Resource Base technical paper, notably sections 4.5.4 and 5.9.

A further caution in interpreting these results is that long-term covertype change, in the absence of harvesting, is strongly affected by new trees growing into a stand. Given limitations in projection model capability, these factors probably lead to an underestimate of natural processes of stand dynamics and species replacement, leading in turn, to underestimates of naturally occurring covertype change.

Overall, results suggest that future covertype areas will change under the base level of harvesting and that the response is either species or covertype specific. For the case of several covertypes, percentage increases or decreases over a 50-year period can be large. In considering practices to contain or direct such changes, however, natural stand dynamics and succession can be important contributors to covertype change. Finally, covertype classification is still subjective and needs to recognize the highly mixed species structure of the forests in Minnesota.

5.2.2
Covertype Size and Age Class Structure

A summary of average stand age from 1977 to 2040 for the base harvest scenario is shown in table 5.9. For a more complete description of age class structure by covertype, see table 2.2 in appendix 2. Forest development from 1977 to 1990 indicates the average age of most covertypes continued to advance despite harvesting during that period. The clear exceptions are aspen and balsam poplar, which are major pulpwood species with potentially short rotation ages. The areas of timberland designated as *not available*, which includes old growth and other areas assumed to be unavailable, and

ERF and other silvicultural constraints have all contributed to this trend of increase in average age.

Table 5.9. Average stand age by covertype under the base scenario 1977-2040.

Covertype	Average Age of FIA Plots (years)*		
	1977	1990	2040
Jack pine	42	48	77
Red pine	43	44	54
White pine	73	80	104
Black spruce	46	59	89
Balsam fir	42	46	82
Northern white cedar	82	97	116
Tamarack	52	57	99
White spruce	33	42	90
Oak-Hickory	63	69	78
Elm-Ash-Soft maple	56	56	86
Maple-Basswood	61	58	90
Aspen	38	41	34
Paper birch	49	58	92
Balsam poplar	39	41	33

Source: Jaakko Pöyry Consulting, Inc. (1992a). Projected ages for stands not clearcut were determined by adding 50 years. See appendix 2, table 2.2 for more detail.

* Weighted by acreage.

A simple interpretation of these results is that under the existing level of harvesting Minnesota's forests will continue to age; and there will be more acreage of the older age classes for most covertypes. The aspen covertype goes against this trend, and the implications for wildlife populations need to be carefully evaluated because such a high proportion of the forests are in this covertype.

Also important in this interpretation of age is that the current model distribution of stand ages near their covertype mean will change. Because of aging and harvesting, most of the covertypes will show both more acreage in the younger age classes and more acreages in the oldest age classes, i.e., the distributions will tend toward more balance and extend over more age classes than at present.

Further background on age class distributions and their interpretation is given in appendix 2.

Changes in age class structure will have important implications for many other values of the forest. Certain characteristics only become apparent after forests reach certain stages. These stages have been recognized for most covertypes, and specific management objectives have been developed. The following section describes these stages and the consequences of the base level of harvesting.

Old Growth Forests
The following is the MNDNR's definition of old growth which was used in the GEIS analysis as required by the FSD:

> "Old-growth forests have developed over a long period of time essentially free from catastrophic disturbances. They contain large, old trees of long-lived species that are beyond rotation age. Typical old-growth forest stands experience frequent ongoing mortality, including some mortality of canopy trees. Such stands contain a relatively high frequency of large snags and large-diameter, downed logs in various stages of decay" (MNDNR 1992).

Old growth can develop in the following forest types: black ash, lowland hardwoods, northern hardwoods, oak/central hardwoods, red and white pine, white spruce, upland white cedar, and lowland conifers. MNDNR guidelines state that stands should generally be greater than 20 acres in size, meet a minimum age or minimum tree diameter criterion, plus exhibit little or no human disturbance. Example criteria are older than 120 years (90 years for white spruce), negligible human disturbance (natural origin), and/or an average tree diameter of at least 20 inches in red and white pine, 15 inches in other forest types in southern Minnesota, and 10 inches in other forest types in northern Minnesota.

Upland Hardwoods and Conifers and Lowland Hardwoods: The amount of old growth in these types that will be reserved depends on two factors: (1) the acreage of natural origin stands left, and (2) the political and administrative processes that determine how much of this remaining old growth is reserved. Political pressures will probably lead to establishment of a target amount of old growth in each administrative unit, or possibly to all qualifying stands being designated as old growth and reserved. To date, at most, half of all candidate pine stands on MNDNR lands have met the criteria for old growth when surveyed in detail in the field. However, the rate of qualification may change for other covertypes (Rose 1993). This rate is due to the fact that inventory records typically do not contain the detail necessary to precisely determine qualification as old growth. Field survey follow-up thus is essential. Similar proportions are likely to qualify as old growth on national forest lands. There is also some old growth on county and private timberlands in the state, but this was not assessed due to a lack of data.

Regardless of the level of harvest, timber harvesting per se will have little impact on the acreage of old growth in these forest types. It is probable that a small acreage will be unknowingly harvested, primarily on private and possibly county lands. However, political and administrative processes will largely determine the ultimate acreage set aside. As an example, within the MNDNR each candidate stand and future old growth stand will likely be officially reserved or officially released for harvest after the appropriate administrative procedures. A similar procedure is also likely to be formalized for other public ownerships. Procedures for designating old growth on private land remains to be developed and will likely require some MNDNR leadership. Some of these sites are already documented in the MNDNR Natural Heritage Information System.

Swamp Conifers: A majority of the old swamp conifer acreage over 120 years of age is of natural origin, and therefore qualifies as old growth. This is because past demand for lowland conifers has been limited, compared with demand for upland types. None of the available timberlands >120 years old was projected to be cut in the base scenario meaning that there would be no reduction in the area of old growth lowland conifer forest under this scenario.

Old Forests

There is no official MNDNR definition of old forest. As used in this report, old forest includes (1) old growth; (2) forests that meet old growth criteria for age (120 years for most conifers, 90 years for white spruce), stand and tree size, but that may have had some selective harvest or other management activities; plus (3) seral stands of (generally short-lived species) >70 years old. This acreage is summarized for 1990 and the base scenario in table 5.10.

For most covertypes, the area of old forest is projected to increase substantially at the base level of timber harvesting. It appears that most of the projected increase in old timberland will come from acreages never cut during the 50-year planning horizon, reflecting the current overabundance of stands that date from major logging around the turn of the century. Whether these old stands would continue to exist in the following 50-year period as the forest approaches a regulated, or balanced age-distribution condition is not clear. Those stands that are in areas not available for harvest or uneconomical are likely to remain.

Red and White Pine: Currently, there are approximately 21,000 acres of old red pine on all forest lands. Under the base scenario this area would quadruple by the year 2040. The increase in the acreage of white pine would be of similar magnitude, from the current 12,300 acres to 91,674 acres.

Table 5.10. Area of old forest for 1990 and projected to 2040 for the base harvest scenario, all forest lands (acres).*

Forest type (threshold age)	Current 1990	Base Scenario 2040
Red pine (120)	21,200	107,496
White pine (120)	12,300	91,674
Black spruce (120)	157,800	614,219
White cedar (120)	60,000	225,600
Tamarack (120)	73,000	299,604
White spruce (90)	27,400	211,815
Oak-Hickory (120)	51,400	342,702
Elm-Ash-Soft maple (120)	69,400	483,185
Maple-Basswood (120)	37,000	404,502
Jack pine (70)	115,100	244,518
Balsam fir (70)	304,000	452,468
Aspen (70)	467,500	982,911
Balsam poplar (70)	24,900	76,629
Paper birch (70)	324,400	643,809

Source: Jaakko Pöyry Consulting, Inc. (1992a,e).
* Acreages are those determined from GEIS covertype algorithm.

Swamp Conifers: The base harvest scenario projects a major increase in the acreage of old black spruce, tamarack, and white cedar forest over the next 50 years. Old black spruce forest acreage would increase from the current 157,800 to 614,219 acres. Old tamarack acreage would increase about fourfold from the current 73,000 acres and old northern white cedar would increase from 60,000 to 226,000 acres under the base scenario. The primary reason for these trends is that the projected level of harvesting under the base scenario in these covertypes is well below the level of growth these forests experience.

White Spruce: A sevenfold increase of the current 27,400 acres in old white spruce is projected for the base harvest scenario.

Elm-Ash-Soft Maple Forest: Old forest in this type would increase from about 69,400 to 483,185 acres, under the base harvest scenario.

Oak-Hickory and Maple-Basswood: There is a common pattern to the projections of these two types. The acreage of old oak-hickory forest is projected to increase from 51,400 acres to 342,702 acres in the year 2040. Maple-basswood is projected to increase from around 37,000 acres to 404,502 acres. Unlike the other forest types discussed so far, much of the oak-hickory type is in small parcels owned by numerous individuals. Thus, the projections to the year 2040 indicate that future patterns of forest cover could look more like southern Wisconsin and Michigan, which currently have large acreages of old oak-hickory and maple-basswood forest in woodlots.

5.2.3 Tree Species Abundance and Diversity

Changes in tree species composition can occur in the form of species composition within a covertype, often related to stand age or stage of development, and in terms of covertype acreage. Table 5.11 presents a summary of species composition in 1990 and that projected to occur in 2040 for the base scenario across all covertypes. Note that the table includes all tree species reported in the FIA database. The figures for American elm and butternut should be interpreted with caution since there was no data available allowing the GEIS to incorporate the effects of dutch elm disease or butternut canker.

The ownership constraints and mitigations used in the second model runs appear to have been very effective in moderating changes in species statewide. This is evident for upland, lowland, and riparian species. Changes, as a percent of 1990 values, are small for most species. The species showing notable declines between 1990 and 2040 under the base scenario are: jack pine, Kentucky coffee tree, other hardwoods, and paper birch.

Because most species are found in many covertypes, results across covertypes are emphasized. The pattern also was found to be similar for trees with a girth, or dbh, of $\geq$4.5 inches. Unfortunately, a lack of FIA plot data for reserved and some unproductive plots precludes a separate analysis for trees located in those categories of forest.

Additionally, the results in table 5.11 are based on the *association* of tree species with the various covertypes and age classes. As such, the table does not provide for projections of change where the association is altered. As an example, butternut is a common but minor species associated with hardwood covertypes, but it seems to be facing a decline due to a canker disease. Consequently, butternut tree numbers may be overestimated. The same overestimation is suggested for elm because of dutch elm disease.

Reduction of Conifer Component in Aspen Stands

Estimated acreage of aspen forest *with no or inadequate* conifer understory is high—about 73 percent in the 1977 FIA. A conifer understory is considered inadequate if the number of trees is so small that to regenerate the conifer the stand would require some treatment, such as planting, in addition to a regeneration cut. In addition, analysis indicated that from 1977 to 1990

Table 5.11. Summary of projected tree species numbers on timberlands for 1990 and 2040 for the base harvest scenario (thousands of trees $\geq$1.0 inch dbh).*

Tree species	1990	2040
Ailanthus	39	15
American hornbeam	14,419	12,049
American basswood	192,090	191,702
American elm	150,006	147,215
Apple	386	430
Balsam fir	979,317	863,263
Balsam poplar	266,466	283,080
Bigtooth aspen	73,184	82,074
Bitternut hickory	8,044	8,573
Black ash	527,482	662,467
Black cherry	35,429	46,605
Black locust	455	133
Black maple	154	125
Black oak	710	792
Black spruce	1,039,098	911,752
Black walnut	2,289	2,222
Black willow	5,702	4,721
Boxelder	66,672	82,430
Bur oak	190,446	183,028
Butternut	2,941	4,442
Chokecherry	33,848	36,689
Eastern cottonwood	2,735	2,272
Eastern redcedar	14,051	17,977
Green ash	86,474	79,551
Hackberry	14,714	14,842
Hawthorn	8,810	8,922
Ironwood	117,990	130,328
Jack pine	164,593	93,530
Kentucky coffee tree	445	142
Mountain ash	1,497	3,273
Mountain maple	105,825	115,557
Northern white-cedar	386,818	615,904
Northern pin oak	5,975	5,541
Northern red oak	111,893	97,402
Other hardwood	41,155	32,342
Paper birch	570,934	440,801
Peachleaf willow	489	642
Pincherry	13,140	16,541
Ponderosa pine	398	387
Quaking aspen	1,986,789	2,730,630

Table 5.11. (continued)

Tree species	1990	2040
Red maple	290,717	223,765
Red mulberry	988	985
Red pine	97,800	107,691
River birch	185	1,682
Rock elm	1,572	1,881
Scotch pine	1,630	1,123
Shagbark hickory	9,145	11,075
Siberian elm	399	391
Silver maple	9,552	8,890
Slippery elm	23,016	27,284
Striped maple	463	397
Sugar maple	283,728	266,355
Swamp white oak	454	1310
Tamarack	361,461	299,180
White ash	2,494	2,835
White oak	10,058	11,377
White pine	29,566	29,709
White spruce	78,620	76,604
Wild plum	5,331	5,361
Yellow birch	11,746	20,882
Grand Total	8,442,827	9,029,168

Source: Jaakko Pöyry Consulting, Inc. (1992a).

aspen covertype acreage increased by 12 percent among harvested, naturally regenerated stands. Most conversion occurred from harvested conifer covertypes including white pine, white spruce, red pine, black spruce, and balsam fir. Except for red pine, fewer FIA plots changed from aspen to conifer than changes from conifer to aspen during the 13-year period. This suggests that large-scale conversion of types to aspen is taking place.

However, the real question is whether the forests later succeed back to conifers at a rate sufficient to balance postharvest conversion to aspen. Further analysis of postharvest conversion to aspen shows that only 89 percent of stands that were aspen prior to harvest remain aspen after harvest. Also, the covertype change matrix for older undisturbed stands shows some conversion of aspen to other types. Thus stands are converted in both directions and overall succession is not clear.

Trend information for the conifer component in aspen stands comes from conifer volume and number of stems data by age class. The proportion of conifer volume in the aspen forests is fairly constant with age, but begins to climb around age 80.

The actual number of trees per acre for balsam fir in the aspen covertype increases steadily to age 65. After age 65, the trends become erratic. Similar trends occur for white spruce and black spruce. The trend for white pine is an exception because the number of stems does not rise substantially until after age 95. These data suggest that, except for white pine, there is currently a sufficient conifer component in the aspen stands for future seed source and maintenance of conifers as aspen stands reach old age.

In summary, the data are helpful but incomplete. More data are necessary to determine at what age it is safe, on average, to harvest aspen stands without causing permanent future loss of the conifer component. In addition, the degree of site disturbance, time of year of harvest, amount of residual left after harvest, and other factors are certain to influence the successional sequence.

At this point, it is impossible to predict whether conifers will be lost in short rotation harvest. However, if a reduction in conifers did occur, the impact on biodiversity would be adverse and directly proportional to the level of harvest.

5.2.4 Forest Fragmentation

Fragmentation of forests changes the structural diversity of forested landscapes, but can affect all three components of biodiversity. These components of diversity are:

- compositional (number of species present in an area and the genetic variation within species);
- structural (spatial arrangement within and between stands and across regions); and
- functional (variety of natural processes occurring in a region).

The number of plant species within an isolated block of forest is roughly a function of the logarithm of land area and its distance to other blocks of forest. One effect of fragmentation involves a change in the *environment* within isolated forest stands. Small fragments of forest landscape provide a different environment from that provided by larger areas of forest. Small fragments provide more edge habitat, which can be characterized as having more light and more exposure to wind. Therefore, edge habitat generally has lower humidity and drier conditions than forest interior habitat. Certain groups of species have adapted to *edge* habitat, while other groups of species have adapted to forest interior habitats. Therefore, a landscape with many small isolated forest stands may ultimately exclude forest interior species.

A second effect of fragmentation is changing *competitive relationships* among species. An example is the relationship between plants such as grasses, and interior forest plants, such as woodfern and maidenhair fern. The ferns will grow better with more light at the edge of the forest, but they cannot compete with the grasses, which grow even better in high light.

A third potential effect of fragmentation is loss of local genotypes or ecotypes, because *inbreeding* may result if seeds and pollen, or individual animals cannot travel between woodlots. Inbreeding results in a decreased reproductive rate among many plants and animals. Genetically isolated islands of habitat must be large enough to maintain a minimum viable population so that inbreeding will not become significant.

There is an unknown *time lag* between the isolation of a block of forest, and a decline in the species richness that may later occur. This is because many forest species are perennials, such as trilliums, violets, ferns, shrubs, and trees, which live for many decades. If the structure or natural functions within a woodlot change so that some species can no longer reproduce, the species may not disappear for a century or more. During this time, it may not be clear whether or not a genuine failure of reproduction is occurring. By the time the failure of reproduction is noticed, it may be too late to save the population.

A fourth effect of fragmentation is *disruption of structure and function* of the landscape. Reducing a forested landscape to scattered fragments (e.g., Twin Cities metro area) impacts the extent of evapotranspiration occurring in the summer and could change the climate of a region. This can lead to a regional increase in mean summer temperature of several degrees F. The change in temperature could, in turn lead to further changes in species composition of forest remnants. Fragmentation can also lead to changes in water flow, soil building processes, and cycling of nutrients that affect the function of future forests. If the natural structure of the landscape is disrupted, it is difficult for species to respond to disturbance. Local catastrophes (windstorms or disease, etc.) may eliminate a species from a forest isolated by surrounding farmlands, or by other types of forest. Under natural conditions without fragmentation, migration of new individuals from adjacent stands would have allowed recovery of the locally lost species.

In Minnesota, two types of forest fragmentation occur. First, there is conversion to nonforest land uses such as field crops, leaving islands of forest surrounded by open habitat. Fragmentation of this type is highly significant in ecoregions 5, 6, 7, and parts of southern ecoregion 4. The second type of fragmentation—more relevant to future harvesting within densely forested northern Minnesota—is fragmentation within a forest. This concept deals with the juxtaposition of forests of different types and ages on the landscape. Fragmentation exists where small conifer stands are surrounded by large areas of aspen, or old growth is embedded within a large area of young forest. This is the case with pine forests in Minnesota, because much of the original pine has been converted to aspen. No detailed studies of within-forest fragmentation have been found for Minnesota. However, conifer patches in a hemlock-sugar maple patchwork in Upper Michigan are larger and have a more complex shape in primary forest than second growth. The result was that the landscape was better *connected*, in that plants and animals could disperse seeds or move relatively long distances while still being within a certain type of habitat.

It is important to realize that the landscape was fragmented prior to settlement. In Minnesota, the large number of lakes, frequent fires and windthrow contributed to a natural pattern of fragmentation on the landscape. However, land use and forest management can change the degree and type of fragmentation, as has happened in ecoregions 5 and 6. It is generally agreed among ecologists that managed forest landscapes are more fragmented than natural landscapes.

The model output did not have sufficient resolution to permit a detailed analysis of the implications of the base level of timber harvesting on fragmentation. However, certain conclusions can be drawn from the output and also from the assumptions that were used to formulate the runs.

The ownership constraints implemented as model constraints have important implications for fragmentation. First, any given ecoregion should, over time, develop a broad range of age classes. Older age classes will come about through old growth reservation, ERF, riparian zone management via BMPs, and forest that is not available for harvesting. Young age classes will develop from harvesting, fire or other disturbance. The expansion of forest area in the southern part of the state should also aid the linking of important habitat. The degree to which land use change and development will diminish the linking of forest areas is uncertain.

Inbreeding

The exact distance scale of isolation needed to cause inbreeding is unknown for forest trees and plants. The farther either pollen or seeds are dispersed, the more isolated a population can be without becoming inbred. Qualitative assessment of susceptibility to inbreeding due to fragmentation is possible, based on general knowledge of seed and pollen dispersal (see table 5.12). No significant fragmentation impacts due to harvesting are expected in Minnesota for species listed in the very low or low susceptibility groups. This is because the species are widespread, and few populations are isolated by more than a few miles in Minnesota, the one exception being woodlots in ecoregion 7. On the other hand, timber harvesting will usually have a significant impact on the genetic architecture of forest herbs listed as high susceptibility (table 5.12). The imposition of a different covertype between two populations only a few hundred yards apart could cause a loss of gene flow between populations. This may result in inbreeding and the loss of some populations.

However, other populations of forest herbs will have a large enough number of individuals and enough variability within one population so that the population is viable, even when isolated. If the gene flow is cut off, isolated populations could evolve into new varieties and (after a few thousand years) new species. This is exactly how the dwarf trout lily, which occurs only in southeastern Minnesota, is believed to have evolved from the white trout lily. There is no way to assess the number of species that would be affected without a detailed map of individual timber harvests.

Table 5.12. Qualitative estimate of susceptibility to inbreeding due to fragmentation. The same species listed as high susceptibility (forest herbs) to inbreeding, species or groups of species in Minnesota. Pollen and seed dispersal effective distances: VL= very long distance (more than 2 miles), L=long distance (0.5-2 miles), M=medium distance (0.1-0.5 mile), S=short populations. The spatial scale of forest operations is similar to that of distance (<0.1 mile).

Species/Group	Pollen/Seed Dispersal	Geographic Scale of Genetic Variation	Overall Susceptibility
Aspen	L/VL	Ecoregion	Very Low
White, red and jack pines, birches	VL/M	Ecoregion	Low
Berry producing shrubs, cherry, mountain ash	S/VL	?	Low
Oaks	L/L	Ecoregion	Low
Spruces, white cedar, tamarack	M/M	Ecoregion	Medium
Walnut, hickory	M/S	Ecoregion	Medium
Maples, basswood, fir	S/M	Ecoregion	Medium
Forest herbs[a]	S/S	Township/county or smaller	High

Source: Jaakko Pöyry Consulting, Inc. (1992e).
[a] Forest herbs includes hundreds of species, and exceptions to short distance pollen and seed transport are sure to occur.

Direct Loss of Genetic Diversity

The same species listed as having high susceptibility to inbreeding (forest herbs), also have relatively fine-scale spatial differences in gene frequencies among populations. The spatial scale of forest operations is similar to that of genetic structure of forest herbs. Therefore, losses of distinctive genetic material of forest herbs caused by changes of covertype, such as plantations that extirpate local populations, will occur as a consequence of forest harvesting.

Species of the low susceptibility group are unlikely to be greatly impacted with the exception of habitat islands, such as swamp conifers separated by many miles (mainly ecoregions 5 and 6). In addition, other outliers (i.e., sugar maple in ecoregion 3) may have genetically distinct populations that would be lost if covertype conversions occurred.

Relationship of Fragmentation to Old Growth

Old growth forests are generally *interior* forests. Old growth communities are those that have an environment of low light (except for the top of the canopy), high humidity, and low windspeed. Old growth areas of 20 acres or more (MNDNR minimum area criterion), probably have some interior-type habitat in the middle. The entire area of a 20-acre stand can be interior forest if a 300-foot wide buffer surrounds the stand. Therefore, buffers are an important component in maintaining old growth interior habitat. Harvesting these buffers can cause impacts on the habitat value of the old growth. Some animal species such as Pileated Woodpeckers require 100 acres or more of contiguous forest.

Relationship of Fragmentation to Climate Change

Timber harvesting at all levels can cause fragmentation that may interfere with the ability of species to adjust to their range when the climate changes in the future, thus impacting genetic diversity of forest herbs and trees.

5.3 Physical Resource Impacts

Harvesting activities will change aspects of the physical or nonliving environment. This section discusses the types of impacts affecting forest soils and water resources (water quantity and quality) expected to occur at the base level of timber harvesting.

5.3.1 Soil Resources

Productivity and Nutrient Availability

All forest harvests remove nutrients contained within the product being removed. Some harvesting activities may also displace nutrients from sites where trees are growing and concentrate them at a single site (e.g., removing branches and tops at the landing rather than at the stump). Finally, some activities associated with preparing a site for subsequent regeneration may also displace and concentrate nutrients (e.g., windrowing as a site preparation technique).

Nutrients are continuously being added to forests through atmospheric deposition and by geological weathering, and being lost by leaching. Over the long-term, rates of removal that exceed rates of replenishment can be considered to be *mining* the nutrient capital of a site. The initial nutrient capital of a site (i.e., the nutrients stored in the soil) should also be considered when nutrient removal is assessed as it affects the degree of nutrient depletion at a site over a rotation. Therefore, although a site may irreversibly lose nutrients, the amount may be a small proportion of the nutrients present on a site with high initial capital. In that case, the mining may be considered relatively insignificant and economically and biologically justifiable. Sites with low capital will be more heavily impacted by equivalent amounts of nutrient removal without replenishment. Impacts will be increasingly severe as the nutrient capital of a site is depleted over many rotations.

Impacts will occur wherever harvesting activities are conducted. As described above, impacts will be most severe on sites with low nutrient capital. These sites can be broadly categorized as those on coarse-textured soils. Such soils occupy about one-fourth of the forested area of Minnesota, or about 4.5 million acres (based on Land Management Information Center [LMIC] forest covertype and soil maps) and are scattered throughout the forested parts of the state.

Data on nutrient removal by harvest and on nutrient additions by atmospheric deposition are comparatively good; it can be assumed that they are accurate with uncertainties of less than an order of magnitude. Similarly, nutrient capital of soils classified into general texture and drainage classes can be estimated with an uncertainty of less than an order of magnitude. There is, however, large uncertainty associated with rates of return of nutrients via geological weathering.

Another major source of uncertainty is the precise quantification of the relationship between quantity of nutrients and stand productivity. Using agricultural experience as an analog, it is known that depletion of nutrients leads to reductions in productivity. In some areas (e.g., upstate New York), soils that have been depleted of nutrients by agricultural activities cannot support normal forest growth without nutrient additions; even species with low requirements require added nutrients. The addition of nutrients via fertilization (especially N and P) to some forests (in the Pacific Northwest and the southeast U.S., respectively) can increase productivity. Although there are suggestions of *second-rotation* productivity declines in pine plantations in the Southern Hemisphere, the cause of such declines has not been unequivocally determined. Part of the uncertainty is due to the characteristics of natural forest systems; systems that are low in nutrients are often also limited in available water and have other characteristics that make them less suitable for tree growth than high-nutrient sites. Experiments that demonstrate decreases in productivity with nutrient depletion have not been carried out. In summary, quantification of the relationship between productivity and nutrient quantity, especially under conditions of nutrient depletion, is lacking.

The time required to replenish a site subject to nutrient depletion can be long-term. If the interval between harvests or other disturbance is long enough, natural processes will replace nutrients and the site will regain its original nutrient capital. Where large quantities of nutrients have been removed from a site that has low rates of natural replenishment, such restoration will require more than 50 years and is, therefore, considered to be long-term. Artificial nutrient addition via fertilization can shorten the duration of the impact.

Under the base scenario, and harvesting the merchantable bole, 1.8 million acres of forest land are projected to lose potassium, 5.0 million acres to lose calcium, and 2.7 million acres to lose magnesium in excess of their replenishment. It should be noted that these assessments of area are not additive, some soil type/covertype combinations are projected to lose two or more nutrients. Both phosphorus and nitrogen are projected to be adequately replenished by natural processes. Almost one million acres associated with potassium loss are coarse-textured soils, and about 700 thousand acres are organic soils. About half the area (2.5 million acres) associated with calcium loss is medium-textured soils, and 1.7 million acres are coarse-textured soils. The large area of medium-textured soils associated with calcium loss is related to the predominance of aspen-birch on those soils, and to the high levels of calcium in the bark of aspen. Coarse-textured and organic soils each account for about one-third of the total acres projected to be depleted of magnesium under the base scenario.

Impacts on Total Nutrient Capital

The loss of each of these nutrients should be evaluated with respect to the nutrient capital present on the sites. For example, potassium losses are the highest proportion of the capital of any of the three nutrients of concern. On coarse-textured soils, potassium losses are about half of the capital. Fortunately, potassium is quickly replenished so losses are replaced in about 40 years. On medium-textured soils, potassium losses are about a third of the capital, and are replaced within about 20 years. Because potassium is replaced at a rapid rate, less area is associated with its depletion than is associated with the depletion of calcium and magnesium. Although the latter two nutrients are depleted from more acres, on most sites depletion is a smaller proportion of total capital. For example, on the average coarse-textured soil, calcium losses associated with harvest are about 10 percent of the capital; harvest removes a smaller proportion on medium- and fine-textured soils (about 5 percent). In the case of magnesium, harvest also removes about 10 percent of the capital on coarse-textured soils but only about 2 percent on fine soils.

Organic soils are a special case because they do not have an input of mineral weathering to replenish nutrients; they depend on atmospheric deposition. Organic soils are commonly recognized to be low in potassium. Harvest removes most of the immediately available potassium on organic soils and rates of replenishment are low; about 100 years are required to rebuild potassium reserves to their original level. Conversely, only about 5 percent of the calcium and magnesium reserves on organic soils are lost by harvesting.

Utilization Levels

The volumes of wood removed and utilized affect the amounts of nutrients removed. Both phosphorus and nitrogen are naturally replenished at adequate rates, irrespective of utilization levels. The other three nutrients, magnesium, potassium, and calcium, differ in their biogeochemistry and therefore, the impact of increased utilization on their loss also differs.

If harvest is restricted to the bole (i.e., the trunk) with the bark stripped off (*bole-only*), then magnesium is not adequately replenished on about 1.4 million acres of harvested forest land under the base scenario. About half of this area is fine-textured soils where magnesium is naturally being lost at a greater rate than it is being replaced; harvest does not affect that loss. For these soils, each rotation removes less than 2 percent of the total magnesium capital. The other large area of magnesium loss, about half of the 1.4 million acres, are organic soils. In this case, harvest removes about 5 percent of the magnesium capital. Removing only the bole, without bark, has a relatively small impact on the magnesium capital of sites.

In contrast, full-tree harvest has significant impact on magnesium depletion, affecting 4.1 million acres of forest land under the base scenario. Under full-tree harvesting, the bole, bark, branches, and leaves/needles are removed from the stump. Major areas of magnesium loss associated with full-tree harvest under the base scenario are coarse-textured soils (about 1.8 million acres) and organic soils (about 1 million acres).

Potassium behaves similarly to magnesium, showing marked increases in the area of land affected as utilization increases from bole-only to full-tree (to about 3 million acres under the base scenario). Potassium is primarily stored in the tree's leaves and branches, which are retained on site in both bole-only and merchantable bole (bole and bark) harvests.

Because of its high levels in bark, but lower levels in branches and leaves, differences in area of calcium loss between bole-only and merchantable bole (with bark) removal are significant. If the harvest is restricted to bole-only, the area at risk decreases from 5.0 million acres to less than 1.5 million acres under the base scenario. The increase in area with significant calcium loss when utilization shifts from merchantable bole to full-tree harvest is relatively smaller (about 1 million acres).

Other Aspects of Forest Management

Other aspects of timber harvesting and forest management can impact the nutrient status of harvested sites. These are discussed below.

Delimbing and topping: Based on the summary of timber harvest operations carried out as part of the GEIS, delimbing and topping is carried out at a landing in about one-third of the harvests. This practice does not recycle or replenish the nutrients on the site, and is equivalent to a full-tree harvest in terms of nutrient depletion. The area estimates developed for harvest of merchantable bole should be increased to take this practice into consideration. The area affected by potassium loss should be multiplied by 2.25, for calcium loss by 1.5, and for magnesium loss by 2.0 to account for the present extent of delimbing and topping at landings.

Mechanical site preparation: Nutrient depletion varies depending on site preparation techniques. A survey conducted for the GEIS estimated that about 18,000 acres are affected annually by mechanical site preparation. Site preparation techniques that displace material can significantly alter site nutrient status. Mechanical techniques that create slash piles or windrows either remove nutrients from the site or localize them, depleting the remainder of the area. In contrast, site preparation techniques that incorporate materials, or only displace materials a few feet, will not produce those negative impacts.

Compaction: Physical damage to soil structure, notably compaction, can occur in the course of harvesting. Whether or not a site is impacted depends on certain variables such as season of harvest and related site factors, soil type, equipment used, and harvest and related road planning.

Soil sensitivity to compaction is a function of soil strength which is governed by soil physical structure, texture, and moisture status. Soils with low strength are unable to support the heavy equipment used in some forest management activities. Also, because of the likely higher levels of compaction, the time needed for recovery of soil physical structure is greater for soils exhibiting low strength. The most sensitive soils are wet soils with a high percentage of silt and clay, and organic soils. It is expected that one to three equipment passes would result in at least a moderate level of site disturbance on the most sensitive soils. Soil sensitivity decreases with increased sand and coarse fragment content or drier conditions. On moderately sensitive soils, four to twelve equipment passes would cause at least a moderate level of disturbance. Sites with the lowest sensitivity are the coarsest, driest sites. More than 12 equipment passes would be required to cause a moderate level of disturbance on these sites.

The seven soil groups identified for the GEIS analysis can be categorized according to their relative sensitivity to physical damage. Soils that are more susceptible when wet appear under more than one category to account for seasonal differences. Soils can be in one of three conditions—wet, dry, or frozen. Soil water status is highly correlated with season, though it is also a function of the texture and drainage class of the soil. Soil water status (and hence season) is a major factor in determining the sensitivity of a site to equipment impacts.

In summary, the degree of compaction is highly variable and depends on combinations of the above variables. The proportion and degree of compaction on a site can range from slight compaction, which ranges from no disturbance up to light scarification; moderate compaction, which shows depressions up to 2 inches deep in the mineral soil; and severe compaction, which shows depressions or ruts in the mineral soil greater than 2 inches deep. All of the area occupied by haul roads is severely impacted.

Compaction reduces site productivity because less soil is available for root development. In addition, site hydrological processes are altered. More overland flow of water is generated, leading to increased potential for erosion and subsequently sedimentation. Additional research is required to fully quantify the effects of these disturbances on Minnesota's forest resource. Although, it has been clearly documented that compaction and related disturbance reduces forest growth, the magnitude and duration of the impact is uncertain. Further uncertainty is added by the fact that, for the purposes of growth, trees adjacent to forest openings may benefit from less canopy competition, thereby reducing the impact. Impacts are likely to persist over the short- to long-term. Recovery rates vary and depend on the severity of damage and the rate of recovery of soil physical characteristics; however, these relationships are not well understood and more data are required.

Based on the 4.0 million cord level of harvesting and the seasonal distribution of harvesting activities outlined in the Silvicultural Systems background paper (Jaakko Pöyry Consulting, Inc. 1992m), approximately 840,000 acres would be vulnerable to moderate or severe compaction within areas harvested and an additional 60,000 acres would be impacted in areas developed as haul roads, assuming haul roads occupy an area equal to one percent of the area harvested.

The type of harvesting equipment used can have a major influence on how much of these sites is actually affected. Approximately 30 percent of highly sensitive sites harvested using hand-felling operations are likely to be compacted, compared with approximately 55 percent for mechanical-felling operations. It was estimated that about 25 percent of the area within moderately sensitive sites would be negatively affected by equipment trafficking for both harvesting configurations.

Based on the above percentages and estimates of the proportion of harvesting operations using hand and mechanical harvesting, it is possible to calculate crude estimates of the potential impact of compaction and related disturbances on future productivity. It was estimated that under the base scenario, the *actual* area moderately or heavily compacted within harvest units totalled approximately 330,000 acres. An additional 60,000 acres would be impacted assuming that 1 percent of the area harvested is occupied by haul roads. Assuming that productivity is reduced by 25 percent in lightly trafficked areas, by 50 percent in heavily trafficked areas, and by 75 percent in haul roads, these impacts would translate to losing the wood-producing equivalent of as much as 170,000 acres under the base scenario.

The statewide results are not distributed evenly between soil types. Most harvesting occurs on well-drained medium-textured soils followed by well-drained coarse-textured soils. As discussed, there are significant differences in the sensitivity of varying soil types to harvesting impacts. The well-drained fine-textured soils, poorly-drained fine-textured soils, and the poorly-drained medium-textured soils are the types most susceptible to these impacts. This is because of the lower soil strength associated with finer soil textures and wetter soil conditions. In contrast, well-drained, coarse-textured soils rarely experience such impacts. The disparities between soil types means that compaction impacts will be more widespread in ecoregions containing higher proportions of the more sensitive soils.

This is illustrated by comparing the relative level of impacts likely in two ecoregions. Ecoregion 1 is dominated by an old lake bed and thus contains a high percentage of poorly-drained, fine-textured soils. In contrast, ecoregion 2 has a low percentage of the three most susceptible soils. It was estimated that 27 percent of the area harvested in ecoregion 1 would be significantly impacted, compared with only 8 percent of the area harvested in ecoregion 2.

Soil Erosion: Forest management activities have the potential to affect site quality if they result in an erosion rate greater than the soil loss tolerance value (T value) as defined by the Soil Conservation Service. The T value is strongly based on the rate of soil formation. Soil formation processes vary considerably and this is reflected in the variation between one and five tons per acre. Variation in the rate of formation is due to several factors including: depth of loose materials above bedrock, climatic conditions (particularly temperature and precipitation), parent material, topography, and vegetation. The T index has been developed for use in agricultural areas. An analogous index has not been developed for use in forests. Consequently, all erosion work in forests has been compared with established T values, resulting in a substantial body of literature from which to consider when assessing impacts.

The impact timber harvesting has on the rate of soil erosion depends on many variables including soil type, site conditions, season, application of water quality BMPs, and timber sale layout and design. Typically, lower levels of erosion occur with care in the location, construction, and maintenance of roads and use of soil conservation measures identified in BMPs.

Erosion impacts vary from short- to long-term. Short-term impacts are associated with the soil loss that accompanies typical harvesting operations prior to revegetation. Longer-term impacts occur when the quantity of soil eroded would require many decades to replace at the prevailing rate of soil formation.

Soil loss impacts site productivity by removing nutrients bonded to eroded particles and by reducing the volume of soil available on the site. Nutrient loss can be exacerbated by losses of the organically rich upper horizon due to surface erosion. Offsite impacts can occur via sedimentation, which reduces water quality and can adversely affect aquatic ecosystems.

Moderately and heavily trafficked areas (skid trails) within harvest units and on haul roads are the areas most likely to be eroded. Erosion is most likely to occur in well-drained mineral soils on steeper slopes.

Under the base scenario, it is estimated that about 25,000 acres subject to harvesting would develop erosion rates that exceed T values. Accelerated erosion caused by skidding and felling activities would exceed T values on less than 1 percent of the total area harvested during the 50-year period.

The greatest erosion rates were estimated to occur in ecoregion 6, particularly a period 1 to 4 years following disturbance when sites are most exposed to erosive forces. This ecoregion has the steepest slopes (averaging 45 percent in many areas) of any ecoregion. The southern portion of the state also has the highest rainfall intensity. It was estimated that initial erosion rates could exceed 14 ton/ac/yr in some areas in ecoregion 6. Initial erosion rates were generally less than 5 ton/ac/yr in other ecoregions.

If an area equal to 1 percent of the harvest area were utilized for haul roads, T values would be exceeded on an additional 6,000 acres under the base scenario. These totals indicate that erosion rates would be exceeded on about 8 percent of the haul road area.

Erosion associated with haul roads would occur faster than erosion on other areas of the harvested site. This is because of the more complete removal of surface protection and smoothing of the ground surface in haul roads. The analyses indicated that maximum initial erosion rates in haul roads could approach 100 ton/ac/yr in some areas.

The effects of timber harvesting and forest management activities on slumping (referred to as mass movements) were not quantified. These activities would increase the probability that mass movements would occur. The literature suggests that mass movement events may at least double following timber harvesting. Poorly located roads pose the greatest risk for triggering mass movement events and can increase the risk up to 25-fold. This is particularly true when road construction activities disrupt marginally stable slopes. The greatest potential for mass movements would occur in areas with steep slopes such as the Coulee region of southeastern Minnesota (in ecoregion 6) and areas with shallow soils over bedrock (ecoregions 2 and 3). However, there is currently no evidence suggesting that mass movements are a major problem in forested portions of Minnesota.

The results of the GEIS analysis are consistent with other reports, finding that surface erosion would rarely exceed T values within harvest units but can be a major concern in conjunction with skid trails and haul roads. These results are attributed to the rapid revegetation and surface roughness within harvest units, which greatly reduces the surface erosion that will occur there. The initial removal of vegetation and forest litter is much more complete in heavily trafficked areas which leads to higher initial erosion rates.

Accelerated erosion was evaluated in the GEIS as a short-term impact (i.e., recovery after four years). If the soil loss had been averaged over a longer period, such as the rotation length, then erosion rates would have exceeded T values in fewer areas.

It appears that accelerated erosion within harvest units due to timber harvesting activities will have a minimal effect on forest productivity in Minnesota. This judgement is based on the minimal area within harvest units (less than 1 percent of total harvest area) where initial erosion rates >T are projected to occur. Furthermore, in terms of productivity, T values represent the annual amount of soil that can be lost indefinitely—not just over the first four years following harvesting.

The higher erosion rates that would occur on haul roads may be more important in terms of water quality impacts. As discussed above, compaction and related disturbances on haul roads would greatly reduce the productivity of these areas. It would be difficult to evaluate the added effect of erosion on productivity. However, the large amount of soil that can be eroded from roads can contribute greatly to water sedimentation problems.

5.3.2 Water Resources

Waterbodies in Minnesota's forested regions are generally of high quality and are not currently subject to significant broad-scale impact from forest management practices. However, these water resources do have local impacts at a variety of spatial and temporal scales. The types of impacts that can occur as a consequence of forest management include: sedimentation; nutrient loading; changes to key aspects of the aquatic environment (discussed further in section 5.4.2) such as the amount of light, stream temperature and organic matter inputs—leaf litter, and larger woody material; and changes to the amount, duration, and timing of runoff.

Sedimentation

At the statewide level assessed in the GEIS, there is a low risk of high rates of sediment production resulting from levels of timber harvest and forest management activities depicted in the base harvest scenario. Minnesota's relatively flat landscape reduces the ability of water to transport sediment from the land surface to water. Roads in most areas of the state do not contribute much sediment input for precisely the same reason; i.e., surface flow is restricted by generally flat to gently sloping terrain. As discussed under soil erosion in the previous section, some areas of the state exhibit naturally high rates of erosion and sediment production. Past experience suggests that incautious harvesting in these areas of steeply sloping, variable terrain with highly erodible soils carries an increased risk that disturbed areas will erode, leading to increased sedimentation of local water bodies. In Minnesota, the North Shore and Nemadji areas and the karst areas of the southeast are areas of high erosion potential, with or without harvest activity.

The levels of harvest projected to occur under the base scenario are not predicted to significantly affect the quality of the state's waters when assessed at the ecoregion scale. The development and application of BMPs is an important factor that reduces the likelihood of impact. BMPs are a set of standard practices that are intended to achieve a balance between forest management activities and water quality protection. The types of practices covered by BMPs include retention of filter strips between harvest sites and water courses and undertaking earthworks to control erosion on disused haul roads. BMPs are applied on a voluntary basis in Minnesota. Most timber harvest in Minnesota now follows BMPs. Recent evidence based on field audits of recently harvested areas indicates the percentage of sites complying with BMPs varies according to ownership. The lowest level of compliance, around 70 percent, is on nonindustrial private forests. Compliance on the industrial private lands and public ownerships is very high, nearly 100 percent. The GEIS assumed slightly more conservative compliance levels of 50 percent for nonindustrial private forest lands and 90 percent for all other ownerships. These assumptions were used in impact analyses conducted as part of the study.

Implementation of BMPs in areas of high slopes and erodible soils will reduce the level of sediment related impacts, as will restricting harvest activities to less sensitive times of the year. The literature suggests that it is safe to assume little deviation from expected levels of sediment production on timberlands managed with BMPs. The relative size of the projected areas harvested without BMPs is small and does not significantly increase the rate of sediment production at the ecoregion scale. Site-specific impacts in erodible areas can be expected in areas that do not follow BMPs. The most effective way to minimize sediment impacts is to increase use of applicable BMPs for all timber harvest.

Land use changes that convert forest to agricultural or urban uses can increase sediment production. If large, contiguous tracts of land become the harvesting norm, then large areas of high site disturbance will appear and these could alter sediment equilibria. The scenarios examined in the GEIS are expected to follow standard silvicultural techniques where trees replace trees, rather than representing land use conversion. Thus, harvested forest sites will be assumed to remain under forestry land use following harvesting. Sediment relationships will not significantly deviate from the level of natural variation as long as sites remain forested. Use of mechanical site preparation techniques to regenerate sites exposes waterbodies draining those sites to greater risks of sedimentation. Lower risks occur if techniques requiring no mechanical disturbance of the soil are used. The Silvicultural Systems background paper (Jaakko Pöyry Consulting, Inc. 1992m) estimated that only approximately 11 percent of regeneration areas were prepared using mechanical techniques.

Nutrient Loading

Results from studies in Minnesota suggest that instream concentrations of nitrate and phosphorus are not likely to increase with increased levels of timber harvest in the Northern Lakes and Forests and North Central Hardwoods ecoregions. However, total loadings (i.e., the total amount yielded from a given area in a given time) are likely to increase temporarily due to increased water yields associated with harvesting.

Nutrient increases in waterbodies following timber harvesting in catchments have been reported in the literature from other states. Increased stream nitrate following timber harvest occurs in many areas, particularly the eastern United States. The most significant increases have been reported in Hubbard Brook (NH), Tennessee, and Arizona. In general, sites in New Hampshire, Tennessee, southern Canada, and Arizona had comparable increases following harvesting while other areas of the country had lower increases in nitrogen export. Increases in stream phosphorus have been reported much less frequently.

The impact of timber harvest on lake nutrient levels has not been studied in Minnesota, but the effects on streams draining areas burnt by wildfire offers some insight. Results from wildfire studies cannot be directly extrapolated to timber harvest scenarios in Minnesota, certain parallels can be drawn. These suggest that increased timber harvest by itself is not likely to pose a significant threat to the nitrogen balance of lakes or streams in Minnesota. Predicted increases in phosphorus concentrations in steams and lakes will not reach levels likely to cause eutrophication of lakes or streams.

Runoff From Uplands

In general, water yield from upland mineral soil watersheds increases as forest cover is reduced. These increases in water yield are observed from normal timber harvesting or clearing of land that is converted to croplands. The important difference between timber harvest and land conversion is that with normal timber harvesting, hydrologic changes diminish as the stand regrows on the site. In the case of land that is converted to agriculture or urban development, hydrologic changes are more permanent.

The magnitude of increased water yield is generally proportional to the percentage of a watershed cleared at any one time, and depends to some extent on the type of forest cover harvested or cleared and stand characteristics (i.e., density). Also, the greater the annual precipitation, the greater the increase in water yield will be due to harvesting. These generalities apply to all ecoregions and forest types in Minnesota with one exception: clearcutting black spruce in peatlands has no effect on annual water yield, although the pattern of streamflow response is altered.

Clearcutting of forests can alter streamflow pattern in two ways: (1) magnitude of stormflow peaks and volumes may be affected; and/or (2) magnitude of streamflow discharge during dry season flow may be affected. These effects have not been studied for every forest type and ecoregion in Minnesota. However, some generalizations can be made, particularly for the northern hardwoods, which has been studied.

Stormflow and *flooding* need to be defined precisely to avoid confusion concerning the effects of timber harvesting. Flooding refers to events in which streamflow exceeds bank full capacity of the streambank and overflows, sometimes causing economic damage or even loss of life. Rises in streamflow which have distinctive peaks and result in greater than normal flows are referred to as stormflow events; some of these result in flooding, while others do not. Hydrologists rate the magnitude of peaks based on the frequency with which they are expected to occur in the future. For example, a 5-year recurrence interval (RI) peak would be expected, on the average, to be equaled or exceeded once every five years. Therefore, there is a 20 percent probability that in any given year the peak would be equaled or exceeded. The magnitude of the 5-year RI peak would be smaller than that of the 20-year RI, which would be smaller than of the 100-year RI. Effects of timber harvesting on stormflow must be discussed in terms of magnitude and RI.

For a given RI, the peak discharge (or maximum flow rate) of stormflow can be increased on small catchments by forestry activities. Peak flow can be sensitive to any modification in the catchment, including minor variations in road or skid trail layout and density, or harvest location and intensity.

Stormflow volumes and peaks can be affected by timber harvesting and forest management activities in the following ways:

- removal of forest cover can increase stormflow volumes and peaks with relative effects diminishing as the amount of snowmelt and/or rainfall causing the stormflow becomes very large;
- activities that reduce infiltration of water into the soil cause more surface runoff and can promote greater stormflow from rainfall events. These occur locally, in association with compacted soils due to roads, skid trails and/or recreation sites;
- development of roads, skid trails, and drainages that facilitate movement of water from an area to stream channels can promote higher peakflow. Such activities may be separate from or in support of logging activities; and
- activities that increase delivery of sediment into stream channels reduce the conveyance capacity of the channel and can result in more frequent over bank flow (i.e., flooding).

Because timber clearcuts are normally small areas, increases in peak flows would be important only in certain instances, including:

- determining the size of culverts for temporary roads (e.g., logging roads);
- small stream confluences in which more frequent large flows could damage stream channel morphology; and
- trout streams with considerable sediment and/or debris are present within a channel where they can be affected by more frequent, high level discharge.

Timber harvesting activities on upland sites will not affect the flood characteristics of larger river systems. This is because harvesting and regenerating trees within a predominantly forested area will not cause large changes in peak flows for large areas. However, forest landscapes that are cut and converted to croplands or pastures can produce more permanent increases in streamflow discharge and often greater amounts of suspended sediment.

Low relief terrain and high water tables cause wetlands to act much like lakes (see below). When wetlands and lakes make up between 5 and 20 percent of the total area of a basin and are connected to the major drainage system, they can reduce peak flows by up to 75 percent compared to watersheds without lakes or wetlands.

The first large snowmelt of the year often produces the highest peak flow event of the season. Forests can influence snow accumulation and timing of runoff peak discharges. Peak flows from harvested or nonforest areas can occur five days earlier than from mature forest areas. A mosaic of mature forest together with harvested or nonforest areas has the effect of desynchronizing peak runoffs within a watershed, and thus lowering the combined peak discharge at the watershed confluence. Forest stands up to 15 years of age can be combined with nonforest areas in this context, in order to assess their effect on spring snowmelt. As a result, in the northern portions of the state where snowfall accumulates throughout the winter without complete melt off until spring, snowmelt peaks can dramatically increase if forest cover on a watershed is reduced from 50 percent of the total area to 30 percent or less.

No adverse effects to water quantity or the pattern of streamflow in any ecoregion are predicted under the base harvest scenario. However, on a site-specific basis water yield might increase. Stormflow might increase on small watersheds; however, none of these changes would be evident at the ecoregion level.

Annual Water Yield From Wetlands

The influence of timber harvest on evapotranspiration from wetlands is closely related to the depth of water table. Where the water table depth is normally less than 12 inches (as measured from hollow bottoms), herbaceous layer plants proliferate after timber harvest and can transpire as much or more water as did the trees. Where the depth to water table is greater and wetlands have fine-grained mineral soils, transpiration rates of shallow rooted herbaceous layer plants remaining after timber harvest do not equal those of deeper rooted trees. In the latter case, water yield response is more similar to that of upland areas, with increases following clearcutting commonly 20 to 30 percent of pre-impact conditions.

When the water table depth is normally less than 12 inches and annual precipitation is within 30 percent of average, harvesting trees on natural peatlands does not affect average water table elevation or annual water yield.

No estimates of effects of timber harvesting on annual water yield outside of this range of precipitation were found. Therefore, no change in annual yield from wetlands due to timber harvesting and forest management activities under the base level scenario is predicted.

In addition to water quality impacts from natural sources there are other potential sources related to human land uses. These sources include fertilizers, compost, sludges and pesticides.

Fertilizers
There is minimal, if any, fertilization of forest lands in Minnesota. This is unlikely to change. Therefore, there are no demonstrable effects of forest fertilization at present, and none are predicted.

Compost
Compost is not currently used on Minnesota forested lands. Future field studies would have to be employed to determine the site-specific impacts of such applications. It is not anticipated that such use will have regional implications under any scenario.

Sludge
Municipal sludge is currently used on only one forested site in Minnesota. Water quality impacts from that application are not evident. Future field studies would have to be employed to determine the site-specific impacts of future applications. It is not anticipated that such applications would have regional implications under any scenario.

Pesticides
Pesticide use currently is minimal on Minnesota forested lands. Under the present usage pattern there is estimated to be less than 18,000 acres treated annually for site preparation and release (Jaakko Pöyry Consulting, Inc. 1992m). If this level of usage continues, no regional impact on water resources is anticipated. In the event that nuisance outbreaks (e.g., gypsy moths) require large-scale spraying, impacts of forest insecticides could be significant. There is currently no evidence to suggest that such impacts will occur, nor that increases in nuisance outbreaks would be correlated with harvest scenarios.

Summary of Cumulative Impacts by Scenario for the Base Scenario
As previously stated, timber harvesting for the base scenario is not likely to alter the quality of Minnesota's water resources. However, if harvesting occurs without widespread *adherence to BMPs*, smaller watersheds (i.e., <third order) would exhibit a variety of local scale changes, as described in tables 5.13 and 5.14. Probably the most dramatic of these small-scale changes would be increases in sediment production in streams, increases in light and decreases in large woody debris in streams and lakes, and decreases

Table 5.13. Worst case (without BMPs) site-specific water resource impacts projected under the base level harvest scenario.

Variable	Ecoregion	Predicted Change
Streamflow volume	All	Localized increases in first and second order watersheds
Light reaching streams	1,2,4	Increase
Stream temperature	1,2,4	Increase
Stream sediment	6	Increase, high uncertainty
Stream organic matter	1,2,3,4,5,6	Small but variable decreases in all but 4; major and variable decreases in 4
Stream coarse woody debris	1,2,3,4,5,6,7	Small but variable decreases in all
Stream periphyton	1,2,3,4,6	Small but variable increases in all but 4; larger and variable increases in 4
Stream macroinvertebrates	1,2,3,4,6	Small but variable increases in all but 4; larger and variable increases in 4

Source: Jaakko Pöyry Consulting, Inc. (1992d).

Table 5.14. Summary of predicted worst case (no BMPs) site-specific impacts to the fish community.

Fish Community	Ecoregion	Predicted Change and Comment
Coldwater streams	2	Small decrease with relatively high uncertainty
	3	Slight decrease with relatively high uncertainty
	4	Decrease with relatively high uncertainty
	5	Slight decrease with relatively high variability and high uncertainty
	6	Large decrease with relatively high variability and very high uncertainty
Coldwater lakes	4	Slight decrease with high variability and very high uncertainty
	5	Slight decrease with relatively high variability and very high uncertainty
	6	Slight decrease with very high variability and very high uncertainty
Coolwater streams	1	Decrease with relatively high variability and relatively high uncertainty
	2	Slight decrease with relatively high variability and very high uncertainty
	3	Slight decrease with relatively high variability and very high uncertainty
	4	Decrease with relatively high variability and relatively high uncertainty
	5	Slight decrease with relatively high variability
	6	Decrease with very high uncertainty
Coolwater lakes	1	Slight decrease with high variability and very high uncertainty
	2	Slight decrease with relatively high variability and very high uncertainty
	3	Slight decrease with relatively high variability and very high uncertainty
	4	Slight decrease with relatively high variability and very high uncertainty
	5	Slight decrease with relatively high variability and very high uncertainty
	6	Slight decrease with very high variability and very high uncertainty

Source: Jaakko Pöyry Consulting, Inc. (1992d).

in stream fish population densities in some regions (especially ecoregions 1, 4 and 6). Small watersheds harvested with BMPs would still have increases in nutrient loads, sediment loads, stream channel morphology and would have altered, but not necessarily worsened the structure and functional rates of the aquatic communities. These changes would generally be limited to a few hundred meters below a timber harvest site. With respect to the fish community, harvesting with BMPs would effectively eliminate the changes predicted in table 5.14, i.e., there would be no impact.

5.4 Biological Resource Impacts

5.4.1 Plant and Animal Species Abundance and Diversity

Animals

In assessing significant impacts, the GEIS analysis assumed that current population levels are appropriate and that deviation from those is a basis for concern. However, target population levels for many species could logically be considered either higher or lower than those that exist today. The current population levels are a function of a complex history, the present extent, composition and structure of Minnesota's forests, and several exogenous factors. Given that the current forest age class structure is far from balanced, then it is possible that habitat dependent wildlife population levels are also out of balance and target populations higher or lower than present may deserve consideration.

Minnesota's forest dependent wildlife can be broadly categorized under four separate subgroups—small- and medium-sized mammals, large mammals, birds, and herptofauna (amphibians and reptiles). Within each of the four subgroups certain species depend on forested habitat for their survival. Species that meet this criterion include 22 small- and medium-sized mammals, 5 large mammals, 138 birds, and 12 herptofauna.

Timber harvesting and forest management activities can alter the habitat value of stands for these various species and species groups. A wide range of habitat factors can change as a consequence of harvesting. These changes can either reduce or enhance habitat values with the potential to impact animal populations accordingly. The following example illustrates these linkages between habitat and population.

Grey squirrel and fox squirrel are strongly dependent on trees that produce food, especially oaks, hickories, and walnuts. These species also use tree cavities as nests and to store food. Complete clearcutting of a stand removes all trees that provide food and cavities, making the stand unsuitable habitat.

After decades, the second growth stands acquire the habitat values required by these species, becoming suitable habitat for these species again.

Statewide data were available for two key factors affecting the habitat value of forests that are relevant to wildlife populations, and are likely to change as a consequence of timber harvesting. These factors are tree species mix and the age or size classes of these trees.

Based on the imputed characteristics of these covertype/age (or size) class combinations, other assumptions regarding the presence or absence of habitat elements can be made. For example, cavities are likely to be found in a 150 year old stand whereas they are not likely to be found in a recently clearcut stand.

Each species of mammal and bird will be relatively more or less abundant (including being absent) in each combination of covertype and age/size class. Using the example above, squirrels would likely be very abundant in a mature oak-hickory stand, while they would likely be absent from a newly regenerated stand. Therefore, the direction and magnitude of population change in each animal species of interest can be estimated by examining projected acreage of forest types and size classes.

A caveat is appropriate for riparian species. Selective harvesting was allowed in those areas and thus the original covertypes were essentially unchanged. However, model resolution did not allow consideration of direct disturbance or subtle changes in stand conditions due to this harvesting that could affect the animals present. Thus, the model may overestimate available habitat. The concern is especially relevant for the Bald Eagle, Osprey, and many herons.

Each of these species has an estimated range distribution within the state. Limitation of a species' occurrence to forests within its range makes it meaningless to assess impacts on *that* species due to habitat changes in forests outside of its range.

The major emphasis in assessing wildlife impacts was at the ecoregion level and results of impact analyses are developed in section 5.6.4. However, for illustration, table 5.15 describes the general direction of projected population levels for the species groups considered under the base harvest scenario. Statewide over the 50-year study period, 97 percent of the total number of species are projected to remain stable or increase under the base scenario; while the populations of five species are projected to decrease. Nearly all species projected to increase statewide under this scenario are *early-succession* species that have considerable habitat outside of forests (open areas, brushland, etc.). As was shown in table 5.7, about 875,000 acres of forest are projected to be lost in the aspen-birch and northern pine FIA units over the next 50 years. This conversion to nonforest within the main forested portion of the state will favor some early succession species. Although forest area is projected to increase in other parts of the state (Central Hardwood and Prairie FIA units), much of this new forest on former farmlands also will be young forest. The increases in these early successional species should not be viewed as offsetting decreases in species more strongly dependent on forests.

Table 5.15 Number of species of interest that are projected to decrease by 25 percent or more, remain stable*, or increase by 25 percent or more, statewide on all forest lands under the base level of harvesting.

Species Group (total number of species)	Decreasing (No. of species)	Stable (No. of species)	Increasing (No. of species)
Small Mammals (22)	0	21	1
Large Mammals (5)	0	5	0
Birds (138)	5	111	22
Herps (8)	0	6	2
All (173)	5	143	25

Source: Jaakko Pöyry Consulting, Inc. (1992f).
* *Stable* is a change of less than 25 percent.

Endangered, Threatened, or Special Concern Species

Species with limited populations in the state have been assessed at a state and federal level and have been classified according to certain criteria that assess the degree to which the populations are at risk. The following criteria are applied by the state to undertake this assessment (Jaakko Pöyry Consulting, Inc. (1992f).

1. *endangered*, upon showing that such species is threatened with extinction throughout all or a significant portion of its range; or
2. *threatened*, upon showing that such species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range; or
3. *species of special concern*, upon showing that while a species is not endangered or threatened, it is extremely uncommon in Minnesota, or has a unique or highly specific habitat requirements and deserves careful monitoring of its status. Species on the periphery of their range which are not listed as threatened may be included in this category along with those species which were once threatened or endangered but now have increasing or protected, stable populations.

Timber harvesting and forest management activities have the potential to affect populations of species (animals and plants) of special concern, threatened, or endangered. Populations of listed species differ in terms of the species ability to rebuild population numbers and to cope with disturbance. Relevant factors influencing this ability include:

- species life history, dispersal ability, ecological, and genetic factors; and
- management objectives and practices of landowners.

State and federal ownerships have policies that are directed towards improving conditions for species on these lists. Other ownerships have less explicit management objectives, with a consequent increase in the risk of adverse impacts.

Medium- to long-term impacts would be associated with reductions of populations. The timeframe would depend on the factors identified above. Irreversible impacts could occur where a species is lost from within and outside Minnesota. There is the potential for a loss of biodiversity as these species diminish or are lost from the ecosystem.

Endangered, Threatened, and Special Concern Animals

The assessment of changes to wildlife populations as a consequence of timber harvesting and forest management activities is centered on changes to habitat. The following sections identify the species with endangered, threatened, or special concern status; and assesses the implications of the level of harvesting projected under the base scenario for the populations of the species explicitly considered in the GEIS analysis.

***Birds*.**—There were five state- or federal-listed, forest-dependent bird species considered in the analysis. At the base level of harvesting, these species are predicted to be affected in the following manner:

1. Osprey: An overall statewide increase is predicted, both on timberland and for all forest lands.
2. Bald Eagle: Stable statewide populations are predicted.
3. Red-shouldered Hawk: An overall statewide decrease is predicted on timberlands and on all forest lands.
4. Loggerhead Shrike: A significant increase in statewide populations on timberlands and all forest lands is predicted. However, it is uncertain if this candidate federally-listed species has a population that uses forest land in Minnesota.
5. Louisiana Waterthrush: Stable populations are predicted statewide.

***Herps*.**—There were four state-listed forest-dependent species considered in the analysis. At the base level of harvesting these are expected to be impacted as follows:

1. Wood turtle: A stable or slightly increasing habitat statewide is predicted.
2. Timber Rattlesnake: A stable or slightly increasing acreage of habitat is predicted.
3. Hognose snake: A >25 percent increase in habitat statewide is predicted.
4. Pickerel Frog: A large increase (>50 percent) in habitat acreage statewide is predicted.

Small Mammals.—There was one state-listed, forest-dependent small mammal considered in the analysis. At the base level of harvesting it is expected to be affected as follows:

1. Pine Marten: Stable or increasing populations are projected.

Large Mammals.—There was one threatened (state and federal) forest-dependent large mammal considered in the analysis. At the base level of harvesting, the effect on this species would be as follows:

1. Timber wolf: No appreciable and direct impact on the timber wolf is expected.

Endangered, Threatened, and Special Concern Plants

A recent inventory of the vascular plants of Minnesota lists 1,618 species. The number of species of mosses in Minnesota is probably around 380; and there are more than 550 species of lichens. Sixty-seven plant species currently are listed as endangered, threatened, or of special concern. These include 8 lichens, 2 mosses, and 57 vascular plants.

In general, the forest-dependent rare plant species of Minnesota are poorly adapted to trampling types of injury. Most (except for the one tree species listed) are of small stature and easily broken. Any harvest that would allow heavy equipment to drive through a population of rare plant species would cause impacts.

There are large numbers of occurrences of endangered, threatened, or special concern plants within Minnesota's forests, in all ecoregions. Table 5.16 summarizes the numbers of species by ecoregion that are projected to be adversely impacted under the base level harvesting scenario.

Table 5.16. Summary of the numbers of rare plant species likely to be adversely impacted directly by harvesting, by ecoregion.

Ecoregion	Endangered	Threatened	Special Concern
1	1	1	5
2	1	3	7
3	4	3	12
4	2	3	17
5	1	2	6
6	4	5	24
7	0	0	3
All ecoregions	9	7	37

Source: Jaakko Pöyry Consulting, Inc. (1992e).

5.4.2 Aquatic Ecosystems

Harvesting activities that remove or alter forest cover and other types of forest management activities within a watershed have wide-ranging effects on waterbodies and the plants and animals that live within them. As discussed in section 5.3.2, these activities can affect the amount, timing, and quality of water yield. The flux of nutrients and ions from the landscape to the water resource is usually altered to some degree. Similarly, disturbance to the soil surface can increase erosion and sediment inputs to waterbodies. In addition to these changes to the physical characteristics of the aquatic environment, there are likely to be changes in the biological component. Changes in the riparian canopy alters inputs of organic matter (a central food resource for the aquatic community) and affects the amount of light reaching the water surface. Light in turn affects primary producers (i.e., algae and higher plants) and may cause water temperatures to increase. All these changes affect the species composition, growth, and production of the animals that inhabit the water resource. Thus, invertebrates as well as fish communities are often changed in type and in function (i.e., the ways they process matter, nutrients, and energy).

It is uncertain how a change in landscape management will affect a specific water resource. Each of the changes discussed above has its own variability as well as an associated uncertainty. For some effects (e.g., water volumes), a significant amount of research has been conducted in the forested regions of Minnesota. Therefore, some degree of confidence is appropriate in discussing probable changes in response to increased timber harvest. In other cases (e.g., stream or lake biology or wetland plant communities) the analysis has relied on research and literature from other parts of the country or the world. Those studies were often conducted under conditions quite different from Minnesota. Because of those differences, generalities were developed from the available literature and professional experience of the authors, and then used to postulate effects that might occur under Minnesota conditions.

The following provides an overview of the key parameters and projected impacts under the base level of harvesting.

Light and temperature
If stream corridors were harvested to the water's edge, large increases in light reaching the stream channel would occur. This could increase the temperature of smaller streams and change the species composition and rates of production of the stream community. These impacts would be local, and not evident at the ecoregion scale. If watersheds are harvested in compliance with BMPs, no significant effects on light or temperature would be expected. Generally speaking, no change in light reaching lakes under any harvest scenario is predicted. The level of light reaching small streams is expected to increase in ecoregions 1, 2, and 4. This will probably cause a small localized increase in average temperature, lasting for two to five years following harvesting.

Organic matter
Harvest in compliance with BMPs may change species composition in the riparian canopy, thereby altering the quantity and chemistry of leaf material that enters a stream or lake. Such changes would probably alter the species composition of insects in the stream of the riparian zone of the lake. Those changes may in turn affect the fish community. In general, such changes are expected to be minimal under the base level scenario. One exception was in ecoregion 1, where the analysis predicted there would be measurable reductions in organic inputs to streams and lakes.

Site-specific changes to organic inputs to wetlands are likely when harvesting is conducted without BMPs. However, no cumulative regional changes to organic inputs to wetlands are projected under the base level scenario.

Coarse Woody Debris
Wood provides a substrate, food resource, and habitat for stream and lake organisms. Wood also serves to control the stream channel (i.e., through debris dams, overhangs, channel obstructions). Changes in the riparian zone related to timber harvest are likely to change inputs of wood to streams, lakes, and wetlands. Those changes would be most important to small streams, exerting their influence on a local, site-specific basis. Effects might include changes in stream animal populations, in rates of flow, and in energy utilization patterns. More specifically, the analysis predicted that large woody inputs to lakes will not change and inputs to streams will be

significantly reduced in all ecoregions except 1 (and 8, for which no wood predictions are made).

Primary producers
Timber harvest in stream riparian zones would alter light and temperature, thus affecting stream algal growth. However, harvest in compliance with BMPs will have no adverse impacts on light and thus none on stream periphyton or lake phytoplankton. More specifically, at the local scale large short-term increases in stream periphyton are predicted in small streams in ecoregion 4, and small increases are predicted in ecoregions 1, 2, 3, 5, and 6. No changes in lake phytoplankton are predicted.

Macroinvertebrates
Water quality, sediment, light, leaf, and woody organic matter all influence macroinvertebrate kinds, numbers, and activities. Therefore, predictions about macroinvertebrate changes are affected by any uncertainty in predicting other changes. Harvest in compliance with BMPs will usually protect the stream and lake from large changes in these variables, and thus in macroinvertebrates. Specifically, the analysis predicts that macroinvertebrate communities in lakes will not change in response to timber harvest at the levels projected to occur under the base level scenario. Substantial increases in macroinvertebrate populations are predicted in streams in ecoregion 4, and small increases in the other ecoregions are predicted.

Forest dependent fish and their habitat
A wide variety of fish species lives in, and is dependent upon the conditions existing in Minnesota forested landscapes. If all timber harvests employ BMPs, no great impacts to fish communities are predicted under the base level scenario (see table 5.18 in section 5.3.2). If BMPs are not enforced, the amount of suitable coldwater fish habitat in ecoregions 3, 4, and 6 is predicted to be reduced by 1 to 3 percent, with the possibility of similar reductions in fish populations. In this case, the analysis predicts there also would be small to slight reductions in the populations of fish in all other coldwater streams, all coolwater streams and lakes, and coldwater lakes in ecoregions 4, 5, and 6 (see table 5.17 section 5.3.2). These impacts would not be evident if BMPs were in place.

Ephemeral ponds and fishless permanent ponds
Timber harvesting can impact these aquatic habitats by siltation or by removal of shade and increased exposure, resulting in early drying. Removal of shade can also lead to increased water temperatures which may exceed tolerance levels for some species of amphibians. These habitats are important for species such as wood frogs, treefrogs, spring peepers, eastern newts, and blue spotted salamanders. In addition, some harvesting practices, particularly full-tree harvesting during winter, can result in substantial

volumes of slash being deposited in these and other small wetland habitats. This is likely to eliminate the habitat value for many species.

5.4.3 Riparian Corridors

Riparian corridors are the strips of land and associated plant communities located adjacent to waterbodies. These areas can often be the focal point for resource management conflicts because of their importance for such widely differing forest values. Because of high soil moisture and nutrient availability, riparian zones are highly productive for both fiber and, in the southeast, fine hardwood sawlogs. Riparian zones are one of the most important components of the water/land interface due to their influence on (1) habitat within the aquatic system, (2) transport of pollutants and erosion to a stream, wetland or lake, (3) habitat for terrestrial species, (4) aesthetic characteristics of the landscape, (5) recreational opportunities for the public, and (6) site of cultural and historical resources.

Harvesting activities in timberlands in riparian zones along larger streams and lakeshores is becoming more constrained. This was reflected in the model assumptions which limited the types of timber harvesting and forest management activities within 100 feet of water; and within 200 feet of lakes or major streams in ecoregions 4, 5, 6, and 7. These measures meant that no riparian bird species were projected to be adversely impacted under the base level of harvesting and that nine of a total of 20 species were projected to show increasing populations. Similarly, herp populations would also benefit.

Maintaining the integrity of riparian vegetation is an important management objective and a frequent objective of BMPs. Note that current BMPs only require an intact filter strip of ground vegetation, and that overstory, understory and shrub layers can be removed without violating these guidelines. In this regard, impacts to aquatic systems occur almost exclusively when the riparian corridor has been disturbed, either by harvesting or roading. Poorly planned and maintained stream crossings can be the main sources of sediment pollution of streams in forested catchments. Impacts to aquatic ecosystems from management within the riparian corridor are apparent through changes in material and energy flows between the terrestrial and aquatic environments.

Reductions in organic matter inputs, changes in timing of inputs and changes in the quality of litter inputs are likely to occur on a site-specific basis when harvest occurs within 200 feet of the stream channel.

A survey of randomly selected tracts of timberlands via aerial photo and ground examination was conducted as part of the GEIS study process. This survey concluded that 29 percent of the locations contained harvesting within 200 feet of water (see table 5.17). Where harvest did occur within 200 feet

Table 5.17. Aerial photo evaluation of recent (within last ten years) timber harvesting near water from 30 FIA locations randomly located throughout the state.

Plot Characteristic	Value
Total Number of FIA Sample Locations	30
Average Size of Tract (acres)	446
Survey Units Examined	
Aspen Birch	12
Northern Pine	12
Central Hardwood	6
Percent of Locations with Water	77
Percent of Locations with Clearcuts <10 yrs old	50
Average Number of Cuts Per Location	1.6
Range in Size of Clearcut (acres)	10-40
Percent Locations with Clearcuts and Water	37
Percent Locations with Partial Cuts and Water	7
Percent of Locations with Cuts within 200 Feet of Water	
Near Streams	3
Near Lakes	3
Near Wetlands	23
Percent of Cuts within 200 Feet of Water	
Aspen Clearcuts	10
Conifer Clearcuts	10
Hardwood Clearcuts	10
Conifer Partial Cuts	3
Average Distance of Cut to Water (feet)	472
Median Distance of Cut to Water (feet)	0

Source: Jaakko Pöyry Consulting, Inc. (1992d).
*All percentages calculated on the basis of 30 locations. Note, that because half of all plots surveyed were immediately adjacent water, the "median" distance to water is statistically set at "0".

of water, half of the harvests were located immediately adjacent to the waterbody. Thus, only one-third of that recent harvesting occurred near water but those activities occurred within a short distance of water. Most of the water was actually wetland, as distinct from streams or lakes. Fewer wetlands and more streams would probably be seen if the photography were extended to southern Minnesota.

5.4.4
Forest Insect and Disease Concerns

Forests are presumed to be healthy when biotic and abiotic influences do not threaten the attainment of current or future management objectives.

Although specific aspects of forest condition can be quantified and measured objectively, assessing forest health depends in part on subjective evaluations and value judgements.

Insects and diseases are important components of the forest ecosystem; they are fundamental agents of change impacting long-lived communities. The effects of insects and diseases on forests in the Lake States include tree mortality, tip dieback, or top-kill; loss of reproduction and regeneration; loss of tree form; and reduced resistance to other stresses. These effects can be translated into impacts such as loss of productivity due to mortality, decay, reduced growth rates and increased risk to fire. In addition, insects and disease can impact the recreational and aesthetic aspect of forest resources. Pests and diseases can also affect wildlife habitat values. Fungal decay provides habitat by creating hollows in trees, and insect pest larvae are a source of food for many species. However, widespread pest outbreaks leading to high levels of tree mortality may also reduce the habitat values for other wildlife species. This is a particular problem where natural checks and balances controlling a pest population cease to function, or where a new pest is introduced and there are no natural controls to check its growth.

The risk to a forest stand of a pest attack or infestation (susceptibility) and the likelihood of damage if an attack occurs (vulnerability) are frequently related to stand age. Typically, as stands get older they become more susceptible to damage and are at greater risk of infestation. However, there are exceptions to this generalization where seedlings and young trees are preferentially attacked. Harvesting that requires multiple entries into a stand may also increase risk. For example, if care is not exercised, harvesting can damage residual trees, leaving them open to attack by insects and disease. Finally, atmospheric pollutants can weaken or stress trees, potentially increasing their susceptibility and vulnerability.

The amount of damage incurred during outbreaks of insects or disease is generally related to stand attributes and environmental conditions. In some cases, especially for insects, pest populations can be regulated by biological control organisms including predators, parasites, and pathogens. Stand and site-related factors associated with severe impacts vary with the nature of the health problem. However, low vigor trees, particularly those stressed by drought, are most likely to be severely affected by insects and diseases. Species and age class diversity within and among stands may reduce impacts relative to large, continuous areas of similarly-aged host trees.

The possible effects of an increase in timber harvesting and associated forest management practices on forest health in Minnesota include changes in the proportion of susceptible/vulnerable age classes, and the incidence of multiple entry harvesting operations.

Under the base scenario, projected harvesting levels will increase the acreage of younger stands for most covertypes. This harvesting will tend to reduce the incidence of many insect pests and diseases that are favored by older forests. Insect species in this category include spruce and jack pine budworm and two-lined chestnut borers. In addition, diseases such as white trunk rot of aspen are also likely to be reduced. Other diseases including cankers and decay of upland hardwoods and oak wilt, will probably decrease in the short-term but may ultimately increase.

In contrast, the incidence of some insect pests, such as white pine weevil, are likely to increase as a consequence of the base level harvests. This is due to an increase in acreage of susceptible younger stands. The incidence of some diseases are also likely to increase, including *Diplodia* shoot blight and canker, and possibly *Scleroderris* canker of red pine. Some of the predicted increases in susceptibility and vulnerability are based on the following assumptions: (1) that an increase in timber harvesting would substitute young, more susceptible stands of pine species to replace older stands that have been cut; (2) changed management objectives including longer rotations will result in more susceptible/vulnerable age classes of other forest types; and (3) increased use of thinning and selection harvests will increase the risk of damage to retained trees.

5.5 Socioeconomic Resource Impacts

5.5.1 Outdoor Recreation Opportunities

Timber harvesting and forest management activities can have an impact on recreation opportunities in a variety of ways. Harvesting can affect the type of recreation opportunities available, the quality of the recreational experience, and the number of hours of recreational activity at a given site. Some of these impacts are related to the recreational user's visual perception and the attractiveness of the forest setting. Some of the impacts are long-term while others are short-term and/or subject to change from forest growth and dynamics on that site or over a broader context or area.

A summary of potential impacts of timber harvesting and forest management on forest recreation opportunities is provided in table 5.18. Impacts 1 through 5 are impacts on recreation opportunities and impacts 6 through 8 are impacts on aesthetic characteristics that affect the recreation opportunities. There is a close relationship between recreational value and aesthetic value.

Table 5.18. Potential impacts of timber harvesting and forest management on forest recreation opportunities.

Impacts
1. Change can, in some cases, eliminate the more primitive recreation opportunities.
2. Harvest operations can create travel barriers and create negative recreation use impacts along improved and unimproved roads in the forest areas (e.g., slash on roadsides, trails, landing and staging areas, ruts in roadways).
3. Harvest operations can create new and improved forest roads. This improved system of roads can change the nature of the recreational opportunity and change the use of the area.
4. Increased harvest operations have the potential to increase offroad vehicle use in forest areas due to increased access via logging related road building. Increased ORV use has the potential to cause recreational user conflicts, stream and trail damage and impacts on sensitive wildlife.
5. Traffic conflicts can occur between logging vehicles and recreational drivers for use of roadways, increased dust from logging traffic, etc.
6. The aesthetic and natural experience of many outdoor recreation users can be reduced by large clearcut areas. Research shows that many outdoor recreation users seek an aesthetic experience, such as viewing the landscape in a natural or relatively unmodified setting. Clearcutting may produce more resources for consumptive recreational use (game, berries) in some areas, but it also will reduce the aesthetic/natural experience opportunities sought by many of these recreational users.
7. Visual and noise impacts of timber harvest operations can change recreational opportunities for persons in adjacent parks, waterways, and other recreation areas designated to provide aesthetic and primitive recreation experiences.
8. Visual impacts of timber harvesting operations on adjacent properties can adversely affect the visual setting of resorts. Noise impacts can also be a nuisance.

This impact assessment clearly indicates that timber harvesting and forest management activities have direct effects on the recreational use of forests. In some cases, harvesting decreases the quality of the recreation experience and increases the amount and kind of recreational activity at a site. In other cases the opposite might occur. And, in still other instances, no change might be expected.

In nearly all cases where the quality of the recreational experience was judged to decrease, activity hours were estimated to increase. The reason for this apparent contradiction is that roads constructed for harvesting operations can provide access into previously inaccessible areas. Improved accessibility enables more people to use the area. In formerly unroaded areas, provision of motorized access can increase the range of recreational uses possible in such an area. However, increased numbers of users may be undesirable for the opportunity provided at the site, and may displace existing users. The implications from a management perspective largely depend on the management objectives for the area. Ownerships that recognize and manage for recreation may take steps to control access, and therefore limit the range of uses, by closing off roads as harvesting is completed. Other ownerships may elect to do nothing and to accept whatever uses occur. The following section discusses the impacts by categories of ROS class and ownership.

Primitive and Semiprimitive Nonmotorized Recreation Opportunities
The management guidelines definition of ROS primitive and semiprimitive areas used by the USDA Forest Service are:

- *Primitive areas* are three or more miles from all maintained roads or railroads. Primitive areas are unmodified natural environments. Evidence of trails or recreational use can exist. Structures in use are rare. Contact with humans is rare and chances of seeing wildlife are good.
- *Semiprimitive nonmotor areas* are one-half to three miles from all maintained roads or railroads. They may be close to primitive roads or trails used only occasionally. Modifications to the natural environment are evident, such as old stumps from prior logging operations, but they are not apparent to the casual observer. Structures in use are rare. Human contact is low and chances of seeing wildlife are good.

Given these specifications, it is clear that the most primitive opportunities are destroyed when such areas are roaded and motorized uses are introduced. Under these circumstances, the opportunities available would shift to those more suited to developed sites.

Across all FIA forested plots (timberland, reserved, and unproductive) in Minnesota, only 3.1 percent of the total were in the ROS primitive class and 9.6 percent of plots were in the semiprimitive nonmotorized class. Of these statewide totals, 0.4 percent and 7.2 percent, respectively, occur on timberland.

Timber harvesting and associated roading on any of these plots has an impact on the plot itself and also on the number and distribution of areas in the state where opportunities for the more primitive and recreation opportunities will be available in the future.

Developed Recreation Opportunities
Timber harvesting and forest management activities in the more developed ROS classes cause changes that are reversible over time. The types of impacts that could be expected include those associated with an increase in

the accessibility of an area, and impacts to the setting caused by changes to the vegetation. The consequences of these changes are twofold. For existing users who appreciate comparatively natural surroundings and lower levels of contact with other groups, the quality of the recreation experience diminishes. However, the improved access increases the opportunities for people who were previously constrained by a lack of access. Therefore, the amount of activity increases as a consequence of the increase in the levels of use. The persistence of these changes depends to a large degree on how the area, and particularly the roads, are planned and managed before, during, and after harvesting is completed.

Some ownerships, notably the USDA Forest Service and MNDNR, employ (or are in the process of introducing) VMGs in the planning and execution of timber harvesting and the subsequent management and regeneration of harvested areas. Under these circumstances, impacts on users are minimized. Also, these ownerships restrict access by closing logging roads not required for other management or land use purposes. Therefore, the recreation values for users seeking relative isolation will be restored as the forest regenerates and usage levels drop. Use of VMGs will likely lessen the time taken to restore the setting sought by this category of user.

However, where ownerships do not use VMGs and apply ad hoc management to access, it is likely that these changes will persist. Unauthorized, or authorized use of unmaintained logging roads by all terrain vehicles (ATV) and offroad drivers will continue to diminish recreation values for users seeking relative isolation.

Table 5.19 describes how harvesting at the base scenario will impact the six recreational opportunity classes. Although the ROS system is not used or appropriate across all ownerships, it is helpful in understanding the opportunities from a statewide perspective.

Harvesting at the base scenario would subject 50.4 percent of the timberland plots to harvesting. Of these, 7.6 percent are currently classified as nonmotorized areas. When all forest land is considered, 5 and 25 percent of plots in the primitive nonmotorized and semiprimitive nonmotorized classes, respectively, are subject to harvesting. Harvesting beyond the year 2040 would tend to concentrate on the accessible and productive plots harvested in the first 50 years, i.e., additional harvesting is not likely to extend far beyond the set of plots harvested in the first 50-year period.

Table 5.19. Distribution of FIA forest and timberland plots and plots projected to be harvested, by ownership and ROS class, 1990-2040.

ROS Class	Total number of plots, all forest	Total number of timberland plots	Percent of timberland plots by ROS class	Number and (percent) of timberland plots harvested by ROS class — Base Scenario: State/federal lands	Other lands
Primitive	425	53	.4	8 (15.1)	15 (28.3)
Semiprimitive nonmotorized	1,306	876	7.2	150 (17.1)	173 (19.7)
Semiprimitive motorized	3,409	3,074	25.4	529 (17.2)	925 (30.1)
Roaded natural	5,232	5,049	41.7	662 (13.1)	2,121 (42.0)
Rural	3,107	3,030	25.0	140 (4.6)	1,366 (45.1)
Urban	57	36	.3	1 (2.8)	18 (50.0)
All classes	13,536	12,118	100.0	1,490 (12.3)	4,618 (38.1)

5.5.2
Aesthetics and Visual Quality

The constraints and mitigations assumed on state and federal lands are driven by the presence of specific management goals, plans, and related policies and the need to be directly responsible to the public. Given that, there appears to be a tendency to harvest areas of high visual sensitivity at a lower rate than areas of moderate to low sensitivity. The converse was found on private lands (see table 5.20). There is also a concern that harvesting may take place on lands adjacent to designated recreation areas such as state and national parks, wilderness areas, wild and scenic rivers, and long distance trails.

Timberlands not in federal or state ownership do not have VMGs in place and therefore, there is a stronger likelihood of adverse impacts on these lands. Under the base scenario, 38 percent of nonfederal and nonstate owned timberland plots were projected to be impacted (see table 5.19).

In terms of dynamics over time, the forests of Minnesota are aging and under the base scenario would continue to do so. Ownership constraints and mitigations that preclude certain areas from clearcutting also increase the area of older forest. Under the base scenario, most future forest covertypes would have an average age older than that of today. Given 50 years of growth, the oldest ages would be greater than found today for many areas. It follows that average tree size, which is an important component of attractiveness, would not be negatively impacted under the base scenario for most covertypes. The covertypes that would be adversely impacted are those subject to substantial harvesting including aspen, balsam poplar, and maple-basswood.

Table 5.20. Percent of FIA timberland plots projected to be harvested (1990–2040) by visual sensitivity rank and by ownership (excluding primitive, semiprimitive nonmotorized, and urban ROS classes).

	Percent of timberland plots harvested by visual sensitivity rank	
	Base Scenario	
Visual Sensitivity Rank	State/federal lands	Other lands
High	10.4	49.6
Moderate	11.4	44.5
Low	12.7	37.3
Very low	13.0	32.5
All ranks (high to very low)	12.1	39.6

5.5.3 Unique Cultural and Historical Resources

Heritage resources can be divided into five main categories: cultural landscapes, standing structures, archaeological sites, cemeteries, and traditional use sites.

Cultural Landscapes are a collection of features which represent interaction between humans and the environment. People may assign cultural meaning to natural features or features which have been made or modified by humans.

Standing Structures include buildings and structures made and used by people, generally in the recent past. Standing structures are rare within the timberlands considered in the GEIS.

Archaeological Sites are located on or below the surface of the ground or under water. They include two major categories: Native American sites such as the remains of large and small villages, camps, and processing sites; and Euro-American sites such as fur trade posts, homesteads, and logging camps. Most of these sites are not visible at the ground surface and require special techniques to locate. Many sites are present within forested areas and could be adversely affected by timber harvesting activities. Most pre-Euro-American sites are probably located within 1,000 feet of past or present water features (including swamps, marshes, abandoned river channels, etc.).

Cemeteries may contain the remains of one or more human beings and are common on forested lands in Minnesota. These include Native American and Euro-American cemeteries.

Traditional Use Sites are locations which have been historically used by one or more groups of people for some type of activity. They may lack the physical evidence of artifacts or structures, and are often characterized by plants, animals, and/or topography which are of cultural and religious significance to Native Americans.

Site Location Density and Size

Inventory of heritage sites has been carried out intermittently for over a hundred years. Site data are entered into the state listing of known sites. This listing is maintained by the state archaeologist's office and contains over 3,000 records; less than one percent of all estimated sites. However, as well as being incomplete, the inventory contains numerous inaccuracies.

Current Inventory Procedures Used in Timberlands

The USDA Forest Service is the only ownership that routinely surveys all timber sales to identify heritage resources. The entire sale area is surveyed.

Site Density

Site density figures were estimated for archaeological sites and cemetery sites combined as one category. No densities could be determined for cultural landscapes or traditional use areas.

Estimated site density varies from 3 sites per 1,000 acres to 32 per 1,000 acres. These estimates are based on a review of existing file data for all the state with the exception of ecoregion 7, which lacked sufficient data on site density in timberland areas to enable an estimate to be made. Of the ecoregions examined, the Eastern Prairie/Forest transition zone (6) probably has the highest density, with an estimated average of 4 sites per 125 acres. For the Western Prairie/Forest transition zone (5) there is an estimated average of 3 sites per 125 acres. For the Central Pine-Hardwood Forests, the estimate is 3 sites per 200 acres. For the Border Lakes and Lake Superior Highlands unit, the estimate is 1 site per 200 acres. For the Glacial Lake Plains, the estimate is 1 site per 325 acres.

Site Size

Most archaeological sites are probably under 5 acres in size, although this varies by ecoregion. Sites in the Eastern Prairie/Forest transition zone may be the largest, generally occupying 5 to 10 acres. Sites in the Central Pine-Hardwood Forests are generally under 5 acres, but over 1 acre. Sites in the Lake Superior Highlands are frequently less than 1 acre. Cemetery sites vary considerably in size, from less than 1 acre to 25 acres. Cultural landscapes range from small features, such as portions of rock outcrops, to large areas which include major topographic features. Traditional use areas may be less than 1 acre to 100 acres.

Impacts on Cultural and Historical Resources
Most heritage sites are extremely fragile and can be seriously affected by timber harvest and associated activities, such as road construction. They are fragile because dislocation of artifacts and the sediments which contain them can destroy or seriously compromise the essential information which they contain. Earth-disturbing activities do not have to be very intense to negatively affect such sites.

Traditional use sites can be altered by modern harvesting operations through change of vegetative cover, reduction of availability of certain plants and animals, and changed frequency and mode of public access.

Past Impacts
A substantial proportion of archaeological and cemetery sites in ecoregions 6, 7, and parts of 5, have suffered damage from plowing. In some cases, this has been severe enough to destroy most of the scientific value of the archaeological sites. In the northern ecoregions, land clearance with chisel plowing has affected only a small portion of the land surface.

Cemeteries retain their religious significance even if they have been plowed or furrowed.

Number of Sites Potentially Impacted
The estimates of site density were applied to the estimates of the total number of acres harvested in each ecoregion under the three scenarios. The maximum number of sites potentially impacted by the level of harvesting projected under the base scenario is 105,000 sites or 55 percent of the estimated total number of sites.

The analysis used several assumptions that are likely to substantially reduce the actual number of sites potentially impacted at the base scenario from the estimated maximum of 105,000. These assumptions are the following:

- More sites are located in shorelands which are less likely to be impacted by timber harvesting because of existing state and/or local regulations, e.g., shoreland ordinances.
- Surveys by the USDA Forest Service locate sites on their lands prior to harvest.
- A proportion of sites are likely to be protected because they are located in areas harvested when the ground is frozen. Approximately 43 percent of all harvesting is undertaken during the winter months in northern and central Minnesota.
- The extent of *undisturbed* areas left after logging varies with the type of operation, from 15 percent (mechanically-felled) to 37 percent (hand-felled). Therefore, a proportion of sites will be wholly or partially retained intact where they are located in undisturbed parts of the site.

- Past land use activities, particularly plowing, have affected a substantial proportion of sites in ecoregions 6, 7, and parts of 5; but relatively small areas of 1, 2, 3, and 4.

Archaeological and Cemetery Sites
Analyzing timber harvesting impacts at the base scenario, the predicted *maximum* number of sites that could be destroyed is 100,000. This total excludes the impacts on USDA Forest Service lands. The actual number of sites affected can be confidently predicted to be less than this total because of the nature of the assumptions discussed above that were used to generate this estimate. In addition, experts consulted as part of the GEIS process conclude that 50 percent of these sites would not contain significant scientific value and could therefore be destroyed without the need for mitigating action.

Cultural Landscapes
There is insufficient data to assess, even qualitatively, the extent of impacts on these sites. Impacts are likely to occur and the relative number of impacts will increase as the level of harvesting increases.

Traditional Use Sites
Traditional use sites will be impacted. However, the extent cannot be quantified, as these sites have not been inventoried.

5.5.4 Economic Impacts

Because the base level of harvesting modelled reflects the existing levels, no changes to the level of economic activity were expected to occur. Estimates of the economic impacts expected to result from the two increased levels of timber harvesting are presented in subsequent sections.

Forest Industries
The following section describes Minnesota's economy and the existing contribution of the timber industry to employment, levels of employee compensation, and total industry output.

In 1988, total employment in Minnesota was about 2.5 million jobs. Personal income in the state amounted to approximately $54 billion. The forestry and forest products sectors of the state provide 54,000 jobs, 2 percent of the state total, and $2.2 billion of personal income, 4 percent of the state total.

The importance and nature of the forest products industries varies from one part of the state to another. Because of these differences, the state was divided into four regions: a north region, a southeast region, a southwest region, and the metro region. The north region is much more heavily forested than the rest of the state, with 45 percent of the region occupied by timberland. The forest products industry is especially important to the economy of the north region, and it is dominated in that part of the state by large pulp and paper producers and OSB and flakeboard mills. Forest products industries are also important, but less so, in the southeast region where hardwood sawmills are the most important industry. There is significant employment in forest products industries in the metro region, but this is a relatively small proportion of the total employment in the metro area. Also, the forest products industries in the metro region are typically secondary producers who do not purchase or process roundwood directly. There is relatively little forest land in the southwest region, and the forest products industries are a relatively small part of the region's economy.

The key primary forest products industries—those purchasing and processing roundwood—are the pulp and paper industry, the OSB and the waferboard industries, and the sawmilling industry. In 1990, pulp and paper mills in the state consumed about 1.0 million cords of pulpwood harvested from timberland in Minnesota. In that same year, OSB and waferboard mills consumed 0.9 million cords of pulpwood, and hardboard/sheathing/other mills consumed 0.2 million cords. Lumber accounted for an additional 0.5 million cords, and residential fuelwood accounted for 0.5 million cords. All other uses accounted for 0.3 million cords. Logging is also an important primary forest products industry; it is unique in that it serves as a provider of roundwood to the other primary producers.

The tourism and recreation industries in Minnesota are responsible for approximately 4 percent of the total employment in the state, 3 percent of the wages and salaries, and 4 percent of industry output. The metro region of the state accounted for over half of these economic impacts of travel and tourism. The north region accounted for 29 percent of the jobs, compensation, and output in the state's travel and tourism industries.

Impacts on Outdoor Recreation and Tourism

Outdoor recreation is highly popular with Minnesota residents and visitors alike, and provides an important contribution to the state's economy. Statewide, in 1985 (the most recent data available), it contributed 2.5 percent of the total economic output of the state, and 3.3 percent of the total number of jobs (including seasonal and part-time) in the state. The metro region accounted for about a third of total economic output. Outdoor recreation is particularly important to the northeastern part of the state, where it accounts for over 10 percent of the total economic output of that region.

Of the wildlife-related outdoor recreation in the state in 1985, sport fishing accounted for $820 million in expenditures, 26,800 jobs, $360 million in wages and salaries, and $1,250 million in industry output in the state.

Hunting accounted for $190 million in expenditures, 5,800 jobs, $100 million in wages and salaries, and $370 million in industry output. Nonconsumptive use of wildlife accounted for 5,400 jobs, $100 million in wages and salaries, and $330 million in industry output. The combined impact of wildlife-related recreation amounts to approximately 38,000 jobs, $560 million in wages and salaries, and $1,950 million in industry output.

All travel and tourism expenditures in the state outside of the metro region, together with nonmetro outdoor recreation equipment expenditures, would generate approximately 59,000 jobs and account for $2,670 million in total economic output. This includes the outdoor recreation and wildlife-associated outdoor recreation impacts in those regions.

Data are not available to establish a long-term trend in the economic impacts of travel and tourism in Minnesota. However, data on annual gross sales from lodging places can serve as an index to tourism expenditures in the state. Gross sales from hotels/motels, resorts, and other lodging places increased from $376 million in 1980 to $695 million in 1990. However, when these gross sales were deflated using the Travel Price Index for Lodging, there was no discernable long-term trend during this period. From 1980 to 1990, annual gross sales of lodging places in Minnesota fluctuated between roughly $660 million and $770 million in 1990 dollars.

Research or studies that examine and quantify how recreation and tourism are directly affected by different levels of timber harvesting are not available. Therefore, it was not possible to directly link the level of timber harvesting with changes in recreation and tourism activities and expenditure patterns. Additionally, it was not possible to quantitatively assess how timber harvesting and forest management activities would impact the economic sectors related to recreation and tourism. Anecdotal evidence suggests increased harvesting can adversely impact individual resort and tourism businesses as well as affected communities. However, specific cause-effect relationships between timber harvesting and tourism sectors have not been documented. Even without these direct linkages, however, it is still possible to quantify what a change in the state's outdoor recreation sector would mean to the state's economy. A ten percent change in outdoor recreation expenditures could affect 3,200 jobs and $160 million in total economic output.

5.5.5
Land Management Organization Service Delivery

National forests and other federal lands account for 14 percent of Minnesota timberlands. Land owned and administered by the state accounts for 21 percent of the timberland area. County ownership accounts for 17 percent. All public agencies in the state account for almost 52 percent of all the timberland in the state. The other 48 percent is in private ownership, including: Native American lands (3 percent); forest industry (5 percent); other corporation (4 percent); farmer (15 percent); and miscellaneous private individuals (21 percent).

Levels of Harvest

Federal, state, and most county lands are under some form of multiple use management, with formal land management plans and professional land management expertise. Although emphasis varies by public ownership, considerable attention is paid to the long-term sustained yield of timber production. However, policy and associated constraints on timber production efforts vary among agencies. For example, some of the county lands have a considerably lower level of land management for multiple uses than federal or state ownerships. Private industry lands are managed intensively for timber production. Few private nonindustrial timberland owners have formal land management plans, and for most timber production is a secondary goal of land ownership. However, most private land will likely become available for harvest at some time.

Projections of the timber volumes harvested from various landownerships over time were made with the assumption that timber harvests would be constrained and/or mitigated by environmental, aesthetic, socioeconomic, and other concerns. These *projections* reflect major existing and prospective land use policies and practices.

The potential impacts of the base level of timber harvesting on forest management organizations in the state under these constraints are summarized below. In reviewing this information, it is important to understand that the GEIS is not a plan of future harvesting activity. Instead, the following reflects what might likely occur on these different ownerships based on the location and composition of the forest land base, as well as the major policies and practices of management.

Based on the projected level and distribution of timber harvesting associated with the base scenario and the assumptions used to develop that characterization, timber harvests from the national forests in Minnesota are projected to decline by roughly 10 to 15 percent from the current level of harvest under the base scenario. This reduction in timber harvest would persist for several decades and reflects increased environmental, aesthetic, economic, and other constraints imposed by this ownership. This relatively small reduction in timber harvests would be unlikely to have much impact on national forest timber management activities.

Constrained projections of timber harvest from MNDNR lands indicate little change from current harvest levels, and thus would have little effect on timber sale activities of the MNDNR, other than those required to meet increasing environmental and aesthetic standards.

Under the base scenario, sales of timber from county lands are projected to increase during the first decade by approximately two-thirds over current levels. If such a large immediate increase in timber harvest occurred, it would have a major impact on county forest management, and would undoubtedly require substantial increases in funding and personnel to handle the increased timber sale activity while meeting environmental and aesthetic constraints. Since most counties have only modest staffing, additional staffing to meet this need would seem to be feasible. However, it would have to be justified at the county level and, at least in part, by increased timber prices.

Constrained projections of timber harvests from forest industry lands indicate that timber harvests would remain roughly at current harvest levels during the first two decades for all three scenarios, followed by sharp increases during the third and fourth decades, and a substantial decline during the fifth and sixth decades.

Timber harvests from Native American lands are projected to rise rapidly during the first decade, followed by a decline in harvests during the following decades for the base scenario.

Constrained projections of timber harvests from other private lands indicate a substantial rise in timber harvest during the first two decades. During the third decade timber harvests would remain high followed by a decline during the fourth and fifth decade. Achieving these increases in timber harvests from other private lands will require considerable timber sale and land management assistance from forest industry and the state and federal government if potential environmental and aesthetic degradation is to be avoided or minimized.

5.6 Identification of Significant Impacts

Criteria were developed and used by the study groups to assess the significance of impacts projected to occur at each level of harvesting. The criteria and relevant background information are reproduced in full in appendix 1.

The following sections list the criteria and present the significant impacts that are projected to occur at the base level of harvesting. The significant impacts have been drawn from the assessments in the technical papers. Criteria have been grouped under the following headings to aid in presentation:

- Forest Resources - Extent, Composition, and Condition;
- Soil Resources;
- Water Resources and Aquatic Ecosystems;
- Wildlife Populations;
- Recreation and Aesthetics;
- Unique Cultural and Historical Resources; and
- Economics.

5.6.1 Forest Resources - Extent, Composition, and Condition

The criteria in this section were used by the Maintaining Productivity and the Forest Resource Base, Forest Health, and Wildlife and Biodiversity study groups to identify projected significant changes in the extent, composition and condition of Minnesota's forest resources.

These criteria cover a wide range of issues, from the size of the forests to their genetic makeup. This section also includes assessment of the impacts on plant species that are federal- or state-listed of special concern, threatened or endangered and their habitats. Impacts on animals are discussed in the following wildlife section.

Changes to Minnesota's Forests - Size and Composition of Forest Land Base (public and private)

An impact is considered significant if it is projected that there will be cumulative over the 50-year study period:
• A change of 3 percent in the size of the total Minnesota forest land base.
• A change of 3 percent in the area of timberland (commercial forest land) available for wood production.
• A change of 7 percent in the area of the total forest land base by ecoregion.
• A change of 7 percent in the area of timberland by ecoregion.

The estimated trends by ecoregions are presented in table 5.21.

Projecting estimates of forest area change is always difficult and can seem exaggerated. However, the history of forest clearing, regrowth, harvesting, and reservation here and elsewhere suggests changes can be large and rapid. Additionally, both the U.S. and state populations are expected to grow substantially over the period to 2040.

Statewide. The total forest area is expected to remain stable over the period 1990–2040, but a significant drop (greater than 3 but less than 7 percent) is expected in commercial forest or timberland area, or that actually available

Table 5.21. Estimated direction of changes in total forest area and timberland by ecoregion, 1990–2040.

Ecoregion	Change in Forest Area			
	All Forest Land		Timberland	
	Direction	Significance	Direction	Significance
1	-	*	-	*
2	no change		-	*
3	-	*	-	*
4	-		-	*
5	+	*	+	*
6	+	*	+	*
7	+		+	
Statewide	no change		-	*

Source: Jaakko Pöyry Consulting, Inc. (1992a).
* Significant.

for harvesting. Thus while table 5.8 projects an increase in timberland acreage, it is likely that formal land reservation and/or ownership constraints on harvesting or certain practices will preclude all of the projected timberland acreage from being available for harvesting. This drop is anticipated due to additional reservation of timberland and, more importantly, from the implementation of constraints on forest management and timber harvesting to meet concerns for nontimber values. Reservation will occur primarily on public lands; constraints will develop on all lands with public lands leading the way. However, this comparatively static statewide picture includes considerable variation in the direction and magnitude of changes when assessed at the ecoregion level. These are described below.

Ecoregion 1, Glacial Lake Plains. This region will continue to decline in total forest area, due primarily to conversion to agriculture in the west. That change could be moderated by agriculturally-related conservation programs. Unproductive areas will remain as such, thus development will occur on productive uplands or timberland. These changes are considered significant for both total forest area and timberland.

Ecoregion 2, Border Lakes. This region has a large proportion of reserved forest land and is not well-suited to development. No significant change in forest area is expected, but projected timberland availability will be reduced by constraints on management and harvest practices. These constraints will effectively diminish the area of available timberland. The reduction in timberland actually available will likely exceed 7 percent and is considered a significant impact.

Ecoregion 3, Lake Superior Highlands. This small region will likely see a significant (greater than 7 percent) decline in forest area and timberland from 1990 to 2040, due primarily to recreation related development along the North Shore, located mostly in the southern portion of the region. Since it is primarily forest now, any development will diminish the area of private timberland.

Ecoregion 4, Central Pine-hardwood Forest. This ecoregion will likely see an overall decrease in forest land and a somewhat greater reduction in the area of timberland. However, conditions will vary widely across this region due to differences in agricultural history, recreation potential, and proximity to existing urban areas. Federal, state and county ownership is large in the region and those areas will remain in forest. Lowland forest acreage will remain stable. Timberland availability will be reduced by constraints on management and harvest practices that will effectively diminish the area available for timber production. The estimated decrease in forest area will be 3 to 7 percent. The corresponding decrease in timberland will likely exceed 7 percent and is considered significant.

Ecoregion 5, Western Prairie/Forest Transition Zone. Forest area in this ecoregion is likely to increase in excess of 7 percent. However, available timberland acreage will be reduced from that expectation near existing urban centers. Land use will shift from agriculture, back to forest and then, for some areas, to urban development or reservation. In its western parts, this region could benefit significantly from conservation programs.

Ecoregion 6, Eastern Prairie/Forest Transition Zone. Forests in this ecoregion have benefitted from the decline of livestock-based agriculture over the last several decades. Reduced grazing, watershed management concerns, and a decline in agriculture have led to a substantial percentage increase in forest area. Both total forest area and timberland acreage are estimated to show significant (greater than 7 percent) increases. However, urbanization and nonfarm rural development will slow positive changes in timberland actually available relative to increases in total forest area.

Ecoregion 7, Western Prairies. The natural forest regrowth potential of regions 5, 6, and 7 has been grossly underestimated in previous analyses. Total forest area and timberland acreage in this region, though a small portion of the state total, will increase significantly (in excess of 7 percent). Although it will take three to four decades before this regrowth can contribute much to timber supply, it will be important sooner for nontimber values.

Another aspect of the projected increase of forest cover in the prairie region, is that some of the increase will come at the expense of native prairie and savanna, both rare natural communities in the state. Many remnants of prairie and savanna are succeeding to forest, due to the lack of fires, which previously maintained the open conditions.

Changes to Minnesota Forests - Patterns of Forest Cover in Areas of Mixed Land Use

An impact is considered significant if noncontiguous forested tracts or patches less than 300 acres in size are projected to experience clearcutting of more than 20 percent of the tract or patch in any one decade.

Statistics on the regrowth of the oak and elm-ash-cottonwood forest types common to agricultural regions suggest that forest cover is returning to ecoregions 5, 6, and 7 quite rapidly on a percentage basis. However, even the large percentage increases estimated for the next 50 years would barely return these regions to the forest acreage levels of the 1950s. Additionally, the concentration of oak-hickory in older age classes (see appendix 8, Jaakko Pöyry Consulting, Inc. 1992a) coupled with currently high harvest levels could negatively affect the overall habitat value of existing forest patches. The small average stand sizes in this covertype and these ecoregions and the projected acreage of unharvested stands suggest these forest patches are being harvested and that this could be a significant impact. However, data limitations in this study preclude the ability to document impacts on a site-specific basis.

These changes in forest patterns have implications for several mammal species as well as forest interior birds occurring largely or entirely in these more developed portions of the state. Note that significant declines were projected for several species in ecoregions 5, 6, and 7. The projected significant impacts on these species discussed in subsequent parts of this section can be assumed to be closely related to further fragmentation of remnant forest patches. Some of the species in question are: gray and fox squirrels, Ovenbird, Cerulean Warbler, and Yellow-throated Vireo. The Red-shouldered Hawk, a species of special concern, will be significantly impacted if further fragmentation of forest cover in mixed land use regions of the state occurs.

Changes to Minnesota Forests—Tree Species Mix

An impact is considered significant if projected gross changes in the relative proportion of any tree species exceeds 25 percent for the respective covertypes over the 50-year planning period.

Timber harvesting will affect the age class structure and thereby the species composition of Minnesota's forest. Under the changes projected at the base scenario, no species would be reduced to a level that would jeopardize their continued presence in the forest. These results plus the generally rich tree species composition by forest type suggest that major species composition changes within types will not occur, except for those changes associated with stand age. Species composition changes do occur from implementation of harvesting or silvicultural practices in specific stands. However, natural forces plus a changing mix of management objectives and harvest operations over time do not show a clear pattern of change in species composition within types. Given the high frequency of mixed species stands, future directions for type acreage could be largely determined by consistent choice of rotation age and harvest practices.

Future covertypes appear to be sensitive to the level of harvesting, both in retaining covertypes and in favoring change to other species. Results are clouded because of an imprecision in determining forest covertypes both now and in the future. This imprecision is due largely to the mixed species composition of Minnesota's forest. However, results suggest the base level of harvesting will contribute to diminishing the area of the jack pine, black spruce, balsam fir, and paper birch covertypes on timberlands by as much as 32, 24, 35, and 32 percent, respectively. However, some of these changes are a consequence of successional changes as stands age, and are not due to harvesting per se. Furthermore, because many stands have very mixed species composition, these changes will not necessarily drastically change the vegetation at a regional level or on specific sites. Instead, a major species may simply become less abundant or may be reduced to a minor species on a particular site.

Minor Tree Species. The minor tree species listed below are an important component of biodiversity. In many cases they are species near the edge of their range, or are species that simply are not abundant within their range:

American hornbeam
Bitternut hickory
Black cherry
Black oak
Black walnut
Butternut
*Eastern hemlock
Hackberry
*Heart-leaved birch
*Honeylocust
Kentucky coffeetree
Mountain ash
River birch
Rock elm
Shagbark hickory
Slippery elm

Striped maple
Swamp white oak
*Sycamore?
White ash
Yellow birch
*Yellow oak

*** indicates that this species was not included in the FIA data and analyses by covertype. Sycamore is listed with a question mark because it is not certain whether the species is native to the state. If any naturally-occurring sycamore are found they likely would be in the extreme southeast corner of ecoregion 6.**

The analysis of stem numbers for the base level timber harvesting scenario in the year 2040 reveals that Kentucky coffeetree would be significantly impacted (>25 percent reduction in stem number). Significant impacts on honeylocust, yellow oak, and sycamore (if investigation shows it to be native) are also likely under the base level of harvesting.

The five asterisked species in the above listing are not included in the FIA data. Four of these species (all except heart-leaved birch), and probably striped maple as well, are so rare in Minnesota that they should never be harvested, unless there is a clear plan for regeneration using native seed stock at the harvest site. Eastern hemlock is a state-listed species and should not be harvested under any circumstance.

Reduction of Conifer Component in Aspen Stands. As discussed in section 5.2, the issue of retention of conifers in aspen stands cannot be resolved due to a lack of data. Therefore, it is not possible to predict whether conifers will be lost in short rotation harvest (and therefore whether the significance criterion is triggered). However, if such a reduction in conifer component were to occur, the impact on biodiversity would be significant and directly proportional to the level of harvest.

Changes to Minnesota Forests - Age Class Structure.

> An impact is considered significant if the projected replacement age class structure of forests, by covertype, at the end of the 50-year planning period, is insufficient to provide replacement of mature stand acreage (i.e., sustainability of forest communities).

This criterion requires examination of age class structures (appendix 8, Jaakko Pöyry Consulting, Inc. 1992a) at the end of the 50-year study to assess the feasibility of relatively short-term sustainability. This examination indicates that, at the base level of harvest, the replacement age class structure for timberland appears deficient for paper birch. This covertype remains unbalanced through the study period because of its current age class structure imbalance. Thus, this covertype is considered to exhibit a significant impact.

The results show increased or stable acreages for white pine, northern white cedar, and white spruce. White cedar is projected to have a very low harvest so the concerns are not a direct consequence of harvesting. Concerns regarding white pine center on the very limited acreage under this covertype. It is likely that much of the acreage increase referred to above is due to covertype definition or determination procedure or succession from other covertypes. Thus, concern for the present or 1990 acreage remains.

The age class structure of aspen is important as its existing imbalance (an accumulation of older age classes) plus constraints and mitigations in the second model runs forced substitution of other species for 25 percent of the aspen demand. This solved the problem of an aspen supply shortfall in the middle of the 1990–2040 study period. In the long-run, given a balanced age class structure, the substitution for aspen would probably be reduced.

Old growth forests.

An impact is considered significant if there is projected to be any net loss of area of forest meeting the DNR definition for old growth by covertype by ecoregion over the 50-year study period.

Timber harvesting per se, will have no significant impact on old growth in upland forest types as long as each candidate stand and future old growth stand is either officially reserved or officially released for harvest after the appropriate administrative procedures. However, some areas of old growth may be harvested if they are not identified by an inventory since not all government land managers have old growth field inventory and protection programs in place. No lowland conifer stands that meet old growth criteria are projected to be harvested under the base scenario. Although few stands meet the requirements of old growth as defined in this study, analysis of future forest conditions as a result of harvesting at current levels suggests a considerable increase in the amount of old forests. It should be noted that the MNDNR has limited consideration for future old growth to stands that are of natural origin and have experienced little or no human disturbance. Table 5.10 in section 5.2.2 indicates that all major covertypes are projected to experience a substantial increase in the acreage of old forest in 2040, relative to current acreages. In many instances, the expected increase is several times the current level of abundance.

Forest species - genetic variability.

> An impact is considered significant if there is projected to be a loss of genetic variability in forest plant or animal species as measured by:
> 1. a reduction or isolation of habitat or communities supporting a species, or
> 2. a reduction of geographic ecotypes such that a species now present as a viable population disappears or is approaching extirpation from any ecoregion.

Major tree species. Many tree species have clinal variation from warm-dry climates to cold-wet climates (southwest to northeast in Minnesota) (Jaakko Pöyry Consulting, Inc. 1992e). Therefore, timber harvesting and forest management activities that eliminate or isolate one or more populations of species in the regions listed in table 5.22, constitutes a significant impact on genetic diversity.

Table 5.22. Major tree species with range limits occurring within Minnesota (ER = ecoregion).

Species	Location of Range Limit
Basswood	Northern Limit: ER 1,2,3
Balsam fir	Western Limit: W. ER 1,4; N ER 5 Southern Outliers: ER 5,6
Balsam poplar	Western Limit: ER 7 Southern Outliers: ER 4,5,6
Bigtooth aspen	Western Limit: W. ER 1,4,5
Black ash	Western Limit: ER 7; W. ER 5,6
Black spruce	Western Limit: ER 7; W. ER 1,4,5 Southern Limit: S. ER 4; ER 5
Bur oak	Northern Limit: ER 1,2,3
Jack pine	Southwestern Limit: ER 7; W. ER 1,4; N ER 5
Paper birch	Western Limit: ER 7; W. ER 1,4 Southern Limit: ER 5,6
Quaking aspen	Western Limit: ER 7
Red maple	Western Limit: ER 7; W. ER 4 Southern Limit: ER 5,6
Red oak	Northern Limit: ER 1,2 Western Limit: ER 7; W. ER 4,5
Red pine	Southwestern Limit: W. ER 1,4; N. ER 5
Sugar maple	Northern Limit: ER 1,2,3 Southwestern Limit: W. ER 4,5; ER 6
Tamarack	Southwestern Limit: W. ER 1,4; S ER 5; N. ER 6
White cedar	Southwestern Limit: W. ER 1,4; ER 5
White oak	Northern Limit: N. ER 5,6; S ER 4
White pine	Southwestern Limit: W. ER 1,4; ER 5,6
White spruce	Southwestern Limit: ER 7; W. ER 1,4; N. ER 5

Source: Jaakko Pöyry Consulting, Inc. (1992e).

Endangered plant communities. Table 5.23 describes the status and occurrence of rare plant communities. Most of these communities occur in the forest transition zone—ecoregions 5 and 6—where agriculture and urban development have caused extensive habitat loss and fragmentation. In northern Minnesota (ecoregions 1 to 4) there have been few surveys of rare plant communities so that remaining occurrences are often unknown. Many of the occurrences are not protected, and any harvest in a listed community would be a significant impact. Accidental harvest of unidentified remnants of these natural communities is likely.

Table 5.23. Occurrence of critically endangered (1), endangered (2), or threatened (3) communities, by ecoregions. Subtypes and geographic sections recognized by the Natural Heritage Program are matched to the GEIS ecoregions as far as the data will allow.

Community, Status	Ecoregion						
	1	2	3	4	5	6	7
Oak savanna, mesic subtype,(1)					X	X	
Jack pine woodland (1)	X			X	X		
Oak savanna, hill subtype (1/2)					X	X	X
Oak savanna, gravel subtype (1/2)					X	X	X
Mixed oak forest, Bigwoods section, mesic subtype (2)					X	X	
Mixed oak forest, central section, mesic subtype (2)					X		X
Maple-basswood forest (Bigwoods section) (2)					X	X	
White pine forest, southeast section (2)						X	
Upland white cedar forest bluff subtype (2)						X	
Northern hardwood-conifer forest, bluff subtype (2)						X	
Oak savanna-bedrock bluff subtype (2)						X	
Jack pine barrens (2)	X	X		X	X		
White cedar swamp seepage subtype (2)	X	X	X	X			
Mixed oak forest, southeast section, mesic subtype (2/3)						X	
Mixed oak forest, southeast section, dry subtype (2/3)						X	
Northern hardwood forest (southern section) (2/3)						X	
Maple-basswood forest, southeast section (2/3)						X	
White pine forest, central section (2/3)	X			X			
Upland white cedar forest, yellow birch subtype (2/3)	X	X	X	X			
White pine-hardwood forest, southeast section, mesic subtype (2/3)						X	
White pine forest, southeast section, dry subtype (2/3)						X	
Northern hardwood-conifer forest, yellow birch-white cedar subtype (2/3)	X		X	X			
Oak savanna dune subtype (2/3)							X
Aspen openings (2/3)							X
Mixed oak forest, Bigwoods section, dry subtype (3)					X	X	
Mixed oak forest, northeast section (3)			X	X			
Northern hardwood forest, northern section (3)	X	X	X	X			

Community, Status	Ecoregion 1	2	3	4	5	6	7
Maple-basswood forest, west central section (3)					X		X
Maple-basswood forest, east central section (3)				X	X		
White pine forest, northeast section (3)		X	X	X			
Red pine forest (3)	X	X	X	X	X		
Upland white cedar forest (3)	X	X	X	X			
White pine-hardwood forest, north central section (3)	X			X	X		
Northern hardwood-conifer forest (3)	X	X	X	X			
Aspen brush prairie (3)							X
Black spruce bog, raised subtype (3)	X	X	X	X			
Black ash swamp, seepage subtype (3)				X	X	X	
Mixed hardwood swamp, seepage subtype (3)				X	X	X	
Mixed oak forest, central section, dry subtype (3)				X	X		
Maple-basswood forest, northern section (3)				X			
Northern conifer scrubland (3)	X	X	X	X			

Source: Jaakko Pöyry Consulting, Inc. (1992e).

The major implications of table 5.23 are:

1. Natural forest communities that depend on frequent fire are endangered or critically endangered. This includes savannas and woodlands, both dominated by pines and oaks. The major problem has been fire suppression, which has allowed former savannas and woodlands to convert to dense forests.
2. Natural forest communities that depend on infrequent severe fires are endangered or threatened. This includes mixed oak forests, white and red pine forests, and pine-hardwood community types. The main problem with the pine communities, in addition to fire suppression, is a failure to restore the pine acreage after early exploitation and land clearing. Limited success in regenerating white pine over the past several decades has contributed to the failure in restoring the white pine acreage to historic levels. This failure in regenerating a large acreage is due in part to the impact of white pine blister rust, expansion of the deer herd, reduced incidence of fire, and the difficulty in controlling competing vegetation. Although red pine has been extensively planted in recent decades, most of it is still young. In addition, pine seed sources were removed over large areas in parts of the state, so that natural reseeding has been slow.
3. Natural forest communities that originally covered the Bigwoods and Prairie-Forest transition zone (ecoregions 5 and 6) are endangered by clearing and conversion of land to other uses, primarily agriculture and urban areas. Included are mixed oak forests, *natural* maple-basswood

forests, and the southernmost white pine and pine-hardwood forests.

4. Upland white cedar forests are endangered. Like the former white and red pine forests, these have been converted to aspen types by land clearing. Reproduction is also hindered by high levels of deer browsing in parts of Minnesota.

Fragmentation. Fragmentation caused by timber harvesting and forest management activities can lead to a range of impacts, which can be categorized under three headings: inbreeding, direct loss of biodiversity, and relationship of fragmentation to climate change. These are discussed separately below.

1 Inbreeding. The exact distance scale of isolation needed to cause inbreeding is unknown for forest trees and plants. The farther either pollen or seeds are dispersed, the more isolated a population can be without becoming inbred. A qualitative assessment of susceptibility to inbreeding due to fragmentation was presented in section 5.2.4 and 5.4.1.

No significant fragmentation impacts due to harvesting are expected in Minnesota for species listed in the very low or low susceptibility groups. This is because the species are widespread, and few populations are isolated by more than a few miles, the one exception being woodlots in ecoregion 7. In contrast, timber harvesting will usually have a significant impact on the genetic pool of forest herbs that are rated as being highly susceptible (see section 5.4.1). Separating two populations by changing the intervening covertype, even for a distance as little as a few hundred yards, could cause loss of gene flow between populations. This may result in inbreeding and the loss of some populations.

However, other populations of forest herbs will have a large enough number of individuals and enough variability within one population, so that the population is viable, even when isolated. If gene flow is cut off, isolated populations could evolve into new varieties and (after a few thousand years), new species. This is exactly how the dwarf trout lily is believed to have evolved from the white trout lily. There is no way to assess the number of species that would be significantly impacted without a detailed map of timber harvests superimposed over a map showing the ranges of all forest herbs.

2 Direct Loss of Genetic Diversity. The same species listed as high susceptibility (forest herbs) to inbreeding also have relatively fine-scale spatial differences in gene frequencies among populations. The spatial scale of forest operations is similar to that of genetic structure of forest herbs. Therefore significant impacts will occur with gross covertype changes such as the establishment of plantations on sites previously carrying native forest. Under these circumstances, extirpation of local herb populations can result in losses of distinctive genetic material.

Significant impacts are unlikely among species of the low susceptibility group. There is one exception, however. Habitat islands such as swamp conifers separated by many miles (mainly ecoregions 5 and 6), and other outliers (i.e., sugar maple in ecoregion 3) may have genetically distinct populations that would be lost if covertype conversions occurred.

3 Relationship of Fragmentation to Climate Change. Timber harvesting at the base level scenario can cause fragmentation that will have a significant impact on genetic diversity of forest herbs and trees under a changing climate. This is because fragmented landscapes create barriers to the dispersion of many plant species. Thus, some species may be prevented from becoming established in new locations which have a favorable climate; while at the same time being confined to sites with increasingly unfavorable climates. Under these circumstances, local populations at least would be extirpated.

Deer Browsing The geographical distribution of forest covertypes and ages caused by forest management directly influences the local deer population, which in turn has consequences for biodiversity. Some plant species are reduced in abundance, or locally extirpated, by high deer populations, including showy and yellow lady slipper orchids, blunt-leaf orchid, tall northern bog orchid, purple fringed orchid, indian cucumber root, large flowered trillium, and Canada yew. In addition, deer browsing can change the entire species composition and dynamics of the woody plants in a community. In Minnesota, deer can cause failure in regeneration for two important tree species—white cedar and white pine. Yellow birch, a minor tree species, and eastern hemlock, a special concern species, can also be reduced in abundance by deer browsing. Significant impacts on biodiversity are likely in areas where the spatial and temporal pattern of harvesting leads to high deer populations.

Federal- or state-listed plant species of special concern, threatened, or endangered or their habitats.

> An impact is considered significant if any harvest or forest management activity is projected to diminish the habitat and disturb a species listed as of special concern, threatened, or endangered (either federal or state).

In general, the forest-dependent rare plant species of Minnesota are poorly adapted to trampling types of injury. With the exception of the one tree species on the list, all species are of small stature and easily broken. Operation of harvesting equipment can significantly impact populations of rare plant species within areas harvested. The lack of knowledge regarding the locations of rare species in the state makes it impossible to undertake a more quantitative analysis. In any case, the comparatively coarse level of resolution of the model output would preclude such an analysis. Table 5.16 provided estimates of the numbers of endangered, threatened, or special concern plants by ecoregion. Statewide, 9, 7, and 37 species listed as endangered, threatened, or of special concern, respectively, are projected to be adversely impacted by harvesting.

Forest Health—change in susceptibility or vulnerability

> An impact is considered significant if projected changes to the forest and activities undertaken lead directly or indirectly to changed susceptibility (risk of an outbreak/infection) or vulnerability (damage if an outbreak occurs) to more than 10 percent by area by covertype.

All timber harvesting and forest management activities affect forest health; all have impacts. Those impacts range from nearly none (where the management activity is minimal) to very significant (where major changes are brought about in the forest). Given changes, vulnerability to impacts is a function of the insect, disease or other health vector, the harvesting or management related disturbance that would favor its expansion or development, and the susceptibility of the forest as defined by relevant vegetation patterns, forest age class structure, etc. The continuum of impacts is impossible to treat in any quantitative sense, so a threshold must be established. Impacts that are greater than that threshold merit attention; impacts below the threshold are not large enough to justify further consideration.

Certain assumptions were made out of necessity to model and analyze significant impacts on forest health. In particular, it was assumed that the MNDNR pest management guidelines and other guidelines would be followed by all ownerships. However, in reality, their application on NIPF lands is highly debateable today. In this light, if the guidelines are not followed, impacts of harvesting on the health of Minnesota's forests could be more severe. The use of ERF in certain areas may increase susceptibility and vulnerability and that will heighten the need for active and integrated pest management. This is because the guidelines are intended to prevent pests and diseases from becoming established by avoiding the creation of conditions that are suitable for pests. The significant impacts projected to occur under the base level harvesting scenario are discussed below.

Aspen-birch forest type group. The area of the aspen-birch forest type group more than 40 years old decreases by more than 10 percent when the final age class distribution projected at the base harvest level is compared with the existing distribution. This change will alter the susceptibility and vulnerability of this forest type group to outbreaks of specific insect and disease pests.

The decrease in the proportion of aspen stands in the older age classes may reduce vulnerability to damage from the forest tent caterpillar. Consequently, mortality and volume loss associated with defoliation may decrease, although quantitative data to support this judgement are lacking. Therefore, this is a significant positive impact. Other impacts, including effects of forest tent caterpillar on aesthetic and recreational values, are not likely to change.

In addition, the incidence and severity of decay due to white trunk rot should be reduced as the older, more decayed stands are cut. Aspen less than 40 years old will not be free from decay but the percent of wood decayed will be less in the younger stands. To maximize the possibility of a positive impact, management must be followed that minimizes decay. Well-stocked aspen stands on average sites grown to a rotation age of 40 to 45 years may be affected less by decay than stands that are maintained to rotation ages in excess of 50 years.

Under the base harvest level, Hypoxylon canker should decrease if management guidelines for its control are followed. Aspen stands with a greater than 25 percent infection rate from Hypoxylon canker should be converted to other species to increase productivity on the site. Good harvesting practices should ensure well-stocked stands, reducing infection.

Under the projected harvest level, Armillaria may increase. Root rot incidence can increase as a function of stand age, but if soil compaction and rutting occur during the harvest, root injury may occur and increase the incidence of *Armillaria* in younger, regenerating stands.

Harvesting will also affect both the susceptibility and vulnerability of birch to dieback and mortality. Under the base harvest scenario, the average age of birch will increase compared to 1990. This will likely increase the potential for losses from the bronze birch borer as a result of the increased percentage of brood trees in the older stands. An increase in bronze birch borer activity may also contribute to increasing levels of *Armillaria* root rot in the stands. Harvesting or other disturbances in pure and mixed birch stands can also cause significant negative impacts as stands are opened up and subjected to drier and warmer conditions. This in turn may lead to stress on the trees and to increased susceptibility and vulnerability to bronze birch borer and *Armillaria* root rot.

Black spruce forest type group. Under the base harvest level in the year 2040, the area of black spruce forest type group less than 40 years old is projected to decline by more than 10 percent, and the area over 60 years old is projected to increase by more than 10 percent. These changes are likely to increase the incidence of root and butt rots caused by *Inonotus tomentosus* which become more prevalent in stands older than 60 years. Therefore, this is a significant negative impact.

Sanitation practices are the key to controlling dwarf mistletoe on black spruce. If sanitation practices are followed when harvesting dwarf mistletoe infested stands, species composition may be moved toward tamarack and lowland brush.

Lowland conifers forest type group. Under the base level of harvest, the area of lowland conifers less than 40 years old is projected to decrease by more than 10 percent, while the area older than 60 years is projected to increase by more than 10 percent. Impacts on balsam fir stands are as discussed under spruce-fir below. For the remaining species, the effects of significant changes in harvest intensity on the susceptibility or vulnerability of lowland conifer stands to insect and disease pests is unknown.

Lowland hardwoods forest type group. The area of lowland hardwoods forest type group less than 40 years old is projected to increase by more than 10 percent under the base harvest levels. In addition, the area in the more than 60-year-old age class would increase by more than 10 percent. There are relatively few major pests that are likely to be affected by changing the level of harvest in lowland hardwood types.

Pine forest type group. Changes in age class structure would be near or less than 10 percent under the base harvest level. Incidence of *Diplodia* and *Sirococcus* shoot blights and canker and possibly *Scleroderris* canker on young (<40 years old) red pine may increase if the areas replanted to red pine are not carefully chosen. Neither of these pests are major problems on older red pine, so the projected increase in area of pine more than 40 years old should not have a significant effect on disease incidence in older red pine. There is a potential for an increase in diseases such as needlecasts and gall rust as nursery seedlings are planted to replace the harvested trees.

Lophodermium needlecast on red pine and gall rust of jack pine are two diseases that can be introduced into the field on infected nursery stock. Additionally the overall increasing average age of jack pine will likely lead to an increase in vulnerability and susceptability to budworm damage.

An increase in the area of older pine forest type group may increase the amount of pine that is less vigorous and able to resist Ips beetles following damage by wind, lightning, flooding, defoliation, or pathogens. Incidence of Ips may therefore increase.

At the base harvest level, harvested white pine stands are projected to be replaced by younger stands which are more susceptible and vulnerable to white pine weevil. This is particularly true for plantations. Therefore, this is a significant adverse impact. The increase in younger white pine could increase the incidence of white pine blister rust, especially if white pine is regenerated in northern Minnesota. This concern includes underplanting efforts in historic pine areas. Therefore, this is a significant adverse impact.

Spruce-fir forest type group. The area of spruce-fir forest type group less than 40 years old is projected to decrease by more than 10 percent under the base harvesting level, and the area more than 40 years old would increase by more than 10 percent at that level. The overall increase in tree age within this forest type group will increase vulnerability and susceptibility of stands to budworm damage. Older trees produce more staminate cones and are more likely to experience population outbreaks. Older trees are also generally less tolerant of defoliation than young trees. The probability of wildfire will increase since risk factors such as mortality, breakage, and windthrow that follow budworm outbreaks will increase. Therefore, this is a significant negative impact.

The increase in area of older spruce-fir forest type group will lead to an increase in the level of susceptibility and vulnerability of these species to trunk, root and butt rots. This is a significant negative impact.

Upland hardwoods forest type group. The area of upland hardwoods forest type group less than 40 years old is projected to increase under the base harvest level, and the area over 60 years old would also increase by more than 10 percent.

Under the higher levels of harvesting intensity, the area of younger trees will increase. Younger trees generally grow more vigorously and have more starch reserves than older trees. They are, therefore, less affected by drought and other environmental stress and are presumably less susceptible to severe damage by two-lined chestnut borer. The reduced susceptibility of the younger trees will be offset by an increase in the area of older forest.

Clearcutting stands of the upland hardwoods forest type group should reduce the incidence of decay in the mid-term (10 to 50 years) and cankers in the short-term (< 10 years) as decayed and cankered trees are removed from the stand. However, selection and shelterwood cuts are often preferred methods of regenerating stands of upland hardwood forest type groups. If some type of multiple entry harvest is chosen, the chances of wounding residual trees increases; the incidence of decay and cankers is also likely to increase. Thinning and other stand entries are projected to increase substantially in stands of upland hardwood forest type. Hence the overall impact of increased harvesting is a likely increase in decays and cankers and a reduction in timber quality. However, the impact of multiple entries may be offset by judicious use of the opportunities they provide to remove damaged and decaying timber.

Under the base level timber harvest, a medium-term (10 to 50 years) decrease in the incidence of oak wilt is expected if clearcutting is the method of harvest. Clearcutting would eliminate oak wilt pockets within the clearcuts. Multiple stand entries may tend to injure oak, making them more susceptible to infection. Given that multiple entry harvest will predominate, the amount of oak wilt is therefore projected to increase (with high uncertainty of prediction).

5.6.2 Soil Resources

Nutrients

> An impact is considered significant if nutrients removed and/or redistributed during harvest and followup activities are not replaced over the term of the projected rotation.

Harvest of merchantable bole did not remove either nitrogen or phosphorus beyond their rates of replenishment. Areas at risk for loss of calcium are most closely associated with harvest of aspen-birch and upland hardwoods on medium-textured soils and especially on coarse-textured soils. Because of this, approximately 5 million acres are at risk for calcium loss. Loss of magnesium beyond rates of replenishment is especially associated with harvest on coarse-textured soils and organic soils. Under the base scenario, about 2.5 million acres are at risk for magnesium loss. Finally, potassium loss is primarily associated with harvest of aspen-birch on coarse-textured soils and the harvest of all deciduous types on organic soils. Under the base scenario, about 1.5 million acres are at risk for potassium loss.

Other Activities

Delimbing and Topping. Based on the summary of timber harvest operations carried out as part of the GEIS, delimbing and topping is carried out at a landing in about one-third of the harvests. This practice does not recycle or replenish the nutrients on the site, and is equivalent to a full-tree harvest in terms of nutrient depletion. The data developed for harvest of merchantable bole should be increased to take this practice into consideration as described in section 5.3.1.

Mechanical Site Preparation. Although not directly considered by the three harvesting scenarios, nutrient depletion related to site preparation techniques has also been evaluated. The Silvicultural Systems background paper (Jaakko Pöyry Consulting, Inc. 1992m) indicates that each year about 18,000 acres are treated using mechanical site preparation techniques. There is virtually no justification, from the standpoint of nutrient status, for any site preparation technique that displaces material. Mechanical techniques that create slash piles or windrows either remove nutrients from the site or localize them, depleting the remainder of the area; from the standpoint of nutrient conservation such techniques should be abandoned. Site preparation techniques that incorporate materials, or only displace materials a foot or two, do not have those negative impacts.

Compaction and Related Disturbances

> An impact is considered significant if the proportion of the harvest unit projected to be moderately to severely compacted/puddled exceeds the following threshold proportions:
> - 5 percent on highly sensitive sites;
> - 10 percent on moderately sensitive sites; and
> - 20 percent on sites with low sensitivity.

The statewide analysis of significant impacts under the base level of harvests indicates that impacts were most frequent on the well-drained medium-textured soils, which are the most common soils in the state, and the poorly-drained medium and poorly-drained fine soils which have the lowest strength.

The following figures are the cumulative results for the 50-year planning period assuming the base level harvesting scenario and the seasonal distribution of harvesting activities outlined in the Silvicultural Systems background paper (Jaakko Pöyry Consulting, Inc. 1992m). Approximately 6.3 million acres would be harvested statewide. The significance criteria would be exceeded in harvesting units representing about 840,000 acres. If 1 percent of the area harvested were devoted to haul roads in order to extract the timber, an additional 60,000 acres would be significantly impacted.

The impact assessment indicated that increased levels of timber harvesting will invariably lead to increased amounts of compaction and related disturbance. The significance criteria were exceeded by both mechanical- and hand-felling operations on moderately and highly sensitive sites. It was estimated that about 25 percent of the area within moderately sensitive sites would be negatively affected by equipment trafficking for both harvesting configurations. The portion of highly sensitive sites that are negatively impacted could increase to about 30 percent for hand-felling operations and 55 percent for mechanical-felling operations.

These results reflect the seasonal harvesting distribution on all soil types within each ecoregion. Limiting timber harvesting to specific seasons on individual soils or sites could greatly affect the impact assessment. The MNDNR and some counties are starting to implement these practices on upland sites, in addition to the long-standing use of these practices on organic soils.

Based on the above results, crude estimates of the potential impact of compaction and related disturbances on future productivity can be made. The *actual* area impacted within harvest units where significance criteria were exceeded is about 330,000 acres. An additional 60,000 acres would be impacted under the base scenario if 1 percent of the area harvested is occupied by haul roads. Assuming that productivity is reduced by 25 percent in lightly trafficked areas, by 50 percent in heavily trafficked areas, and by 75 percent in haul roads, these impacts would translate to losing the wood-producing equivalent of as much as 170,000 acres.

Soil Erosion

An impact is considered significant if the rate of soil loss is projected to exceed the limits prescribed by the U.S. Soil Conservation Service expressed as:

$$\text{rate} > T$$

where T varies between 1-5 (tons/ac/yr)

Surface erosion rates exceeded T values on less than 1 percent of the area harvested, and this significant impact was predominantly limited to well-drained soils which exist on steeper slopes.

These results represent the total area impacted over the 50-year planning period. The analyses indicated that significance criteria would be exceeded only in moderately and heavily trafficked areas (skid trails) within harvest units and on haul roads. Also, significant impacts were concentrated in well-drained mineral soils, which is to be expected since they are the soils with steepest slopes.

Under the base level of harvest, about 25,000 acres within harvest units would develop erosion rates that exceed T values. Accelerated erosion caused by skidding and felling activities would exceed T values on less than 1 percent of the total area harvested during the 50-year period.

The greatest erosion rates were estimated to occur in ecoregion 6. This ecoregion has the steepest slopes. The southern portion of the state also has the highest rainfall intensity. It was estimated that initial erosion rates could exceed 14 ton/ac/yr in some areas in ecoregion 6. Initial rates rarely exceeded 5 ton/ac/yr in other ecoregions.

If an area equal to 1 percent of the harvest area were utilized for haul roads, T values would be exceeded on an additional 6,000 acres under the base level of harvest. These totals indicate that erosion rates would be exceeded on about 8 percent of the haul road area.

Erosion associated with haul roads would occur at faster rates than erosion within harvest units. This is a function of the more complete removal of surface protection and smoothing of the ground surface in haul roads. The analyses indicated that maximum initial erosion rates in haul roads could approach 100 ton/ac/yr in some areas.

The effects of timber harvesting and forest management activities on mass movements were not quantified. The greatest potential for mass movements would occur in areas with steep slopes such as the Coulee region of southeastern Minnesota (in ecoregion 6) and areas with shallow soils over bedrock (ecoregions 2 and 3). However, there is currently no evidence suggesting that mass movements are currently a major problem in forested portions of Minnesota.

5.6.3 Water Resources and Aquatic Ecosystems

These criteria were applied to identify significant impacts affecting water resources and aquatic ecosystems.

Lakes, rivers, streams and wetlands - level of sedimentation/nutrient loading.

> An impact is considered significant if timber harvesting and associated management activities are projected to cause changes in the level of sedimentation and/or nutrient loading of waterbodies such that more than 25 percent of monitoring observations following harvest exceed the 85th percentile of preharvest or reference conditions.

Lakes, rivers, streams and wetlands - runoff.

> An impact is considered significant if projected timber harvesting and associated management activities cause changes that result in greater than 60 percent of a *Minor Watershed*[2] to be in a *disturbed condition*[3] at any time.

[2]Minor watersheds as defined in MNDNR 1979 Watershed Map.

[3]Disturbed condition is defined as cleared land or regenerated forest younger than age 15 years.

Lakes, rivers, streams and wetlands/peatlands - aquatic ecosystems.

> An impact is considered significant if timber harvesting and forest management activities are projected to result in changes to one or more aquatic ecosystem variables such that:
>
> a. more than 25 percent of observations exceed the 85th percentile of preharvest or reference conditions for the following variables:
>   - sediment levels,
>   - water nutrient levels; or
>
> b. peak streamflows more than double or if minimum flows fall below the *7Q10*[4] level; or
>
> c. more than 25 percent of observations exceed the 85th percentile or fall below the 15th percentile of preharvest or reference conditions for
>   - *aquatic community structure, community function or fish populations*[5].

Application of the above criteria to the impacts identified in section 5.3.2 indicates that the effects of timber harvest at the ecoregion level will not cause impacts that will exceed the thresholds specified in the criteria.

However, there will be a series of changes in the landscape and water resource. Most of those changes will be relatively local and short-term. Timber harvest which complies with Minnesota BMPs will have significantly fewer local water resource impacts than timber harvest carried out in the absence of BMPs.

Timber harvest is, by nature, a disturbance to the forest community and the landscape. The degree to which a given disturbance represents an *impact* is a matter of scale. For example, few if any landscape modifications associated with timber harvest will be detectable in large rivers such as the upper Mississippi. As one progresses further upstream, the probability of detecting impacts increases as changes outside of the identified standards and tolerances become more noticeable.

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[4] The 7Q10 designation is a measure of the lowest flow for any 7-day period within any 10-year interval, and is widely used to protect water quality. Other methods for which significance criteria could be developed (e.g., wetted perimeter, Tennant's method, Instream Flow Incremental Methodology) would be more appropriate in representing fish habitat values.

[5] Specific variables to be measured might include kinds and numbers of organisms, rates at which the community processes energy or nutrients or the populations of fishes. The specific variables to be measured will be chosen by scientists assessing any given timber harvest operation(s).

Thus, one can imagine a landscape drained by a series of lakes and rivers, and within which timber harvest occurs. In the lowest reaches of the watershed (i.e., in the largest waterbodies) no water resource changes are attributable to the timber harvest. As one moves further upstream, changes in the water resource become more apparent. At a higher intensity of timber harvest, changes will be detectable further downstream. The first (i.e., furthest downstream) changes that will be detected will be slight increases in annual water yield and peak snowmelt runoff. There will also be a relatively small area in which peak snowmelt streamflow will double, compared to baseline conditions. The next most upstream change will be increases in stream dissolved ions, followed by increases in lake nitrogen. These kinds of changes might be detectable in a third-order watershed. (Stream ordering compares streams within and among watersheds. Small streams at the uppermost part of a stream system or watershed are called *first order*. Two first-order streams join to form a *second-order* stream, two second-order streams join to form a *third-order* stream, etc.)

5.6.4 Wildlife Populations

These criteria were used to determine the significance of impacts of projected changes in wildlife populations.

Forest-dependent wildlife - habitats.

An impact is considered significant if the available habitat of a species is projected to be changed by 25 percent in any ecoregion.

In most circumstances, reduction in area of habitat was regarded as a negative impact. However, in some cases, an increase in habitat may also have negative impacts, e.g., where the species are known to have ecological or economic impacts under certain circumstances, such as cowbirds, foxes, deer (in some regions), and beavers.

There may also be positive impacts from increases in habitat, particularly for favored game species that increase with increasing early succession forests, such as deer and Ruffed Grouse.

The criterion was not applied in cases where the species increase is not of any presently perceived ecological or economic importance.

A total of 173 species of interest were assessed by the above criteria (22 small- and medium-sized mammals, 5 large mammals, 138 birds, and 8 herptofauna). Of the various significance criteria that relate to biodiversity and forest wildlife, the criterion *forest-dependent wildlife - habitats* can be tied most directly, explicitly, and quantitatively to the FIA data; the harvest model output; and the subsequent analyses. In an attempt to maintain the strongest link possible between the analyses and the FIA data/model output, all four subgroups (small- and medium-sized mammals, large mammals, birds, and amphibians and reptiles) emphasized use of this criterion in assessing impacts.

The term *available habitat* used in the criterion has been interpreted to indicate not only the habitat in which a species is present, but also differences in abundance among several habitat types used by the species. Under this approach, a change in forest composition that involves a shift in proportions of high and low density habitats, even where total acreage remains the same, would be projected into a change in potential population abundance (via habitat association). Such an approach was used for all species categories except herps. Data on distribution and habitat requirements of herps are inadequate to permit this level of analysis.

A second criterion listed in this section assesses the significance of impacts on populations of endangered, threatened, or species of special concern. Its application is directly related to the analyses used to assess the overall population changes under the first criterion presented in this section. This second criterion uses **any** negative change in habitat as the threshold for significance. A decrease of 5 percent in habitat or population index statewide was interpreted to be a significant impact to allow for error in the analyses; a 1 or 2 percent decrease in the type of projections used here may not be statistically valid.

Table 5.24 summarizes the wildlife species showing significant negative impacts by this criteria and the second one involving endangered, threatened, or species of special concern or their habitat. Note that with the first criteria, an adverse impact occurred whenever a species in any ecoregion and decade met the criteria. Forty-six species, about 27 percent of all wildlife species included in the analysis, were projected to be significantly impacted over the 50-year study period under the base scenario. Most species significantly impacted under this scenario were also projected to be impacted under the medium and high scenarios; for some of these the number of ecoregions and/or decades in which the impacts occurred was higher under the medium and high harvest scenarios.

Table 5.24 (as well as the analogous tables for the medium and high harvest scenarios, section 6.6.4 and 7.7.4), shows those species that are expected to decline at least 25 percent statewide, as well as by ecoregion. It is well known that changing the geographic extent of a land unit changes the resulting projected impacts. For example, the appropriate habitat for a given species may comprise only 1 percent of the land area of ecoregion 1, but most or all of the land area in other ecoregions. In this case, one small harvest in ecoregion 1 may negatively impact the species, whereas large areas of harvest would not adversely impact the species in any other ecoregion, and the statewide population could be stable. On the other hand, if the species occurred only in one ecoregion, and there was a significant impact in that ecoregion, then there would also be a statewide impact. The

Table 5.24. Species significantly negatively impacted on all forest lands under the base level of harvest using criterion 8 (≥5 percent statewide decline for a species listed as endangered, threatened, or special concern) and criterion 11 (≥25 percent decline in any ecoregion). Numbers in parentheses indicate ecoregions with a projected decline ≥25 percent. Double x (xx) shows those species with a ≥25 percent decline statewide, plus all species affected by criteria 8.

Species	Species Significantly Impacted
Small- and medium-sized mammals:	
Beaver	x (2,6)
Northern flying squirrel	x (5)
Gray squirrel	x (4,7)
Fox squirrel	x (4,7)
Bobcat	x (3)
Lynx	x (3)
Birds	
Green-backed Heron	x (3,6)
Cooper's Hawk	x (4)
Northern Goshawk	x (4)
Red-shouldered Hawk	xx (4,5,6)
Eastern Screech-owl	x (4)
Great Gray Owl	x (3)
Whip-poor-will	x (7)
Hairy Woodpecker	x (6)
Northern Flicker	x (2)
Pileated Woodpecker	x (6)
Eastern Wood Pewee	x (4)
Acadian Flycatcher	x (6)
Eastern Phoebe	x (2)
Gray Jay	x (3)
Boreal Chickadee	x (3)
Eastern Bluebird	x (2)
Swainson's Thrush	x (3)
Gray Catbird	x (2)
Brown Thrasher	x (2)
Yellow-throated Vireo	xx (4,6)
Yellow Warbler	x (2)

Table 5.24. (continued)

Species	Species Significantly Impacted
Magnolia Warbler	x (3)
Cerulean Warbler	x (6)
Ovenbird	x (6)
Louisiana Waterthrush	x (7)
Connecticut Warbler	x (3)
Common Yellowthroat	x (2)
Hooded Warbler	xx (6)
Wilson's Warbler	xx (2)
Yellow-rumped Warbler	x (3)
Scarlet Tanager	x (6)
Song Sparrow	x (2)
Lincoln's Sparrow	xx (1,2,3,4)
Dark-eyed Junco	x (3,4)
Common Grackle	x (2)
Northern Oriole	x (4)
Purple Finch	x (3)
Pine Siskin	x (5)
American Goldfinch	x (2)
Amphibians and Reptiles:	
Ringneck snake	x (1)

Source: Jaakko Pöyry Consulting, Inc. (1992f).

reason for showing statewide impacts is simply to provide the reader with comparisons of projected wildlife populations at different spatial scales. The main reason for assessing the significance of harvesting impacts at the ecoregion level, is so that an increase in population of a given species in one ecoregion cannot be seen as balancing a decrease in another ecoregion. If this were the case, then a species could contract its range without showing a significant impact. The GEIS Advisory Committee and consultant consider developing a strategy for managing forests that allows species to maintain their entire range within Minnesota to be very important.

No large mammals would be significantly impacted under the base scenario. Six small mammals would be negatively impacted. Species included beaver, bobcat, northern flying squirrel, gray and fox squirrels, and lynx. Thirty-nine bird species (28 percent) were projected to be adversely affected.

Small mammals: The six small mammals adversely impacted at the base harvest level include gray and fox squirrels, which are associated with mature oak forests. The northern flying squirrel requires large tracts of forest to maintain stable populations and may be adversely affected by forest fragmentation. Beaver are projected to be impacted for one decade in two ecoregions. The projected decline in this species must be viewed against a trend of population increases elsewhere. The remaining species showing negative impacts, lynx and bobcat, occupy a variety of covertypes and impacts on these species may reflect an overall reduction in the area of mature forests in these covertypes.

Birds: Three hardwood dependent species, Red-shouldered Hawk, Yellow-throated Vireo, and Hooded Warbler were projected to be impacted statewide when all forest land was considered. Lincoln's Sparrow (conifer dependent) and Wilson's Warbler were the other two species impacted. Loss of mature, contiguous hardwood forest in the southern part of the state was the likely cause of projected declines in the Hooded Warbler population. Projected loss of mature hardwood forests in ecoregions 4, 5, and 6 is the likely cause of the predicted drop in the population of Yellow-throated Vireo. The Red-shouldered Hawk was adversely affected by projected declines of contiguous, mature, deciduous forests in ecoregions 4, 5, and 6.

The changes for some species also translate into 25 percent or more declines on a statewide basis. These are summarized in table 5.19 in section 5.4.1. Statewide, 5 species would decline by 25 percent or more under the base scenario. The statewide declines include one species that is listed as endangered, threatened, or of special concern (Red-shouldered Hawk).

Herps: The ringneck was the only species showing adverse impacts under the base scenario.

Federal- or state-listed wildlife species of special concern, threatened, or endangered or their habitats.

> An impact is considered significant if any harvest or forest management activity is projected to diminish the habitat and disturb a species listed as of special concern, threatened, or endangered (either federal or state).

For analysis, a decrease of 5 percent or more in habitat or population index statewide was interpreted to be a significant impact.

Under the base level of harvest the following significant impacts are projected to occur for animal species within these categories.

Birds

- Red-shouldered Hawk: *An overall statewide decrease is predicted on timberlands and on all forest lands.*

In addition to the direct assessments of population change listed above, two other criteria were used to identify impacts on key habitat factors for some species. These criteria and the assessments of significance are discussed below.

Forest-dependent wildlife - habitats (lowland conifers).

An impact is considered significant if, by ecoregion, net loss of patches of mature lowland conifer between 10 and 200 acres is projected to exceed 25 percent of total patches over the 50-year study period.

This issue is relevant in regions of the state where lowland conifers occur as relatively small, separate patches within more extensive upland forests. As part of a forest mosaic, these patches provide local cover for a variety of mammals, and are often being more important in winter than summer, except in the case of moose. For deer, one study recommends that in northern Minnesota lowland conifers comprise a minimum of forest cover within each square mile. Mature northern white cedar is the most suitable for thermal cover.

Good year-round habitat for deer, moose, and snowshoe hare includes lowland conifer cover adjacent to productive young hardwood stands. Both the snowshoe hare and its chief predators, the lynx and bobcat, are closely tied to lowland conifers, and during years of low hare abundance, this is the primary habitat where they are found during winter. Other closely associated species are the northern flying squirrel, pine marten, and fisher. Spruce Grouse are seldom found anywhere in winter other than lowland conifer, generally dominated by black spruce and tamarack. Characteristic breeding bird species are the Connecticut Warbler, Palm Warbler, Yellow-bellied Flycatcher, and Swainson's Thrush.

Available data do not allow quantifying the number and acreage of these patches. However, covertype acreage changes in table 5.8 suggest it can be at least locally important for patches of black spruce and balsam fir.

In regions where great expanses of lowland conifers, particularly black spruce, predominate on the landscape, protection of this covertype is not as critical to wildlife as where the type occurs as isolated patches.

Forest-dependent wildlife - food species.

> An impact is considered significant if, by ecoregion, the projected rate of removal of tree species that provide vital food for wildlife (oaks, hickories and mountain ash), exceeds their projected rate of replacement.

Under the base harvest level, some species projected to have significant declines in certain ecoregions, such as the grey and fox squirrels, rely on mature oak forests for food and cavity resources. However, precise estimates of trends in specific food trees was not possible. In cases where the food producing species is also part of the dominant cover and the age at which that species begins producing the food were known, then the relationship was modelled. An example is the projected changes in populations of acorn-eating mammals such as the two mentioned above. These projections were based on the projected changes in oak-dominated covertypes in ecoregions 5, 6, and 7 and the southern part of ecoregion 4.

The following list includes some of the more obvious instances of vital linkages between food trees and individual bird or mammal species:

- porcupine—white pine, red pine, maples, oaks, basswood, and tamarack;
- black bear, white-tailed deer, southern flying squirrel, fox squirrel, gray squirrel, Wood Duck, and Wild Turkey—oaks and other trees that produce mast;
- red squirrel—conifers, particularly white spruce;
- Ruffed Grouse—quaking aspen;
- Pine Grosbeak, American Robin, Cedar and Bohemian Waxwings, and red fox—mountain ash and cherries; and
- Pine Siskin and Common Redpoll—birches.

Although these tree species are conspicuously important as food sources for some wildlife, both reproductive and vegetative parts of *all* tree species provide some type of forage to some bird or mammal.

Forest species - genetic variability.

> An impact is considered significant if there is projected to be a loss of genetic variability in forest plant or animal species as measured by:
> 1. a reduction or isolation of habitat or communities supporting a species, or
> 2. a reduction of geographic ecotypes such that a species now present as a viable population disappears or is approaching extirpation from any ecoregion.

The issue here is one of fragmentation, isolation, and, finally, the loss of local segments of a species' geographic distribution, assuming that distinct genetic variation is spread across that geographic range. That is, loss of population segments that are separated by many miles from the nearest segment may mean a permanent loss of unique genetic traits that are an integral part of the species genetic diversity. The importance of a change affecting individual species can be assessed by weighing several factors, including the overall size of the population, the distances involved, and particularly the mobility of the animal. Thus, birds would probably be the least affected and herps would be the most vulnerable, particularly those that are unlikely to disperse along major streams and rivers. Some species show genetic variability over their range; others have a more homogeneous genetic makeup. Information on this is essentially lacking, so this discussion must be confined to generalities. This issue is fully discussed with regard to plants in the Biodiversity technical paper.

In general, when fragmented populations at or near the boundaries of a species range are in jeopardy, genetic loss is much more likely than when an equal degree of local loss occurs well inside the geographic range of a species. Minnesota, with its great diversity of forest and climatic types, includes the distributional limits of many wildlife species—including cases of northern, southern, eastern, and western edges of species' distributions. Thus, among midwestern states, Minnesota has an unusually large number of cases where the edges of a species' genetic variability might be jeopardized. Species with significant predicted impacts from timber harvesting that reach the edge of their range in the state include: black bear, fisher, pine marten, northern flying squirrel, fox squirrel, red squirrel, woodland jumping mouse, lynx, Great Gray Owl, Boreal Owl, and red-backed salamander.

5.6.5 Recreation and Aesthetics

Changes to Minnesota forests - Patterns of forest cover in predominately forested areas-forest roads

> An impact is considered significant if there is projected to be development of permanent forest roads in areas meeting the criteria for either of the following Recreation Opportunity Spectrum (ROS) categories:
> - unroaded primitive areas.
> - semiprimitive nonmotorized areas.

The two ROS classes used in the criterion are defined as:

Primitive.—An area three or more miles from all maintained roads or railroads and which has an unmodified natural environment. There can be evidence of foot trails, or recreational use. Structures in use are rare. Contact with humans is rare and chances of seeing wildlife are good. Example: BWCAW. Approximately 3 percent of total forest land and 0.4 percent of timberland in Minnesota meet these criteria.

Semiprimitive nonmotorized.—An area one-half to three miles from all maintained roads or railroads, but which can be close to primitive roads or trails used only occasionally. Modifications to the environment are evident, such as old stumps from logging, but are not apparent to the casual observer. Structures in use are rare. Human contact is low and chances of seeing wildlife are good. Example: Recently undisturbed state lands. Approximately 9 percent of total forest land and 7.2 percent of timberland meet these criteria.

A permanent forest road is defined as a formed road that is graveled or paved and is maintained in a trafficable condition (as distinct from being allowed to revegetate). The criterion is intended to identify changes in the pattern of disturbance to the least disturbed areas of the unreserved forest lands. The ROS criteria assess levels of disturbance, particularly roads. The criterion was applied to northern counties that are predominantly forested (see table 5.25).

Harvesting and the development of roads needed to access timber from forests within these categories of lands is indicative of an increased level of disturbance. Improved access provides opportunities for additional use by people who depend on motorized access. This will likely displace a proportion of existing users and will impact animals that are adversely affected when the level of human contact increases.

Table 5.25. Distribution of FIA timberland plots and percent of plots projected to be harvested in primitive and semiprimitive nonmotorized ROS classes, by physiographic class under the base scenario.

ROS Class	Total number of plots	Percent of timberland plots harvested by scenario and ownership*			
		Base Scenario			
		State/federal lands		Other lands	
		dry	wet	dry	wet
Primitive	53	11.3	3.8	20.7	7.6
Semiprimitive nonmotorized	876	10.8	6.3	15.3	3.9

* See table 5.19 for total number of plots harvested by scenario.

According to the criterion used, only plots harvested on dry sites constitute significant impacts to primitive and semiprimitive nonmotorized recreation opportunities. The criterion specified for use in assessing impacts on primitive class lands further requires identification of those areas designated unroaded *primitive* lands and *semiprimitive nonmotorized* lands, where construction of permanent forest roads is projected.

Under the base scenario, 32.0 percent of the 53 timberland plots designated as primitive and dry are projected to be harvested and therefore significantly impacted. Additionally, 26.1 percent of the 876 timberland plots designated as semiprimitive nonmotorized are projected to be significantly impacted. These impacted plots correspond to 4.0 and 17.4 percent of all forested plots in the primitive and semiprimitive nonmotorized ROS classes, respectively. Based on the criterion, no significant impacts occur when plots in the "wet" physiographic classes are projected to be harvested. These plots would be accessed when the ground is frozen and therefore are assumed not to require permanent roads.

Forest Recreation and Aesthetics

> An impact is considered significant if VMGs are not used in the planning and execution of projected timber sales for visually sensitive areas.

The criterion refers to VMGs, which are planning tools used by the federal and state ownerships to reduce visual impacts. Significant impacts can be avoided where visual planning is used to identify *where* and *how* harvesting and associated forest operations should take place, i.e., road location and design, use of buffers, size and shape of cut, and slash and debris disposal practices.

Harvesting can reduce the aesthetic experience for subsequent users, therefore limiting the recreation value of harvested areas and the adjacent unharvested areas. However, harvest operations and associated roading can also create additional recreation opportunities of a more developed type.

Visually sensitive forested areas recognized in this criterion can include such areas as those adjacent (within one-fourth mile) to water (lakes and rivers), important tourist and recreation areas, and along recognized tourist access routes. The criterion assumes that significant impacts occur where harvesting operations take place in visually sensitive areas on lands where owners do not practice formalized visual management planning. For example, the USDA Forest Service has had formalized VMSs in place for a long time. Other ownerships, including MNDNR Management Region 2 and Beltrami County, are in the process of developing and applying guidelines. Once developed, the MNDNR guidelines are expected to be extended to other MNDNR regions over the next several years.

Typically, other ownerships do not have formalized systems in place. Hence, while in some cases efforts are made to reduce visual impacts on a site by site basis, impacts can still occur when viewed from a wider context.

The certainty of the impact is dependent on the degree to which visual planning is used in timber sale layout and BMPs are adhered to in the execution of the harvesting and postharvest closure of the site. Impacts can extend into the medium-term depending on the circumstances. Existing guidelines that mitigate against impacts are:

- USDA Forest Service VMS;
- DNR - Draft VMGs;
- Wisconsin DNR - Silvicultural and Forest Aesthetics Handbook;
- Shipstead-Newton-Nolan Act;
- Statewide Shoreline Rules (p.31 subpart 8) prescribes use of BMPs within
  - 1,000' of lakes, ponds, flowages
  - 300' of rivers and streams
  - floodplains;
- Upper Mississippi Headwaters Ordinances seeks to preserve the scenic and aesthetic character of the shoreland along the river;
- DNR operational order (95) establishes a ¼-mile buffer around BWCAW for leasing minerals;
- Federal Wild and Scenic Rivers Act (1968) established a 200-foot buffer; and
- State Wild and Scenic Rivers Act.

There are no direct biological implications associated with the use of visual planning to plan harvesting activities although some side effects may occur under certain circumstances. For example, the retention of riparian vegetation as visual buffers along major waterbodies is likely to benefit plant and animal species that live in this habitat. Also, visual planning may increase the amount of older forest and forest managed with selective harvests. If this occurs, it will have biological implications for plant and animal species found in older stands. Changes in recreational use will also impact the recreation/tourism industries that have developed to support such uses.

Based on the interpretation of the significant impact criterion, significant visual impacts occur when timber harvesting and forest management activities do not follow VMGs. Analysis found that 58.7 percent of the timberland area harvested under the base scenario would not be treated according to VMGs and these are therefore judged to be significantly impacted.

5.6.6
Unique Cultural and Historical Resources

> An impact is considered significant if heritage resources including cultural landscapes, structural remains, archaeological remains, Native American traditional use sites are destroyed; or cemeteries are disturbed.

Use of the criterion requires that the term *destroyed* be defined prior to analyses of significance. The term destroyed has been interpreted to mean damage to a site such that its scientific, cultural, or spiritual values are diminished in whole or in part. Adoption of this interpretation will result in a *conservative* assessment of impact by including those sites with a partial loss of values; however, this is appropriate for the purpose of a GEIS.

The following maximum levels of significant impacts are predicted for each type of heritage resource, based on the above interpretation of destroyed and the assessments of impacts presented in section 5. There is insufficient data to assess, even qualitatively, the extent that these sites will be impacted. However, significant impacts are likely to occur, and the number of impacts will increase as the level of harvesting increases.

Archaeological and Cemetery Sites

Based on the analysis presented in section 5.5.3, the predicted *maximum* number of sites that would be destroyed is set out in table 5.26.

Table 5.26. Predicted maximum number of archaeological and cemetery sites to be destroyed in ecoregions 1 to 6 under the base harvesting scenario.

Harvest Scenario	Number of Sites Destroyed	
	Number	Percent of Total Predicted Sites Affected*
Base	100,000	52

Source: Jaakko Pöyry Consulting, Inc. (1992g).
*The total number of sites predicted in ecoregions 1 to 6 (see section 2.3) is approximately 190,000.
Note: excludes impacts on USDA Forest Service lands.

Due to the reasons discussed in section 5.5.3, the actual numbers of sites affected can be confidently predicted to be less than these totals. However, because of the assumptions used to generate these estimates, it is impossible to quantitatively assess the effects of most of these assumptions. The only data that can be quantified are the acres that are projected to be harvested on national forests. Preharvest surveys detect most sites on these lands and therefore it is valid to assume that no impacts occur. The figures in table

5.26 reflect this reduction. However, it is not possible to set a lower bound on these estimates.

Traditional Use Sites

As discussed in section 5.5.3, traditional use sites will be impacted. However, the extent cannot be quantified, as these sites have not been inventoried. Therefore, there will likely be significant impacts that will increase with the level of harvesting.

5.6.7 Economics

Regional economics - changes in economic parameters.

An impact is considered significant if there is projected, for each region (north, south, and metro), a change in the following economic parameters by economic sector over 50 years:

- output ± 5 percent
- employment ± 5 percent
- income (wages and salaries) ± 5 percent

The base scenario depicted the current level of harvesting and therefore no changes to forest industries and hence level of economic activities were projected. The base level of economic activity is described in section 6.6.7 and 7.6.7 in comparison with the medium and high scenarios.

5.6.8 Summary of Significant Impacts

The base scenario significant impacts identified in sections 5.2 to 5.5 are summarized below:

1. projected significant loss of forest area in ecoregions 1, 2, 3, and 4 due to land use change (also includes consideration of the loss of timberland in the north);
2. projected harvesting affecting patterns of forest cover in areas of mixed land use (considers amount, type, and fragmentation of cover important to wildlife habitat);
3. projected changes to tree species mix (important to maintaining biodiversity and wildlife habitat; four tree species show significant declines in stem number);
4. projected changes in the age class structure of paper birch (important to community replacement capability for this species; the young age classes appear deficient in acreage for replacing the older age classes);

5. projected harvesting affecting genetic variability of plant or animal species (important to maintaining biodiversity; critically endangered, endangered or threatened communities are identified);
6. projected harvesting affecting federal- or state-listed plant species of special concern, threatened, or endangered or their habitats (statewide 9, 7, and 37 species listed as endangered, threatened, or of special concern are projected to be adversely impacted by harvesting);
7. changes in the susceptibility and vulnerability of covertypes to forest health risks (important to community stability and productivity; largely dependent on age class structure and the amount and type of harvesting activity);
8. projected harvesting affecting site nutrient capital, i.e., nutrient supplies present and/or actually available (important to sustainability of forest growth and yield; results indicate nutrient losses with certain types of harvesting on various types of soils, approximately 5 million acres are at risk for calcium loss);
9. projected harvesting affecting soil physical structure (important to maintenance of forest growth; the actual area where significance criteria for compaction are exceeded is estimated at 330,000 acres plus haul road area);
10. projected harvesting causing accelerated erosion from forest roads (important to site productivity and water quality; about 25,000 acres plus haul roads are estimated to be impacted with major concern in ecoregion 6);
11. projected changes in the populations of forest dependent wildlife (by changes in amounts of habitat available; 46 species, about 25 percent of all wildlife species studied, were projected to be significantly impacted). Negative impacts are projected for the ringneck snake, beaver, northern flying squirrel, gray and fox squirrels, bobcat, lynx, as well as 39 bird species, for example, Cooper's Hawk, Great Gray Owl, Pileated Woodpecker, Eastern Bluebird, Ovenbird, Song Sparrow, Yellow Warbler and Hooded Warbler;
12. projected harvesting affecting populations of endangered, threatened, or special concern species of animals (Red-shouldered Hawk and Louisiana Waterthrush are negatively impacted);
13. projected harvesting affecting patterns of mature lowland conifer stands (important to wildlife habitat; many important patches of lowland conifer habitat may be lost with harvesting);
14. projected harvesting affecting the availability of food producing trees (important to wildlife; particularly oaks and other mast producing species);
15. projected harvesting in the absence of VMGs on visually sensitive areas (important to aesthetics and recreational use; visual aspects of landscapes and recreational settings are impaired);

16. projected development of permanent forest roads in primitive (undeveloped) and semiprimitive nonmotorized areas (important to maintaining primitive or undeveloped recreational opportunities; harvesting leads to a loss of such areas); and
17. projected harvesting affecting unique cultural and historical resources (important to the protection and integrity of these resources; disturbance from harvesting can effectively destroy these resources).

5.7 Recommended Mitigation Strategies

The mitigation strategies presented in appendix 1 were recommended by the study groups as ways to mitigate the significant impacts projected to occur at the base level of harvesting. The recommended strategies were selected from a wider range of possible mitigation alternatives that were developed in each of the technical papers. These alternatives were assessed using the mitigation strategies criteria described in section 2.3.2. The strategies described in the appendix cannot mitigate all impacts; those that cannot be mitigated are identified in section 5.7.4.

5.7.1 Recommended Strategies Development

Mitigation Alternatives Criterion

The significant impacts identified in sections 5.2 to 5.5 are projected to occur at the base level of harvesting if management practices, including selected mitigations, are applied as described for the second model runs. The impacts also include exogenous factors such as land use change. They apply in varying degrees to all ecoregions.

The criterion used to select among the mitigation alternatives is reproduced below.

> Based on an analysis of mitigation alternatives identified, preferred mitigation strategies will be selected by considering in relative terms:
> 1. the effectiveness at mitigating the identified significant impacts;
> 2. the beneficial effects on other resource values;
> 3. the adverse effects on other resource values;
> 4. the physical, biological, administrative (implementation and oversight), financial (costs, public and private, direct and indirect), and social (ability to organize, support and effect implementation) feasibility; and
> 5. the probability of success and duration of success.

In practice, the verbal and written input from the Advisory Committee on the potential mitigation strategies led to acceptance, rejection, and/or refinement of the potential strategies. These results were then approved by the EQB and comprise the strategies considered and evaluated in detail. Additionally, for this analysis the above criteria were grouped as follows:

1. *Effectiveness* addresses a mitigation strategy in terms of its ability to either avoid or reduce the identified impacts.
2. *Feasibility* addresses the likelihood that the mitigation strategy can be implemented, based on existing or future economic, social, biophysical, or administrative constraints.
3. *Duration* of mitigation can be divided into four classes: 1=long-term—greater than 50 years and irreversible; 2=medium-term—10 to 50 years; 3=short-term—2 to 10 years; 4=very short-term—less than 2 years.
4. *Concomitant effects* refers to those strategies with the potential to significantly affect other resources. No forest management practice will affect only a single resource; forests are intricately interacting ecosystems, and each practice affects many resources.
5. *Probability of success,* though not explicitly tabulated in the following tables, is a combination of effectiveness, feasibility and duration with minimal negative concomitant effects. The strategies identified as highly effective, highly feasible, of long duration, and with minimal negative concomitant effects are assumed to have the greatest chance of success in the long-term.

These criteria were applied to the various mitigation strategies for the purpose of selecting preferred mitigation strategies.

Evaluation of Specific Strategies

A variety of strategies can mitigate potential adverse impacts of timber harvesting and forest management activities at the base harvest level. A comparison of the strategies under each of the groupings used in section 5.6 is presented in the following section.

5.7.2 Recommended Strategies

This section identifies the strategies developed to mitigate significant impacts projected to occur at the base level of harvest (4.0 million cords per year). These strategies, many of which reflect the mitigation measures developed in the technical papers, have been combined and modified where required in order to achieve multiple objectives and resource protection goals. Mitigation strategies that would improve the standard of forest practice in Minnesota but do not directly mitigate significant impacts are also presented.

The strategies recommended to address significant impacts at the base level of harvesting are presented under three categories which reflect their main focus:

1. forest-based research;
2. landscape-level responses; and
3. site-level responses.

Forest-based Research: Strategies in this category are intended to: obtain the information needed to undertake strategic and operational planning; to monitor changes at the landscape- and site-level; and to provide the basis for developing management and direction and planning tools. The responses considered here are:

- monitor the age class and covertype structure of the state's forests;
- complete an inventory of the state's biodiversity features;
- conduct an inventory of old growth forests across all ownerships;
- develop and fund a research program to investigate the effects of timber harvesting and forest management activities on the tourism and travel industry in Minnesota; and
- upgrade and maintain a listing of known archaeological, historical, and traditional use sites in the state.

Landscape-level Responses: These are typically long-term or broad-based solutions that require coordinated planning and/or implementation to identify and achieve the intended objectives of developing regional or statewide responses. A key to the success of these responses is to provide direction and coordination across ownerships. The responses considered here are:

- measures to reduce the area of forests converted to other land uses;
- balancing age class and covertype structure;
- riparian corridors;
- ERF;
- protection of sensitive sites for plant species;
- landscape-based road and trail plan;
- VMGs; and
- IPM strategies.

Site-level Responses: Strategies in this category are intended to modify operational procedures used in the planning and execution of timber harvesting and forest management activities on an individual site or local scale. The responses considered are:

- modifications to harvesting practices and equipment;
- modifications to silvicultural practices;

- protection of sensitive sites for wildlife; and
- increasing the wood fiber productivity of timberlands.

The following discussion describes these strategies.

Forest-based Research

Monitor the age class and covertype structure of the state's forests and their pattern across the landscape. This strategy would develop monitoring of the age class and covertype structure of the state's forests. This would provide the information necessary to set statewide resource objectives for age class distributions by covertype and covertype acreage to achieve several resource objectives. These age class and covertype acreage objectives are crucial to minimizing future impacts. Further, monitoring progress toward these objectives is essential to their utility as the forest changes naturally and due to human influences. Trends in age class changes in certain covertypes and covertype area were determined to be the cause of significant impacts for forest health, tree species mix, wildlife habitats, and biodiversity. Thus these subject areas have a need to be involved in the design of monitoring and analysis of results. Additionally, it is important that the pattern of cover across the landscape be monitored to assist in developing an understanding of wildlife-pattern relationships and appropriate management.

Any research program examining trends in the structural aspects of forests should be coordinated with statewide inventories. Additionally, forest growth and change models should be used to project future age class and covertype distributions based on likely demand scenario(s). The USDA Forest Service NCFES and the UofM's College of Natural Resources are both well-placed to undertake this analysis. The MFRMA of 1982 specifically charters the College of Natural Resources for such support (as part of the MAES of the UofM).

It is also evident that the frequency of this monitoring is presently inadequate. FIA inventories have been 10 to 15 years apart, leading to much uncertainty about trends. Thus, monitoring that provides results or updates in a shorter time period are needed. That might be accomplished through more frequent surveys or design changes that provide for frequent updates.

A recent report by the Blue Ribbon Panel on Forest Inventory and Analysis (1992) includes the timeliness of forest inventory data as a major concern and recommends a five-year inventory cycle.

There is also a need to coordinate current and future inventories of natural resource being undertaken by agencies at the state and federal levels.

Undertake an inventory of the state's biodiversity features. Minnesota currently has a County Biological Survey Program. However, this program has completed comprehensive inventories in only a few counties, the majority of which are predominantly nonforested. Thus this strategy will speed up the identification of the occurrences of rare plant species and communities, old growth forests, and key habitat features for wildlife species classified as endangered, threatened, or of special concern in forested areas. Knowledge of the locations of these features permits forest planners and managers to avoid or modify operations in relevant areas. This mitigation, when combined with other operational mitigations, would address significant impacts on: plant and animal species classified as endangered, threatened, or of special concern; wildlife populations; old growth forests; and biodiversity.

At current staff and funding levels, the MNDNR's County Biological Survey will complete the last county in Minnesota by the year 2020. Based on the current level of harvest (as projected under the base scenario), approximately 6.3 million acres will be harvested at least once over the 50-year modelled period ending in 2040. Thus, approximately 3 to 4 million acres will have been harvested before the inventory is completed. Therefore, an accelerated inventory of the state's biological resources is needed to identify and develop appropriate protection for many of the populations of rare plants and animals found within the state's forested regions. If an accelerated inventory is economically infeasible, then attention should be given to redesign of the inventory or prioritizing its application across the state. The intent of redesign would be to provide at least some information for all areas soon by interpolation and extrapolation.

Conduct an inventory of old growth forests across all ownerships. Federal, state, and, to some extent, county land management agencies have begun inventories of old growth, but little is known about the types and extent of old growth on private lands. Further, since these data may be gathered by several different agencies, there is a need to insure that all vegetative databases are compatible with each other and the county biological survey efforts. This effort needs the leadership of the MNDNR to provide necessary coordination. Also, monitoring of old growth stand protection and health, regardless of the level of harvesting, seems appropriate and could provide for updating of databases. These data will help ensure the protection of these important sites, although once the stands are identified, strategies for their protection will have to be implemented, and specific guidelines will have to be developed for USDA Forest Service, MNDNR, and county-managed lands.

Develop and fund a research program to investigate the effects of timber harvesting and forest management activities on the tourism and travel (particularly outdoor recreation) industry in Minnesota. This strategy is intended to define and quantify the relationship between changes in the forest resource and induced changes in recreational/tourist user patterns in forested areas in the northern part of the state. This information would enable more informed regional planning regarding the spatial and temporal distribution of timber sales, use of VMGs, and other mitigations.

Upgrade and maintain a listing of known archaeological, historical and traditional use sites in the state. This strategy seeks to upgrade the quality, extent, and utility of the database on the state listing of known sites and their locations. A more accessible, secure, useable, and accurate database would be useful for assessing the probabilities of finding sites under certain circumstances. Access to this data would assist forest planners and managers to avoid impacting known sites, and would also be valuable for refining procedures to locate or avoid sites not yet identified. Database security and utility also will be key for effective long-term applications.

Forest management is one land use that will likely impact the state's cultural and historical resources. Other land uses, particularly urban and infrastructural developments, are also likely to adversely impact these resources. The state archaeologist office has the responsibility for these resources. The state should provide staffing and funding, that are not tied exclusively to forest management programs. The current level of funding clearly fails to recognize the magnitude of the problem.

The release of information on traditional use sites is a sensitive issue for contemporary Native Americans. However, this information is required before efforts can be made to avoid adverse impacts caused by timber harvesting and forest management activities, as well as other land use changes. The office of the state archaeologist has well-developed contacts with Native American groups living in the state. Information on traditional use sites could be provided through the state archaeologist, who could maintain the high level of confidentiality required by traditional users.

Landscape-level Responses

Measures to reduce the area of forests converted to other land uses. This strategy seeks to develop policy instruments to discourage conversion of forested land to other, nonforest, land uses. Loss of forest area to agricultural or urban uses is not a consequence of timber harvesting and is therefore independent of the level of harvesting. These policies would be directed at private property as conversion activities are unlikely to occur on public lands. Thus, any initiatives that seek to limit or control uses must be framed in ways that recognize private property rights, including the rights of owners to use their land for its highest economic use. Currently, there are a variety of policy instruments directed at retaining forest land that are available at the federal, state, and local level. The effectiveness of these policy instruments to compete with economic forces varies considerably across the state. They are likely to be less effective and/or more costly closer to major urban areas, where the value of the land for other purposes increases. Conversely, in the northern part of the state these instruments will likely be more effective where they are applied as the relative value of land decreases. Also, *any* change in land use in heavily forested areas will likely reduce the area of forest land, as there are limited stocks of nonforest land in such regions.

The projected loss of forest area in the northern part of the state exacerbated impacts on some wildlife species and the projected increase in forest area in the south mitigated impacts on some species that would otherwise have been significant. Therefore, the strategy to reduce the loss of forest area will be important if the modelled trend towards an increase in forest land is reversed in ecoregions 5, 6, and 7 which are located in the southern and southwestern parts of the state.

Policies should be prioritized to favor the retention of key habitat types such as those on riparian lands particularly those in the southern and western parts of the state. Existing mechanisms such as shoreland rules already give some protection to these lands. Additionally, land zoning regulations and special property tax laws may offer protection to these areas. A comprehensive assessment of the effectiveness of these laws and regulations is needed before any additional policy instruments are developed.

The strategy is rated as being of low effectiveness because of the constraints identified above, particularly as they relate to private property rights. Changes brought about under this mitigation are likely to persist over the medium-term.

Balancing age class and covertype structure. The future age and/or size class and covertype structure of the state's forests will have important implications for forest wildlife habitat, biodiversity, timber production, recreation and aesthetics, and forest health. Significant impacts such as those projected for forest health, biodiversity (tree species mix), and wildlife populations were associated with changes to the age class structure for some key covertypes and covertype acreage itself. For example, some impacts were projected to occur because the low level of harvesting in some covertypes meant that average stand age increased: the paper birch cover type is a good example of this. In contrast, the oak-hickory covertype is projected to show a substantial acreage in the young age classes and old (>100 years) age classes, while there are comparatively few acres in the middle (35- to 95-year) age classes.

Aside from large-scale natural disturbance, timber harvesting and forest management activities, including fire are the only tools available to effect large-scale changes to the age class structure; and these changes can only be effected over a very long time. Therefore, this strategy seeks to develop statewide objectives that cross ownership boundaries. The age class monitoring identified above will be essential to the strategy and would provide both the initial data to identify where imbalances exist to allow objectives to be set; and subsequently, to monitor changes.

Statewide targets for areas of older age classes could be coordinated with existing ERF and old growth forest programs of the MNDNR and USDA Forest Service. In addition, other strategies that promote older age classes, such as management of riparian zones and connected landscapes (discussed below), should be considered when assessing age class targets. By combining these targets with other strategies, opportunities to achieve multiple objectives can be maximized. The inventory of the state's biodiversity features could be used to guide selection of sites. For example, where rare or threatened communities depend on older forests, known locations of these communities should be included in meeting targets of increased acreages of older age classes. Note that target development needs to include the normal public participation mechanisms at all levels, referenced elsewhere in this study (primarily sections 4 and 8).

Maintaining a proportion of the forest in each age class in each covertype will provide ongoing habitat for the full range of plant and animal species. Depending on the forest type and existing age class distribution, the process of achieving a balanced age and/or size class distribution and overall acreage for the range of covertypes in Minnesota will invariably affect some wildlife species positively and some negatively.

This strategy would also alter tree species composition, particularly if combined with variations in the types of harvesting and silvicultural practices used for particular covertype/age class distributions which are discussed further under site-level responses.

Balancing age classes and maintaining covertype acreages is technically feasible, but practically it is dependent on markets and/or management investments to fund implementation. Such investments are most likely to develop for species with commercial value. This balance also needs to be considered in the context of the desired species composition for the forest and the long-term goals for that. The task is complicated by the varied forest land ownership. These mitigations would logically apply to public ownerships with a mandate for managing to promote biodiversity at a state or national level.

Administration of this mitigation is feasible and could be coordinated with the existing ERF programs of the MNDNR and USDA Forest Service. Manipulation of stands to effect species or covertype changes would necessarily be a long-term process. The feasibility of this alternative would be constrained by the ability to obtain consistent funding and the willingness of all major landowner categories to participate. The NIPF lands can potentially participate in this program formally via covenants or through purchase of land by organizations such as The Nature Conservancy. The contribution of such stands to the maintenance of biodiversity and the provision of other values, including aesthetics, would make expenditures by public ownerships more justifiable.

Riparian corridors. Riparian corridors are the strips of land and associated plant communities that border waterbodies. These areas are often the focal point for resource management conflicts because of their importance for widely differing forest values. Riparian zones are one of the most important components of the water/land interface due to their influence on (1) habitat within the aquatic system, (2) transport of pollutants and erosion to a river, stream, wetland or lake, (3) habitat for terrestrial species, (4) aesthetic characteristics of the landscape, (5) recreational opportunities for the public, and (6) cultural and historical resource sites.

Harvesting activities in timberlands in riparian zones along larger streams and lakeshores are becoming more controlled through combinations of policies and programs. These constraints vary considerably. For example, BMPs, are widely used voluntary codes of practice intended to minimize water quality impacts caused by timber harvesting and related activities that take place near waterbodies. Other constraints are imposed by policies generated from within land management agencies. The MNDNR's 200-foot leave strip prohibits clearcutting on state lands along designated state wild rivers. The USDA Forest Service also designates a 200- to 300-foot wide buffer along streams and rivers that is managed to optimize riparian values. Lastly, there are externally imposed constraints such as shoreland rules and regulations that restrict certain activities in riparian areas. The existence of these constraints was reflected in the harvesting model assumptions for all ownerships, which limited the types of harvesting and forest management activities in stands occurring within 100 feet of water and within 200 feet of lakes or major streams in ecoregions 4, 5, 6, and 7.

Riparian management zones specified in BMPs and regulations used elsewhere in the United States vary in the designation of width and the types of activities that are permitted. In Minnesota, the width of riparian or streamside management zones can vary from zero to 300 feet. The types of harvesting permitted within the nominated zone range from clearcutting to maintenance of at least 50 percent of the existing canopy or volume of standing timber.

Maintaining the integrity of riparian vegetation is an important management objective within riparian zones and can be supported by the proper use of BMPs. Timber harvesting impacts on aquatic systems occur when riparian corridors have been disturbed, either by inappropriate harvesting or by roading. Poorly planned and maintained stream crossings can be the main sources of sediment pollution of streams in forested catchments. Impacts to aquatic ecosystems from management within riparian corridors are apparent through changes in material and energy flows between the terrestrial and aquatic environments. Site-specific reductions in organic matter inputs, changes in timing of inputs, and changes in litter quality associated with different types of litter inputs are likely to occur on a site-specific basis when harvest occurs within 200 feet of a stream channel.

Visual values are also important within riparian zones. Protection of these values is important for recreational uses and to maintain the settings of many resorts and other tourist/recreation facilities with water-based settings.

The importance of these zones for wildlife habitat and the potential for offsite impacts such as localized sedimentation and visual impacts requires more uniformity in the standards of management applied across all ownerships. The existing Minnesota BMPs have been well accepted and there has been a high level of compliance across most ownerships. Notably, compliance on private lands is approximately 70 percent. However, BMPs were intended primarily to address one key factor, sedimentation, that impacts riparian resources. Other factors likely to be affected such as visual amenity, wildlife habitats, and recreational uses are not particularly well served by the existing BMPs guidelines. Consequently, it is appropriate to expand the existing BMPs.

The modified standards would vary reflecting the differing needs and the variety in riparian lands and their relative importance in different parts of the state. In the southern and western parts of the state (ecoregions 5, 6, and 7), rivers have relatively wide bottomlands that contain valuable wildlife habitat. Furthermore, they often exist as corridors through otherwise nonforested land. In the northeast (ecoregions 1 through 4), bottomlands are not as common. There are many lakeshores, with relatively low erosion hazards, and the riparian zones are embedded in a forest landscape, so that the habitat is not as critical. Therefore, riparian zones would be wider in the south than the north, are more critical as a landscape corridor, and would appear to be more unique to their surrounding environment than in the north. In the southwestern portion of the state where riparian zones are critical habitat for many plant and animal species, buffers of 200 feet on both sides of watercourses would be required. Harvesting can be carried out within these buffers; however, uneven-aged management or thinning rather than clearcutting are the most appropriate silvicultural systems. Choice of silvicultural system within these buffers would mitigate negative effects of harvesting on wildlife species that live within the riparian zone. Wildlife species that would benefit include most herps as well as birds such as the Prothonotary Warbler, Louisiana Waterthrush, Northern Waterthrush, Cerulean Warbler, and tree nesting species such as herons and egrets. In addition, harvests planned using statewide visual management BMPs (discussed below) would protect recreational uses and visual amenity.

In the remainder of the state, riparian zones 100-feet wide along lakes, wetlands, and each bank of rivers and streams (<third order) would be designated. Existing shoreland rules apply only to the extent that they recommend the application of voluntary BMPs on water quality. The choice of silvicultural system is important in this zone. Thinning, ERF or uneven-aged management are the preferred systems. Application of statewide visual management BMPs (discussed below) within these buffers would mitigate negative effects of harvesting on visual amenity and recreational uses.

Mechanisms that could be applied under this mitigation strategy range from statewide regulations to voluntary guidelines. Uniform application of this strategy is important to protect values within these essentially linear environments. If several landowners fail to comply with the guidelines there could be serious consequences for visual, recreation, water quality, and wildlife habitat values above and below the disturbed area, i.e., offsite impacts. The estimated current levels of compliance with voluntary BMPs on private lands make it unlikely that uniform compliance will be achieved.

ERF. ERF can be described as: *any forest managed on a rotation length that is longer than that recommended for the covertype for timber production.* Typically, these stands are managed on rotations approximately 50 percent longer than normally prescribed. ERFs are an effective strategy because they directly help to mitigate a large number of the potential effects of shorter rotations on biodiversity. Management as ERF does not preclude harvesting and therefore does not remove lands from the timberland base; yet it helps provide many of the biodiversity features of older forests over large areas.

Generally, with increased frequency of timber harvest, there is an increased short-circuiting of both plant succession and the development of structural diversity. ERF assure the continued presence of large tree gaps, dead wood, and the species that depend on them, without being designated old growth and removed from the base of timberland. Extended rotations can mimic the natural rotation period for Minnesota forests. Management with shorter rotations can be compatible with biodiversity, as long as sufficient area in other portions of the landscape are managed with extended rotations.

The harvesting scenarios assumed that 20 percent of state and federal lands would be managed, explicitly or implicitly, under an ERF-based management regime. Levels in that order of magnitude are feasible and consistent with the policies of these agencies. For example, the MNDNR expects to manage between 10 and 25 percent of state forest lands as ERF (Jaakko Pöyry Consulting, Inc. 1992k).

However, increased recognition of nontimber values on county lands is expected. While there are no written policies concerning ERF on county lands, there is some scope for the larger counties to adopt more flexibility in the silviculture applied on their lands, particularly with regard to the rotation length for a proportion of stands. In addition, an unknown proportion of NIPF timberlands will be managed without harvesting for prolonged periods, effectively increasing ERF acreages. Because of the uncertainty regarding management objectives, this latter category of ERF lands cannot be relied upon as part of a formal strategy in the same way as public lands. The exceptions are where such lands are managed under a conservation covenant or have been purchased by groups such as The Nature Conservancy, which has explicit conservation management objectives outlined for each property. At present, such lands represent only a small fraction of the total NIPF landbase.

The existing age class distributions show that substantial areas of many covertypes could already be classified as ERF using the above description. The projected age classes show trends of increasing acreages being recruited into the older age classes (section 5.2.2).

Increasing the proportion of ERF stands will also increase the volumes of sawtimber-sized logs produced, which is likely to benefit the sawmilling industry.

Note: Linkages between remnant areas of older forest or natural areas are potentially very important. The need for these linkages is based on an understanding of the ecological needs and dynamics of natural dispersal of many plant and animal species associated with large tracts of mature forest habitats. Populations can be jeopardized by fragmentation of mature forests into islands of inadequate size. Linkages can be provided by *connected landscapes*, which may take the form of riparian corridors, wide corridors of ERF, or uneven-aged selection harvest forest between core areas such as patches of old growth, research natural areas, and scientific and natural areas. In other cases, an ERF or uneven-aged buffer can be used to reinforce a riparian corridor. The networks potentially reduce the effects of fragmentation without reserving large contiguous blocks of forest. They can be achieved by changing the spatial pattern of harvest, not the amount of harvest. The widths may be prescribed on the basis that one half of a corridor's width could be harvested and the corridor could still function.

The connected forest corridors could be managed under ERF as part of the recommended ERF forest percentage in the state or where appropriate under uneven-aged management. In addition, buffers managed under ERF guidelines or uneven-aged management would also be maintained around old growth forest patches. Linkage of patches of old growth by ERF managed corridors could overcome some of the current problem of old growth patches that are probably too isolated to allow exchange of genetic material among old growth species. This problem exists in all ecoregions except the border lakes (ecoregion 2).

Creating corridors for the dispersal of plant and animal species would be a way of allowing Minnesota's forest to respond to future climate change. Genetic variation in Minnesota generally occurs along a cline correlated with climate, from southwest to northeast. For some species, it is important not to disrupt the spatial genetic structure of vegetation by harvesting. Paleoecology shows the climate perpetually changing and this will continue, whether or not human-caused global warming occurs. However, predictions under climate change models indicate that the rate of change is likely to be much faster than in the past. The prospect of accelerated climate change adds impetus to the need to make provision for vegetation to respond to changing climate, and gene flow and the movement/distribution of seed/propagules from southwest to northeast should be facilitated.

In the northern ecoregions, the focus for these networks would be on public lands where existing policies and mandates to manage for biodiversity already exist, and ownerships manage substantial, often contiguous, blocks of land. Planning corridors on lands managed by a single agency will be comparatively straightforward. However, interagency cooperation will be required where corridors cross agency boundaries. The need for consultation and reconciling certain issues on the ground will likely add to the complexity of the planning task. Overall, agencies should be encouraged to incorporate linkages in their plans to advance their joint goals.

The area of land under public ownership is small in the lower central, western, and southern ecoregions. Most forested land in these ecoregions is on private land. Forests are typically in small blocks, hence coordination becomes more difficult as the number of individual landowners increases. Therefore, in these parts of the state, the strategy should focus on strengthening existing corridors. The riparian zones discussed above are the most suitable corridors within this part of the state. These zones already contain a significant proportion of the forest cover in ecoregions 5, 6, and 7. Riparian areas are also afforded some protection under existing Shoreland Rules. Where future management within identified corridors is unlikely to be consistent with ERF guidelines, some benefits can accrue by changing the silvicultural and harvesting systems used on these private lands. For example, owners of lands within such zones should be encouraged to employ partial cutting techniques when harvesting.

There are likely to be ongoing opportunities to expand existing corridors and provide additional linkages to other remnant patches of forest. Federal and state agencies responsible for existing agricultural land retirement programs should be encouraged to preferentially fund replanting or restoration of sites that link with, or augment such corridors.

Given the potential of connected landscape concepts, they are an appropriate area for research. However, since their utility by species can vary and because of their potential expense (Simberloff et al. 1992), they are recommended as an area of research rather than for broad application at this time.

Protection of sensitive sites for plant species. The known locations of rare plant species (see Jaakko Pöyry Consulting, Inc. 1992e for complete list) and rare plant communities (listed in table 5.23) that are likely to be sensitive to harvesting impacts should be excluded from harvesting. The strategy depends on the availability of information from an inventory of biological resources, as described under research strategies, to be able to pinpoint the landscapes these sites are found in, or better, the specific locations of these sites.

The MNDNR and USDA Forest Service currently afford such protection to some of these areas through registry sites, Research Natural Areas, or Scientific and Natural Areas. Extending this protection to other ownerships will be more problematic due to differing ownership management objectives.

Landscape-based road and trail plan. This strategy would involve planning and coordination between ownerships to develop landscape-based road and trail plans. Landscape-based plans would be most appropriate in the northern ecoregions. These plans could be used to mitigate significant impacts under several issue areas including soil compaction, recreation, wildlife, and cultural resources. The plan would cover the following: development of new roads, particularly in primitive and semiprimitive nonmotorized areas; long-term access needs; and closure policies.

The complex patterns of ownership in Minnesota mean that significant benefits can accrue from coordination of road and trail plans. The likely benefits include:

- insuring that development of new roads in primitive and semiprimitive nonmotorized areas minimize inadvertent adverse impacts on nonmotorized recreation opportunities within these areas;
- rationalizing road layouts by removing ownership constraints from route selection to reduce the length of new roads and the number of stream crossings;
- developing fewer roads but of a better, more uniform standard of construction and maintenance, thereby reducing the amount of poorly planned, constructed, and maintained forest roads;

- providing opportunities for consultation with traditional users in areas where such uses continue to reduce access-related impacts on traditional uses; and
- making consistent decisions on road closures to maintain adequate access for fire control and other management requirements, while reducing the likelihood of impacts from recreational use of roads by off-road vehicle users.

Development of landscape-based plans would require a leadership role to initiate the process and to coordinate responses from other ownerships. The MNDNR is the agency best placed to undertake this role. This strategy is feasible given the MNDNR responsibility to produce an inventory of state forest roads under the MFRMA of 1982. In addition, the number of ownerships likely to be developing new roads in remote areas is limited. The cost of adopting this mitigation would center on the additional planning that some ownerships would require before participating. Additional costs would also be incurred by the MNDNR in coordinating and compiling inputs from others.

Develop VMGs. VMGs are a highly effective way of retaining primitive kinds of recreational opportunities in the overall landscape and in specific areas that will be harvested. VMGs, especially if used in conjunction with nonpermanent roads, give attention to the important social attributes and long-term benefits of primitive recreation opportunities.

VMGs would also address maintaining visual quality and recreation opportunities for all ownerships on all forest lands. The state is already moving in this direction. The approach would also ensure that resort interests were addressed. VMGs could also incorporate buffer zones for the most visually sensitive areas.

IPM strategies. The state should initiate and oversee development of IPM strategies for the major pests likely to increase as a consequence of timber harvesting. In addition, IPM strategies are required to prepare for the likely introduction of exotic pest species such as the gypsy moth.

Pests are a community problem, particularly those species that are prone to major outbreaks. Development of regional, statewide, and interstate IPM strategies in advance of pest outbreaks allows time for all parties to agree on the types of intervention that are appropriate; the circumstances under which the various methods of intervention can be used; and the responsibilities and cost sharing arrangements that should apply where outbreaks occur. Development of these endorsed IPM approaches will reduce the potential for conflict at the time when early, decisive action can be most effective. Examples of IPM strategies include

- undertake a risk/hazard rating to identify susceptible areas;
- monitor populations;
- implement appropriate control methods, such as release of sterile males, pheromone traps, insecticide spraying, and silvicultural treatments, when populations reach predetermined levels; and
- increase tree diversity at site and landscape levels.

Certain aspects of IPM strategies may be controversial and gaining the level of support needed will require the active participation of representatives from the following: MNDNR; USDA Forest Service; counties; forest industries; NIPF owners; other forest ownerships, e.g. Native American bands; the resort and tourism industries; conservation groups; and the state Department of Agriculture. A leadership role is required to initiate this process and to promote implementation of the resulting IPM strategies. The MNDNR is the most appropriate state agency as its responsibilities extend over many of the aspects of Minnesota's forests likely to be affected by pest outbreaks. The MNDNR already is (along with certain other ownerships) engaged in the recommended insect and disease-related strategies. Research support for IPM as per the MFRMA of 1982 should come from the UofM's MAES. Additional research activity by the USDA Forest Service NCFES would be a major asset.

The process used to develop the *Memorandum of Agreement regarding the aerial herbicide spraying program of the Division of Forestry, MNDNR* provides a precedent for the development of this initiative. This process proved to be unsuccessful in practice because of a lack of sustained effort to implement the agreement by all involved parties. Also impeding its success was the lack of funding for research which was an integral part of the agreement. However, the experience gained in that effort could be a valuable lesson in how to shape the process needed to develop IPM strategies.

Programs to monitor pest populations are an integral part of IPM strategies. The current Forest Health Management (FHM) program is currently supported by the USDA Forest Service and the MNDNR. However, pest problems are a community problem and the responsibility should therefore be shared. Counties and the forest industry should actively participate in this program as an effective way of bringing additional resources to monitor pest populations. This measure gains added urgency in view of the likely introduction of gypsy moth into Minnesota, which will undoubtedly have significant impacts on industry and all forest ownerships.

Additional support for the FHM program will increase its effectiveness and will insure that resources are directed towards all forested lands in the state. The projected increases in the area of older age classes for many covertypes will require closer monitoring of pest populations.

Site-level Responses

Modifications to harvesting practices and equipment. The following modifications to the practices and equipment used in Minnesota can be used to mitigate significant impacts projected to occur as a consequence of timber harvesting and forest management activities.

1 Retain Slash. This strategy is intended to modify harvesting systems and techniques in order to reduce the loss of nutrients from harvested sites (especially those with aspen-birch and upland hardwood on coarse-textured soils, and organic soils), and to maximize habitat values for small animals in the resulting cutovers. These two objectives can be achieved in part by retaining slash from harvesting as close as possible to the tree stump. Slash comprised of branches and leaves/needles can either be trimmed in the cutover, or be returned to the cutover as part of the logging operation. This mitigation is feasible using existing equipment and requires a modification to existing operational practices. The Harvesting Systems background paper (Jaakko Pöyry Consulting, Inc. 1992l) estimated that nearly one-third of operations delimbed at the roadside (1 percent of operations did not delimb). Under these circumstances, large slash heaps remain at the landing. These heaps represent a redistribution of site nutrients and do not provide good wildlife habitat.

Redistribution of slash can also have both positive and negative impacts on regeneration activities. For example, it can provide a healthy microclimate that stimulates seed germination and young stem establishment. Hand-planted seedlings also will likely benefit in this regard. However, redistributed slash may interfere with site preparation activities and certainly can be an impediment to machine planting. The potential also exists for the redistributed slash to facilitate new growth of vegetation that competes with seedling development. Then there is also the issue of habitat for diseases and pests as well as the potential to add to the low level fuel mass in event of a wildfire. Overall, then, the redistribution of slash does have many positive aspects, but each situation needs specific consideration in light of potential drawbacks.

Redistribution of slash can be accomplished using existing logging equipment. Grapple skidders, which make up more than two-thirds of offroad log transporters used in Minnesota, can return slash into the cutover as backloads during normal operations with little added cost. Cable skidders or slash pilers would require more effort to load; however, the practice is feasible. Slash should be distributed away from ephemeral wetlands and ponds within the cutover.

The exceptions to slash retention would include circumstances where pest management guidelines require that slash and debris be removed to prevent the build-up of pest populations. Such debris removal is termed *stand* *hygiene* and applies in covertypes such as red pine which can be attacked by the Ips bark beetle. In addition, if a stand is in a visually sensitive area and the presence of slash causes adverse visual impacts, then slash should not be redistributed within the nominated visual buffer.

The necessary modifications to practices relating to slash retention could be achieved through a range of measures. Changing the specifications that form part of the stumpage sale agreement is likely to be the most straightforward approach. The specifications could be modified to preclude loggers from leaving slash piles and could specify that slash is not to be piled or distributed in small wetlands and ponds within the cutover. Education programs for loggers to equip them with an understanding of preferred techniques would also be useful. Finally, a code of logging practice could specify such modified practices.

In addition to the above measures, site nutrient losses can be reduced by retaining bark in the cutover for operations where species type and product specifications allow debarking prior to delivery to the mill. Debarking in the cutover is not commonly practiced in Minnesota. Unbarked logs are usually transported to the mill where the bark is removed. Past attempts at infield bark removal have been aimed at meeting mill bark specifications. This mitigation is not directed at achieving this level of removal, but it is aimed at developing techniques to remove as much bark as feasible. Therefore, for some easily debarked species it should be feasible to remove a high proportion of bark in the cutover. Lower levels of removal would have to be tolerated where species have bark that is more difficult to remove or where the difficulty in removing bark varies by season or where other important operational considerations conflict significantly. For example, debarked logs can become slippery and create handling safety problems, or they can degrade wood quality by accelerated stem drying at the mill yard.

Equipment is available that can debark in conjunction with the tree processing function at the stump. This equipment is used elsewhere for smooth-barked species similar to aspen and should be investigated for its application in Minnesota. In addition, there is other equipment that can debark at the landing. Landing-based debarking would require bark to be transported from the landing and redistributed throughout the cutover. Testing such equipment under Minnesota conditions is likely to be beyond the means of most loggers in Minnesota. Therefore, these tests could be sponsored by industry and major land ownerships, possibly through some subsidy for innovative loggers that encourages them to undertake such trials.

Removing bark at the site rather than the mill may adversely affect those mills which use bark as part of their energy needs or other markets for this resource. The energy equation for these mills would be altered if a substantial proportion of the bark was no longer available.

2 Equipment and practices for use in multiple entry harvesting operations. The projected increase in the use of multiple entry, i.e., thinning, or uneven-aged silviculture will require modifications to existing equipment and practices to avoid excessive damage to retained stems during harvesting operations. Damage can degrade retained stems, leading to an increased incidence of diseases and pests and to a reduction in the quality and volume of usable wood.

Harvesting practices and equipment that minimize damage to residual stems and the site have been developed, notably in Scandinavia. Training of fellers and operators to be aware of damage to retained stems and teaching them falling and equipment operating skills that minimize damage using existing equipment would be a good interim measure.

In the long-term, changes to the types of equipment used will be required if damage levels are to be reduced. Possible machines were discussed in the Harvesting Systems background paper (Jaakko Pöyry Consulting, Inc. 1992l) and include the *long-reach one-grip harvester* and *low ground pressure forwarder*. Use of this equipment with well-trained operators can reduce levels of damage to less than 2 percent of residual stems in thinning operations.

This equipment can also mitigate significant impacts associated with compaction. These machines reduce the proportion of the site impacted because the reaching booms mean they are not required to drive up to each tree. The harvester can delimb and stack logs ready for collection by the forwarder and can deposit the slash in windrows which can provide additional support. Use of this equipment and operating techniques can reduce the area affected as well as the degree of compaction.

As discussed previously, logging companies in Minnesota are unlikely to have the financial resources to undertake field scale equipment evaluations. Consequently, new types of equipment are unlikely to be introduced into Minnesota, unless loggers are provided with some form of assistance.

The forest industry could take the initiative by evaluating alternative systems and then promoting trials of the most suitable systems. Financial support for loggers willing to participate in the trials may be required for the period between when the new systems are introduced and when they reach full productivity. Voluntary contributions or a levy on the volume of wood cut or used by each processing or logging company would be equitable ways to obtain funding from the industry at large. The federal, state, and county governments could also provide support.

The forest industry, loggers, and major public ownerships should cooperate to develop logger training programs. These programs should be backed with a form of skill certification that would be required before people could be employed in the forest. Proof of attendance at training sessions would be a basic requirement before certification could be issued.

3 Modify season of equipment operation to minimize compaction. This strategy is intended to reduce compaction by identifying susceptible sites and limiting operations on those sites to the period when the soil is frozen and the risk of compaction is lowest.

Because differences in susceptibility to compaction and related disturbances are due to soil texture and soil water status, identification of susceptible sites is requisite to developing strategies for minimizing these disturbances. Table 5.27 identifies the combinations of soil types by season that are susceptible to equipment related disturbances.

Table 5.27. Susceptible soil types by season.

Soil type	Winter	Spring	Summer	Fall
Well-drained fine		X		X
Poorly-drained fine		X	X	X
Well-drained medium		X		
Poorly-drained medium		X		X
Well-drained coarse				
Poorly-drained coarse		X		

Source: Jaakko Pöyry Consulting, Inc. (1992b).

Based on these assessments, equipment operations should be limited on susceptible soil types during the spring and fall periods. Medium- and fine-textured soils most often exhibit low soil strength during the spring and fall, with low strength most often occurring in poorly-drained positions. Forest managers need to be aware that the strength of medium- and fine-textured soils can decrease rapidly during the summer and fall in response to intense rain storms. Equipment operation on some poorly-drained soils will be limited to frozen soil conditions. The strength of coarse-textured soils will be adequate for all but the wettest conditions which generally occur in poorly-drained areas in the spring. Where possible, well-drained, coarse-textured soils should be identified and held in reserve for wet season harvesting.

Site susceptibility must be identified at an operational scale if preventative measures are to be effective. In most areas, soil maps and other tools are *not* available at the stand or harvest unit scale. Confirmation of site susceptibility will require on-the-ground inspection by natural resource professionals. Site disturbance can be effectively reduced by carefully monitoring soil strength conditions before and during forest management operations. This may require additional training and staffing of forest management organizations. In reality, these measures will be easier to implement on public agency lands than NIPF lands which lack organization structures and mechanisms to facilitate effective actions.

Imposing seasonal restrictions on harvesting on some soil types or delaying operations that are already underway could cause financial hardship to loggers, depending on the availability of other harvestable sites not considered susceptible to compaction. In addition, these restrictions may interfere with the continuity of supply to some mills.

These problems may be alleviated by:

- stockpiling wood near all-weather roads during the winter for subsequent delivery during the spring;
- identifying sites that can be harvested during spring and fall periods and retaining these exclusively for harvest during these periods;
- increasing stockpiles at mills by increasing the levels of harvest during winter; and
- introducing lower impact harvesting equipment and techniques as discussed previously.

This mitigation will require cooperation between landowners, the forest industry and loggers. A leadership role is required to develop techniques to enable field identification of susceptible soil types, and to develop operational guidelines for harvesting on these types. This role would best be handled by the MNDNR in conjunction with the other major land ownerships.

Identification of soil types that are not susceptible to compaction should be a priority. Sites of these soil types should be set aside for wet weather harvest.

The forest industries should re-examine their wood supply requirements to identify opportunities for seasonal changes in delivery schedules.

Modifications to silvicultural practices. The Silvicultural Systems background paper (Jaakko Pöyry Consulting, Inc. 1992m) provided a summary of the applicability of various silvicultural systems to Minnesota covertypes.

The following mitigation strategies specify the circumstances where modifications to normal silvicultural practices are required to maintain wildlife habitat and aesthetic values. Typically, the modifications represent a shift from clearcutting to techniques that retain a proportion of the stand following harvesting.

1 Patterns of forest cover in areas of mixed land use. A strategy to mitigate the negative impacts of changing patterns of forest land in the southern parts of the state requires modifications to the silvicultural practices used and specification of the size of individual cuts. Thinning or uneven-aged management should be used where feasible. Potentially suitable covertypes for these systems include: lowland hardwoods, red oak, and northern hardwoods (see table 3.2, Silvicultural Systems background paper [Jaakko Pöyry Consulting, Inc. 1992m]). The application of these silvicultural systems in any stand should be subject to stand conditions and the owners' management objectives. Harvesting should be limited to small portions of any given tract in any one decade.

Use of thinning or uneven-aged management silvicultural systems will minimize the reduction in key habitat features found only in older forests. These features include food trees, cavities, dead trees for cavity excavators and suitable forest floor cover, humidity conditions, and shade. They are needed by some small- and medium-sized mammals, birds, amphibians, and reptiles. This pattern of cutting will favor deer year-round, by leaving thermal cover while producing temporary patches of forest herbs and of shrubs that provide good quality summer and winter browse. In addition, selective cutting in forests inhabited by gray squirrels should retain cavity trees at around 2.4 trees/acre. Southern flying squirrels and tree-cavity nesting birds would also benefit.

When forests dominated by oaks are cut in this manner rather than clearcut, all mast (acorn) dependent wildlife will be favored; particularly fox squirrel and gray squirrels, bears, deer, Wood Ducks, and Wild Turkey. The habitat needs of many forest birds are maintained by the use of these systems. These species would disappear from clearcut stands until the regrowth matured.

Since most hardwood stands cut for sawlogs are in private ownership, education, incentive and assistance programs would likely be most cost effective. Regulation of practices is an alternative, but is likely to be very expensive due to the scattered ownership. In reality, partial cutting as opposed to clearcutting is feasible and the most common practice in such regions. Unfortunately, much of this harvesting is really *high grading*, which can impair the future timber productivity of the stand. The impacts of changes to harvesting practice are likely to be long-term, but are subject to the vagaries of changing ownership.

Some forest raptors can be protected by reserving a few acres around nesting sites. Although the Red-shouldered Hawk may not tolerate even this level of disturbance. More data are needed to determine the extent to which this species will tolerate harvesting and at what times. Because of the sensitivity of this species to disturbance, relatively large tracts (>300 acres) of mature forest in ecoregions 4, 5, 6, and 7 should be encouraged. These larger sized blocks will also mitigate harvesting impacts on the gray squirrel and all forest interior birds in that part of the state including: Pileated Woodpecker, Acadian Flycatcher, Cerulean Warbler, Black-and-white Warbler, Ovenbird, and Scarlet Tanager. Much of this mitigation is related to reducing nest parasitism by the Brown-headed Cowbird, also an edge species.

The fragmented ownership structure in NIPF lands in the southern parts of the state make it unlikely that large blocks of forest would be held under single ownerships. Therefore, retention of larger blocks may be achievable only where specific blocks are identified and the current owners approached and asked to participate in such a scheme. The MNDNR County Biological Survey should be used to identify candidate sites. Special incentive programs should be developed for this purpose. Alternatively, these sites would be good candidates for purchase to augment the state's reserve system.

2 Retention of key habitat requirements in clearcut areas. Certain key habitat can be retained within clearcuts to maintain some habitat values required for the species that formerly occupied the stand. Habitat requirements can be maintained by retaining snag trees, trees with cavities; and retention of conifer patches and isolated trees when harvesting in predominantly deciduous forests, using *Forestry-wildlife guidelines to habitat management* (MNDNR 1985) as a model.

Clearcutting with residuals generally prescribes:

- the number of snags to be left uncut, e.g., 2 to 6 per acre;
- inclusion of dense, lowland conifer patches of 5 to 10 acres each; and
- the types of live trees to be retained on the site, with preference to food producing trees such as oaks, hickories, mountain ash, and cherries as well as rare tree species.

Deer, moose, snowshoe hare, and pine marten will use the conifer inclusions as cover from heat, cold, or predators while still having access to the emergent forage in the clearcut. Black bears will use conifer shade in summer while feeding on berries in clearcuts. A variety of birds will use the snags for nesting when cavities develop, including Tree Swallows, Northern Saw-whet Owls, Eastern Bluebirds, and most woodpecker species (which can create cavities). Other birds use the snags for territorial singing perches, including Golden-winged Warbler, American Robin, and Chestnut-sided Warbler. Raptors, including the Red-tailed Hawk, American Kestrel, and Northern Saw-whet Owl, use the snags for hunting perches.

3 Retention of cavity trees or mature trees that are likely to produce cavities in stands that are clearcut, will provide nesting and security substrate for a wide range of birds as well as some mammals in postharvest forests.

This mitigation is intended to provide these resources pending new cavity formation in the regrowth forest, which begins after a number of decades for most tree species. Diseased or damaged trees typically have more cavities, or have a high potential for developing that cavities. Snag retention should be directed toward trees that are not infested with insects and diseases other than wood decay. This restriction would not be necessary when stands are regenerated to nonsusceptible forest species. In southern Minnesota, tree quality is frequently low and thus cavities are probably not in short supply.

Individual animal species' requirements for cavity trees are not fully understood and more research is needed to gain a quantitative understanding of wildlife requirements.

Harvesting in forests inhabited by gray squirrels and southern flying squirrels should aim at retaining a minimum of 2.4 cavity trees/acre. This mitigation should be applied over all Minnesota ecoregions, but for mammals it may be critical within the range of the gray squirrel, projected to be heavily impacted under all harvest scenarios.

Many bird species depend upon cavities for nesting, and some overwintering song birds such as chickadees require cavities for thermal protection in cold weather. Tree-cavity nesters range through all forest types and stand sizes; some species prefer lone trees in openings, hence the importance of cavity-snags on edges and within clearcuts. Cavity nesters in Minnesota forests include owls—Boreal, Barred, Screech, and Northern Saw-whet; woodpeckers—Red-headed, Red-bellied, Downy, Hairy, Three-toed, Pileated, Black-backed, and Northern Flicker; Black-capped and Boreal Chickadees; Red-breasted and White-breasted Nuthatches; Eastern Bluebird; Tree Swallow; Yellow-bellied Sapsucker; and several ducks—Common Goldeneye, Common and Hooded Mergansers, and Wood Duck.

These mitigations would require nontechnical guidelines that could be applied by loggers or land owners. These guidelines should reflect many of the current practices on the major public ownerships. Their adoption by NIPF landholders is likely to depend on the owner's management objectives and the value of timber foregone by retaining trees which could be sold. Therefore, the guidelines need to include educational materials that explain the value of these habitat requirements.

Protection of sensitive sites. Sensitive nest sites, habitats, rookeries, and rare communities should be identified and protected by appropriate buffers. Current guidelines followed by the MNDNR and USDA Forest Service around nests of Bald Eagles and rookeries of colonial birds should be used as the model for protecting sensitive sites for all rare species, including plants. Rare communities should be protected by establishing Scientific and Natural Areas (state lands), Research Natural Areas, or Special Botanical

Areas (federal lands). The Nature Conservancy conservation easement program would be a good model for protecting rare communities on county and private lands.

The Bald Eagle guidelines include: no new roads or trails and no logging, even during the nonbreeding season, within 660 feet; all activities prohibited except those related to protecting the site, within 330 feet; no activities during the breeding season from mid-February to early October, within 1,320 feet; and no logging even in the nonbreeding season, within 660 feet. These recommendation are based on studies and management applications by the Chippewa National Forest. These guidelines also include a lakeside buffer of one-fourth mile, rather than 200 feet, in areas where eagles are likely to feed. However, modifications would be appropriate where eagles colonize already active logging areas or right-of-ways.

Based on current MNDNR guidelines, for rookeries of colonial wading birds (herons and egrets), there should be no logging within 330 feet, and no logging or other disturbance during the nesting season (April to July inclusive) within 660 feet. Finally, no logging should be carried out within 300 feet of bluffs with hibernacula of massasauga and timber rattlesnakes, or near known populations of five-lined skinks, rat snakes, and lined snakes. Many of these sites are likely associated with the riparian zones discussed previously.

The locations of some of these sensitive sites are already known and where there is a risk of disturbance from harvesting, owners can be made aware of the risks to these species. In addition, assistance should be provided to insure that appropriate mitigations can be implemented by the landholder.

The USDA Forest Service and the MNDNR undertake identification and management of some rare species and communities on their lands. The MNDNR is the most appropriate agency to oversee preparation of suitable guidelines for application on NIPF lands and on other ownerships which do not have access to the skills necessary to properly manage these sites.

Increasing the wood fiber productivity of timberlands. The area of timberlands available for harvesting in the state is projected to decrease. The reduction is likely due to land use changes, as well as to additional reservation of land and the imposition of constraints on the types of practices that can be undertaken on the remaining lands.

This strategy identifies ways to increase the yield of wood fiber from the land base managed primarily for wood production. There are two elements to the strategy. The first provides short- to long-term benefits, and the second provides medium- to long-term benefits.

1 Increasing Utilization. In Minnesota the level of utilization of wood from an individual stand varies depending on a range of factors. There are differences in the standards of utilization achieved by individual logging companies. In addition, the harvesting and silvicultural prescriptions imposed by some landowners reduce the level of utilization.

This strategy is intended to increase utilization by making maximum use of the stems (not slash) available for harvest. This strategy must be applied carefully while taking into consideration the strategy noted previously for slash retention to avoid conflicts in implementation of both strategies.

Utilization standards are specified by industry. Typically, these standards specify minimum diameters, log lengths, and wood quality. Existing standards and practices likely reflect the relatively low stumpage paid for most wood in Minnesota which, in turn, reflects the relative abundance of wood. The consequences of the existing specifications are graphically illustrated at sites where topping and slashing occurs on the landing. Substantial volumes of potentially usable wood are left at the landing following application of current minimum diameter standards.

The strategy has several components. The first involves using more of each stem harvested by relaxing the minimum top diameter and length specifications of logs. This strategy would particularly apply to the conifer-based pulp and paper industry. Industry should actively seek ways to adapt processing equipment to handle smaller, less uniform pieces of wood and subsequently, to improve utilization. This includes the development of technology to attain increasing product standards using resources of lower quality.

The second component involves changing production processes, especially in the pulp industry, to accept the range of species available from the mixed species stands typical in Minnesota. This industry is selective in its use of species so there are substantial volumes of undesirable species that are left in the cutover following harvesting. Some of these trees meet wildlife needs and therefore would not be harvested irrespective of industry specifications. However, the remaining trees could be utilized and thus increasing the productivity of the site (as measured by fiber yield).

The feasibility of this alternative depends on the ability of the forest products industry to adapt to changing input specifications while remaining competitive with other domestic and international competitors. New industries are moving in this direction; retrofitting existing plants will be more difficult.

The third component of the strategy would take up the same theme as the second but would provide more immediate benefits. Purchasers of stumpage should insure that all the wood potentially available from each stand is put to its best end use. This mitigation would require some of the current exclusive arrangements between loggers and particular industries be relaxed to allow more effective movement of wood to multiple industries from a single sale. This could be achieved through direct negotiation between loggers and specific industries, or through greater use of brokers specializing in this service.

The last component of the strategy is to train loggers in ways to improve utilization. This includes techniques as simple as reducing the stump height which can add to the volume yielded. The forest industry, loggers, and the major landowners should develop logger training programs to improve the levels of utilization.

Removal of more biomass under improved utilization practices would need to be cognizant of concerns about soil nutrients and wildlife habitat. Both are affected by the amount, distribution and nature of slash and residual trees left after logging. The major landowners should utilize existing guidelines on all lands and where needed develop additional standards on minimum levels of utilization to apply on their lands. These minimum standards should incorporate guidelines covering the retention of large logs and slash needed to meet wildlife management objectives.

This strategy would provide benefits ranging from immediate/short-term extending into the long-term. The forest industry is the most suitable to take a leadership role in implementing this strategy. The long-term security of timber supplies for the state's forest industry will depend on maximizing yields.

2 Increasing Productivity. Increasing productivity of existing and future stands is likely to be a more effective way to maintain future resource security than relying on gross area of forests. There are many ways to increase productivity of timberlands. Regeneration to full stocking levels and site-species matching are two of the most readily implemented and effective ways on a statewide scale. This mitigation would be feasible as much can be achieved by changing the way harvesting is done, and through improved site survey and planning. The focus of this mitigation is on NIPF timberlands where standards of harvest planning and silvicultural management can be most improved. Improving these standards and therefore stand productivity is feasible using a combination of landowner education and broad BMPs that include good harvesting practices likely to maximize regrowth success. This alternative would provide long-term mitigation. Additionally, intermediate harvests (thinnings) and stand hygiene practices could capture much of the natural mortality although some snags and trees with cavities should be retained for the benefit of wildlife.

Additionally, improved pest management program also would lead to enhanced productivity and also should be a focus of productivity enhancement efforts.

In addition to improving productivity of NIPF lands, the forest industry is also likely to have strong incentive to invest in their own timberlands. These decisions will be motivated by the individual company's perceptions of the financial returns from such ventures and the security of the company's future wood supply.

Where plantations are contemplated, care should be taken in the choice of exotic and hybrid stock to avoid the potential loss of biodiversity. As background, exotics by definition introduce nonnative genes. Hybrids can be formed from exotic parents, from a combination of native and exotic stock, or simply from combining different native plant materials. By contrast, tree improvement efforts primarily involve selection from among native species or genotypes. In practice, hybrids developed from native stock and tree improvement efforts typically seek to improve growth and disease resistance by increasing a tree population's frequency of genes that are effective in promoting such performance.

Further, such efforts also attempt to conserve or retain the full breadth of genes in the population originally. In contrast, exotic stock, if aggressive, can potentially lead to a reduction in the original gene pool. In Minnesota, forest tree genetics programs are or will likely emphasize tree improvement over approaches involving exotics. In terms of risk, a long history of Scotch pine planting and plantings of a wide variety of poplars have shown little impact on native forest tree species. However, some introduced shrub species are very aggressive and have displaced native species, especially in areas subject to human disturbance and development.

Judicious plantings can increase the habitat value of landscapes now largely in a single covertype. Because of their high productivity, plantations can also greatly reduce the acreage that might otherwise need to be harvested.

The major landowner groups, forest industries and loggers should develop guidelines for effective harvest and silvicultural practices for application in all harvesting operations in the state. These guidelines would be similar to the existing water quality BMPs and would be directed at site level operations and planning. Other existing USDA Forest Service and MNDNR guidelines should be at least considered here to assure a more efficient and useful set of statewide guidelines.

5.7.3
Effectiveness at Mitigating Significant Impacts

The base level harvest scenario significant impacts identified in section 5.6 were summarized in section 5.6.8. The following section discusses the relative effectiveness of the strategies recommended in section 5.7.2 as mitigations for significant impacts projected to occur under the base scenario.

1 Impact
Projected significant loss of forest area in ecoregions 1, 2, 3, and 4
Reduce the area of forest converted to nonforest land uses: The process of land use conversion is independent of the level of harvesting. The proposed strategy seeks to influence NIPF ownership to maintain forested land under forest cover, irrespective of their management objectives.

As discussed in the previous section, the likelihood of influencing landowner decisions depends largely on the economic value of the property. The policy instruments available to the state to influence decisionmaking by the NIPF ownership including zoning, property tax, financial incentives, and purchase of easements are limited and likely to be marginally effective given the number of forest land holdings in the state. Past experience in the state has shown a limited willingness to adopt these increases on a scale commensurate with the problem.

2 Impact
Projected harvesting affecting patterns of forest cover in areas of mixed land use
These impacts would affect species that depend on the features of mature forest and forest interior species. The following mitigation strategies will mitigate these impacts.

Maintain patches of forest intact in areas of mixed land use: This can be done by reducing clearcutting and even-aged silvicultural systems and by linking patches and augmenting existing patches of forest. This strategy incorporates aspects of mitigations concerning management of riparian corridors and use of uneven-aged silvicultural systems in the patches that are harvested. These mitigations will benefit the animal species that depend on features of mature forest such as cavities and mature mast trees. Other forest interior species will likely remain impacted. Modification of existing silvicultural systems (e.g., clearcutting) has to be consistent with acceptable practices on the covertype in question.

Mitigations to maintain populations of forest interior species and the Red-shouldered Hawk will need to maintain forest interior conditions in remnant patches. Large (>300 acre) blocks of mature forest will likely have to be retained with only periodic disturbance to maintain the most sensitive species.

Effectiveness: If applied at a regional scale, this mitigation strategy will likely be effective at mitigating impacts by maintaining these important habitats.

Feasibility: The feasibility of this strategy depends on NIPF owners adopting constraints on management of their forests. The restrictions on the use of clearcutting are likely to be successful as this method of harvesting is not routinely practiced in the areas affected. Therefore, that aspect of the strategy will likely be moderately effective as a proportion of landowners will probably adopt these guidelines for management of their forests. The modification of harvesting and silvicultural practices has to be consistent with workable practices for those covertypes and regional goals for such cover.

Retention of large blocks of undisturbed forest is less likely to be successful because this aspect of the strategy will likely require cooperation of more than one NIPF landowner. As more landowners become involved, the likelihood of **all** owners cooperating will decrease. Purchase of these blocks for inclusion in the state's forest ownership system is probably the most effective means to achieve this mitigation. However, the state investment required could become large.

The GEIS analysis was unable to quantify the projected extent of these impacts, and therefore it is not possible to quantify the effectiveness of the proposed mitigations.

3 Impact

Projected changes to tree species mix

Projected changes to tree species mixes in the state's forests are likely to result from changes in the age class distributions of covertypes, as well as from covertype acreage changes and direct impacts on minor tree species. Consequently, the strategy seeks to monitor and, where needed, to manipulate age class and covertype distributions. The strategy depends on several distinct elements which are discussed below.

Monitor the age class and covertype structure of the state's forests and their pattern across the landscape: This mitigation would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Complete the MNDNR county biodiversity inventory: This mitigation would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Conduct an inventory of old growth forests across all ownerships: This mitigation would not mitigate impacts directly, but would contribute information to assist decisions on other mitigations.

Maintain desired age class distributions for each covertype: This offers the prospect of modifying the tree species mix by insuring the presence of adequate areas and numbers of stands that are likely to provide suitable conditions for the full range of species. Age class distributions can be manipulated by increasing harvesting of a particular covertype, using prescribed fire, or by managing a proportion of stands as ERF. This strategy is the only mitigation likely to be able to modify tree species mix at a landscape scale.

Maintain desired covertype distributions: This provides for maintenance of tree species mix by management to achieve acreage goals by covertype. The available tools include harvesting and a range of silvicultural practices that favor certain species and covertypes. In some areas, restoration of forest cover by planting or enrichment may be appropriate. In other situations minimal disturbance might be effective to allow natural succession.

Effectiveness: This mitigation strategy would likely be only moderately effective, requiring long periods to achieve detectable change. Because harvesting and silvicultural practice are the only practical tools available for these landscape scale manipulations, there are inherent constraints on the range of covertypes likely to be manipulated. Typically changes will be on covertypes dominated by the more commercial species. Stands of noncommercial covertypes and those within reserved forests will likely continue the trend towards older age classes. Use of other tools such as fire and special silvicultural systems would likely be very expensive and confined to small areas.

Feasibility: The mitigation strategy is moderately feasible as the major public ownerships have policies to maintain biodiversity. The other ownerships typically have no clear management objectives in this area and are less likely to direct their management to achieve these goals. Therefore, the mitigation would be focussed on the major public owned forests. However, to be successful, coordination among ownerships is essential, especially in areas with intermingled ownership. Success will also require agreement on acreage and age class goals for specific covertypes.

4 Impact

Projected changes in the age class structure of paper birch

This was the only covertype projected to have significant changes to the age class distribution. The covertype showed a trend towards older age classes with little young acreage and reflects the low level of harvesting projected for this species. The following elements comprise the mitigation strategy for this covertype.

Monitor the age class and covertype structure of the state's forests and their pattern across the landscape: This would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations. As described in section 5.8.1, FIA survey design refinements could add measurably to the timeliness and effectiveness of this monitoring.

Conversion of older stands to young stands to balance the age class structure: This would require that old stands be harvested and new stands regenerated.

Effectiveness: If a proportion of older stands could be replaced by younger stands, then the mitigation would be effective.

Feasibility: The mitigation strategy is unlikely to be feasible because the covertype is not a widely sought after commercial species, and it is difficult to regenerate once stands become too old to reliably stump sprout. Major public ownerships are likely to undertake limited regeneration efforts but these will probably be inadequate to balance the age class distribution statewide. Research on the ecology of birch regeneration may be a prerequisite to success.

5 Impact
Projected harvesting affecting genetic variability of plant or animal species
Harvesting is projected to lead to further fragmentation of the forest and to impact outlier populations of some species and plant communities. These impacts can create conditions likely to reduce genetic variability of plant and animal species. The following elements make up the mitigation strategy to mitigate these impacts.

Complete the MNDNR county biodiversity inventory: This would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Develop blocks of ERF: This would promote additional diversity of covertype and provide habitat for species dependent on mature/older forest. ERF policies are likely to be confined to the major public ownerships.

ERF and riparian corridors would likely maintain many opportunities for transfer of genetic materials between separated populations of forest plants and animals. In the northern ecoregions where public ownerships dominate ownership patterns, remnant old growth is being preserved, and ERF policies are being implemented. In contrast, the increasing proportion of lands under NIPF ownership in the south of the state means few areas are managed in a way likely to maintain the conditions needed to assure genetic transfer in the long-term. In this region, the riparian zones will likely be an important vector for genetic transfer for some species, i.e., for connecting key habitat features of landscapes.

Modified silvicultural systems: The use of uneven-aged management and thinning for harvesting and retention of key habitat requirements would likely maintain conditions that are suitable for many of the species likely to be significantly adversely impacted. NIPF owners are more likely to adopt these modified silviculture systems in the southern part of the state than in the north. This is because the covertypes and range of products sought in the south are more suited to these systems.

Effectiveness: Combinations of these mitigations will likely be effective at reducing significant impacts by providing a range of age classes in each covertype and linkages for transfer of genetic material.

Feasibility: The major public ownerships have mandates to manage for biodiversity. However, application of these mitigations by other landowners is likely to be mixed, and will depend on owners' objectives. Consequently, the mitigation is rated at low to moderate feasibility. It will likely be more feasible in the north and less feasible in the south of the state.

6 Impact

Projected harvesting affecting federal- or state-listed plant species of special concern, threatened, or endangered or their habitats

Impacts on populations of these species of plants and the communities that contain them are interpreted to occur as a consequence of harvesting because little is known of their locations. The significant impact criterion threshold was set at any diminution or disturbance of habitat or populations of these species.

The strategy directed towards maintaining genetic variability discussed previously will mitigate some of these significant impacts.

Complete the MNDNR county biological survey: There is a strong likelihood that populations of these species and the communities which support them will be disturbed and diminished if the locations of these species remains unknown. Therefore, significant impacts are likely to be higher in areas that have not been surveyed by the MNDNR county biological survey.

Effectiveness: The effectiveness of the strategy depends on access to information on the locations of these species and the communities that support them. If the locations of these populations were noted, then plans to redirect harvesting could be made. Therefore, the effectiveness of the strategy relies largely on increasing the funding and staffing allocated to the MNDNR county survey and/or refinement of the design as suggested earlier in this section. This strategy would also require some administrative procedure to ensure appropriate notice and protection.

The inventory of old growth could be conducted by several agencies, but coordination is appropriate to ensure database compatibility.

Feasibility: The strategy is likely to be moderately feasible subject to needed survey design changes and adequate funding being provided to complete the biodiversity survey. Also important here is the need to secure at least a sample coverage of the entire state within ten years.

7 Impact

Changes in the susceptibility and vulnerability of covertypes to forest health risks

Impacts were interpreted based on projected changes to age class distributions and circumstances where multiple-entry harvesting systems were used. The projected changes in forest health primarily reflect the increasing age of stands in noncommercial covertypes on timberlands and all covertypes within reserved lands. These impacts are not a consequence of timber harvesting per se. How the management responds to these changes to forest health will depend on the management objectives for the stand. Increases in insect and disease attacks would likely be viewed as an integral part of the stands' ecology by the manager of a reserved area. In contrast, the same attacks would be viewed as a threat to productivity by managers concerned with wood production. Consequently, the need for mitigation and the likely responses would be different under each circumstance. Conflicts are expected between production-oriented landowners and reserved forest management when they are in close proximity because insect and disease problems endemic to older reserved forests may spill over to nearby timberlands. Both ownerships would view attacks from introduced pests such as the gypsy moth as a major adverse impact.

The mitigation strategy is aimed at developing statewide plans to handle pest outbreaks and to modify the equipment and techniques used in multiple-entry harvests. The following section outlines the elements of this strategy.

IPM: This will assist to mitigate impacts associated with major outbreaks such as gypsy moth. The planning advocated under this mitigation will allow a more rapid response and is therefore likely to reduce the level of impact experienced.

Modify equipment and practices for use in multiple entry harvesting operations: This will likely reduce damage to residual stems and will therefore reduce the incidence of pests and diseases that are associated with wounds. This will have particular application in the south of the state.

Maintain desired age class distributions for each covertype: Seeking such distributions will provide opportunities to reduce the proportion of susceptible and vulnerable covertypes on ownerships with wood production objectives. This mitigation would only effect change over the long-term.

Effectiveness: These three mitigation strategies are likely to be moderately effective at reducing damage caused by major outbreaks of pests, particularly pests such as gypsy moth. The localized impacts caused by damage to retained stems would likely be reduced if the changes to equipment and practices were introduced.

Feasibility: These strategies are likely to be moderately feasible, subject to participation by the major stakeholders in the development of IPM strategies. Adoption of new harvesting equipment and techniques will likely be of moderate feasibility subject to the provision of assistance to undertake trials and subsequently, the loggers willingness and ability to make the investments needed to replace equipment.

8 Impact
Projected harvesting affecting site nutrient capital
Nutrient losses above estimated levels of replenishment were projected for several combinations of covertype/soil type/harvesting practices. These significant impacts can be mitigated by changing the length of rotations and the harvesting methods used. The following strategy has been developed to mitigate these impacts.

Retain or redistribute slash within the cutover: This will maintain the nutrients contained in the leaves (needles) and branches within the cutover. This can be achieved either by favoring use of equipment and/or harvesting practices that retain slash at the site where the tree was felled; or, slash from landings can be redistributed using existing equipment.

The mitigation would require the development of guidelines to specify acceptable patterns of redistribution, including avoidance of ephemeral wetlands and small ponds.

The development of systems that could undertake partial or full bark removal in the cutover would also greatly aid nutrient retention. These systems are untried in Minnesota.

Manage a proportion of stands under ERF guidelines: Would extend the period for nutrient replenishment prior to the next harvesting operation.

Effectiveness: The mitigation of retaining or returning slash and (if feasible) bark within the cutover is likely to be very effective in reducing nutrient loss. Longer rotations are also effective, allowing natural processes to replenish the nutrients lost in harvest or in site preparation. The duration is long term, but effectiveness is reduced with time as species reach advanced ages and become less vigorous and more susceptible to forest health problems.

Feasibility: In some cases the strategy can be implemented easily. However, overall feasibility will depend upon operational and technical constraints, particularly on the harvesting technique, the equipment available, and, to some extent, the season of harvesting as it facilitates removal of bark. Equipment to remove branches and bark at the stump is currently operational overseas. In the long-term, feasibility should be high. Return of slash to a site from a landing or elsewhere would also be similarly effective and long-term. Its feasibility would be affected by the added cost of another pass of equipment over the site and the potential compaction and puddling associated with such an activity. Returning material in winter would minimize the latter effect. The duration of the effect is long-term.

The feasibility of applying longer rotations is problematic for short-lived species, and benefits diminish with time as nutrient levels return to preharvest levels.

9 Impact

Projected harvesting affecting soil physical structure

Compaction and puddling is projected for the most frequently impacted well-drained medium-textured soils (the most common soil in the state) and poorly-drained medium- and fine-textured soils. The likelihood of impacts is affected by the extent of roading, the type of equipment and the season of harvest. Therefore, the strategy is intended to manipulate these aspects in order to mitigate impacts. Additionally, implementing these recommendations may require soil survey information. However, soil surveys are not complete in several forested counties. The following section describes this strategy.

Develop landscape based road and trail plans: This strategy would involve planning and coordination between ownerships to develop landscape-based road and trail plans. The plans would cover development of new roads, long-term access needs, and closure policies.

The complex patterns of ownership that exist in Minnesota mean that significant benefits can accrue from coordination of road and trail plans. The likely benefits include rationalizing road layouts by removing ownership constraints from route selection which can reduce the length of road developed and reduce the number of stream crossings; and developing fewer roads but of a better, more uniform standard of construction and maintenance, thereby reducing the extent of poorly planned, constructed, and maintained forest roads.

Modify times of equipment operation to minimize compaction: This will reduce the occurrence of compaction likely to occur by identifying susceptible sites and limiting operations on those sites to periods when the risk of compaction is lowest. Based on these assessments, equipment operations should be limited on susceptible soil types during the spring and fall. Medium- and fine-textured soils most often exhibit low soil strength during the spring and fall, with low strength most often occurring in poorly drained positions. In addition, the strength of medium- and fine-textured soils can decrease rapidly during the summer and fall due to intense rainstorms. Equipment operation on some poorly-drained soils will be limited to frozen soil conditions. The strength of coarse-textured soils will be adequate for all but the wettest conditions, which generally occur in poorly-drained areas in the spring. Where possible, well-drained, coarse-textured soils should be identified and reserve for wet season (spring) harvesting.

This mitigation will require cooperation between landowners, the forest industry and loggers. A leadership role is required to develop techniques to enable field identification of susceptible soil types, and to develop operational guidelines for harvesting on these types. This role could best be handled by the MNDNR in conjunction with the other major landownerships. Identification of soil types that are not susceptible to compaction should be undertaken as a priority. These sites should be set aside for wet weather harvest.

Effectiveness: If fully implemented, the strategy would likely be moderately effective at mitigating the significant impacts.

Feasibility: Development of landscape-based plans would require a leadership role to initiate the process and to coordinate responses from other ownerships. The MNDNR is the agency best placed to undertake this role. This strategy is feasible given the existing MNDNR responsibilities to produce an inventory of state forest roads under the MFRMA of 1982. In addition, the number of ownerships likely to be developing new roads in the more remote areas is limited. The cost of adopting this mitigation would center on the additional planning that some ownerships would have to undertake to participate in the process. Additional costs would also be incurred by the MNDNR in coordinating and compiling inputs from others.

Constraints on equipment operation during susceptible periods will require assessments of site susceptibility at an operational scale if preventative measures are to be effective. In most areas, soil maps and other tools are *not* available at the stand or harvest unit scale. Confirmation of site susceptibility will require on-the-ground inspection by natural resource professionals. This will likely require additional training and staffing of forest management organizations. The MNDNR, USDA Forest Service and possibly the larger counties and forest industries are best equipped to undertake this mitigation. It is unlikely that planning and assessments on NIPF lands would reach this level of sophistication and consequently this mitigation is less feasible on these lands.

The feasibility of imposing seasonal restrictions on harvesting on some soil types or delaying operations that are already underway would likely be constrained by possible financial hardship to loggers. In addition, these restrictions may interfere with the continuity of supply to some mills. The feasibility will therefore be constrained by the flexibility of forest industries delivery schedules.

10 Impact
Projected harvesting causing accelerated erosion from forest roads
Forest roads are the primary sources of accelerated erosion from harvested areas. The most susceptible region in the state is in the southeast where steep slopes exacerbate erosion problems. The strategy aimed at reducing compaction will mitigate erosion impacts.

The key elements of this mitigation strategy include: adherence to BMPs, consistent road closure policies; a reduction of the length of road constructed; and an improvement in the standard of design, construction and maintenance.

Effectiveness: These mitigations will reduce the extent of poor standard forest roads that are likely to cause erosion. If applied throughout the state, this strategy would provide moderately effective mitigation of the impact.

Feasibility: The main erosion problems in the state occur in the southeast, where there is less likelihood that these measures will be adopted because of the predominance of NIPF lands in this region. Thus, a variety of programs will be required to increase compliance with harvesting practice codes. These include education, technical assistance, and/or possibly more stringent measures.

11 Impact
Projected changes in the populations of forest dependent wildlife
Projected changes to wildlife populations were based on changes in the amount and quality of likely habitat within the known ranges of each species or group of species. The mitigation strategy is intended to:

- identify and protect important habitats;
- provide a range of age classes within each covertype with particular attention to maintaining habitat features of old and old growth forests;
- maintain patches of forest in areas of mixed land use;
- provide a landscape with connections necessary for movement of animals among separated populations;

- modify harvesting practices to maintain within cutovers some of the key habitat needs for animals dependent on features of mature forests; and
- distribute logging slash to provide cover for small animals in clearcuts.

The following section discusses each element of the proposed mitigation strategy and assesses the overall effectiveness and feasibility of the strategy.

Complete the MNDNR county biological survey: The information from the survey is essential to identify important habitats for forest dependent species.

Conduct an inventory of old growth forests across all ownerships: This information is important to identify habitat for species dependent on old growth forests.

Develop blocks of ERF: This would promote additional diversity of covertype condition and would provide habitat for species dependent on mature/older forest. ERF policies are likely to be confined to the major public ownerships.

Maintain linkages between patches of remnant forest or old growth via corridors: This would likely maintain opportunities for movement of animals between separated populations. In the northern ecoregions where public ownerships dominate ownership patterns, remnant old growth is preserved and, on state- and federal-managed lands, ERF policies are being implemented. In contrast, the increasing proportion of lands held under NIPF ownership in the south of the state means that few areas are managed in a way likely to assure that connections will be maintained in the long-term. In this region, the riparian zones will be the most important vectors for genetic transfer for some species. However, the limitations currently existing for use of such linked landscapes must be kept in mind.

Maintain patches of forest intact in areas of mixed land use: This can be done by reducing use of clearcutting silvicultural systems, linking patches, and augmenting existing patches of forest. This mitigation strategy incorporates aspects of other mitigations, including management of riparian corridors and use of uneven-aged silvicultural systems in the patches that are harvested. These individual mitigations will benefit animal species that depend on features of mature forest such as cavities and mast trees. The habitat needs of the species dependent on forest interior will be met by mitigations to maintain forest interior conditions in remnant patches. Large (>300 acre) blocks of mature forest will likely have to be retained with no disturbance to maintain populations of the most sensitive species, especially the Red-shouldered Hawk.

Modify silvicultural systems to maintain key habitat components: This includes the use of uneven-aged and thinning systems as substitutes for clearcutting where appropriate, i.e., in certain covertypes that can be managed using these systems. For covertypes managed by clearcutting systems, the retention of key habitat requirements including mast trees, cavity trees, snags, and conifer inclusions is prescribed to maintain key habitat requirements.

Retention of trees with cavities and trees that are capable of forming cavities as the regrowth forest develops is an important part of this mitigation. This mitigation will maintain these important habitat features over the period of decades required for cavities to develop in regrowth trees.

Redistribute slash across the cutover: This would maintain cover for small mammals in cutovers following clearcutting. Maintenance of suitable habitat conditions for these small mammal species will also benefit predator species.

Effectiveness: The maintenance of key habitat requirements and slash spreading would likely be moderately effective at maintaining habitat for adversely impacted species in covertypes harvested using clearcutting systems. Strategies that substitute uneven-aged silvicultural systems for clearcutting are likely to be effective at maintaining suitable habitat conditions for species dependent on elements of mature forests. However, these strategies would likely provide only moderate to low levels of mitigation for species dependent on forest interior conditions and limited disturbance.

ERF, old growth, riparian, and other corridors would provide habitat for species that depend on old forest and forest interior species. These mitigations are likely to focus on the northern half of the state because of the pattern of ownership. They are less likely in the south because of predominantly NIPF ownership. Maintenance of large patches of forest unharvested for long periods in these areas will likely be moderately effective at maintaining populations of forest interior species present in the south.

Species specific mitigations appropriate to bird populations are shown in appendix 3.

Feasibility: Modifications to maintain key habitat features are widely practiced on lands by the major public ownerships and are being introduced by some counties. The successful introduction of these mitigations to NIPF and industrial lands is likely to depend on the costs associated with their adoption, the owner's awareness of the need for these mitigations, and the willingness of loggers to implement the mitigations at an operational level.

Replacement of clearcutting with uneven aged silviculture systems is actively being considered by the major public landowners as part of their ERF programs. In addition, these systems are likely to be used on NIPF lands in the south of the state. This is because the covertypes and range of products sought in the south are more suited to these systems. However, the changes in harvesting and silvicultural systems need to recognize the costs of doing so. In some cases it may mean covertype change and/or shifting the costs of maintaining a covertype to the regeneration stage of management. For example, harvesting systems that cause minimal site disturbance may not create conditions that are required for regenerating white pine. If these systems are used, additional effort and expense will be required as part of regeneration efforts to ensure suitable conditions are created for this species.

ERF, old growth, and corridors are likely to be most feasible on public lands in the northern part of the state. These measures are consistent with the mandate given these ownerships. As discussed previously, it is less feasible to maintain large blocks of forest or corridors in the south because of the problems associated with coordinating uniform management with more than one owner.

The overall strategy is likely to be moderately successful at mitigating impacts on those species projected to be significantly impacted.

12 Impact
Projected harvesting affecting populations of the Red-shouldered Hawk
This was the only animal species listed as a federal or state species of special concern, threatened, or endangered projected to be significantly impacted at the base level of harvesting as a result of cutting in larger patches of forest. As discussed under the previous strategy, this species requires large (>300 acres) blocks of forest that experience little disturbance (the amount the species will tolerate has yet to be determined).

The strategy discussed above under impact 11, which seeks to mitigate impacts on all significantly impacted wildlife populations, includes all the elements likely to benefit the Red-shouldered Hawk.

13 Impact
Projected harvesting affecting patterns of mature lowland conifer stands
Patches of mature lowland conifers are important habitat, particularly in those parts of the state where lowland conifers occur as small isolated patches within more extensive upland forests. The strategy is intended to maintain such stands as an ongoing part of the landscape. The following section describes the proposed elements of this strategy.

Retention of conifer patches in clearcut stands: This is part of existing federal and state management guidelines. This mitigation would seek to retain these patches in harvested areas on other ownerships that are primarily directed at obtaining upland species.

Effectiveness: If applied, the mitigation would maintain these habitat elements within cutovers in predominantly upland stands.

Feasibility: The mitigation is straightforward and could be easily applied at an operational level. The major public ownerships already undertake elements of this mitigation in their current management strategies guidelines, particularly for deer management. It is less likely that industrial owners will adhere to these guidelines because of the cost of retaining conifers. The level of compliance will likely reflect the value of the species retained. Similarly, the level of compliance by unsupervised loggers harvesting on private lands will likely be higher where no markets exist for the lowland conifers. In general, NIPF owners have a relatively high level of interest in wildlife habitat, and this will be reflected in the level of compliance.

14 Impact
Projected harvesting affecting the availability of food producing trees
The loss of food producing trees such as oak and hickory was projected to impact species like the gray and fox squirrels, which rely on mature oaks to provide food and shelter (cavities). The following mitigations make up the strategy directed at maintaining these habitat features.

Clearcutting with residuals: This will retain mature food producing trees in covertypes that include such trees as part of the species mix. This would favor retention of trees such as oak, hickory, mountain ash, and cherry. Federal and state management guidelines favor retention of these trees on the major public timberlands.

Effectiveness: This mitigation would preferentially maintain these important habitat elements in areas subjected to clearcutting. Retention of these trees would be moderately effective in sustaining populations of animals dependent on food from these trees.

Feasibility: The feasibility of this mitigation depends on ownership. The state and federal lands are likely to forgo the possible revenues from the sale of these trees (especially oak). In contrast, the mitigation is less feasible on NIPF and industry owned lands and on many county managed lands as these owners are less likely to forgo the revenues. In addition, operations on these lands are less likely to be planned to maintain these habitat features prior to harvesting.

15 Impact
Projected harvesting in the absence of VMGs on visually sensitive areas
Timber harvesting and forest management activities that occur within the visual catchment of resorts or other outdoor recreation facilities are projected to cause significant impacts on aesthetic values where VMGs are not used. The mitigation strategy is aimed at developing (1) VMGs that can be applied

as a minimum standard for all timberlands, and (2) coordinated planning of future road and trail development and closures.

Develop landscape-based road and trail plan: This would enable resort operators to be aware of future harvesting activities likely to affect the visual amenity of the resort setting or access to it. This mitigation would allow resort owners to have input into plans that might affect their operations.

Development and promotion of VMGs for use on all timberlands: This would reduce the level of visual impact likely to occur as a consequence of harvesting related activities on ownerships that do not use VMGs.

Effectiveness: This strategy would provide a moderate level of effectiveness at reducing the likelihood of conflicts between the forest products industry and the tourism/recreation resort industry.

Feasibility: There is already some dialogue between resort owners and timber producers regarding timber harvesting within the visual catchment of resorts. By active promotion on timberlands that are important to their resort setting, and on travel corridors that are used by their clients, resort operators could then contact local timber producers and landowners to make them aware of their interest in how these lands are managed. A variety of options are available that range from a cooperative agreement with the landowner to limit logging and/or to use VMGs if logged to purchase of visual easements.

16 Impact
Projected development of permanent roads in primitive and semiprimitive nonmotorized areas
Harvesting is projected to result in the development of permanent roads in primitive and semiprimitive nonmotorized areas. Doing so affects these sites by changing the recreational opportunities present and restoration to the original opportunities is by definition not possible.

Develop landscape-based road and trail plan: This would improve the chances for minimizing roads and trails that would change recreational opportunities on the more primitive sites and ensure that a variety of recreation opportunities are maintained across ownerships.

Develop guidelines for management road construction: Would provide for protection of recreational values and use in primitive and semiprimitive nonmotorized areas which are managed for timber production.

Effectiveness: In addition to the above noted benefits of road and trail planning for resort operators, such plans would provide the overview needed to develop an understanding of where primitive and semiprimitive nonmotorized recreational opportunities exist and might exist in the future. Coordination between ownerships is important to the success of this planning.

The basis for guidelines for nonpermanent road construction has already been developed. Use of nonpermanent roads and VMGs can reduce the degree and period over which impacts persist.

Feasibility: These alternatives are potentially feasible subject to cooperation of the major timberland ownerships. However, this will require leadership by the MNDNR as the most appropriate agency to initiate and oversee the planning and development of nonpermanent road guidelines and their implementation. There would be costs associated with the efforts and implementation of nonpermanent road guidelines would vary by ownership. This planning and the development and implementation of guidelines would have long-term benefits.

17 Impact
Projected harvesting affecting unique cultural and historical resources
Harvesting is projected to significantly impact a range of archaeological, cemetery, and traditional use sites used by contemporary Native Americans. The archaeological sites may be buried or on the surface. Soil disturbance caused by logging equipment and road construction are likely to damage or destroy the scientific and cultural values of these sites. Traditional use sites can be adversely impacted by changes in the types of animals and plants present at these sites. In addition, changes in access can adversely affect these uses. The extent of impacts is related to the level of harvesting and the site specific impacts are a function of the harvesting method, equipment used, and season.

Provide adequate resources to maintain the state listing of known sites: This would allow the state archaeologist to discharge current responsibilities to maintain an important reference describing the occurrences of sites in the state; and to provide a leadership role in developing a better understanding of the state's heritage resources. This mitigation is not linked to just timber harvesting but extends to all land uses that involve soil disturbance and is driven by the likelihood of positive results.

Increase the proportion of harvests undertaken during winter: Reducing soil compaction by changing the season of harvest for susceptible soil types will mitigate some impacts, as frozen soil will not experience the levels of compaction that would occur during other seasons. However, it is not possible at this time to *quantitatively* assess the degree to which such sites would or would not be damaged or protected as a result of shifting harvesting to the winter months.

Development of a landscape-based road and trail plan : This would provide opportunities for traditional users to comment on roading issues during the planning phase. This could avoid conflicts between forestry and these uses.

Effectiveness: This strategy would provide a low level of effectiveness at mitigating the significant impacts projected to occur. The USDA Forest Service lands have a more effective mitigation strategy which reflects their mandate regarding these resources.

Feasibility: The feasibility of these mitigations is likely to be relatively low, due to the low priority given these resources by the majority of ownerships.

5.7.4 Cumulative Unmitigated Significant Impacts

The mitigation strategies described in the previous section will likely mitigate many, but not all, of the significant impacts projected to occur under the base level of harvesting. This section identifies the cumulative unmitigated impacts that are likely to remain despite implementation of the mitigation strategies.

Loss of Forest Area and Timberlands
There is a strong likelihood that the area of forest in the north of the state will continue to decline. The area of timberlands will continue to decline as a consequence of the loss of forest area and the increased area of forest managed primarily for nontimber values. These reductions are unlikely to significantly constrain wood supply at the base level of harvesting. Increasing the productivity of the acres that remain available for harvest is achievable and could offset any losses of acreage. However, increasing productivity would likely require additional investments.

Changes to Age Class and Covertype Structure
The levels of harvesting projected to occur under the base level of harvesting will cause shifts away from balance in the age class distributions for several of the less frequently harvested species and/or covertypes. The shift will be towards older age classes. This is a consequence of aging, the comparatively low levels of harvesting projected, and the maturing of forests in areas where harvesting is constrained or prohibited.

Changes to the paper birch covertype were assessed as being the only significant impact under the relevant criterion. Other covertypes including black spruce, white cedar, tamarack, and white spruce, will be similarly affected, but not to the same degree.

These trends are likely to continue unmitigated as there are no management methods aside from harvesting and fire to achieve the required replacement of old stands with regrowth. The consequence is succession to other covertypes and/or to uneven-aged stand conditions.

Incidence of Pests and Diseases
The likely increase in the vulnerability and susceptibility of some covertypes to impacts from pests and disease is closely linked to the age class changes discussed above. Despite the effectiveness of an IPM plan, some impacts cannot be mitigated for the reasons set out above. The incidence of losses to pests and disease will likely increase and may cause age class changes via the broad-scale mortality of some covertypes. An example of this is spruce budworm outbreaks in the balsam fir covertype.

Impacts on Biodiversity
The lack of knowledge concerning the distributions and specific populations of endangered, threatened, and special concern species and their vulnerability to forest disturbance will likely lead to ongoing localized impacts on these species as a consequence of timber harvesting operations. In the absence of this data, impacts on these categories of plants will continue.

Populations of the Red-shouldered Hawk will likely be maintained under the proposed mitigations, although there is some uncertainty due to inadequate knowledge of the precise habitat requirements of this species.

Impacts on Forest Soils
Some forest soils will continue to lose a proportion of their nutrient capital; others may be compacted and experience accelerated rates of erosion. The following discusses the consequences of these impacts for Minnesota's forests.

Nutrients. Over the long-term, rates of removal that exceed rates of replenishment can be considered to be ***mining*** the nutrient capital of a site. Impacts will be most severe on sites with low nutrient capital. These sites can be broadly categorized as those on coarse-textured soils. Such soils occupy about one-fourth of the forested area of Minnesota, or about 4.5 million acres, and are scattered throughout the forested parts of the state.

The initial nutrient capital of a site will affect the degree of depletion over a rotation. Although a site may irreversibly lose nutrients, the amount lost may be a small proportion of the nutrients present on a site with high initial capital. In that case, the mining may be relatively insignificant and economically and biologically justifiable. Sites with low capital will be more heavily impacted by equivalent amounts of nutrient removal without replenishment. Impacts will be increasingly severe as the nutrient capital of a site is depleted over many rotations.

The duration of the impact of nutrient depletion is long-term. If natural processes continually replenish site nutrients, then with sufficient time between harvests or other disturbances, a site will regain its original nutrient capital. The probable implication of continued mining of nutrients is a decline in the productivity of those forests. This decline will be most apparent on sites low in nutrients (i.e., on coarse-textured soils) that are currently occupied by aspen-birch or upland hardwood forests. However, impacts will have to be closely monitored to ascertain their occurrence as a decline in a nutrient(s) will manifest itself differently for various combinations of nutrients, species, site and management.

Soil physical structure. Harvesting and roading activities will inevitably cause significant impacts on soil physical structure. For example, all nonwinter haul roads are heavily compacted. Under the base level of harvesting, approximately 60,000 acres are projected to be impacted. This level may be reduced as a consequence of the proposed mitigations. However, a substantial area will remain impacted.

Compaction and puddling will also result from equipment operation within harvested areas. Compaction and puddling will likely impact site timber productivity by reducing the growth rates of trees that become established within compacted areas. This effect will likely be offset by increased growth from adjacent trees because of a reduction in canopy competition. In addition, a proportion of heavily compacted areas such as log landings will not return immediately to forest cover but will provide grassy openings that are beneficial for wildlife species. The estimate of 330,000 acres projected to be affected under the base level harvesting scenario will be reduced by the mitigation strategy proposed. However, these reductions are likely to be in the lightly trafficked areas. Therefore, compaction will remain unmitigated in the heavily trafficked areas.

Erosion. Erosion from roads and other compacted areas will continue. Improved road design, construction, and maintenance will likely reduce the rates of soil loss. Consistent road closure policies and practices will also likely reduce the incidence of erosion by allowing unused roads to stabilize. Erosion in ecoregion 6 is likely to remain the most significant problem because of the combination of steep slopes and mainly NIPF ownership of forest lands.

Increased erosion can have subsequent impacts on water quality. Hence the localized (but insignificant) water quality impacts will likely continue, but at fewer sites as improved riparian management practices begin to show benefits.

Impacts on Archaeological and Cemetery Sites
Uncertainty regarding the locations of these sites and their vulnerability to damage means that impacts will continue except on timberlands owned by the USDA Forest Service and on the comparatively high proportion of other lands where operations are conducted when the ground is frozen.

Of the sites impacted, approximately 50 percent would not meet the criteria for inclusion on the State or National Registers of Historic Sites and thus would not be mitigated even if the location were known prior to harvesting occurring. Since most of these sites have not been inventoried, it is difficult to quantify impacts.

Impacts on Traditional Use Sites
Improved liaison between forest managers and Native American groups regarding future roading plans will likely reduce the incidence but is unlikely to eliminate impacts on these uses. Impacts are difficult to quantify as many of these sites have not been inventoried.

Loss of Primitive and Semiprimitive Nonmotorized Recreation Opportunities
Roading in these areas will likely reduce the areas of primitive and semiprimitive nonmotorized recreational experiences that are potentially available in the state. The consequences of this loss cannot be accurately gauged because the amount of use within these areas and the number of users affected is not known. Use of VMGs and the development of a coordinated road and trail plan will likely reduce the adversely impacted area and the duration of impacts.

Impacts on Motorized Recreational Uses
Harvesting in visually sensitive areas without VMGs will adversely impact existing users of these sites. However, the maturing of many areas of forest, including formerly harvested areas, will likely provide new or replacement opportunities for these recreational activities. Users seeking motorized recreational activities will likely find additional sites as new roads are constructed.

Impacts on the Tourism and Travel-based Industries
The lack of information on relationships between the level of harvest and its consequences for the tourism industry means the likelihood of unmitigated impacts cannot be quantified. However, resorts and other tourism-based facilities depend on the visual amenity of the surrounding forest for their setting. It is likely that individual resort operations will be adversely impacted by visually obtrusive harvesting operations within their viewshed or along access routes. The consequences for the use levels of the facility or the recreational experience of users would depend on the expectations of

the clientele attracted to the resort. Use of VMGs will likely reduce the area adversely impacted and duration of impacts.

5.8 Conclusions

The study results indicate that the base level of harvesting is well below the level of tree and forest growth potential if timber production was the only objective. It also appears sustainable from a biological standpoint as it would allow retention of other forest characteristics and values of concern in this study. Yet, as with any modelling effort, this conclusion is valid within a range of error and subject to the assumptions used representing actual on-the-ground conditions. In this light, the harvesting projected to occur at the base level (4 million cords) will likely be sustainable in a broad sense. That means this timber harvest level could be continued indefinitely and other forest resource characteristics such as soil productivity, water quality, wildlife habitat, and aesthetic values can be maintained providing recommended mitigation strategies are implemented. The following paragraphs discuss the degree of certainty in these conclusions and implications.

There will be changes to the forest; however, the most profound of these will be a consequence of the natural forest aging process.

Localized impacts will continue, even with the introduction of proposed mitigations. These impacts will likely be on NIPF lands as a consequence of generally lower standards of planning and supervision of field operations compared to large ownerships with professional staffing. However, the mitigations proposed would reduce the likelihood of significant impacts that might degrade the long-term sustainability of the state's forest resources. The only exception is the projected reductions in the nutrient capital of some low productivity sites. These reductions will need to be carefully monitored. The relationship between changes in nutrient capital and changes in site productivity also needs to be closely observed.

The current standard of harvesting practices in Minnesota are consistent with those found in most lightly regulated jurisdictions. Equipment used by the logging industry is typically old and there are no regional or statewide mechanisms to promote the introduction of new equipment and harvesting techniques.

The base level of harvesting is well below the level of sustainable yield of Minnesota's forests as defined from a biological standpoint. Consequently, there is considerable flexibility in terms of meeting timber supply demands while making provision for nontimber values. The comparative abundance of timber means that few investments to increase productivity of timberlands are warranted at a statewide level. However, additional investments can increase the productivity of stands thereby decreasing the area harvested and allowing more area to be used for other activities, specifically nontimber uses.

Aspen, which has experienced significant increases of demand coupled with an unbalanced age class distribution, is one covertype where current consumption levels pose difficulty. Consequently, there will likely be constraints in the supplies of this species during the middle of the modelled period. The base scenario projections assumed that 25 percent of the demand for this species would be transferred to the northern hardwood species. Current industry expansion proposals emphasize the need for this shift. Widening the range of acceptable species to more closely reflect the mixed species stands found in Minnesota will benefit the management of the forests and possibly reduce the area that has to be harvested by reducing the amount of potentially usable wood fiber left on harvested sites.

The proposed mitigations will require a leadership role to oversee their development and application. At present, there is no agency with the authority for such responsibility extending across ownerships to discharge these responsibilities. In addition, the current diverse ownership patterns and associated objectives means that there is no broad-based direction or goals for a future forest condition being set within the state.

Future forest industry developments should be directed towards addressing the unbalanced age class distributions identified in this analysis. The assumed timber demand used to prepare the medium scenario provides some guidance for possible species mixes for forest industries that could address these age class distribution concerns. The next section indicates the consequences, positive and negative, that are projected if these developments occur.

6
STATEWIDE IMPLICATIONS: 4.9 MILLION CORD ANNUAL HARVEST

This section of the study describes the modelling assumptions used, and the outputs from the middle level of harvesting modelled which is termed the *medium* level of harvest. The section is intended to provide an understanding of what was harvested over the GEIS 50-year study period and why; what effects this had on the future condition of Minnesota's forests and their associated resources and values as defined in the FSD issues of concern; what mitigations should be used to ameliorate the significant adverse impacts that result from this level of timber harvesting and forest management activity; and the effectiveness of these strategies at mitigating the identified impacts as well as the impacts that will likely not be mitigated.

A substantial amount of additional background information on the forest resource was provided in the previous section and is not repeated in this section. This section focusses on the *changes to the levels and types* of impacts projected to occur at the medium level of harvesting when compared with those discussed in the previous sections under the base level of timber harvesting and forest management activities.

This section draws heavily on information and analyses presented in the GEIS technical and background papers. Those papers set out in greater detail the methodology used and also identify the limitations of the methodology and the data used to undertake the analyses. Section 2.3 of this document discusses how the three statewide timber harvesting scenarios were generated. Unless otherwise stated, this section refers to the second model run results.

6.1
Description of Harvesting Activities

6.1.1
Underlying Assumptions

The medium scenario was modelled to represent the level of harvest likely to occur if all announced or planned industry expansions were to occur. A listing of the industry expansions, the additional volume by species group, and the locations are given in table 6.1. The scenario was modelled using the existing levels of roundwood consumption as the starting point for demand that applied for the period 1990-96. Projected consumption increases during this period reflect mills already under construction or constructed that come online during this period. Consumption increases due to new mill expansions were assumed to commence in 1997. Further expansions were assumed to occur in 2000 which lifted demand up to the 4.9 million cord per year level. This level of harvest was then continued for the balance of the 50-year modelled period, i.e., no further forest-based industrial developments were assumed.

Table 6.1. Assumed roundwood consumption increases for defining the medium harvest level scenario.

Year	Increase (cords/year)	Species Group	Location (description)
1997	260,000	N. Hardwood	Duluth (Cloquet Potlatch Expansion)
1997	65,000	Pine	Duluth (Cloquet Potlatch Expansion)
1997	85,000	Aspen	Duluth (Cloquet Potlatch Expansion)
2000	160,000	Spruce-fir	Duluth (Lake Superior Paper)
2000	85,000	Aspen	Grand Rapids (Blandin)
2000	45,000	Spruce-fir	Grand Rapids (Blandin)
2000	30,000	Aspen	Brainerd (Champion International)
2000	30,000	Spruce-fir	Brainerd (Champion International)
2000	50,000	Other Wood	Southern Region
2000	15,000	Red oak Sawlogs	Southern Region
2000	825,000	Total	Statewide

Source: Jaakko Pöyry Consulting, Inc. (1992a).

The assumed shift of 25 percent of the aspen demand to other hardwoods used under the base scenario was also required for this analysis (see section 5.1.1). Table 6.2 describes the assumed roundwood consumption levels by species group and market for the medium scenario.

6.1.2
Covertypes and Species Harvested

Table 6.3 summarizes projections for the base and medium scenarios of the total acres, acres uncut, acres clearcut once in 50 years, acres clearcut twice, acres thinned but never clearcut, and acres thinned and clearcut for both the southern and the northern study regions and the state as a whole. These data indicate that approximately 8.6 million acres of timberland would be harvested under the medium scenario over the next 50 years. Conversely, adding the area of productive land *not cut* to the productive land *not considered* in the scheduling model, shows that a total of 6.5 million acres of timberland *would not* be harvested over this same period under this scenario. In addition, the 1.9 million acres of reserved and unproductive forest acreage (not included in table 5.2) would not be disturbed by harvesting. This means that under the medium scenario, 8.6 million acres would experience some form of harvesting and 8.4 million acres would not be harvested over the 50-year study period. By comparison, under the base scenario 7.2 million acres would experience some form of harvesting and 9.5 million acres would not be harvested.

Table 6.2. Assumed roundwood consumption levels by species group and for the medium harvest scenario market (thousands of cords per year).

Species, Market	Period						1990-99 Ave.	2000+ Ave.
	1990	1991	1992	1993-94	1995-96	1997-99		
Aspen, Bemidji	460	490	605	605	605	580	572	580
Pine, Bemidji	40	114	114	129	129	144	122	144
Spruce-fir, Bemidji	5	6	6	6	6	6	6	6
N. Hardwoods, Bemidji	64	65	87	87	87	89	83	89
subtotal Bemidji	569	675	812	827	827	819	783	819
Aspen, Brainerd	169	169	234	269	289	289	256	319
Pine, Brainerd	49	49	49	49	54	54	52	54
Spruce-fir, Brainerd	70	70	70	70	70	70	70	100
N. Hardwoods, Brainerd	177	181	185	185	196	197	190	198
subtotal Brainerd	465	469	538	573	609	610	568	671
Aspen, Cook	213	213	213	213	213	203	210	203
Pine, Cook	34	34	34	34	34	34	34	34
Spruce-fir, Cook	5	5	5	5	5	5	5	5
N. Hardwoods, Cook	46	46	47	47	48	59	51	59
subtotal Cook	298	298	299	299	300	301	300	301
Aspen, Duluth	510	510	505	505	505	590	532	590
Pine, Duluth	99	99	99	99	99	164	119	164
Spruce-fir, Duluth	207	207	207	207	207	207	207	367
N. Hardwoods, Duluth	87	87	93	93	94	355	171	355
subtotal Duluth	903	903	904	904	905	1,316	1,029	1,476
Aspen, G. Rapids	389	404	414	454	454	434	433	519
Pine, G. Rapids	34	34	34	34	34	44	37	44
Spruce-fir, G. Rapids	85	85	105	105	105	105	101	150
N. Hardwoods, G. Rapids	55	56	57	57	58	69	61	69
subtotal Grand Rapids	563	579	610	650	651	652	632	782
Aspen, I. Falls	213	338	418	443	458	458	415	458
Pine, I. Falls	109	99	89	74	64	64	77	64
Spruce-fir, I. Falls	25	20	20	15	15	15	17	15
N. Hardwoods, I. Falls	46	46	47	47	48	49	48	49
subtotal Int. Falls	393	503	574	579	585	586	557	586
Total, Northern Region	3,191	3,427	3,737	3,832	3,877	4,284	3,869	4,635
Red Oak Sawlogs, South	50	50	50	50	50	50	50	65
Other Wood, South	250	250	250	250	250	250	250	300
Total Southern Region	300	300	300	300	300	300	300	365
Total, North + South	3,491	3,727	4,037	4,132	4,177	4,584	4,169	5,000

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 6.3. Summary of original timberland acres clearcut and/or thinned for the base and medium harvesting scenarios, 1990–2040.

Action Category*		Base Scenario			Medium Scenario		
		North	South	Total	North	South	Total
1	Total Timberland			14,773,400			14,773,400
2	Not Considered			1,356,500			1,356,500
3	Considered	12,409,900	1,007,000	13,416,900	12,409,900	1,007,000	13,416,900
4	Not cut	5,591,300	652,200	6,243,500	4,217,100	582,800	4,799,900
5	Clearcut once	5,775,300	320,700	6,096,000	6,931,200	376,900	7,308,100
6	Clearcut twice	846,000	0	846,000	970,200	0	970,200
7	Thinned but not clearcut	197,300	34,100	231,400	291,400	47,300	338,700
8	Thinned and clearcut	2,100	19,900	22,000	7,300	37,400	44,700
9	Total not cut, sum (2+4)			7,600,000			6,516,400
10	Total cut, sum (5-7)			7,173,400			8,617,000

Source: Jaakko Pöyry Consulting, Inc. (1992a).
**Not considered* are those plots representing young stands that would not reach rotation age by 2040, old growth, or areas assumed not available and therefore not considered for harvest in the period 1990-2040. *Considered* are those plots representing stands that are available and in terms of age, etc., feasible to consider for harvest during the 50-year study period. Action category 8, thinned and clearcut, is included in the clearcut once category.

Table 6.4 shows the acreage harvested and not harvested by covertype. Most of the harvesting activity is concentrated in the aspen and other hardwood covertypes. Comparison with the base scenario data, presented in table 5.3 in the previous section, shows a trend towards increases in the area harvested for most covertypes.

Notable increases in acres harvested by covertype for the medium versus the base scenario included black spruce (412,800); balsam fir (166,800); tamarack (69,600); oak-hickory (83,900); elm-ash-soft maple (146,100); maple basswood (193,400); and paper birch (132,100).

Breakdown of Harvest Volumes by Product Group
Table 6.5 summarizes the scheduled harvests for products within each group for the northern and southern regions of the state. As in the base scenario, production of aspen sawlogs decreases substantially over the 50-year study period. Nevertheless, aspen sawlog production projected by the model remains above estimated current consumption levels. Also, projected red and white pine sawlog production is about one-third lower in the medium scenario than in the base scenario (see table 5.4).

Table 6.4. Projected timberland acres harvested and not harvested by initial FIA covertype under the medium scenario (1990-2040).*

Forest Type	Clearcut Once	Clearcut Twice	Thinned	Total Acres Harvested	Total Acres	Acres Never Harvested	Harvest Acres as % of Total Acres	Harvest Acres as % of Total Harvest	Forest Type Acres as % of Acres
Medium Scenario									
Jack pine	171,200	11,600	1,100	183,900	446,600	262,700	41.2	2.1	3.0
Red pine	180,400	8,100	9,200	197,700	354,700	157,000	55.7	2.3	2.4
White pine	32,800	6,500	0	39,300	68,600	29,300	57.3	0.5	0.5
Black spruce	653,600	15,700	46,100	715,400	1,349,900	634,500	53.0	8.3	9.1
Balsam fir	458,200	54,100	28,700	541,000	809,200	268,200	66.9	6.3	5.5
Northern white cedar	30,900	5,600	900	37,400	648,400	611,000	5.8	0.4	4.4
Tamarack	112,600	0	6,300	118,900	719,400	600,500	16.5	1.4	4.9
White spruce	37,100	0	2,900	40,000	91,700	51,700	43.6	0.5	0.6
Oak-Hickory	539,600	0	34,400	574,000	1,124,700	550,700	51.0	6.7	7.6
Elm-Ash-Soft maple	385,400	3,300	22,500	411,200	1,124,600	713,400	36.6	4.8	7.6
Maple-Basswood	496,000	3,100	29,700	528,800	1,470,200	941,400	36.0	6.1	10.0
Aspen	3,464,500	749,000	124,600	4,338,100	5,242,200	904,100	82.7	50.3	35.5
Paper birch	461,100	6,700	12,000	479,800	819,000	339,200	58.6	5.6	5.5
Balsam poplar	284,700	106,500	20,300	411,500	504,200	92,700	81.6	4.8	3.4
Total	7,308,100	970,200	338,700	8,617,000	14,773,400	6,156,400	58.3	100.0	100.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).
*Totals may differ slightly from table 6.3 due to date of database.

Table 6.5. Scheduling model harvest summary under the medium scenario (thousands of cords per year).

Product Group	Component	Period 1990-99	2000-09	2010-19	2020-29	2030-39	2040-49
a) Northern Region							
Aspen	Aspen pulp	1,294	1,333.9	1,350	1,484.1	1,401.5	1,483.2
	Aspen saw	1,117	1,046.1	639	463.5	539.9	508.5
	Total	2,411.1	2,380.1	1,989	1,947.6	1,941.5	1,991.5
	Target	2,418	2,402.1	2,001.75	2,001.75	2,001.75	2,001.75
Spruce-fir	S-fir pulp	244.6	344.9	310.7	297.7	293.2	254.5
	S-fir saw	161.5	294.9	329.2	342.8	325.8	364.4
	Total	405.9	639.7	640	640.5	618.9	618.8
	Target	406	643	643	643	643	643
Pine	Pine pulp	62.6	93.9	85.8	76.8	111.7	125.5
	R&W saw	219.6	209	214	267.1	203.6	145.8
	Other saw	35.5	104.3	100	60.9	98.1	133.9
	Total	317.7	407.2	399.7	404.7	413.4	405.3
	Target	330	406	406	406	406	406
N. Hardwoods	Pulp	483.9	749.1	932.3	897.5	895.1	853.1
	R Oak saw	40.4	86.4	175.7	134.6	103.2	56.5
	Other saw	104.1	251.8	381	469.6	495.7	578.2
	Total	628.5	1,087.1	1,489	1,501.5	1,493.8	1,488
	Target	604	1,085.9	1,486.25	1,486.25	1,486.25	1,486.25
All Groups	Total	3,763.2	4,517.4	4,517.7	4,494.3	4,467.6	4,503.6
	Target	3,758	4,537	4,537	4,537	4,537	4,537
b) Southern Region							
Red oak	Sawlogs	50.1	66.7	62.5	65.7	64.6	64.2
	Target	50	65	65	65	65	65
Other wood	Various	248.5	302.0	398.4	304.4	294.3	300.0
	Target	250	300	300	300	300	300
All Groups	Total	298.6	368.7	360.9	370.1	358.9	364.3
	Target	300	365	365	365	365	365

Source: Jaakko Pöyry Consulting, Inc. (1992a).

6.1.3 Harvesting by Ownership

As discussed in section 2.3.1 the second model runs assumed that allocation of timberlands to be harvested was constrained by assumed levels of availability by ownership category. These constraints reflect current and prospective agency policies and land management practices as well as past trends in availability for ownerships with no articulated policies. Table 6.6 shows the total area harvested from timberlands on each ownership under the base and medium scenarios.

Table 6.6. Original acres harvested by ownership for the base and medium scenarios, 1990-2040.

Ownership	Scenario				Timberland	
	Base		Medium			
	Acres Harvested	Percent	Acres Harvested	Percent	Total Acres	Percent
Chippewa National Forest	160,200	2.23	170,200	1.98	567,200	3.84
Superior National Forest	349,500	4.87	352,100	4.09	1,253,900	8.49
Miscellaneous federal	53,700	0.75	62,900	0.73	197,700	1.34
Native American	171,200	2.39	193,800	2.25	490,600	3.32
State	1,296,900	18.08	1,741,400	20.21	3,077,900	20.83
County and municipal	1,612,800	22.48	1,924,700	22.34	2,505,600	16.96
Forestry industry	451,400	6.29	561,200	6.51	751,300	5.09
Other private	3,077,700	42.90	3,610,700	41.90	5,929,200	40.13
Total	7,173,400	100.00	8,617,000	100.00	14,773,400	100.00

Source: Jaakko Pöyry Consulting, Inc. (1992a).

The projected harvesting activities by ownership must be considered in the context of the GEIS, which is not a *planning* document. Thus the harvesting scenarios are not meant to predict that specific stands will or will not be harvested. The scenarios were developed as a tool to assess how much of the forest would have to be harvested statewide to meet the levels of demand specified in the FSD—in this case, 4.9 million cords per year. The emphasis is on *statewide*, as this is the level of analysis that the GEIS is directed toward.

With the exception of the two national forests, the percentage of timberland projected to be harvested from the various ownership groups remained broadly the same from the base to the medium scenario. The national forest harvests were constrained to the estimated ASQ levels in both scenarios and therefore little difference in the area harvested on that ownership was expected. Major increases occurred on the *other private* and *state* ownerships which showed increases of 533,000 and 444,500 acres respectively.

6.1.4 Spatial Distribution

Table 6.7 describes the pattern of harvesting by ecoregion. Figure 6.1 shows the plots harvested during the first ten-year period, and figure 6.2 shows the total number of plots harvested under the medium scenario. Comparison of the data for the two scenarios shows that the biggest increases are projected to occur in ecoregion 4, where nearly 800,000 additional acres are projected to be harvested under the medium scenario. Notable increases for the other ecoregions include increases of approximately 350,000 acres in ecoregion 1 and 130,000 in ecoregion 3.

Table 6.7. Original forest acreage and timberland acres cut and not cut by ecoregion under the base and medium scenarios, 1990-2040.

	Ecoregion							Total
	1	2	3	4	5	6	7	
Total forest land acres	3,372,000	2,023,700	903,000	8,172,900	934,700	637,200	666,300	16,714,800
Reserve/unproductive	509,600	973,900	36,300	359,800	24,400	17,300	20,100	1,941,400
Timberland acres (1-2)	2,862,400	1,049,800	871,700	7,813,100	910,300	619,900	646,200	14,773,400
Acres not cut, **base**	1,566,000	619,200	546,900	3,447,300	629,200	408,200	378,200	7,600,000
Acres cut, **base**	1,296,400	430,600	319,800	4,365,800	281,100	211,700	268,000	7,173,400
Acres not cut, **medium**	1,207,500	566,800	413,100	2,668,600	567,800	364,400	363,200	6,156,400
Acres cut, **medium**	1,654,900	483,000	453,600	5,144,500	342,500	255,500	283,000	8,617,000

Source: Jaakko Pöyry Consulting, Inc. (1992a).

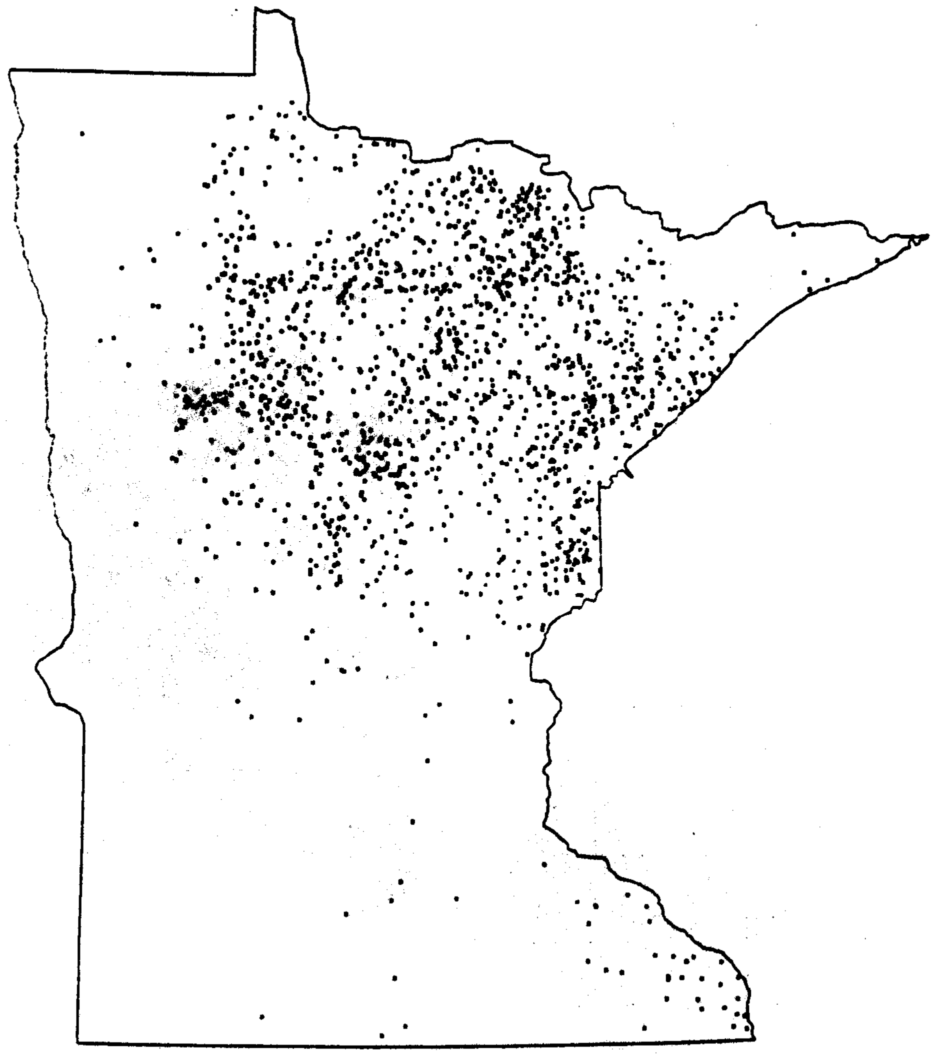

Figure 6.1. Location of medium scenario harvested plots for 1990-2000.

6.1.5 Temporal Distribution

The patterns describing the distribution of harvesting activities across the state under the medium scenario showed no distinguishable differences from those projected to occur under the base scenario. As discussed in section 5.1.5, the well-developed road transport network makes most timberland accessible for harvesting. The corollary to this is that the intensity of harvesting must then increase for the increased level of harvesting to be accommodated within a similar sized geographic region.

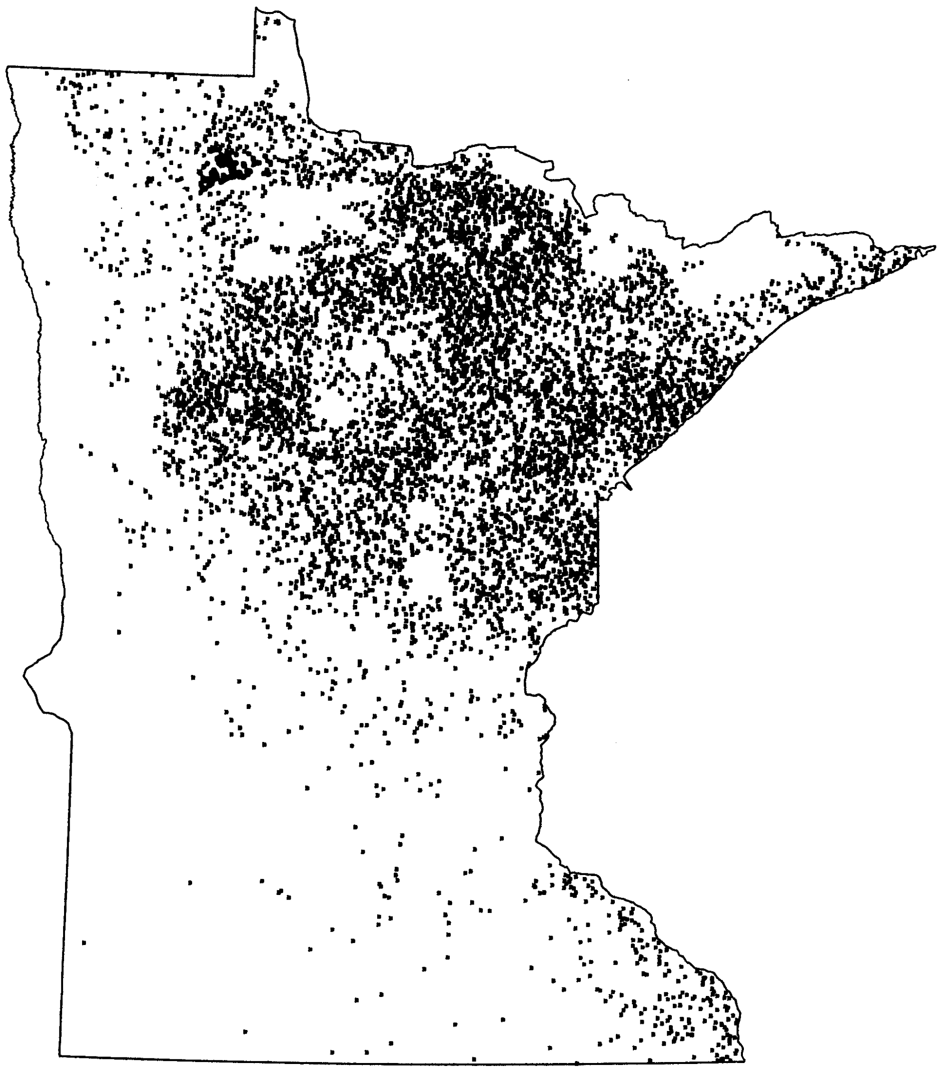

Figure 6.2. Location of all medium scenario harvested plots 1990-2040.

6.1.6
Relationship to Long-term Sustainable Timber Removal

Based on a long-term sustained yield analyses similar to the techniques used by the MNDNR (see section 5.1.6 for details of methodology), a timberland area of approximately 9.7 million acres (or 2.3 million acres more than under the base scenario) could sustain close to the 4.9 million cord annual harvest level. These results, together with the potential to shift additional acreage into plantations or more intensive management options, means that the 4.9 million cord level could be sustained in the long-term once a regulated condition is achieved. However, as described in section 5.1.6, this conclusion is subject to several important assumptions.

Beyond the 50-year study period, the assumed shift to other hardwoods to make up the deficit in aspen volume would need to be reversed. This follows from long-term sustained yield analysis results that suggest the assumed levels of demand for other hardwoods under this scenario are not sustainable in the long-term.

This scenario would leave over 4.1 million acres unharvested out of 13.4 million available and potentially harvestable acres over the long-term. These acres appear uneconomic to harvest. Thus, from a purely wood fiber production perspective, it is unlikely that sustainable annual harvest levels much higher than 4.9 million cords (see section 7.8) can be readily achieved without (1) investments to increase the productivity of the already economic timberlands; (2) to shift uneconomic acres to the economic category; and (3) such investment includes the site-specific and other mitigations needed to mitigate otherwise significant impacts. This shift of uneconomic acres to the economic category could be made by improvements in access and/or stocking of desired species, as these improvements and prices are the most important factors in determining whether lands are economic. Uneconomic areas could also become economic with higher prices. These results suggest that timberland in some covertypes could potentially be shifted towards nontimber management objectives, for example wildlife habitat, without severely impacting timber production at the 4.9 million cord level.

6.2
Characterization of Future Forest Resource Conditions and Impacts

Forests, as with any living entity, change over time irrespective of human intervention. In addition to these natural changes, human activities such as harvesting can also change the forests. The GEIS has been structured to identify the key characteristics that are likely to change; to project the extent of these changes under the three levels of harvesting; and to examine the implications of such changes for the identified issues of concern.

This section describes the projected changes to these key parameters that occur as a consequence of harvesting at the 4.9 million cord level, as well as those associated with the background levels of change that would occur over a 50-year period. The descriptors discussed include age class, acres under different covertypes, abundance and diversity of tree species within covertypes, and structural changes in the patterns of forest cover.

6.2.1
Forest Area and Covertype Abundance

Forest Area
These projected impacts were independent of harvest level, and therefore, the discussion in section 5.2.1 is also relevant to the medium scenario.

Covertype Acreages
Table 6.8 describes the projected covertype acreages for timberland, reserved, and unproductive forest land. Table 6.9 compares the base and medium scenarios. The key projected changes for timberlands as a consequence of the level of harvesting projected under the medium scenario are:

- The jack pine type declines in acreage due to both succession to other types and with increased harvesting (from 487,100 to 307,400 acres for timberland in the medium scenario). Compared with the base scenario, this covertype shows a further marginal decline under the medium scenario.
- The acreage in the black spruce covertype appears to have declined further under the medium level by 2040 with subsequent gains to the tamarack and aspen covertype acreages. (For timberland the decline was from 1,320,800 to 1,001,200 acres for the base scenario to 945,400 acres for the medium scenario.)
- The balsam fir acreage for timberland declined from 1990 to 2040 from 1,012,500 to less than 598,400 acres under both scenarios. The aspen covertype appears to be a major recipient of that acreage.
- The northern white cedar type acreage increased over the study period.
- The acreage of tamarack appears to increase slightly over the study period for the medium scenario.
- The white spruce covertype acreage increases but less than it increased under the base scenario.
- Oak-hickory covertype acreage increases from 1,288,000 to 1,322,300 acres. However, the increase was less than under the base scenario.
- Elm-ash-soft maple covertype acreage increases substantially over the study period, but to a lesser extent than under the base scenario.
- Maple-basswood covertype acreage increases, but to a lesser extent than under the base scenario.
- Aspen covertype acreage appears to increase 22.3 percent over its initial extent (4,496,000 acres) for the medium scenario over the 50-year study period. However, interpretation should recognize that several other covertypes, notably paper birch and balsam fir, have stands with high proportions of aspen that could, by a slight change in species composition or the algorithm for determining covertype, be called aspen. Likewise, much of the aspen acreage is mixed and with a slight change could be reclassified as paper birch, balsam fir, jack pine, etc.

Table 6.8. Forest type acreage (as determined by GEIS covertype algorithm) for timberland, reserved, and unproductive plots under the medium scenario, 1990 and projected 2040, statewide (thousand acres).

Forest Type	1990				2040			
	Timberland	Reserved	Unproductive	Total	Timberland Medium Scenario	Reserved	Unproductive	Total Medium Scenario
Jack pine	487.1	125.9	1.2	614.2	307.4	56.2	1.2	364.8
Red pine	350.6	78.6	0.9	430.1	454.4	87.7	.9	543.0
White pine	137.3	9.7	1.3	148.3	136.0	32.6	1.3	169.9
Black spruce	1,320.8	129.6	527.5	1,997.9	945.4	88.3	547.5	1,581.2
Balsam fir	1,012.5	117.0	21.9	1,151.4	598.4	72.9	18.5	689.8
Northern white cedar	322.4	8.2	37.3	367.9	370.4	8.5	40.7	419.6
Tamarack	696.2	7.9	118.1	822.2	704.4	6.9	118.2	829.5
White spruce	137.0	43.9	0	181.0	202.7	106.7	0	309.4
Oak-Hickory	1,288.0	13.6	14.0	1,315.6	1,322.4	18.6	18.8	1,359.8
Elm-Ash-Soft maple	1,564.2	64.9	33.4	1,662.5	1,714.8	95.4	35.2	1,845.5
Maple-Basswood	1,301.8	30.6	2.1	1,334.5	1,368.6	34.8	2.1	1,405.5
Aspen	4,496.0	358.1	33.9	4,888.0	5,496.5	393.5	36.8	5,926.8
Paper birch	1,179.3	109.7	6.1	1,295.1	806.2	123.6	6.5	936.4
Balsam poplar	480.1	15.4	10.6	506.1	451.8	14.5	9.5	475.8
Nonstocked	0	0	0	0				
Other	0	0	0	0				
Total	14,773.4	1,113.1	828.3	16,714.8	14,879.4	1,140.2	837.3	16,857.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 6.9. Forest type acreage for timberland and all forest plots under the base and medium scenarios, 1990 and projected 2040, statewide (thousand acres).

Forest Type	1990		2040			
	Timberland	Total	Timberland Base Scenario	Timberland Medium Scenario	Total Base Scenario	Total Medium Scenario
Jack pine	487.1	614.2	329.6	307.4	387.0	365.8
Red pine	350.6	430.1	452.4	454.4	541.0	543.0
White pine	137.3	148.3	141.0	136.0	174.9	169.9
Black spruce	1,320.8	1,997.9	1,001.2	945.4	1,637.0	1,581.2
Balsam fir	1,012.5	1,151.4	657.4	598.4	748.8	689.8
Northern white cedar	322.4	367.9	360.9	370.4	410.1	419.6
Tamarack	696.2	822.2	678.7	704.4	803.8	829.5
White spruce	137.0	181.0	227.9	202.7	334.6	309.4
Oak-Hickory	1,288.0	1,315.6	1,370.2	1,322.3	1,407.6	1,359.8
Elm-Ash-Soft maple	1,564.2	1,662.5	1,744.0	1,714.8	1,874.6	1,845.5
Maple-Basswood	1,301.8	1,334.5	1,460.2	1,368.6	1,497.1	1,405.5
Aspen	4,496.0	4,888.0	5,238.7	5,496.5	5,669.0	5,926.8
Paper birch	1,179.3	1,295.1	803.4	806.2	933.5	936.4
Balsam poplar	480.1	506.1	413.7	451.8	437.7	475.8
Nonstocked	0	0				
Other	0	0				
Total	14,773.4	16,714.8	14,879.4	14,879.4	16,857.0	16,857.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

- The paper birch covertype appears to decline by several hundred thousand acres. However, as with aspen, many acres are composed of mixed species. Consequently, while the acreage classified as *paper birch covertype* has changed, the overall species composition change of the original areas was probably less than the covertype area change would suggest. Also, aging of this type is also a factor contributing to succession to other species.
- The balsam poplar covertype acreage declined but to a lesser extent than under the base scenario.
- With the harvesting level increase from the base to the medium scenario, covertype acreage for timberland declines for eight covertypes (jack pine, white pine, black spruce, balsam fir, white spruce, oak-hickory, elm-ash-soft maple, and maple basswood).
- Projections for reserved and unproductive forests were unchanged from those noted for the base scenario.

Overall, results suggest that future covertype area *is* sensitive to the level of harvesting and that the response is either species or covertype specific.

6.2.2
Covertype Size and Age Class Structure

A summary of age classes from 1977-2040 for the base and medium harvest scenarios are shown in table 6.10. Forest development indicates the average age of most covertypes continues to increase over 1990 despite the harvesting that took place during that period. However, when comparing the base and medium scenarios, the size of these increases is less under the medium scenario. The smaller increases in average age are particularly noticeable for those types that are subjected to increased demand under the medium scenario. For example, black spruce, tamarack, elm-ash-soft maple, and maple-basswood.

Table 6.10. Average stand age by covertype for the base and medium harvest scenarios 1977-2040.

Forest Type	Average Age of FIA Plots*			
			2040	
	1977	1990	Base	Medium
Jack pine	42	48	77	69
Red pine	43	44	54	54
White pine	73	80	104	102
Black spruce	46	59	89	61
Balsam fir	42	46	82	71
Northern white cedar	82	97	116	106
Tamarack	52	57	99	85
White spruce	33	42	90	82
Oak-Hickory	63	69	78	71
Elm-Ash-Soft maple	56	56	86	75
Maple-Basswood	61	58	90	80
Aspen	38	41	34	33
Paper birch	49	58	92	81
Balsam poplar	39	41	33	31

Source: Jaakko Pöyry Consulting, Inc. (1992a). Projected ages for stands not clearcut were determined by adding 50 years. See appendix 2, table 2.2 for more detail.
*Weighted by acreage.

Aspen and balsam poplar are clear exceptions to the trend of increasing average age under both scenarios. When compared with the base scenario, the medium scenario shows a marginal decrease in average age for these types. The areas of timberland designated as *not available*, which includes old growth and other areas assumed to be unavailable, and ERF and other silvicultural constraints have all contributed to this trend of an increase in average age.

A simple interpretation of these results is that under the existing (base) and medium levels of harvesting, Minnesota's forests will continue to age; and there will be distinctly more acreage of the older age classes for most covertypes than at present. The aspen covertype goes against this trend in that projected harvest levels will reduce average age, even though many older stands will remain. The implications for wildlife populations using aspen will need careful evaluation because such a high proportion of the forests are in this covertype.

Changes in age class structure will have important implications for many other values of the forest. Certain characteristics only begin to be expressed after forests reach certain stages. These stages have been recognized for most covertypes, and specific management objectives have been developed. Section 5.2.2 discussed these stages and the consequences of the base level of harvesting. As described above, the trends towards an increase in average age of covertypes continued under the medium scenario, but at a slower rate than was projected to occur under the base scenario. Consequently, as shown by table 6.11, similar trends in terms of recruitment of stands into older age classes of forest and old growth forest are likely under the medium scenario. However, the final area of old forest in most covertypes will be less. This is because the proportion of timberlands *not harvested* under the medium scenario is less than under the base scenario (see table 6.3).

Table 6.11. Area of old forest for 1990 and projected to 2040 for the base and medium harvest scenarios, all forest lands (acres).*

Forest type (threshold age)	Current 1990	Base Scenario 2040	Medium Scenario 2040
Red pine (120)	21,200	107,496	110,344
White pine (120)	12,300	91,674	87,743
Black spruce (120)	157,800	614,219	471,636
White cedar (120)	60,000	225,600	211,569
Tamarack (120)	73,000	299,604	268,390
White spruce (90)	27,400	211,815	185,720
Oak-Hickory (120)	51,400	342,702	293,044
Elm-Ash-Soft maple (120)	69,400	483,185	416,120
Maple-Basswood (120)	37,000	404,502	344,407
Jack pine (70)	115,100	244,518	207,612
Balsam fir (70)	304,000	452,468	335,385
Aspen (70)	467,500	982,911	961,039
Balsam poplar (70)	24,900	76,629	74,129
Paper birch (70)	324,400	643,809	559,835

Source: Jaakko Pöyry Consulting, Inc. (1992a,e).
* Acreages are those determined from GEIS covertype algorithm.

The covertypes showing the biggest changes are black spruce and elm-ash-soft maple which is consistent with the average age information presented in table 6.10. Clearly, the projected increased levels of harvesting in these covertypes are being manifested in changes in the areas harvested which in turn is affecting the acreage of forest that is moving into the older age classes.

However, despite the reduction in the area projected to move into the older age classes, the overall trend under the medium scenario is for significant increases in the areas of old forest for all covertypes when compared with the present levels.

6.2.3
Tree Species Abundance and Diversity

Tree species composition changes can occur in the form of species composition within a covertype, often related to stand age or stage of development, and in terms of covertype acreage. Table 6.12 presents a summary of species composition in 1990 and that projected to occur in 2040 for the base and medium scenarios across all covertypes.

The ownership constraints and mitigations used in the second model runs appear to have been very effective in moderating changes in species statewide. This is evident for upland, lowland, and riparian species. Changes, as a percent of 1990 values, are small for most species. The species showing notable declines between 1990 and 2040 under the medium scenario are: ailanthus, black locust, black spruce, black maple, jack pine, Kentucky coffee tree, and other hardwoods.

Because most species are found in many covertypes, results across covertypes are emphasized here. The pattern was also found to be similar for trees with a girth, or dbh, of $\geq$ 4.5 inches.

Reduction of Conifer Component in Aspen Stands
Section 5.2.2 discussed the difficulty of determining whether or not a reduction in the conifer component of aspen stands would occur. There is more concern at the medium as compared to the base level of harvest.

Table 6.12. Summary of projected tree species numbers on timberlands for 1990 and 2040 for the base and medium harvest scenarios (thousands of trees $\geq$1.0 inch dbh).

Species	1990	2040	
		Base	Medium
Ailanthus	39	15	14
American hornbeam	14,419	12,049	12,500
American basswood	192,090	191,702	184,698
American elm	150,006	147,215	146,216
Apple	386	430	509
Balsam fir	979,317	863,263	849,201
Balsam poplar	266,466	283,080	314,295
Bigtooth aspen	73,184	82,074	88,197
Bitternut hickory	8,044	8,573	8,590
Black ash	527,482	662,467	640,214
Black cherry	35,429	46,605	48,805
Black locust	455	133	129
Black maple	154	125	101
Black oak	710	792	735
Black spruce	1,039,098	911,752	769,542
Black walnut	2,289	2,222	2,277
Black willow	5,702	4,721	5,453
Boxelder	66,672	82,430	81,689
Bur oak	190,446	183,028	186,455
Butternut	2,941	4,442	4,235
Chokecherry	33,848	36,689	39,035
Eastern cottonwood	2,735	2,272	2,340
Eastern redcedar	14,051	17,977	19,194
Green ash	86,474	79,551	80,027
Hackberry	14,714	14,842	14,054
Hawthorn	8,810	8,922	9,476
Ironwood	117,990	130,328	134,496
Jack pine	164,593	93,530	98,865
Ky. coffee tree	445	142	143
Mountain ash	1,497	3,273	3,122
Mountain maple	105,825	115,557	107,763
N. white-cedar	386,818	615,904	530,282
Northern pin oak	5,975	5,541	5,865
Northern red oak	111,893	97,402	97,153
Other hardwood	41,155	32,342	27,419
Paper birch	570,934	440,801	459,276
Peachleaf willow	489	642	678

Table 6.12. (continued)

Species	1990	2040	
		Base	Medium
Pincherry	13,140	16,541	17,905
Ponderosa pine	398	387	434
Quaking aspen	1,986,789	2,730,630	2,930,033
Red maple	290,717	223,765	237,572
Red mulberry	988	985	1,172
Red pine	97,800	107,691	112,701
River birch	185	1,682	1,660
Rock elm	1,572	1,881	1,609
Scotch pine	1,630	1,123	1,346
Shagbark hickory	9,145	11,075	11,376
Siberian elm	399	391	562
Silver maple	9,552	8,890	8,239
Slippery elm	23,016	27,284	27,220
Striped maple	463	397	370
Sugar maple	283,728	266,355	243,789
Swamp white oak	454	1310	1,118
Tamarack	361,461	299,180	306,991
White ash	2,494	2,835	2,936
White oak	10,058	11,377	10,607
White pine	29,566	29,709	29,298
White spruce	78,620	76,604	77,665
Wild plum	5,331	5,361	5,824
Yellow birch	11,746	20,882	19,500
Grand Total	8,442,827	9,029,168	9,022,970

Source: Jaakko Pöyry Consulting, Inc. (1992a).

6.2.4 Forest Fragmentation

The assessment of forest fragmentation is qualitative, not quantitative. Therefore, no specific acreage totals could be discussed.

As discussed in section 5.2.4, fragmentation of forests changes the structural diversity of forested landscapes and can affect biodiversity. When compared with the base scenario, the distribution of timber harvesting and forest management activities at the statewide level is not expected to change under the medium scenario. However, the patterns at localized levels will change because the rate of harvesting will increase and more area will be harvested.

Therefore, at any time there will likely be more sites affected by harvesting in any given location.

6.3
Physical Resource Impacts

Harvesting activities will change aspects of the physical or nonliving environment including forest soils and water resources (water quantity and quality). The consequences of timber harvesting and forest management activities for these resources were discussed at length in section 5.3 in reference to the base level scenario. The *type* of impact will likely not change with the changes in the level of harvesting. However, the *area affected* will change with increasing levels of harvesting. Impacts on these resources tend to be related linearly to the area harvested. This is particularly true for soil impacts. Therefore, the information presented in section 5.3 is not repeated. The significant impacts under the medium scenario are assessed in section 6.6.

6.4
Biological Resource Impacts

6.4.1
Plant and Animal Species Abundance and Diversity

Animals

This section compares changes to animal populations projected under the base level scenario with those under the medium level scenario. As discussed in section 5.4.1, timber harvesting and forest management activities can alter the habitat value of stands for these various species and species groups. A wide range of habitat factors can change as a consequence of harvesting. Changes in these factors can either reduce or enhance habitat values with the potential to then impact populations of animals accordingly.

There are two key factors affecting the wildlife habitat value of forests that are likely to change as a consequence of forest harvesting and for which statewide data were available. These factors are stand tree species mix and the age or size classes of these trees. Based on these factors, the direction and magnitude of population change in each animal species of interest can be estimated by examining projected acreage of forest types and size classes.

Section 6.2 provided a characterization of the future forest condition under the medium scenario, and contrasted this with the base scenario. The major differences are fewer acres reaching older age classes, more acres affected by harvesting, and reductions in the balsam fir and black spruce covertypes. In addition, the reduction in the average ages of the aspen and balsam poplar covertypes would also have an impact on stand composition and therefore the habitat values for some species. These changes will increase habitat values for some species and will diminish values for others. As discussed in section 5.4.1, nearly all species projected to increase under the medium scenario are early-succession species that have considerable habitat outside of forests (open areas, brushland, etc.).

The major emphasis in assessing wildlife impacts was at the ecoregion level and results of impact analyses are developed in section 6.6.4. However, for illustration, table 6.13 describes the general direction of projected population levels by harvest scenario. Statewide over the 50-year study period, 97 and 94 percent of the total number of species are projected to remain stable or increase under the base and medium scenarios, respectively. The number of species projected to decrease in population level was 5 in the base scenario and 11 under the medium scenario.

Table 6.13. Number of species of interest that are projected to decrease by 25 percent or more, remain stable, or increase by 25 percent or more, statewide on all forest lands by harvest scenario.*

Species Group (number of species)	Decreasing		Stable		Increasing	
	Base	Medium	Base	Medium	Base	Medium
Small Mammals (22)	0	2	21	19	1	1
Large Mammals (5)	0	0	5	4	0	1
Birds (138)	5	8	111	106	22	24
Herps (8)	0	1	6	5	2	2
All (173)	5	11	143	134	25	28

Source: Jaakko Pöyry Consulting, Inc. (1992f).
* *Stable* is a change of less than 25 percent.

Endangered, Threatened, or Special Concern Species

Animals. The assessment of changes to wildlife populations as a consequence of timber harvesting and forest management activities is centered on changes to habitat. Populations of the same two species were projected to decline under the medium scenario as declined under the base scenario. The first species, Red-shouldered Hawk, is projected to decline in ecoregions 4, 5, and 6 and statewide. The second species, Louisiana Waterthrush, is projected to decline in ecoregion 7, but remain stable statewide.

Plants. The threat of disturbance and/or damage to a population of rare plants will increase as the area of the state subjected to harvesting increases. This is because the forest dependent rare plant species of Minnesota are typically poorly adapted to trampling types of injury. Most (except for the one tree species listed) are of small stature and easily broken. Any harvest that would allow heavy equipment to drive through a population of any rare plant species would cause impacts. Therefore, the medium level of harvest would likely cause additional impacts that are proportional to the additional area affected by harvesting (see table 5.16).

The lack of data concerning these species and the level of resolution of the GEIS analysis precluded quantification of these impacts.

6.4.2 Aquatic Ecosystems

As the level of harvesting increases, it is reasonable to conclude that harvesting activities that remove or alter forest cover and other types of forest management activities will increase within any given watershed. The differences are likely to be marginal for most watersheds. These activities can have wide-ranging effects on waterbodies and the plants and animals that live within them. These changes are therefore likely to be proportional to the area affected. The general discussion of impacts on aquatic ecosystems under the base scenario (section 5.4.2) characterizes the *types* of impacts likely under the medium scenario. The *extent* of aquatic ecosystems that experience these impacts will increase under the medium scenario when compared with the base scenario.

6.4.3 Riparian Corridors

The relationship between the level of harvest and the type and extent of likely impacts under the base and medium scenarios that was described under aquatic ecosystems would similarly apply to riparian corridors which are the strips of land and associated plant communities that are located adjacent to waterbodies. When compared with the base scenario, the medium scenario would likely affect additional areas with the same types of impacts.

6.4.4 Forest Insect and Disease Concerns

As discussed in section 5.4.4, the risk to a forest stand of a pest attack or infestation (susceptibility) and the likelihood of damage if an attack occurs (vulnerability) are frequently related to stand age and the incidence of multiple entries into a stand may also increase risk.

The possible effects of an increase in timber harvesting and associated forest management practices on forest health in Minnesota include changes in the proportion of susceptible/vulnerable age classes, and the incidence of multiple entry harvesting operations.

The timber harvesting activities projected under the medium level scenario will tend to slow the trend towards a general aging of the forest as was described for the base level.

The medium level of harvesting increases the acreage of younger stands for most covertypes as compared to the base scenario. This comes at the expense of acreage in older stands and thus tends to reduce the incidence of many insect pests and diseases that are favored by older forests. Insect species in this category include spruce and jack pine budworm and two-lined chestnut borers. In addition, diseases such as white trunk rot of aspen are also likely to be reduced. Other diseases including cankers and decay of upland hardwoods and oak wilt will probably decrease in the short-term but may ultimately increase.

In contrast, the incidence of insect pests, such as the white pine weevil, are likely to increase as a consequence of the medium level harvests. This is due to an increase in acreage of susceptible younger stands. The incidence of some diseases are also likely to increase, including *Diplodia* shoot blight and canker, and *Scleroderris* canker of red pine.

6.5 Socioeconomic Resource Impacts

6.5.1 Outdoor Recreation Opportunities

Timber harvesting will likely have an impact on the quality of the recreational experience and on the number of hours of recreational activity at a given site. These impacts are related to the recreational user's visual perception and the attractiveness of the forest setting. Some of the impacts are long-term while others are short-term and/or subject to change from forest growth and dynamics on that site or over a broader context or area. Section 5.5.1 discussed the nature and likely extent of impacts.

Table 6.14 describes the harvesting extent by recreational opportunity classes. Harvesting at the medium scenario would affect approximately 59.2 percent of timberland plots which compares with 50.4 percent of timberland plots projected to be harvested under the base scenario. Of these, 7.6 percent are currently classified as nonmotorized areas. When all forest is considered 6 and 32 percent of plots in the primitive nonmotorized and semiprimitive nonmotorized classes, respectively, are projected to be subjected to harvesting. Harvesting beyond the year 2040 would tend to concentrate on the accessible and productive plots harvested in the first 50 years, i.e., additional harvesting is not likely to extend far beyond the areas harvested in the first 50-year period.

6.5.2
Aesthetics and Visual Quality

Given the harvesting and management constraints and mitigations assumed to be practiced on state and federal lands, there appears to be a tendency to harvest areas of high visual sensitivity at a lower rate than areas of moderate to low sensitivity. The converse was found on private lands (see table 6.15).

Timberlands not in federal or state ownership do not have VMGs in place and therefore, there is a stronger likelihood of adverse impacts on these lands. Under the base scenario 38 percent of nonfederal and nonstate owned timberland plots were projected to be impacted. By comparison, under the medium scenario 44 percent are projected to be impacted (see table 6.14).

In terms of dynamics over time, the forests of Minnesota are aging and under the base and medium scenarios would continue to do so. Ownership constraints and mitigations that preclude certain areas from clearcutting also increase the area of older forest. Under the medium scenario, the future forest would have an average age older than that of today for most covertypes. The oldest ages, given 50 years of growth, would also be greater than found today for many areas. It follows that average tree size, which is an important component of attractiveness, would typically not be heavily impacted under the medium scenario for most covertypes. However, average ages by covertype would be less than under the base scenario. The covertypes that would be the most adversely impacted compared to the base scenario are those subject to substantial harvesting including aspen, balsam poplar, and black spruce.

6.5.3
Unique Cultural and Historical Resources

Heritage resources can be divided into five main categories which include: cultural landscapes, standing structures, archaeological sites, cemeteries, and traditional use sites. These were discussed under section 5.5.3. The impacts on archaeological sites are closely linked to the likelihood of impacts on soil physical structure. As discussed above, the types of impacts are likely to stay the same irrespective of the level of harvesting; however, the area affected will increase and thus the number of sites will also increase.

The predicted maximum number of sites affected under the medium scenario would be 121,000 sites, up from the 105,000 predicted to be affected under the base scenario. It must be stressed that these estimates are the maximum values and the actual number of sites disturbed or destroyed would be substantially less.

Table 6.14. Distribution of FIA forest and timberland plots and plots projected to be harvested, by ownership and ROS class for the base and medium scenarios, 1990–2040.

ROS Class	Total number of plots, all forest	Total number of timberland plots	Percent of timberland plots by ROS class	Number and (percent) of timberland plots harvested by ROS class			
				Base Scenario		Medium Scenario	
				State/federal lands	Other lands	State/federal lands	Other lands
Primitive	425	53	.4	8 (15.1)	15 (28.3)	10 (18.7)	15 (28.3)
Semiprimitive nonmotorized	1,306	876	7.2	150 (17.1)	173 (19.7)	211 (24.1)	201 (22.9)
Semiprimitive motorized	3,409	3,074	25.4	529 (17.2)	925 (30.1)	691 (22.5)	1,119 (36.4)
Roaded natural	5,232	5,049	41.7	662 (13.1)	2,121 (42.0)	777 (15.4)	2,428 (48.1)
Rural	3,107	3,030	25.0	140 (4.6)	1,366 (45.1)	158 (5.2)	1,548 (51.1)
Urban	57	36	.3	1 (2.8)	18 (50.0)	1 (2.8)	19 (52.8)
All classes	13,536	12,118	100.0	1,490 (12.3)	4,618 (38.1)	1,848 (15.2)	5,330 (44.0)

Table 6.15. Percent of FIA timberland plots projected to be harvested (1990–2040) by visual sensitivity rank and by ownership (excluding primitive, semiprimitive nonmotorized, and urban ROS classes).

Visual Sensitivity Rank	Percent of timberland plots harvested by visual sensitivity rank			
	Base Scenario		Medium Scenario	
	State/federal lands	Other lands	State/federal lands	Other lands
High	10.4	49.6	11.3	56.0
Moderate	11.4	44.5	12.3	50.4
Low	12.7	37.3	15.2	43.7
Very low	13.0	32.5	17.5	38.5
All ranks (high to very low)	12.1	39.6	14.6	45.7

Traditional Use Sites are locations which have been historically used by one or more groups of people for some type of activity. They may lack the physical evidence of artifacts or structures, and are often characterized by plants, animals, and/or topography which are of cultural and religious significance to Native Americans. The impacts on these sites could not be quantified.

6.5.4 Economic Impacts

Economic impacts were measured in terms of changes in employment, personal income, and the level of output for various sectors of the state economy and for the regions directly affected by the modelled increases in timber harvests.

Input-output Analysis

The traditional tool for assessing impacts on local, regional, and national economies is *input-output analysis*. Input-output studies provide the fundamental framework for most national accounting systems, and are widely used to estimate employment and other impacts of changes in economic activities within economic regions. An input-output analysis describes how various sectors of the economy (such as manufacturing, transportation, or retail sales) interact in terms of purchases from and sales to each other. An input-output database gives a *snapshot* at one point in time of the value of goods and services purchased and sold among the various economic sectors. The methods of input-output analysis make it possible to estimate the impacts of changes in any one sector of the economy (such as the construction and operation of new pulp and paper manufacturing facilities) on the other sectors of the economy.

The specific input-output model and database used for this analysis is IMPLAN (Palmer, Siverts, and Sullivan 1985). The IMPLAN system is capable of constructing and providing analyses of input-output accounts for the economic sectors of any region of the United States comprising a set of counties. This feature is especially useful for the present study as it allows the analysis to focus on the regions of Minnesota that will be affected most by changes in forest harvesting activities.

The IPASS model (Olson, Maki, and Schallau 1985) was also used to analyze the economic impacts of timber harvesting for this study. IPASS uses the same input-output database as IMPLAN, but adds a time dimension to the standard input-output analysis provided by IMPLAN. The IPASS model simulates the yearly development of a regional economy and provides forecasts of several basic socioeconomic indicators such as population, employment, earnings, and investment.

IMPLAN used 441 economic sectors (out of a possible 528 available within the model) to characterize Minnesota's economy. These economic sectors are based upon the U.S. Bureau of Census Standard Industry Classification system, which classifies business firms into defined classes of industry based on their principal business activity. In some cases this may result in an apparent underreporting of some types of business activity, and overreporting of others. For example, although there is a large amount of pulp produced in Minnesota, there is no formally defined pulp industry, because all of the pulp is produced as an integral part of other industries, such as the paper industry. This means that the economic activity represented by the pulp industry does not show up as such, but is included in the economic activity represented by other industries, such as the paper industry.

Three levels of impacts are recognized in input-output analysis: *direct, indirect,* and *induced.*

Direct Impacts. Direct impacts are the increased output, income, and employment attributable to some changes in economic activities. For example, the direct impacts of an expansion of pulp and paper facilities are the value of the additional paper output, the new jobs created in the new facilities, the income generated as a result of those additional jobs, and the income from the capital invested in the new facilities.

Indirect Impacts. An increase in the output of pulp and paper products requires increases in the purchase of raw materials and other goods and services required in pulp and paper manufacturing (e.g., roundwood, chemicals, electricity, and office supplies and equipment). These increases in purchases by the expanded facilities create new jobs and generate additional output and income in those industries that supply these inputs. Industries supplying inputs required by the pulp and paper sector will, in turn, have to increase their purchases. For example, logging contractors would have to increase their purchases of standing timber from forest landowners, chemical wholesalers would have to increase their purchases from chemical manufacturers, and electric power producers would have to increase their production of electricity and obtain more coal and/or other sources of energy. All of the industries that supply inputs to the logging industry, the chemical industry, and the electric power producers—and the industries that supply inputs to them—would also have to increase their production. These effects are termed indirect impacts.

Induced Impacts. The direct and indirect impacts on the economy create new jobs and provide an increase in income to consumers. Consumers will use most of this income to buy additional goods and services from retail stores, automobile dealerships, etc. This additional purchasing activity will set off new rounds of purchases among producers as they increase their output to meet these new demands. These increases in consumer purchases that result from the increased employment generated by the original changes (in our example, the increase in pulp and paper manufacturing capacity)—and the direct and indirect impacts of the new purchases—are termed induced impacts.

Together, the sum of direct, indirect, and induced impacts are the total impacts of a change in economic activities. The impacts for the medium scenario are summarized in table 6.16.

Statewide economic model (IMPLAN) output indicated that at the medium level of timber harvest, forest industry expansion would produce approximately 6,800 jobs in the state, an increase of 0.3 percent over the baseline level of employment. Of this, about 4,800 jobs (71 percent) would be added within the north region. The medium level of timber harvest would produce an estimated $146 million (in 1985 dollars) in additional employee compensation in the state, an increase of 0.3 percent. Of this, $101 million (69 percent) would be in the north region. Finally, the medium level of timber harvesting would produce an estimated $1,100 million (in 1985 dollars) of increased total industrial output (TIO) in the state, an increase of 0.8 percent. Of this, $900 million (87 percent) would occur in the north region. More details are presented in Economics and Mangement Issues (Jaakko Pöyry Consulting, Inc. 1992h) technical paper.

6.5.5
Land Management Organization Service Delivery

In order to meet the increased timber consumption projected for the medium scenario, forest landowners will need to increase their level of timber harvesting. Harvest levels are projected to increase by 22 percent to meet the medium timber harvest scenario. Such increases could have substantial impacts on public forest land management agencies. This level of harvest would require more planning and supervision, capital expenditures on roads, and investments in replanting. Additional revenue from timber sales receipts would also be generated. These changes would be reflected in an increased workload for personnel and a need for additional budget allocations.

Projections of the timber volumes harvested from various land ownerships over time were made with the assumption that timber harvests would be constrained and/or mitigated by environmental, aesthetic, socioeconomic, and other concerns. The *constrained or mitigated projections* reflect major existing land use policies and practices.

Table 6.16a. Minnesota—employment. Increase in number of jobs above baseline employment.

IMPLAN sector	Baseline Employment	Medium Scenario Direct Effect	Indirect Effect	Total* Effect	Percent of Base
Sectors Contributing Most to Employment					
461 Other Wholesale Trade	114,921		750	871	1
463 Other Retail Trade	213.626		67	574	0
160 Logging Camps and Log	2,016		488	489	24
188 Paper Mills, Except Building	8,252	352	0	352	4
491 Eating and Drinking Pla	109,412		95	323	0
448 Motor Freight Transport	34,880		197	218	1
456 Electric Services	12,116		173	192	2
470 Real Estate	54,807		45	155	0
504 Hospitals	47,838		0	152	0
446 Railroads and Related	8,732		135	138	2
490 Accounting, Auditing an	17,615		105	133	1
24 Forestry Products	1,386		131	132	10
74 Maintenance and Repair	14,951		108	118	1
480 Personnel Supply Services	19,810		69	104	1
464 Banking	23,073		53	96	0
467 Insurance Carriers	29,417		24	96	0
465 Credit Agencies	23,161		43	91	0
503 Doctors and Dentists	25,632		0	82	0
482 Management and Consu	14,406		68	82	1
508 Colleges, Universities	19,806		31	80	0
Total	795,857	352	2,582	4,477	1
Selected Forest Products and Forestry Sectors					
27 Landscape and Horticul	8,827		44	49	1
199 Paperboard Containers	8,002		21	23	0
26 Agricultural, Forestry	3,293		12	15	0
22 Forest Products	75		6	6	7
161 Sawmills and Planing Mills	941		10	10	1
170 Wood Pallets and Skids	193		4	4	2
164 Millwork	6,579		2	2	0
172 Wood Products, N.E.C.	1,459		2	2	0
23 Greenhouse and Nursery	844		0	3	0
173 Wood Containers	213		1	1	1
Total	30,426	0	102	115	0
Total, All Sectors in Minnesota	2,085,517	352	3,788	6,752	0

Note: Sectors 160, 446, 464, 27, 161, 172, and 23 adjusted to reflect IMPLAN revisions in the North region. Units are number of jobs above baseline employment.
* Total refers to direct, indirect and induced effects.

Table 6.16b. Minnesota—employee compensation. Increase in employee compensation above baseline compensation ($ millions).

IMPLAN sector	Baseline Compensation	Medium Scenario			
		Direct Effect	Indirect Effect	Total* Effect	Percent of Base
Sectors Contributing Most to Employee Compensation					
461 Other Wholesale Trade	3,413.14		22.28	25.87	1
188 Paper Mills, Except Building	380.22	16.19	0.01	16.20	4
463 Other Retail Trade	3,356.52		1.06	9.02	0
456 Electric Services	455.54		6.49	7.23	2
446 Railroads and Related	384.95		5.86	6.04	2
160 Logging Camps and Log	23.13		5.60	5.61	24
448 Motor Freight Transport	775.02		4.38	4.83	1
504 Hospitals	993.51		0.00	3.16	0
503 Doctors and Dentists	873.74		0.01	2.79	0
467 Insurance Carriers	845.22		0.70	2.76	0
491 Eating and Drinking Places	919.33		0.80	2.71	0
74 Maintenance and Repair	314.84		2.27	2.49	1
464 Banking	547.90		1.23	2.29	0
465 Credit Agencies	562.50		1.05	2.20	0
516 U.S. Postal Service	471.69		1.36	2.15	0
454 Communications, Except	508.30		0.90	1.97	0
488 Legal Services	452.03		0.94	1.82	0
482 Management and Consu	318.38		1.50	1.81	1
77 Ammunition, Except For	246.09		1.73	1.74	1
521 Other State and Local	180.14		1.35	1.75	1
Total	16,022.19	16.19	59.52	104.44	1
Selected Forest Products and Forestry Sectors					
199 Paperboard Container	317.08		0.82	0.92	0
27 Landscape and Horticulture	116.23		0.56	0.62	1
24 Forestry Products	1.89		0.18	0.18	10
26 Agricultural, Forestry	29.32		0.11	0.13	0
161 Sawmills and Planing Mills	9.64		0.16	0.16	2
164 Millwork	205.29		0.06	0.07	0
170 Wood Pallets and Skids	2.34		0.05	0.06	3
193 Paper Coating and Glaz	159.20		0.04	0.05	0
172 Wood Products, N.E.C.	31.03		0.04	0.05	0
173 Wood Containers	4.42		0.03	0.03	1
Total	876.44	0	2.05	2.26	0
Total, All Sectors in Minnesota	43,230.86	16.19	84.42	146.38	0

Note: Sectors 188, 160, 521, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the North region. Unites are employee compensation above baseline compensation ($ millions).
* Total refers to direct, indirect and induced effects.

Table 6.16c. Minnesota—total industrial output (TIO). Increase in TIO above baseline TIO ($ millions).

IMPLAN sector	Baseline TIO	Medium Scenario Direct Effect	Indirect Effect	Total* Effect	Percent of Base
Sectors Contributing Most to TIO					
188 Paper Mills, Except Building	1,568.1	611.2	0.3	611.4	39
461 Other Wholesale Trade	7,288.6		47.6	55.3	1
456 Electric Services	2,814.1		40.1	44.7	2
160 Logging Camps and Logging	126.9		30.7	30.8	24
470 Real Estate	7,710.1		6.3	21.9	0
463 Other Retail Trade	7,933.6		2.5	21.3	0
457 Gas Production and Distribution	885.0		13.5	15.2	2
448 Motor Freight Transport	2,147.4		12.1	13.4	1
235 Petroleum Refining	1,038.0		11.4	13.1	1
446 Railroads and Related Se	758.6		11.6	11.9	2
469 Owner-Occupied Dwelling	4,111.2		0.0	11.2	0
491 Eating and Drinking Place	3,676.8		3.2	10.8	0
74 Maintenance and Report O	1,058.5		7.6	8.4	1
467 Insurance Carriers	2,397.2		2.0	7.8	0
504 Hospitals	2,003.4		0.0	6.4	0
24 Forestry Products	65.7		8.7	8.8	13
464 Banking	1,476.6		3.4	6.2	0
454 Communications, Except R	1,523.5		2.7	5.9	0
521 Other State and Local Go	550.1		4.4	5.6	1
503 Doctors and Dentists	1,596.1		0.0	5.1	0
Total	50,729.5	611.2	208.1	915.0	2
Selected Forest Products and Forestry Sectors					
199 Paperboard Containers A	1,123.6		2.9	3.2	0
27 Landscape and Horticulture	238.4		1.2	1.3	1
161 Sawmills and Planing Mills	47.8		0.9	0.9	2
26 Agricultural, Forestry, F	88.1		0.3	0.4	0
22 Forest Products	4.7		0.3	0.4	7
164 Millwork	710.9		0.2	0.2	0
193 Paper Coating and Glazing	657.4		0.2	0.2	0
170 Wood Pallets and Skids	8.6		0.2	0.2	2
172 Wood Products, N.E.C.	95.2		0.1	0.1	0
195 Die-cut Paper and Board	546.5		0.1	0.1	0
Total	3,521.2	0.0	6.4	7.0	0
Total, All Sectors in Minnesota	140,462.7	611.2	297.0	1,059.5	1

Source: IMPLAN runs 08/12/92, Jaakko Pöyry Consulting, Inc. (1992h).
Note: Sectors 188, 160, 24, 521, 464, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the North region. Units are increase in TIO above baseline ($ millions).
* Total refers to direct, indirect and induced effects.

The potential impacts of increased timber harvesting on forest management organizations in the state under these constraints are summarized below.

Timber harvests from the national forests in Minnesota are projected to decline by roughly 10 to 15 percent from the current level of harvest under both the base and the medium scenarios. This reduction in timber harvest would persist for several decades and reflects increased environmental, aesthetic, economic, and other constraints imposed by this ownership. This relatively small reduction in timber harvests would be unlikely to have much impact on national forest timber management activities.

Constrained projections of timber harvest from MNDNR lands indicate little change from current harvest levels during the first decade under both the base and medium scenarios. The medium scenario projects an increase in timber harvest from state lands to about 20 percent higher than current levels during the second and third decades, with further increases in timber harvests during the following decades. Such changes would require an increased level of funding to support timber sale planning and administration in coordination with increasing levels of other uses. Additional effort and funding would also be needed to address increased forest regeneration needs.

Sales of timber from county lands are projected to increase during the first decade by approximately two-thirds over current levels under the base and medium scenarios. This large immediate increase in timber harvest would have a major impact on county forest management, and would undoubtedly require substantial increases in funding and personnel to handle the increased timber sale activity while meeting environmental and aesthetic constraints. Under the medium scenario, timber harvests from county lands would remain relatively constant at the new higher level during subsequent decades.

Constrained projections of timber harvests from forest industry lands indicate that timber harvests would remain roughly at current harvest levels during the first two decades for the base and medium scenarios, followed by sharp increases during the third and fourth decades, and a substantial decline during the fifth decade.

Timber harvests from Native American lands are projected to rise more rapidly during the first decade, followed by a decline in harvests during the following decades for the base and medium scenarios. Such large increases in timber harvests would require substantial increases in funding and personnel during the next two decades to plan and administer sales, and to avoid environmental degradation.

Constrained projections of timber harvests from other private lands indicate a substantial rise in timber harvest under the base and medium scenarios during the first two decades. During the third decade timber harvests would remain high under both the base and medium scenarios, then begin to decline during the fourth and fifth decade. Achieving these increases in timber harvests from other private lands will require considerable timber sale and land management assistance from forest industry and the state and federal government if potential environmental and aesthetic degradation is to be avoided or minimized.

6.6
Identification of Significant Impacts

Criteria were developed and used to assess the significance of impacts projected to occur at each level of harvesting. The criteria and relevant background information are reproduced in full in appendix 1.

The following sections list the criteria and present the significant impacts that are projected to occur at the medium level of harvesting. Where meaningful, these impacts are compared with those projected to occur under the base level scenario. The significant impacts have been drawn from the assessments in the technical papers. Criteria have been grouped under the same headings used in section 5.

6.6.1
Forest Resources - Extent, Composition, and Condition

The criteria in this section were used by the Maintaining Productivity and the Forest Resource Base, Forest Health, and Wildlife and Biodiversity study groups to identify projected significant changes in the extent, composition and condition of Minnesota's forest resources.

These criteria cover a wide range of issues ranging from the size of the forests to their genetic makeup. Impacts on federal- and state-listed species of special concern, threatened, or endangered or their habitats were assessed for plants in this section and for animals under the wildlife section following.

Changes to Minnesota's Forests - Size and Composition of Forest Land Base (public and private)

> An impact is considered significant if it is projected that there will be cumulative over the 50-year study period:
> - A change of 3 percent in the size of the total Minnesota forest land base.
> - A change of 3 percent in the area of timberland (commercial forest land) available for wood production.
> - A change of 7 percent in the area of the total forest land base by ecoregion.
> - A change of 7 percent in the area of timberland by ecoregion.

The estimated trends by ecoregions were presented in section 5.6.1. Since change in forest area is projected to be independent of the level of harvest, the analysis presented in that section also describes the significant impacts for the medium scenario.

Projecting estimates of forest area change are always difficult and can seem exaggerated. However, the history of forest clearing, regrowth, harvesting, and reservation here and in other regions, notably from Wisconsin to New England to Europe, suggests changes can be large and rapid. Additionally, the U.S. and state population is expected to grow substantially over the period to 2040.

Changes to Minnesota Forests - Patterns of Forest Cover in Areas of Mixed Land Use

> An impact is considered significant if noncontiguous forested tracts or patches less than 300 acres in size are projected to experience clearcutting of more than 20 percent of the tract or patch in any one decade.

Statistics on the regrowth of the oak and elm-ash-cottonwood forest types common to agricultural regions suggest that forest cover is returning to ecoregions 5, 6, and 7 quite rapidly on a percentage basis. However, even the large percentage increases estimated for the next 50 years would just return these regions to the forest acreage levels of the 1950s. Additionally, the concentration of oak-hickory in older age classes (see appendix 8, Jaakko Pöyry Consulting, Inc. 1992a) coupled with currently high harvest levels could negatively affect the overall habitat value of existing forest patches. Based on the small average stand sizes in this covertype and these ecoregions and the projected acreage of unharvested stands by scenario, it is evident that this is occurring and that it is a significant impact. However, data limitations in this study preclude the ability to document it on a site-specific basis.

The covertypes likely to be present in such patches (i.e., oak-hickory and elm-ash-soft maple) show increased levels of harvesting under the medium scenario when compared with levels projected under the base scenario. Data presented in table 6.4 indicates that approximately 230,000 more acres were harvested in the oak-hickory and elm-ash-soft maple covertypes under the medium scenario than were cut in the same area under the base scenario. Therefore, intuitively, greater impacts on these resources are likely as the area harvested increases.

These changes in forest patterns have implications for several mammal species as well as forest interior birds occurring largely or entirely in these more developed portions of the state. Note that significant declines were projected for several species in ecoregions 5, 6, and 7. The projected significant impacts on these species discussed in the following section can be assumed to be closely related to this criterion, i.e., further fragmentation of remnant forest patches. Some of the species in question are: gray and fox squirrels, Ovenbird, Cerulean Warbler, and Yellow-throated Vireo. The Red-shouldered Hawk, a species of special concern, will be significantly impacted if further fragmentation of forest cover in mixed land use regions of the state occurs.

Changes to Minnesota Forests—Tree Species Mix

An impact is considered significant if projected gross changes in the relative proportion of any tree species exceeds 25 percent for the respective covertypes over the 50-year planning period.

The harvesting scenarios would affect the age class structure and thereby the species composition of Minnesota's forest. Under the changes projected at the medium level scenario the following tree species are projected to experience significant adverse impacts, black spruce, black locust, black maple, and other hardwoods.

Future covertypes appear to be sensitive to the level of harvesting, both in retaining covertypes and in favoring change to other species. Results are clouded because of an imprecision in determining forest covertypes both now and in the future. This imprecision is due in large part to the mixed species composition of Minnesota's forest. However, results suggest the medium level of harvesting will contribute to a continued decrease in area of the jack pine, black spruce, and balsam fir covertypes beyond that projected for the base scenario. However, some of these changes are a consequence of successional changes as stands age, and are not due to harvesting per se. Furthermore, because many stands have very mixed species composition, some of these changes will not necessarily drastically change the vegetation at a regional level or on specific sites. Instead, a major species may simply become less abundant or be reduced to a minor species on a particular site.

Minor Tree Species

Minor tree species are an important component of biodiversity. In many cases they are species near the edge of their range, or are species that simply are not abundant within their range:

The analysis of stem numbers for the medium level timber harvesting scenario in the year 2040 reveals that Kentucky coffeetree would be significantly impacted (>25 percent reduction in stem number). Also, in the judgement of the study group, significant impacts on honeylocust, yellow oak, and sycamore (if investigation shows it to be native) are likely under both the base and medium level of harvesting.

Reduction of Conifer Component in Aspen Stands
As discussed in section 5.2, the issue of retention of conifers in aspen stands cannot be resolved due to a lack of data. Therefore, it is not possible to predict whether conifers will be lost in short rotation or other harvest of aspen (and therefore whether the significance criterion is triggered). However, if such a reduction in conifer component were to occur, the impact on biodiversity would be significant and proportional to the level of harvest.

Changes to Minnesota Forests - Age Class Structure

An impact is considered significant if the projected replacement age class structure of forests, by covertype, at the end of the 50-year planning period, is insufficient to provide replacement of mature stand acreage (i.e., sustainability of forest communities).

This criterion requires examination of age class structures at the end of the 50-year study to assess the feasibility of relatively short-term sustainability. Upon doing so it is apparent that the replacement age class structure for timberland appears deficient for paper birch in the medium scenario. This covertype remains unbalanced through the study period because of its current age class structure imbalance. Thus, this covertype is considered to exhibit a significant impact.

Results show increased or stable acreages for white pine, northern white cedar, and white spruce. White cedar is projected to have a very low harvest so the concerns are not a direct consequence of harvesting. Concerns regarding white pine center on the very limited acreage under this covertype. It is likely that much of that acreage increase referred to above is due to covertype definition or determination procedure, or succession from other covertypes. Thus, concern for the present or 1990 acreage remains.

The area of old forest of all covertypes is expected to remain stable (e.g., balsam fir) or increase up to sixfold (e.g., oak-hickory) (see table 6.11).

Old growth forests.

An impact is considered significant if there is projected to be any net loss of area of forest meeting the DNR definition for old growth by covertype by ecoregion over the 50-year study period.

Timber harvesting per se, will have no significant impact on old growth in upland forest types since each candidate stand and future old growth stand is assumed to be either officially reserved or officially released for harvest after the appropriate administrative procedures. However, some areas of old growth may be harvested if they are not identified by an inventory. Small acreages of lowland conifer stands that meet old growth age criteria are projected to be harvested under the medium scenario. This includes 2,800 acres of white cedar, 1,000 acres of tamarack, and 21,300 acres of black spruce.

Forest species - genetic variability.

> An impact is considered significant if there is projected to be a loss of genetic variability in forest plant or animal species as measured by:
> 1. a reduction or isolation of habitat or communities supporting a species, or
> 2. a reduction of geographic ecotypes such that a species now present as a viable population disappears or is approaching extirpation from any ecoregion.

The genetic factors relevant to the criterion were discussed in section 5.6.1. These factors cannot be quantified and as a consequence, the details provided in that section are not repeated. The medium and base level scenarios differ in several ways that are relevant to forest genetics. The rise in harvesting operations projected under the medium scenario will increase the likelihood that a particular stand would be harvested at some period and also increase the number of harvested stands within a given landscape.

The increased likelihood that a site will be harvested will increase the chances that rare plants and communities will be physically disturbed or destroyed. Similarly, the increase in harvesting operations at a landscape level will likely increase the degree of fragmentation. Both increase the likelihood of significant impacts, but to an unknown degree.

Federal- or state-listed plant species of special concern, threatened, or endangered or their habitats.

> An impact is considered significant if any harvest or forest management activity is projected to diminish the habitat and disturb a species listed as of special concern, threatened, or endangered (either federal or state).

In general, the forest dependent rare plant species of Minnesota are poorly adapted to trampling types of injury. With the exception of the one tree species on the list, all species are of small stature and easily broken. Operation of harvesting equipment can significantly impact populations of rare plant species within areas harvested. The lack of knowledge regarding the locations of rare species in the state makes it impossible to undertake a more quantitative analysis. In any case, the comparatively coarse level of resolution of the model output would preclude such an analysis.

Table 6.7 in section 6.1.4 shows that the aggregate area harvested under the medium scenario will increase by 20 percent when compared with the base scenario, and that the additional harvest will be spread across all the ecoregions. Therefore, the medium scenario will likely result in additional (but unquantified) impacts above those projected to occur at the base level of harvesting.

Forest Health—change in susceptibility or vulnerability

An impact is considered significant if projected changes to the forest and activities undertaken lead directly or indirectly to changed susceptibility (risk of an outbreak/infection) or vulnerability (damage if an outbreak occurs) to more than 10 percent by area by covertype.

All timber harvesting and forest management activities affect forest health; all have impacts. Those impacts range from nearly none (where the management activity is minimal) to very significant (where major changes are brought about in the forest). That continuum of impacts is impossible to treat in any quantitative sense so a threshold must be established to aid in communication. Impacts that are greater than that threshold merit attention; impacts below the threshold are not large enough to justify further consideration.

Certain assumptions were made as part of the analysis of significant impacts on forest health. In particular, it was assumed that the MNDNR pest management guidelines and other guidelines would be followed by all ownerships. If the guidelines are not followed, impacts of harvesting on the health of Minnesota's forests could be more severe. The following assess the significant impacts projected to occur under the medium level harvesting scenario.

Differences in the levels of harvesting in the black spruce and lowland conifers causes the main differences between the projected outcome under the medium scenario versus that projected under the base scenario.

Aspen-birch forest type group. The area of the aspen-birch forest type group more than 40 years old would be reduced by more than 10 percent when comparing the final age class distribution projected at the medium harvest level with the existing distribution. This change will alter the susceptibility and vulnerability of this forest type group to outbreaks of specific insect and disease pests. This change is similar to that experienced under the base level of harvesting and the consequences would also be similar. These include a reduction in vulnerability to forest tent caterpillar; and a reduction in susceptibility to white trunk rot and hypoxylon canker (if disease control guidelines are followed). In addition there is a risk of an increase in Armillaria root rot.

Black spruce forest type group. The substantial increase in the level of harvest in black spruce forest type group under the medium scenario is projected to increase the acreage in age classes less than 40 years old by more than 10 percent, and the area over 60 years old would decline by more than 10 percent in the year 2040. These changes are likely to decrease the incidence of root and butt rots caused by *Inonotus tomentosus* which become more prevalent in stands older than 60 years. Therefore, this is a significant positive impact and in direct contrast to the significant negative impact projected to occur under the base level harvesting.

Lowland conifers forest type group. Under the medium level of harvest, the area of lowland conifers less than 40 years old is projected to increase by more than 10 percent, while the area older than 60 years is projected to decrease by more than 10 percent. Impacts on balsam fir stands are as discussed under spruce-fir below. For the remaining species, whether significant changes in harvest intensity are likely to change susceptibility or vulnerability of lowland conifer stands to insect and disease pests is unknown.

Lowland hardwoods forest type group. The area of lowland hardwoods forest type group less than 40 years old is projected to increase by more than 10 percent under the medium scenario. This is a substantial change from that projected to occur under the base scenario. In addition, the area in the more than 60-year-old age class would decrease by more than 10 percent. Although this represents a major decrease in extent of the 60-year-old-plus age class, there are relatively few major pests that are likely to be affected by changing the level of harvest in lowland hardwood types.

Pine forest type group. Changes would be 10 percent or less under the medium scenario. Such change is similar to that projected under the base scenario. Incidence of *Diplodia* shoot blight and canker and *Scleroderris* canker on young (<40 years old) red pine may increase if the areas replanted to red pine are not carefully chosen. Both of these pests are not major problems on older red pine so the projected increase in area of pine more than 40 years old should not have a significant effect on disease incidence in older red pine. This situation is very similar to the base scenario. There is a potential for an increase in diseases such as needlecasts and gall rust as nursery seedlings are planted to replace the trees that have been harvested.

Lophodermium needlecast on red pine and gall rust of jack pine are two diseases that can be introduced into the field on infected nursery stock.

An increase in area of older pine forest type group may increase the amount of pine that is less vigorous and less able to resist Ips beetles following damage by wind, lightning, flooding, defoliation, or pathogens. Incidence of Ips may therefore increase.

At the medium harvest levels, harvested white pine stands are projected to be replaced by younger stands which are more susceptible and vulnerable to white pine weevil. Therefore, this is a significant adverse impact. The increase in younger white pine could increase the incidence of white pine blister rust, especially if white pine is regenerated in northern Minnesota. Therefore, this is a significant adverse impact.

Spruce-fir forest type group. In contrast to the projections under the base level of harvesting, the area of spruce-fir forest type less than 40 years old is projected to increase by more than 10 percent under the medium harvesting level, and the area more than 40 years old would decrease by more than 10 percent at that level. The overall decrease in tree age within this forest type group, relative to the base scenario, will decrease vulnerability and susceptibility of stands to budworm damage. Probability of wildfire should decrease since mortality, breakage, and windthrow that follow budworm outbreaks will decrease. Therefore, this is a significant positive impact and an important change from the base scenario.

The decrease in area of older spruce-fir forest type group will lead to an decrease in the level of susceptibility and vulnerability of these species to trunk, root, and butt rots and can be considered a significant positive impact.

Upland hardwoods forest type group. The area of upland hardwoods forest type group less than 40 years old is projected to increase under the medium harvest level, and the area more than 60 years old would decrease by more than 10 percent. These changes are similar to those projected under the base scenario.

Under the medium harvest level, the area of younger trees will increase. Younger trees are generally more vigorously growing and have more starch reserves than older trees. They are therefore less affected by drought and other environmental stress and presumably less susceptible to severe damage by two-lined chestnut borer. The reduced susceptibility of the younger trees will be offset by an increase in the area of older forest.

Clearcutting stands of upland hardwoods forest type group should reduce the incidence of decay in the mid-term (10 to 50 years) and cankers in the short-term (< 10 years) as decayed and cankered trees are removed from the stand. However, selection and shelterwood cuts are often preferred methods of regenerating stands of upland hardwood forest type groups. If some type of multiple entry harvest is chosen, the chances of wounding residual trees increases; the incidence of decay and cankers is also likely to increase. Thinning and other stand entries are projected to increase substantially in stands of upland hardwood forest type. Hence the overall impact of increased harvesting is a likely increase in decays and cankers.

Under the medium level timber harvest, a medium-term (10 to 50 years) decrease in the incidence of oak wilt is expected if clearcutting is the method of harvest. Clearcutting would eliminate oak wilt pockets within the clearcuts. Multiple stand entries may tend to injure oak, and make them more susceptible to infection. Given that multiple entry harvest will predominate, the amount of oak wilt is therefore projected to increase (with high uncertainty of prediction).

6.6.2 Soil Resources

Nutrients

> An impact is considered significant if nutrients removed and/or redistributed during harvest and followup activities are not replaced over the term of the projected rotation.

Impacts of the medium level of harvesting were assessed by determining the area of each covertype that was harvested on each soil. More area of aspen-birch was harvested than of any of the other types; aspen-birch is also the dominant covertype in the state. Similarly, the extent of harvesting was greatest on well-drained medium-textured soils; that is also the dominant soil type in the state.

Harvest of merchantable bole did not remove either nitrogen nor phosphorus beyond their rates of replenishment. Areas at risk for loss of calcium are most closely associated with harvest of aspen-birch and upland hardwoods, on both medium- and, especially, coarse-textured soils. Thus under the medium scenario, the area at risk for nutrient loss increased compared to the base scenario. The increased calcium loss is primarily associated with increased harvest of upland hardwoods. As a result, over 5.5 million acres (up 0.5 million acres from the base scenario) are at risk of calcium loss under the medium scenario. Increased harvest of black spruce on organic soils, and increased harvest of most species on coarse-textured soils under the medium scenario, leads to an increase of about 0.5 million acres at risk for magnesium loss (up to a total of 3 million acres). Finally, increased area at risk for potassium loss is also associated with increase in harvest on coarse-textured soils, leading to an increase of about 200,000 acres at risk for potassium loss under the medium scenario which takes the total area affected up to 2.0 million acres.

Compaction and Related Disturbances

An impact is considered significant if the proportion of the harvest unit projected to be moderately to severely compacted/puddled exceeds the following threshold proportions: • 5 percent on highly sensitive sites; • 10 percent on moderately sensitive sites; and • 20 percent on sites with low sensitivity.

The analysis of significant harvest unit impacts under the medium scenario indicates they were most frequent on the well-drained medium-textured soils, which are the most common soils in the state, and the poorly-drained medium and poorly-drained fine soils which have the lowest strength.

Harvesting

The following figures are the cumulative results for the 50-year study period assuming the medium level harvesting scenario and the seasonal distribution of harvesting activities outlined in the Silvicultural Systems Background Paper (Jaakko Pöyry Consulting, Inc. 1992m). Approximately 7 million acres of timberlands on mineral soils would be harvested statewide during the study period. The significance criteria would be exceeded on harvesting units representing an area of just in excess of 955,000 acres. The area devoted to haul roads in order to extract the timber means an additional 700,000 acres would be significantly impacted.

The impact assessment indicated that increased levels of timber harvesting will invariably lead to increased amounts of compaction and related disturbance. The significance criteria were exceeded by both mechanical and hand-felling operations on moderately and highly sensitive sites. It was estimated that about 25 percent of the area within moderate sensitive sites would be negatively affected by equipment trafficking for both harvesting configurations. The portion of highly sensitive sites that are negatively impacted could increase to about 30 percent for hand-felling operations and 55 percent for mechanical felling operations.

These results reflect the seasonal harvesting distribution on all soil types within each ecoregion. Limiting timber harvesting to specific seasons on individual soils or sites could greatly affect the impact assessment. The MNDNR and some counties are starting to implement these practices on upland sites in addition to the long standing use of these practices on organic soils.

Soil Erosion

> An impact is considered significant if the rate of soil loss is projected to exceed the limits prescribed by the U.S. Soil Conservation Service expressed as:
>
> $$\text{rate} > T$$
>
> where T varies between 1-5 (tons/ac/yr)

Surface erosion rates exceeded T values on less than 1 percent of the area harvested, and this significant impact was predominantly limited to well-drained soils which exist on steeper slopes.

These results represent the total area impacted over the 50-year planning period. The analyses indicated that significance criteria would be exceeded only in moderately and heavily trafficked areas (skid trails) within harvest units and on haul roads. Also, significant impacts were concentrated in well-drained mineral soils which is to be expected since they are the soils with steepest slopes.

Under the medium level of harvest, about 30,000 acres within harvest units would develop erosion rates that exceed T values. Accelerated erosion caused by skidding and felling activities would exceed T values on less than 1 percent of the total area harvested during the 50-year period.

The greatest erosion rates were estimated to occur in ecoregion 6. This ecoregion has the steepest slopes (averaging 45 percent in many areas). The southern portion of the state also has the highest rainfall intensity. It was estimated that initial erosion rates could exceed 14 ton/ac/yr in some areas in ecoregion 6. Initial rates rarely exceeded 5 ton/ac/yr in other ecoregions.

If an area equal to 1 percent of the harvest area were utilized for haul roads on mineral soils, T values would be exceeded on an additional 7,000 acres under the medium level of harvest. These totals indicate that erosion rates would be exceeded on about 8 percent of the haul road area.

Erosion associated with haul roads would occur at faster rates than erosion within harvest units. This is a function of the more complete removal of surface protection and smoothing of the ground surface in haul roads. The analyses indicated that maximum initial erosion rates in haul roads could approach 100 ton/ac/yr in some areas.

As stated in section 5.6.6, the effects of timber harvesting and forest management activities on mass movements were not quantified. The greatest potential for mass movements would occur in areas with steep slopes such as the Coulee region of southeastern Minnesota (in ecoregion 6) and areas with shallow soils over bedrock (ecoregions 2 and 3). However, there is currently no evidence suggesting that mass movements are currently a major problem in forested portions of Minnesota.

6.6.3
Water Resources and Aquatic Ecosystems

These criteria were applied to identify significant impacts affecting water resources and aquatic ecosystems.

Lakes, rivers, streams, and wetlands - level of sedimentation/nutrient loading.

> An impact is considered significant if timber harvesting and associated management activities are projected to cause changes in the level of sedimentation and/or nutrient loading of waterbodies such that more than 25 percent of monitoring observations following harvest exceed the 85th percentile of preharvest or reference conditions.

Lakes, rivers, streams, and wetlands - runoff.

> An impact is considered significant if projected timber harvesting and associated management activities cause changes that result in greater than 60 percent of a *Minor Watershed*[1] to be in a *disturbed condition*[2] at any time.

[1]Minor watersheds as defined in MNDNR 1979 Watershed Map.

[2]Disturbed condition is defined as cleared land or regenerated forest younger than age 15 years.

Lakes, rivers, streams, and wetlands/peatlands - aquatic ecosystems.

> An impact is considered significant if timber harvesting and forest management activities are projected to result in changes to one or more aquatic ecosystem variables such that:
>
> a. more than 25 percent of observations exceed the 85th percentile of preharvest or reference conditions for the following variables:
>   - sediment levels,
>   - water nutrient levels; or
>
> b. peak streamflows more than double or if minimum flows fall below the *7Q10*[3] level; or
>
> c. more than 25 percent of observations exceed the 85th percentile or fall below the 15th percentile of preharvest or reference conditions for
>   - *aquatic community structure, community function or fish populations*[4].

Application of the above criteria to the water resource impacts projected to occur at the medium scenario indicates that the effects of timber harvest at the ecoregion level will not cause impacts that will exceed the thresholds specified in the criteria.

However, there will be a series of changes in the landscape and in the water resource. Most of those changes will be relatively local and relatively short-term in scale. Timber harvest which is accomplished in compliance with Minnesota BMPs will have significantly fewer local water resource impacts than will timber harvest in the absence of BMPs. Therefore, the increased harvesting under the medium scenario is likely to increase the number of sites affected, but will not change the types of impacts that were projected to occur under the base scenario.

6.6.4 Wildlife Populations

These criteria were used to determine the significance of impacts of projected changes in wildlife populations.

[3] The 7Q10 designation is a measure of the lowest flow for any 7-day period within any 10-year interval, and is widely used to protect water quality. Other methods for which significance criteria could be developed (e.g., wetted perimeter, Tennant's method, Instream Flow Incremental Methodology) would be more appropriate in representing fish habitat values.

[4] Specific variables to be measured might include kinds and numbers of organisms, rates at which the community processes energy or nutrients or the populations of fishes. The specific variables to be measured will be chosen by scientists assessing any given timber harvest operation(s).

Forest dependent wildlife - habitats.

> An impact is considered significant if the available habitat of a species is projected to be changed by 25 percent in any ecoregion.

Table 6.17 summarizes the wildlife species showing significant negative impacts by this criteria and the next one involving species of special concern, threatened, or endangered or their habitat. Seventy-six species, about 44 percent of all wildlife species included in the analysis, were significantly impacted over the 50-year study period under the medium scenario. Most species impacted significantly under this scenario were also impacted under the base scenario; for some of these the number of ecoregions and/or time periods in which the impacts occurred was higher under the medium as compared to the base scenario.

No large mammals would be significantly impacted under the medium scenario. The same six small mammal species would be impacted under the medium scenario as were affected under the base level of harvest. Species included beaver, bobcat, northern flying squirrel, gray and fox squirrels, and lynx. The number of bird species projected to be adversely affected by the medium scenario increased to 69 under the medium scenario, which is up from the 39 species under the base scenario. Species projected to be adversely impacted include all owl species, most woodpecker species, and many warbler species.

Small mammals: The six small mammals adversely impacted include gray and fox squirrels which are associated with mature oak forests. The northern flying squirrel requires large tracts of forest to maintain stable populations and may be adversely affected by forest fragmentation. Beaver are projected to be impacted for one decade in two ecoregions. The projected decline in this species must be viewed against a trend of population increases elsewhere. The remaining species showing negative impacts, lynx and bobcat, occupy a variety of covertypes and impacts on these species may reflect an overall reduction in the area of mature forests in these covertypes.

Birds: Impacts on riparian species were projected to be the same under the medium as for the base scenario. Two conifer dependent species were projected to declining populations under the medium scenario the species were Lincoln's Sparrow and the Pine Siskin. Three hardwood dependent species, Red-shouldered Hawk, Yellow-throated Vireo, and Hooded Warbler, were projected to be impacted statewide when all forest land was considered. Loss of mature, contiguous hardwood forest in the southern part of the state was the likely cause of projected declines in the Hooded Warbler population and the projected declines in the forest raptor populations. As under the base scenario, the projected loss of mature hardwood forests in ecoregions 4, 5,

Table 6.17. Species significantly negatively impacted on all forest lands under the base and medium levels of harvest using criterion 8 (≥5 percent statewide decline for a species listed as endangered, threatened, or special concern) and criterion 11 (≥25 percent decline in any ecoregion). Numbers in parentheses indicate ecoregions with a projected decline ≥25 percent. Double x (xx) shows those species with a ≥25 percent decline statewide, plus all species affected by criteria 8.

Species	Species Significantly Impacted	
	Base	Medium
Small- and medium-sized mammals:		
Beaver	x (2,6)	x (2,7)
Northern flying squirrel	x (5)	x (3,5)
Gray squirrel	x (4,7)	xx (4,6)
Fox squirrel	x (4,7)	xx (4)
Bobcat	x (3)	x (3)
Lynx	x (3)	x (3)
Birds		
Spruce Grouse		x (4)
Green-backed Heron	x (3,6)	x (6)
Sharp-shinned Hawk		x (3)
Cooper's Hawk	x (4)	x (1,4)
Northern Goshawk	x (4)	x (4)
Red-shouldered Hawk	xx (4,5,6)	xx (4,5,6)
Broad-winged Hawk		x (4)
Merlin		x (4)
Eastern Screech-owl	x (4)	x (4)
Great Horned Owl		x (4)
Barred Owl		x (6)
Great Gray Owl	x (3)	x (3)
Long-eared Owl		x (3,4)
Boreal Owl		x (3,4)
Northern Saw-whet Owl		x (3)
Whip-poor-will	x (7)	x (7)
Red-headed Woodpecker		x (3,4)
Yellow-bellied Sapsucker		x (4)
Hairy Woodpecker	x (6)	x (3,6)
Black-backed Woodpecker		x (3,4)
Northern Flicker	x (2)	x (2)
Pileated Woodpecker	x (6)	x (1,6)
Eastern Wood Pewee	x (4)	x (4)
Acadian Flycatcher	x (6)	x (6)

Table 6.17. (continued)

Species	Species Significantly Impacted	
	Base	Medium
Eastern Phoebe	x (2)	x (2)
Gray Jay	x (3)	x (3)
Blue Jay		x (4)
Common Raven		x (4)
Boreal Chickadee	x (3)	x (3)
White-breasted Nuthatch		x (4)
Brown Creeper		x (4)
Golden-crowned Kinglet		x (3)
Ruby-crowned Kinglet		x (3)
Blue-gray Gnatcatcher		x (4)
Eastern Bluebird	x (2)	x (2)
Swainson's Thrush	x (3)	x (3)
Wood Thrush		xx (4)
Gray Catbird	x (2)	x (2)
Brown Thrasher	x (2)	x (2)
Solitary Vireo		x (3,4)
Yellow-throated Vireo	xx (4,6)	xx (1,4,5,6)
Red-eyed Vireo		x (6)
Yellow Warbler	x (2)	x (2)
Magnolia Warbler	x (3)	x (3)
Cape May Warbler		x (3)
Black-throated Green Warbler		x (4)
Pine Warbler		x (1,3)
Bay-breasted Warbler		x (3)
Cerulean Warbler	x (6)	xx (6)
Ovenbird	x (6)	x (4,6)
Louisiana Waterthrush	x (7)	x (7)
Connecticut Warbler	x (3)	x (3)
Common Yellowthroat	x (2)	x (2)
Hooded Warbler	xx (6)	xx (6)
Wilson's Warbler	xx (2)	xx (2)
Yellow-rumped Warbler	x (3)	x (3)
Northern Cardinal		x (4)
Scarlet Tanager	x (6)	x (4,6)
Song Sparrow	x (2)	x (2)
Lincoln's Sparrow	xx (1,2,3,4)	xx (1,2,3,4)

Table 6.17. (continued)

Species	Species Significantly Impacted	
	Base	Medium
Dark-eyed Junco	x (3,4)	x (3)
Common Grackle	x (2)	x (2)
Northern Oriole	x (4)	xx (4)
Purple Finch	x (3)	x (3,4)
Red Crossbill		x (3)
White-winged Crossbill		x (3)
Pine Siskin	x (5)	x (1,3,4,5)
American Goldfinch	x (2)	x (2)
Evening Grosbeak		x (3)
Amphibians and Reptiles:		
Ringneck snake	x (1)	xx (1,3,4)

Source: Jaakko Pöyry Consulting, Inc. (1992f).

and 6 is the likely cause of predicted drop in the population of Yellow-throated Vireo. However, under the medium scenario, the Cerulean Warbler, Hooded Warbler, and Scarlet Tanager are also adversely affected. The Red-shouldered Hawk was adversely affected by projected declines of contiguous, mature, deciduous forests in ecoregions 4, 5, and 6.

Herps: The ringneck snake was the only species showing adverse impacts under the medium scenario.

The changes for some species also translate into 25 percent or more declines on a statewide basis. These are summarized in table 6.13 in section 6.4.1. Statewide, 11 species would decline by 25 percent or more; that is more than twice the number adversely affected on the base scenario. The statewide declines include two species that are endangered, threatened, or of special concern (Red-shouldered Hawk and Louisiana Waterthrush).

Federal- or state-listed wildlife species of special concern, threatened, or endangered or their habitats.

An impact is considered significant if any harvest or forest management activity is projected to diminish the habitat and disturb a species listed as of special concern, threatened, or endangered (either federal or state).

For analysis, a decrease of 5 percent or more in habitat or population index statewide was interpreted to be a significant impact.

The same significant impacts are projected to occur for the Red-shouldered Hawk and Louisiana Waterthrush under the medium scenario as occurred under the base scenario.

In addition to the direct assessments of population change assessed above, two other criteria were used to identify impacts on key habitat factors for some species. These criteria and the assessments of significance are discussed below.

Forest dependent wildlife - habitats (lowland conifers).

> An impact is considered significant if, by ecoregion, net loss of patches of mature lowland conifer between 10 and 200 acres is projected to exceed 25 percent of total patches over the 50-year study period.

In regions where great expanses of lowland conifers, particularly black spruce, predominate on the landscape, protection of this covertype is not as critical to wildlife as where the type occurs as isolated patches. However, the increased demand for black spruce will likely increase pressure on this covertype in areas where it predominates and where it exists in patches. Relative to 1990, the medium scenario in 2040 shows a 28 percent decline (see table 6.8) in black spruce covertype acreage for timberland. Consequently, there is concern that mature lowland conifer patches would be significantly impacted.

Forest dependent wildlife - food species.

> An impact is considered significant if, by ecoregion, the projected rate of removal of tree species that provide vital food for wildlife, (oaks, hickories, and mountain ash), exceeds their projected rate of replacement.

A number of species such as the grey and fox squirrels projected to have significant declines under the medium level harvest rely on mature oak forests for food and cavity resources. Three factors that were part of the output will provide some guidance as to landscape scale changes to some of these species. The covertype area and age variables allow an interpretation of very broad change in the availability of these resources. In addition, the number of trees by species on timberlands was also projected.

The projected area changes in the oak-hickory covertype (table 6.8 section 6.2.1) shows that the area of this covertype is projected to increase slightly over the 50-year period, probably reflecting projected increases in the area of forest in the southern ecoregions. The average age of this covertype is projected to increase slightly from the present 69 years to 71 years under the medium scenario (table 6.9 section 6.2.2). This is seven years less than that projected under the base scenario.

The projected numbers for food tree species (from table 6.13, section 6.2.3) generally show increases under the medium scenario compared to the base scenario. It should be stressed, however, that the numbers include all trees larger than 1-inch dbh. Trees this small would not provide food resources, hence these figures should only be used to gauge broad trends. Species showing increases over current levels include mountain ash, bitternut hickory, black oak, white oak, swamp white oak, and butternut. Those showing stable or slight increases/decreases included black walnut, bur oak, and northern pin oak. Northern red oak was projected to show a decline of approximately 15 percent under both the base and medium scenarios.

Forest species - genetic variability.

An impact is considered significant if there is projected to be a loss of genetic variability in forest plant or animal species as measured by:

1. a reduction or isolation of habitat or communities supporting a species, or
2. a reduction of geographic ecotypes such that a species now present as a viable population disappears or is approaching extirpation from any ecoregion.

As discussed previously, fragmentation is likely to increase as a consequence of increased harvesting projected to occur under the medium scenario. The range of animal species previously listed under the base scenario are likely to be more affected under this level of harvesting than was the case under the base level. The importance attached to change affecting individual species can be assessed by weighing several factors including the overall size of the population, the distances involved, and particularly the mobility of the animal. Thus, birds would probably be least affected and herps would be most vulnerable, particularly those that are not likely to disperse along major streams and rivers. Some species show genetic variability over their range, whereas others have a more homogeneous genetic makeup. Information on this is essentially lacking, so this discussion must be confined to generalities. This issue is fully discussed with regard to plants in the Biodiversity technical paper.

In general, when fragmented populations at or near the boundaries of a species range are in jeopardy, it suggests that genetic loss is much more likely than where the same amount of local loss occurs well inside the geographic range of a species. Minnesota, with its great diversity of forest and climatic types, includes the distributional limits of many wildlife species—including cases of northern, southern, eastern, and western edges of species' distributions. Thus, among midwestern states, Minnesota has an unusual number of cases where the edges of a species' genetic variability might be jeopardized. Species with significant predicted impacts from timber harvesting that reach the edge of their range in the state include: black bear, fisher, pine marten, northern flying squirrel, fox squirrel, red squirrel, woodland jumping mouse, lynx, Great Gray Owl, Boreal Owl, and red-backed salamander.

6.6.5 Recreation and Aesthetics

Changes to Minnesota forests - Patterns of forest cover in predominately forested areas-forest roads

An impact is considered significant if there is projected to be development of permanent forest roads in areas meeting the criteria for either of the following Recreation Opportunity Spectrum (ROS) categories:
- unroaded primitive areas.
- semiprimitive nonmotorized areas.

The two ROS classes used in the criterion are defined as:

Primitive.—An area three or more miles from all maintained roads or railroads and which has an unmodified natural environment. There can be evidence of foot trails, or recreational use. Structures in use are rare. Contact with humans is rare and chances of seeing wildlife are good. Example: BWCAW. Approximately 3 percent of total forest land and 0.4 percent of timberland in Minnesota meet these criteria.

Semiprimitive nonmotorized.—An area one-half to three miles from all maintained roads or railroads, but which can be close to primitive roads or trails used only occasionally. Modifications to the environment are evident, such as old stumps from logging, but are not apparent to the casual observer. Structures in use are rare. Human contact is low and chances of seeing wildlife are good. Example: Recently undisturbed state lands. Approximately 9 percent of total forest land and 7.2 percent of timberland meet these criteria.

A permanent forest road is defined as a formed road that is graveled or paved and is maintained in a trafficable condition (as distinct from being allowed to revegetate). The criterion is intended to identify changes in the pattern of disturbance to the least disturbed areas of the unreserved forest lands. The ROS criteria assess levels of disturbance, particularly roads. The criterion was applied to northern counties that are predominantly forested (see table 6.18).

Harvesting and the development of roads needed to access timber from forests within these categories of lands is indicative of an increased level of disturbance. Improved access provides opportunities for additional use by people who depend on motorized access. This will likely displace a proportion of existing users and will impact animals that are adversely affected when the level of human contact increases.

Table 6.18. Distribution of FIA timberland plots and percent of plots projected to be harvested in primitive and semiprimitive nonmotorized ROS classes, by physiographic class under the base and medium scenarios.

ROS Class	Total number of plots	Percent of timberland plots harvested by scenario and ownership*							
		Base Scenario				Medium Scenario			
		State/federal lands		Other lands		State/federal lands		Other lands	
		dry	wet	dry	wet	dry	wet	dry	wet
Primitive	53	11.3	3.8	20.7	7.6	13.2	5.6	21.5	6.8
Semiprimitive nonmotorized	876	10.8	6.3	15.3	3.9	12.1	12.0	17.3	5.6

* See table 5.19 for total number of plots harvested by scenario.

According to the criterion used, only plots harvested on dry sites constitute significant impacts to primitive and semiprimitive nonmotorized recreation opportunities. The criterion specified for use in assessing impacts on primitive class lands further requires identification of those areas designated unroaded *primitive* lands and *semiprimitive nonmotorized* lands, where construction of permanent forest roads is projected.

Under the medium scenario, 34.7 percent of the 53 timberland plots designated as primitive and dry are projected to be harvested and therefore significantly impacted. Additionally, 29.4 percent of the 876 timberland plots designated as semiprimitive nonmotorized are projected to be significantly impacted. These impacted plots correspond to 4.3 and 19.7 percent of all forested plots in the primitive and semiprimitive nonmotorized ROS classes, respectively. Based on the criterion, no significant impacts occur when plots in the "wet" physiographic classes are projected to be harvested. These plots would be accessed when the ground is frozen and therefore are assumed not to require permanent roads.

Forest Recreation and Aesthetics

> An impact is considered significant if VMG are not used in the planning and execution of projected timber sales for visually sensitive areas.

The criterion refers to VMG, which are planning tools used by the federal and state ownerships to reduce visual impacts. Significant impacts can be avoided where visual planning is used to identify *where* and *how* harvesting and associated forest operations should take place, i.e., road location and design, use of buffers, size and shape of cut, and slash and debris disposal practices.

Harvesting can reduce the aesthetic experience for subsequent users, therefore limiting the recreation value of harvested areas and the adjacent unharvested areas. However, harvest operations and associated roading can also create additional recreation opportunities of a more developed type.

Visually sensitive forested areas recognized in this criterion can include such areas as those adjacent (within one-fourth mile) to water (lakes and rivers), important tourist and recreation areas, and along recognized tourist access routes. The criterion assumes that significant impacts occur where harvesting operations take place in visually sensitive areas on lands where owners do not practice formalized visual management planning. For example, the USDA Forest Service has had formalized VMSs in place for a long time. Other ownerships, including MNDNR Management Region 2 and Beltrami County, are in the process of developing and applying guidelines.

Typically, other ownerships do not have formalized systems in place. Hence, while in some cases efforts are made to reduce visual impacts on a site by site basis, impacts can still occur when viewed from a wider context.

The certainty of the impact is dependent on the degree to which visual planning is used in timber sale layout and BMPs are adhered to in the execution of the harvesting and postharvest closure of the site. Impacts can extend into the medium-term depending on the circumstances.

Based on the interpretation of the significant impact criterion, significant visual impacts occur when timber harvesting and forest management activities do not follow VMGs. Analysis found that 67.1 percent of the timberland plots harvested under the medium scenario would not be treated according to VMGs and these are therefore judged to be significantly impacted.

6.6.6
Unique Cultural and Historical Resources

> An impact is considered significant if heritage resources including cultural landscapes, structural remains, archaeological remains, Native American traditional use sites are destroyed; or cemeteries are disturbed.

The following maximum levels of significant impacts are predicted for each type of heritage resource, based on the interpretation of *destroyed* and the types of impacts discussed in section 5.5.3, and estimated likelihood of impacts under the medium scenario in section 6.5.3. There is insufficient data to assess, even qualitatively, the extent that these sites will be impacted. Significant impacts are likely to occur and the relative number of impacts will increase as the level of harvesting increases.

Archaeological and Cemetery Sites
Based on the analysis presented in section 5.5.3, the predicted *maximum* number of sites to be destroyed is shown in table 6.19.

The actual numbers of sites affected can be confidently predicted to be less than these totals. However, because of the nature of the assumptions used to generate these estimates, it is not possible to quantitatively assess the effect of most of these assumptions. The only data that can be quantified are the projected acres that are harvested on national forest. Preharvest surveys detect most sites on these lands and therefore it is valid to assume that no impacts occur. The figures in table 6.18 reflect this reduction. However, it is not possible to set a lower bound on these estimates.

Table 6.19. Predicted maximum number of archaeological and cemetery sites to be destroyed in ecoregions 1 to 6 under the base and medium harvesting scenarios.

Harvest Scenario	Number of Sites Destroyed	
	Number	Percent of Total Predicted Sites Affected*
Base	100,000	52
Medium	116,000	61

Source: Jaakko Pöyry Consulting, Inc. (1992g).
*The total number of sites predicted in ecoregions 1 to 6 (see section 2.3) is approximately 190,000.
Note: Excludes impacts on USDA Forest Service lands.

Traditional Use Sites
As discussed in section 5.5.3, traditional use sites will be impacted. However, the extent cannot be quantified, as these sites have not been inventoried. Thus, significant impacts on these sites are likely to increase with the level of harvesting.

6.6.7 Economics

Regional economics - changes in economic parameters.

An impact is considered significant if there is projected, for each region (north, south and metro), a change in the following economic parameters by economic sector over 50 years:
- output - ± 5 percent
- employment - ± 5 percent
- income (wages and salaries) - ± 5 percent

The significance criterion outlined above assesses the significance of the economic impacts projected as a consequence of the medium level of harvesting. The factors assessed include employment, employee compensation, and TIO. Applying this criterion to the economic impacts generated by the medium scenario indicated that significant positive impacts are projected to occur in several economic sectors in the north region of Minnesota and in the state as a whole. In the southeast region, only two sectors are projected to have significant positive economic impacts. No significant impacts are projected to occur in the metro and southwest regions, because no forest industry expansion was projected to take place in these regions. Significant economic impacts are summarized in table 6.20.

Significant Economic Impacts in the North Region
All of the expansion of the timber industry under the medium scenario was projected to occur in the pulp and paper industry, and to occur entirely within the north region. This level of harvesting was projected to have significant positive economic impacts in terms of employment, employee compensation, and TIO, within the north region.

Relatively few of the north region's economic sectors showed significant increases in economic activity as the result of medium scenario expansion. Only four (160-Logging, 456-Electrical Services, 446-Railroads, and 24-Forestry Products) of the top twenty sectors showed significant increases in employment (5 percent or more), and only two of the forestry related sectors showed significant increases in employment (170-Wood Pallets and Skids and 22-Forestry Products). Overall, the increase in employment in all sectors of the north region was not significant.

Table 6.20. Economic sectors in Minnesota with significant increases in employment, employee compensation, and TIO due to increased levels of timber harvesting under the medium scenario. (Direct, indirect, and total impacts, in employment [jobs] and in millions of dollars.)

IMPLAN Sector	Baseline TIO	Medium Scenario			
		Direct Effect	Indirect Effect	Total* Effect	Percent of Base
Sectors with significant increases in employment (jobs)[a]					
160 Logging Camps and Logging	2,016		488	489	24
24 Forestry Products	1,386		131	132	10
22 Forest Products	75		6	6	7
Total, all sectors in Minnesota	2,085,517	352	3,788	6,752	0
Sectors with significant increases in employee compensation ($ millions)[b]					
160 Logging Camps and Logging	23.13		5.60	5.61	24
24 Forestry Products	1.89		0.18	0.18	10
Total, all sectors in Minnesota	43,230.86	16.19	84.42	146.38	0
Sectors with significant increases in TIO (any scenario) ($ millions)[c]					
188 Paper Mills, Except Building	1,568.1	611.2	0.3	611.4	39
160 Logging Camps and Logging	126.9		30.7	30.8	24
24 Forestry Products	65.7		8.7	8.8	13
22 Forest Products	4.7		0.3	0.4	7
Total, all sectors in Minnesota	140,462.7	611.2	297.0	1,059.5	1

Source: Jaakko Pöyry Consulting, Inc. (1992h).
[a]Sectors 160, 446, 464, 27, 161, 172, and 23 adjusted to reflect IMPLAN revisions in the north region. Units are number of jobs above baseline employment.
[b]Sectors 188, 160, 24, 521, 464, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the north region. Units are employee compensation above baseline compensation ($ millions).
[c]Sectors 188, 160, 24, 521, 464, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the north region. Units are increase in TIO above baseline ($ millions).
* Total effect in industry output includes direct, indirect, and induced (not shown) increases.

Only three of the top twenty sectors (456-Electrical Services, 446-Railroads, and 160-Logging) and two of the selected forest products and forestry sectors (170-Wood Pallets and Skids and 22-Forestry Products) showed significant increases in employee compensation. Overall, the projected increase in employee compensation in all sectors of the north region was not significant.

Six of the top twenty sectors showed significant increases in TIO, with the Paper Mills (sector 188), Logging (sector 160), and Forestry Products (sector 24) sectors showing the largest percentage gains. Overall, the top twenty sectors together showed a significant 8 percent gain in TIO. Only two of the forest products and forestry sectors showed a significant gain in TIO. When all economic sectors in the north region are considered, the projected increase in TIO was not significant.

Expansion of the Paper Mills sector (188), which initiated the assumed industry expansions under the base level scenario, resulted in a significant 39 percent gain in TIO. However, it generated only a 4 percent increase in employment and employee compensation. These employment and employee compensation increases were not significant under the criteria established for this analysis.

Significant Economic Impacts in the Southeast Region

No forest products industry expansion was projected for the southeast region under the medium scenario. Without an expanding sector to force an expansion in this region's economy, an IMPLAN run could not be made for the southeast region for this scenario. Thus, no direct, indirect, or induced economic impacts were projected for this region at the medium level of harvest.

Significant Economic Impacts for the State of Minnesota

The projected expansion of the timber industry would result in significant increases in employment, employee compensation, and TIO for many sectors in the northern region, especially under the high scenario. However, the increases for the state as a whole were less significant. At the medium level of timber harvest, only two of the top twenty sectors contributing most to employment gains in Minnesota had projected increases that were significant (5 percent or greater), and both of these were sectors related to forestry (160-Logging, and 24-Forestry Products). Only one of the top ten forest products and forestry sectors (22-Forest Products) indicated a significant increase in employment. Among the top twenty sectors contributing most to employee compensation, only one (160-Logging) showed a significant increase. Only one of the selected forest products and forestry sectors (24-Forestry Products) showed significant gains in employee compensation. Table 6.19 shows those sectors of Minnesota's economy with significant (5 percent or greater) increases in employment, employee compensation, and TIO resulting from the medium scenario.

Overall, total output in the state's economy increases by about a billion dollars under the medium scenario. Also, about 60 percent of the total increase occurs in the paper sector. All of the direct impacts occur in the paper sector. The output of the paper sector increases by 39 percent and the logging sector increases output by 24 percent under the medium scenario. Impacts are measured relative to the base scenario; therefore, there are no impacts resulting from the base scenario.

Impacts on Forest Management Activities

The changes to management agencies caused by an increase in the level of harvest will not trigger the significance criterion as this was developed to assess impacts by sector at a regional scale. Precise estimates are not available for the additional funding and personnel that might be required by federal, state, and county land management agencies to meet future increase in timber harvests. However, additional resources will need to be committed by state government and the counties to implement the harvest level and mitigations recommendations.

Impacts on Recreation and Tourism
It was not possible to directly link increased timber harvesting with changes in recreation activities. In addition, it was not possible to develop linkages between the level of harvesting and the levels of tourism activities or expenditure patterns. As a consequence, it has not been possible to quantitatively assess how the increased timber harvesting levels considered would economically impact the sectors identified in the FSD. In the absence of quantitative assessments it is not possible to trigger the significance criterion.

6.6.8 Summary of Significant Impacts

The medium scenario significant impacts identified in sections 6.6.1 to 6.6.7 are the same as those listed in section 5.6.8. *The difference between scenarios is in the degree or scale of impacts rather than in the type of impact. For example, wildlife habitat or species were impacted by habitat changes under the base scenario, but more acres and/or more species were significantly impacted in more ecoregions under the medium scenario.*

6.7 Recommended Mitigation Strategies

The strategies developed to mitigate significant impacts projected to occur at the medium level of harvest (4.9 million cords per year) will include those developed to mitigate the significant impacts identified at the base (4 million cord) level of harvest. For most covertypes, the difference between the two scenarios is related to the intensity of harvesting activity at the landscape level. *The types of site level impacts will be unchanged and therefore, the same mitigations will be required; although, mitigations would typically need to be applied to more area than under the base scenario.* For example, the area of harvest units expected to be significantly impacted by compaction was approximately 840,000 acres under the base scenario; and 1,050,000 acres under the medium scenario. Therefore, the same mitigation strategies would have to be applied to an additional 190,000 acres to mitigate significant impacts under the medium scenario.

In addition, the same mitigations applied because of significant impacts identified at the base level may also mitigate other impacts projected to occur at the medium level of harvest. For example, the intensity of harvesting in a covertype projected under the base level may have resulted in projections of significant impacts on a single squirrel species; while under the medium scenario, the more intensive harvesting in the same covertype may have resulted in significant impacts on two additional squirrel species and two bird species. The same mitigation strategy, e.g., retain cavity and mast trees may mitigate all impacts.

Similarly, more intensive harvesting at the landscape level will not change the types of impacts; however, the *need* for mitigations will likely increase with increasing intensity of harvest. Hence, the strategy to develop a connected landscape, and the principles guiding development of that strategy remain the same at either level of harvest; however, the need for this mitigation increases as the level of harvest increases and the degree of human induced change in the landscape increases.

The rate of harvest over the 50-year study period will also affect the level of impacts. This is particularly the case with mitigations that depend on information being gathered. Information on the locations and ecology of plant species classified as endangered, threatened, and special concern is a good example. Stands harvested without that information increase the likelihood of impacts. Therefore, the more stands harvested before the information becomes available, the greater the impacts.

Therefore, the strategies presented in section 5 will apply to the mitigations required under this scenario. However, these mitigations will often need to be applied to more areas or there is greater urgency to their implementation.

6.7.1 Recommended Strategies Development

The criteria and process for developing recommended mitigation strategies was described in section 5.7.1.

6.7.2 Recommended Strategies

This section identifies the strategies developed to mitigate significant impacts projected to occur at the medium level of harvest (4.9 million cords per year). These strategies, many of which reflect the mitigation measures developed in the technical papers, have been combined and modified where required in order to achieve multiple objectives and resource protection goals. Mitigation strategies that would improve the standard of forest practice in Minnesota but do not directly mitigate significant impacts are also presented.

The strategies recommended to address significant impacts at the medium level of harvesting are presented under three categories which reflect their main focus:

1. forest-based research;
2. landscape-level responses; and
3. site-level responses.

The actual mitigations recommended for each of these categories were listed in section 5.7.2.

6.7.3
Effectiveness at Mitigating Significant Impacts

The following section discusses the relative effectiveness of the proposed strategies as mitigations for the significant impacts projected to occur under the medium scenario.

1 Impact
Projected significant loss of forest area in ecoregions 1, 3, and 4
Reduce the area of forest converted to nonforest land uses: The process of land use conversion is independent of the level of harvesting. The proposed strategy seeks to influence NIPF ownership to maintain forested land under forest cover, irrespective of their management objectives for the land. The effectiveness and feasibility of this mitigation strategy was discussed in section 5.7.3 and those findings apply as well to the medium harvest scenario.

2 Impact
Projected harvesting affecting patterns of forest cover in areas of mixed land use
These impacts would affect species that depend on the features of mature forest and forest interior species. The following strategies will mitigate these impacts.

Maintain patches of forest intact in areas of mixed land use: By reducing use of clearcutting silvicultural systems, linking patches, and augmenting existing patches of forest.

Mitigations to maintain populations of forest interior species and the Red-Shouldered Hawk will need to maintain forest interior conditions in remnant patches. Large (>300 acre) blocks of mature forest will likely have to be retained with only periodic disturbance to maintain the most sensitive species.

Effectiveness: If applied at a regional scale this mitigation strategy will likely be effective at mitigating impacts by maintaining these important habitats. The increased level of harvest is projected to be mainly within ecoregions 1 to 4 which are not the focus of the mitigation strategy.

Feasibility: As discussed in section 5.7.3, the feasibility of this strategy is heavily dependent on NIPF owners adopting the constraints on management of their forests.

Retention of large blocks of forest with constraints on the amount of disturbance is less likely to be successful because this aspect of the strategy will likely require cooperation of more than one NIPF landowner. As more landowners become involved the likelihood of **all** owners cooperating will decrease. Purchase of these blocks for inclusion in the state's reserve system is likely the most effective means to achieve this mitigation.

3 Impact
Projected changes to tree species mix
Projected changes to tree species mixes in the state's forests are likely to result from changes in the age class distributions of covertypes as well as from direct impacts on minor tree species. The strategy depends on several distinct elements which are discussed below.

Monitor the age class and covertype structure of the state's forests and their patterns across the landscape: This mitigation would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Complete the MNDNR county biodiversity inventory: This mitigation would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Conduct an inventory of old growth forests across all ownerships: This would not mitigate impacts directly, but would contribute information to assist decisions on other mitigations. Specific guidelines for managing the identified sites will have to be developed for USDA Forest Service, MNDNR, and county-managed lands.

Maintain desired age class distributions for each covertype: Offers the prospect of modifying the tree species mix by insuring that there are adequate numbers of stands present in the state that are likely to provide suitable conditions for the full range of species.

Maintain desired covertype distributions: This provides for maintenance of tree species mix by management to achieve acreage goals by covertype. The available tools include harvesting and a range of silvicultural practices that favor certain species and covertypes. In some areas, restoration of forest cover by planting or enrichment may be appropriate. In other situations minimal disturbance might be effective to allow natural succession.

Effectiveness: The mitigation strategy would likely be only moderately effective and would require long periods to achieve even detectable change. Because harvesting is the only practical tool available for these landscape-scale manipulations, there are inherent constraints on the range of covertypes that will likely be manipulated. Typically changes will be focussed on covertypes dominated by the more commercial species. The projected increases in demand for some species such as black spruce and balsam fir will assist in efforts to balance age classes. Stands of other noncommercial covertypes and those within reserved forests will likely continue the trend towards older age classes. Use of other tools such as fire and special silvicultural systems would likely be very expensive and confined to important stands.

Feasibility: The mitigation is moderately feasible as the major public ownerships have policies to maintain biodiversity. The other ownerships typically have no clear management objectives in this area and are less likely to direct their management to achieve these goals. Therefore, the mitigation would be focussed on the major public owned forests

4 Impact
Projected changes in the age class structure of paper birch
This was the only covertype projected to have significant changes to the age class distribution. The following elements comprise the mitigation strategy for this covertype.

Monitor the age class structure and covertype of the state's forests and their patterns across the landscape: This would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Conversion of older stands to young stands to balance the age class structure: Would require that old stands be harvested and new stands regenerated.

Effectiveness: If a proportion of older stands could be replaced by younger stands the mitigation would be effective.

Feasibility: The mitigation is unlikely to be feasible because the covertype is not a sought after commercial species and is difficult to regenerate once stands become too old to reliably stump sprout. The major public ownerships will likely undertake limited regeneration programs but these will likely be inadequate to balance the age class distribution.

5 Impact
Projected harvesting affecting genetic variability of plant or animal species
Harvesting is projected to lead to further fragmentation of the forest and to impact outlier populations of some species and some plant communities. The following elements make up the mitigation strategy to mitigate these impacts.

Complete the MNDNR county biodiversity inventory: This would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Develop blocks of ERF: Would promote additional diversity of covertype condition and would provide habitat for species dependent on mature/older forest. Because more acreage is harvested under the medium scenario than the base scenario, more ERF may be necessary to maintain the same level of genetic variability. This would, in turn, lower the feasibility of complete mitigation. ERF policies are likely to be confined to the major public ownerships.

ERF and riparian corridors would likely maintain many opportunities for transfer of genetic materials between separated populations of forest plants and animals. In the northern ecoregions where public ownerships dominate ownership patterns, remnant old growth is preserved and ERF policies are being implemented. In the southern part of the state, the riparian zones will be the most important vectors for genetic transfer.

Modified silvicultural systems: Such as use of uneven-aged and thinning for harvesting and retention of key habitat requirements would likely maintain conditions that are suitable for many of the species likely to be significantly adversely impacted. As with ERF, a larger portion of the landscape may have to be managed under modified silvicultural systems to mitigate the higher harvest under the medium scenario as compared to the base scenario.

Effectiveness: Combinations of these mitigations will likely be effective at reducing significant impacts by providing a range of age classes in each covertype and linkages for transfer of genetic material.

Feasibility: The major public ownerships have mandates to manage for biodiversity. However, application of these mitigations within forests managed by ownerships other than the major public landowners is likely to be mixed and will depend on owners' objectives. Consequently, the mitigation is rated at low to moderate feasibility. It will likely be more feasible in the north and less feasible in the south of the state.

6 Impact

Projected harvesting affecting federal or state listed species of special concern, threatened, or endangered or their habitats

Impacts affecting populations of these species of plants and the communities that contain them are interpreted to occur as a consequence of harvesting because little is known of their locations. The significant impact criterion threshold was set at any diminution or disturbance of habitat or populations of these species. Projected increases in levels of harvesting, particularly in ecoregions 3 and 4, will increase the risk that such impacts will occur.

The mitigation strategy directed towards maintaining genetic variability discussed previously will likely mitigate these significant impacts.

Complete the MNDNR county biological survey: There is a strong likelihood that populations of these species and the communities which support them will be disturbed and diminished under circumstances where the occurrences of these species remains unknown. Therefore, significant impacts are likely to be higher in areas that have not been surveyed by the MNDNR county biological survey.

Concern for completion of an old growth inventory, as noted in section 5, increases with the level of harvesting.

Effectiveness: The effectiveness of the strategy is highly dependent on access to information on the occurrences of these species and the communities that support them. Consequently, the rate at which harvesting occurs is an important factor. The increased level of harvesting under the medium scenario means that during any given period, approximately 20 percent more timberland will be harvested. Therefore, to maintain the risk of impacting these species it will be necessary as a minimum to increase the rate at which the survey is done. Planning based on information available from this program would enable the locations of these populations to be noted and harvesting redirected. The effectiveness of the strategy relies largely on increasing the funding and staffing allocated to the MNDNR county survey.

Feasibility: The strategy is likely to be moderately feasible subject to adequate funding being provided to complete the biodiversity survey.

7 Impact

Changes in the susceptibility and vulnerability of covertypes to forest health risks

Impacts were interpreted based on projected changes to age class distributions and circumstances where multiple-entry harvesting systems were to be used. The changes in forest health projected to occur primarily reflect the increasing age of stands in the noncommercial covertypes on timberlands and all covertypes within reserved lands. The mitigation strategy is aimed at developing statewide plans to handle pest outbreaks and to modify the equipment and techniques used in multiple-entry harvests. The following outlines the elements of this strategy.

IPM strategies: Will assist to mitigate impacts associated with major outbreaks such as gypsy moth. Planning such as advocated under this mitigation will allow a more rapid response and therefore will likely reduce the level of impact experienced.

Modify equipment and practices for use in multiple entry harvesting operations: Will likely reduce the incidence of damage to residual stems and will therefore reduce the incidence of pests and diseases that are associated with wounds. This will have particular application in the south of the state.

Maintain desired age class distributions for each covertype: Will allow the prospect of reducing the proportion of susceptible and vulnerable covertypes on ownerships with wood production objectives.

Effectiveness: The mitigation strategy is likely to be moderately effective at providing the basis for reducing the scale of damage caused by major outbreaks of pests, particularly pests such as gypsy moth. The localized impacts caused by damage to retained stems would likely be reduced if the mitigations to equipment and practices were introduced.

Feasibility: The strategy is likely to be moderately feasible subject to participation by the major stakeholders in the process of developing IPM strategies. Adoption of new harvesting equipment and techniques will likely be of moderate feasibility subject to provision of assistance to undertake trials and subsequently, to loggers willingness to make the investments needed to replace equipment.

8 Impact

Projected harvesting affecting site nutrient capital

Nutrient losses above estimated levels of replenishment were projected to occur for several combinations of covertype/soil type/harvesting practices. The increased harvesting projected to occur under the medium scenario will increase the requirement for this mitigation by increasing the area of timberland projected to be significantly impacted. These significant impacts can be mitigated by changing the length of rotations and the harvesting methods used. The following strategy has been developed to mitigate these impacts.

Retain or redistribute slash within the cutover: Will maintain the nutrients contained in the leaves (needles) and branches within the cutover. This can be achieved either by favoring use of equipment that retains slash at the site where the tree was felled; or, slash from landings can be redistributed using existing equipment. Development of systems that could undertake partial or full bark removal in the cutover would also greatly aid nutrient retention.

Manage a proportion of stands under ERF guidelines: Would extend the period for nutrient replenishment prior to the next harvesting operation.

Effectiveness: The mitigation of retaining or returning slash and (if feasible) bark within the cutover is likely to be a very effective strategy for reducing nutrient loss. Longer rotations are also effective by allowing natural processes to replenish the nutrients lost in harvest or in site preparation. The duration is long-term, but effectiveness is reduced with time as species reach advanced ages and become less vigorous and more susceptible to forest health problems.

Feasibility: In some cases the strategy can be implemented relatively easily. However, overall feasibility will depend upon operational and technical constraints, particularly on the harvesting technique, the equipment available, and to some extent the season of harvesting as it facilitates removal of bark. Equipment to remove branches and bark at the stump is currently operational overseas. In the long-term, feasibility should be high. Return of slash to a site from a landing or elsewhere would also be similarly effective and long-term. Its feasibility would be affected by the added cost of another pass of equipment over the site and the potential compaction and puddling associated with such an activity. Returning material in winter would minimize the latter effect. The duration of the effect is long-term.

The feasibility of applying longer rotations is problematic for short-lived species and benefits diminish with time as nutrient levels return to preharvest levels.

9 Impact

Projected harvesting affecting soil physical structure

Compaction and puddling is projected to most frequently impact well-drained medium-textured soils (the most common soil in the state) and poorly-drained medium- and fine-textured soils. The likelihood of impacts is affected by the extent of roading, type of equipment, and the season of harvest. The following describes the mitigations that comprise this strategy.

Develop landscape based road and trail plans: This strategy would involve planning and coordination between ownerships to develop landscape-based road and trail plans. The plans would cover development of new roads, long-term access needs, and closure policies.

Modify times of equipment operation to minimize compaction: Is intended to reduce the occurrence of compaction by identifying susceptible sites and limiting operations on those sites to periods when the risk of compaction is lowest.

Effectiveness: If fully implemented, the strategy would likely be moderately effective at mitigating the significant impacts.

Feasibility: Development of landscape-based plans would require a leadership role to initiate the process and to coordinate responses from other ownerships. The MNDNR is the agency best placed to undertake this role. This strategy is feasible given the existing MNDNR responsibilities to produce an inventory of state forest roads under the MFRMA of 1982. In addition, the number of ownerships likely to be developing new roads in the more remote areas is limited. The cost of adopting this mitigation would center on the additional planning that some ownerships would have to undertake to participate in the process. Additional costs would also be incurred by the MNDNR in coordinating and compiling inputs from others.

Constraints on equipment operation during susceptible periods will require assessments of site susceptibility at an operational scale if preventative measures are to be effective. In most areas, soil maps and other tools are *not* available at the stand or harvest unit scale. Confirmation of site susceptibility will require on-the-ground inspection by natural resource professionals. This will likely require additional training and staffing of forest management organizations. The MNDNR, USDA Forest Service, and possibly the larger counties and forest industries are best equipped to undertake this mitigation. It is unlikely that planning and assessments on NIPF lands would reach this level of sophistication and consequently this mitigation is unlikely to be feasible on these lands.

The feasibility of imposing seasonal restrictions on harvesting on some soil types or delaying operations that are already underway would likely be constrained by the financial hardship to loggers that would likely happen as a consequence of these actions. In addition, these restrictions may interfere with the continuity of supply to some mills. The feasibility will therefore also be constrained by the flexibility of forest industries delivery schedules.

10 Impact
Projected harvesting causing accelerated erosion from forest roads
Forest roads are the primary sources of accelerated erosion from harvested areas. The mitigation strategy aimed at reducing compaction will also mitigate erosion impacts.

The key elements of the above strategy that will mitigate accelerated erosion impacts include: adherence to BMPs, consistent road closure policies, and reducing the length of road constructed while improving the standard of design, construction, and maintenance.

Effectiveness: These mitigations will reduce the amount of poor standard forest roads that are likely to cause erosion. If applied throughout the state this strategy would provide moderately effective mitigation of the impact.

Feasibility: The main erosion problems in the state occur in the southeast where there is less likelihood that these measures will be adopted because of the predominance of NIPF lands in this region.

11 Impact
Projected changes in the populations of forest dependent wildlife
Projected changes to wildlife populations were based on changes in the amount and quality of likely habitat within the known ranges of each species or group of species. The mitigation strategy is intended to:

- identify and protect important habitats;
- provide a range of age classes within each covertype in particular to maintain habitat features of old and old growth forests;
- maintain patches of forest in areas of mixed land use;
- provide a landscape with connections necessary for movement of animals among separated populations;
- modifications to harvesting practices to maintain within cutovers some of the key habitat needs for animals dependent on features of mature forests; and
- distribute logging slash to provide cover for small animals in clearcuts.

The following discusses each element of the proposed mitigation strategy and assesses the overall effectiveness and feasibility of the strategy.

Complete the MNDNR county biological survey: The information from the survey is essential to identify important habitats for forest dependent species. Earlier comments on the importance of the rate of harvesting and its relation to the speed of the survey also apply here.

Conduct an inventory of old growth forests across all ownerships. This information is important to identify habitat for species dependent on old growth forests.

Develop blocks of ERF: Would promote additional diversity of covertype condition and would provide habitat for species dependent on mature/older forest. ERF policies are likely to be confined to the major public ownerships.

ERF and riparian corridors would maintain many opportunities for movement of animals between separated populations.

Maintain patches of forest intact in areas of mixed land use: By reducing use of clearcutting silvicultural systems, linking patches, and augmenting existing patches of forest. This mitigation strategy incorporates aspects of mitigations including management of riparian corridors and use of uneven-aged silvicultural systems in those patches that are harvested. Large (>300 acre) blocks of mature forest will likely have to be retained with limited disturbance to maintain populations of the most sensitive species, especially the Red-Shouldered Hawk.

Modify silvicultural systems to maintain key habitat components: Such as use of uneven-aged and thinning systems as substitutes for clearcutting where appropriate, i.e., in certain covertypes that can be managed using these systems.

Redistribute slash across the cutover: Would maintain cover for small mammals in cutovers following clearcutting.

Effectiveness: Maintenance of key habitat requirements and slash spreading would likely be moderately effective at maintaining habitat for adversely impacted species in those covertypes harvested using clearcutting systems. Mitigations that substitute uneven-aged silvicultural systems for clearcutting will likely be effective at maintaining suitable habitat conditions for species dependent on elements of mature forests, but would likely provide moderate to low levels of mitigation for species dependent on forest interior conditions and limited disturbance.

ERF, old growth, and connected landscapes would provide habitat for species dependent on old forest and forest interior species. The focus of these mitigations is likely to be in the northern half of the state because of the pattern of ownership. These mitigations are less likely in the south because of predominantly NIPF ownership. Maintenance of large patches of unharvested forest in these areas will likely be moderately effective at maintaining populations of forest interior species present in the south.

Feasibility: Modifications to maintain key habitat features are widely practiced on lands by the major public ownerships and are being introduced by some counties. Introduction of these mitigations to NIPF and industrial lands will likely be dependent on the costs associated with their adoption, the owner's awareness of the need for these mitigations, and the willingness of loggers to implement the mitigations at an operational level.

Replacement of clearcutting with uneven-aged silviculture systems is actively being undertaken by the major public landowners as part of their ERF programs. In addition, these systems are likely to be used on NIPF lands in the south of the state. This is because the covertypes and range of products sought in the south are more suited to these systems.

ERF and old growth are likely to be feasible on public lands in the northern part of the state. These measures are consistent with the mandate given these ownerships. The feasibility of maintaining large blocks of forest in the south is less likely because of the problems associated with coordinating uniform management with more than one owner as were discussed previously.

Similarly, connecting corridors of ERF would be more feasible in the north, where there are large contiguous blocks of public ownership. Given that a sizable portion of the landscape is going to be managed as ERF anyway, the cost of ERF corridors might be modest, since corridors might simply be a different spatial arrangement of ERF—some of it in strips instead of all in blocks. ERF corridors would likely be infeasible in the south, due in large part to the high cost of purchasing easements across private lands in areas that are intensively farmed. As a consequence, riparian corridors will probably always provide the major habitat linkages in the southern part of Minnesota.

The overall strategy is likely to be moderately successful at mitigating impacts on those species projected to be significantly impacted. The need for it increases under the medium scenario as compared to the base harvest level.

12 Impact
Projected harvesting affecting populations of the Red-Shouldered Hawk
This was the only animal species listed as a federal or state species of special concern, threatened, or endangered. This species is projected to be significantly impacted because of harvesting in larger patches of forest.

The strategies discussed under impact 11 which seek to mitigate impacts on all significantly impacted wildlife populations includes all the elements likely to benefit this species.

13 Impact
Projected harvesting affecting patterns of mature lowland conifer stands
Patches of mature lowland conifers are important habitat, particularly in those parts of the state where lowland conifers occur as small isolated patches within more extensive upland forests. The strategy is intended to maintain such stands as an ongoing part of the landscape. The substantial increases in the volumes of lowland conifers projected to be harvested under the medium scenario will likely increase the need for this mitigation. The following describes the proposed elements of this strategy.

Retention of conifer patches in clearcut stands: Is part of existing federal and state management guidelines. This mitigation would require that these patches be excluded from harvests on other ownerships that are primarily directed at obtaining upland species.

Effectiveness: If applied, the mitigation would maintain these habitat elements within cutovers in predominantly upland stands.

Feasibility: The mitigation is straightforward and could be easily applied at an operational level. The major public ownerships already undertake elements of this mitigation in their current management strategy guidelines, particularly for deer management. It is less likely that NIPF and industrial owners will adhere to these guidelines because the retention of conifers could present a real cost. The level of compliance will likely reflect the value of the species retained.

14 Impact
Projected harvesting affecting the availability of food producing trees
The loss of food producing trees such as oak and hickory were projected to impact species such as the gray and fox squirrels that rely on mature oaks to provide food and shelter (cavities). The following mitigations make up the strategy directed at maintaining these habitat features.

Clearcutting with residuals: Will retain mature food producing trees in those covertypes that include such trees as part of the species mix. This mitigation would favor retention of trees such as oak, hickory, mountain ash, and cherry. Federal and state management guidelines favor retention of these trees on the major public timberlands.

Effectiveness: This mitigation would preferentially maintain these important habitat elements in areas subjected to clearcutting. Retention of these trees would be moderately effective in sustaining populations of animals dependent on food from these trees.

Feasibility: The feasibility of this mitigation is dependent on ownership. The state and federal lands are likely to forgo the revenues possible from sale of these trees (especially oak). In contrast, the mitigation is less likely to be feasible on NIPF and industry owned lands and on many county managed lands as these owners are less likely to forgo the revenues. In addition, operations on these lands are less likely to be planned to maintain these habitat features prior to harvesting.

15 Impact
Projected harvesting in the absence of VMGs on visually sensitive areas
Timber harvesting and forest management activities that occur within the visual catchment of resorts or other outdoor recreation facilities are projected to cause significant impacts on aesthetic values where VMGs are not used. The mitigation strategy is aimed at developing (1) VMGs that can be applied as a minimum standard for all timberlands, and (2) coordinated planning of future road and trail development and closures.

Develop landscape-based road and trail plan: This would provide opportunities for a broad audience to learn about and affect the visual aspects of forest settings.

Development and promotion of VMGs for use on all timberlands: This would reduce the level of visual impact likely to occur as a consequence of harvesting related activities on ownerships that do not use VMGs.

Effectiveness: This strategy would provide a moderate level of effectiveness at reducing the likelihood of conflicts between the forest products industry and the tourism/recreation resort industry.

Feasibility: There is already some dialogue between resort owners and timber producers regarding timber harvesting, travel corridors, and the visual catchment of resorts. A variety of options are available that range from a cooperative agreement with the landowner to limit logging and/or to use VMGs if logged to purchase of visual easements.

16 Impact
Projected development of permanent roads in primitive and semiprimitive nonmotorized areas
Harvesting is projected to result in the development of permanent roads in primitive and semiprimitive nonmotorized areas. Doing so affects these sites by changing the recreational opportunities present and restoration to the original opportunities is by definition not possible. The problem is intensified by increased harvesting in the medium scenario as compared to the base scenario.

Develop landscape-based road and trail plan: This would improve the chances for minimizing roads and trails that would change recreational opportunities on the more primitive sites and ensure that a variety of recreation opportunities are maintained across ownerships.

Develop guidelines for management road construction: Would provide for protection of recreational values and use in primitive and semiprimitive nonmotorized areas which are managed for timber production.

Effectiveness: In addition to the above noted benefits of road and trail planning for resort operators, such plans would provide the overview needed to develop an understanding of where primitive and semiprimitive nonmotorized recreational opportunities exist and might exist in the future. Coordination between ownerships is important to the success of this planning. Use of nonpermanent roads and VMGs can reduce the degree and period over which impacts persist.

Feasibility: These alternatives are potentially feasible subject to cooperation of the major timberland ownerships. However, this will require leadership by the MNDNR as the most appropriate agency to initiate and oversee the planning, development of nonpermanent road guidelines, and their implementation. This planning and the development and implementation of guidelines would have long-term benefits.

17 Impact
Projected harvesting affecting unique cultural and historical resources
Harvesting is projected to significantly impact a range of archaeological, cemetery, and traditional use sites used by contemporary Native Americans.

Provide adequate resources to maintain the state listing of known sites: This would allow the state archaeologist to discharge current responsibilities to maintain an important reference describing the occurrences of sites in the state; and to provide a leadership role in developing a better understanding of the state's heritage resources. This mitigation is not linked to timber harvesting but extends to all land uses that involve soil disturbance.

Increase the proportion of harvests undertaken during winter: Reducing soil compaction by changing the season of harvest for susceptible soil types will likely mitigate some impacts as frozen soil will not experience the levels of compaction that would occur during other seasons.

Development of a landscape-based road and trail plan : This would provide opportunities for traditional users to comment on roading issues during the planning phase. This could help avoid conflicts.

Effectiveness: This strategy would provide a low level of effectiveness at mitigating the significant impacts projected to occur.

Feasibility: The feasibility of these mitigations is likely to be relatively low, due to the low priority given these resources by the majority of ownerships.

6.7.4
Cumulative Unmitigated Significant Impacts

The mitigation strategies described in the previous section will likely mitigate many of the significant impacts projected to occur under the medium level of harvesting. This section identifies the cumulative unmitigated impacts that are likely to remain despite implementation of the mitigation strategies.

Loss of Forest Area and Timberlands
There is a strong likelihood that the area of forest in the north of the state will continue to decline. The area of timberlands will continue to decline as a consequence of the loss of forest area and the increased area of forest

managed primarily for nontimber values. These reductions will constrain wood supply at the medium level of harvesting. Increasing the productivity of the acres that remain available for harvest is achievable and could offset any losses of acreage over the long-term.

Changes to Age Class and Covertype Structure

The levels of harvesting projected to occur under the medium level of harvesting will improve the balance in the age class distributions for several of the less frequently harvested species and/or covertypes. The shift will be towards younger age classes. However, aging, the comparatively modest levels of harvesting projected, and the maturing of forests in areas where harvesting is constrained or prohibited will lead to more acreage of old forest under this scenario than exist at the present time.

Changes to the paper birch covertype were assessed as being the only significant impact under the relevant age class criterion. However, there is a projected increase in the aspen covertype acreage at the apparent expense of conifer covertypes, particularly black spruce, jack pine, and balsam fir. These losses would be mitigated only by natural succession to conifer covertypes, retention of conifers in harvested stands, and regeneration of harvested aspen stands by planting or other practices to conifers on a large-scale. This situation argues for statewide covertype goals and practices to achieve them over the long-term.

Incidence of Pests and Diseases

The likely increase in the vulnerability and susceptibility of some covertypes to impacts from pests and disease is closely linked to the age class changes discussed above. Despite the effectiveness of an IPM plan, some impacts cannot be mitigated for the reasons set out above. The incidence of losses to pests and disease will likely lessen under the medium scenario as compared to the base scenario via the broad-scale movement to younger overall age class distributions.

Impacts on Biodiversity

The lack of knowledge concerning the distributions and specific populations of endangered, threatened, and special concern species will likely lead to ongoing localized impacts on these species as a consequence of timber harvesting operations. In the absence of this data, impacts on these categories of plants will continue and likely increase over the base scenario.

Populations of the Red-shouldered Hawk will likely be maintained under the proposed mitigations, although there is some uncertainty due to inadequate knowledge of the precise habitat requirements of this species.

Impacts on Forest Soils
Losses of nutrient capital will occur on greater acreage under the medium as compared to the base scenario and more acres will be compacted and experience accelerated rates of erosion. This increases the importance of mitigation strategies to treat these impacts.

Erosion from roads and other compacted areas will continue and likely increase under the medium scenario as compared to the base level of harvesting. Improved road design, construction, maintenance, and consistent road closure policies will also become more important practices. Increased erosion can have subsequent impacts on water quality, though mitigations appear to treat that adequately.

Impacts on Archaeological and Historical Resources
Uncertainty regarding the locations of these resources and their vulnerability to damage means that impacts will continue except on timberlands owned by the USDA Forest Service and on the comparatively high proportion of other lands where operations are conducted when the ground is frozen.

Impacts on Traditional Use Sites
Improved liaison between forest managers and Native American groups regarding future roading plans will likely reduce the incidence but is unlikely to eliminate impacts on these uses. The medium scenario will increase the importance of this liaison.

Loss of Primitive and Semiprimitive Nonmotorized Recreation Opportunities
Roading in these areas will likely reduce the areas of primitive and semiprimitive nonmotorized recreational experiences that are potentially available in the state. The consequences of this loss cannot be accurately gauged because the amount of use within these areas and the number of users affected is not known. Use of VMGs and the development of a coordinated road and trail plan will become imperative under the medium scenario.

Impacts on Motorized Recreational Uses
Harvesting in visually sensitive areas without VMGs will adversely impact existing users of these sites. The maturing of many areas of forest, including formerly harvested areas, will likely provide new or replacement opportunities for these recreational activities. However, population growth and increased harvesting will exacerbate the problems of providing for this use.

Impacts on the Tourism and Travel Industries
The lack of information on relationships between the level of harvest and its consequences for the tourism industry means the likelihood of unmitigated impacts cannot be quantified. However, it is likely that individual resort

operations will be more adversely impacted by visually obtrusive harvesting operations within their viewshed or along access routes under the medium scenario as compared to the base level of harvesting. Use of VMGs will likely reduce the area adversely impacted and duration of impacts and will become imperative under the medium scenario.

6.8 Conclusions

The GEIS analyses have been based, in part, on a comprehensive modelling exercise and a wide array of necessary assumptions. As such, results must be kept in perspective: current estimates utilizing the best available information, techniques, and assumptions. With this as a backdrop, the harvesting projected to occur at the medium level (4.9 million cords) appears sustainable. Practically, this also assumes that the site-specific or other mitigations below the modelled level of resolution are implemented and do mitigate otherwise significant impacts. This is essential to ensure that other forest characteristics such as soil productivity, water quality, wildlife habitat, and aesthetic values are truly maintained. The following paragraphs discuss the degree of certainty in these conclusions and implications.

The medium scenario will bring changes to the forest beyond those of the base scenario; however, the process and consequences of the natural forest aging will remain very important.

Localized impacts will continue and increase, even with the introduction of proposed mitigations. These impacts will be most evident on NIPF lands as a consequence of likely lower standards of planning and supervision of field operations compared to large ownerships with professional staffing. However, the mitigations proposed would reduce the likelihood of significant impacts that might degrade the long-term sustainability of the state's forest resources. The only exception is the projected reductions in the nutrient capital of some low productivity sites. These reductions will need to be carefully monitored. The relationship between changes in nutrient capital and changes in site productivity also needs to be closely observed.

The medium level of harvesting still offers some flexibility to meet timber supply demands while making provision for nontimber values. However, the increased pressure on the resource from many interests means that investments to increase productivity of timberlands become more significant when viewed at a statewide level. These investments can increase the productivity of stands thereby allowing more area to be used for other activities. However, such investment is a long-term strategy that must consider nontimber values in execution.

As with the base scenario, there will likely be constraints in the supplies of aspen during the middle of the modelled period. The base scenario projections assumed that 25 percent of the demand for this species would be transferred to the northern hardwood species. Current industry expansion proposals emphasize the need for this shift. However, that shift cannot be sustained indefinitely. Widening the range of acceptable species to more closely reflect the mixed species stands found in Minnesota increases management flexibility and possibly reduces the area that has to be harvested by reducing the amount of potentially usable wood fiber left on harvested sites.

The proposed mitigations will require a leadership role to oversee their development and application. At present, there is no agency with the authority for such responsibility extending across ownerships to discharge these responsibilities. In addition, the current diverse ownership patterns and associated objectives means that there are no broad-based direction or goals for a future forest condition being set within the state. Direction and goal setting clearly becomes very important with the medium level harvest scenario.

Future forest industry developments should be directed towards addressing the unbalanced or wanting age class and covertype structure that have been identified in this analysis. The assumed timber demand used to prepare the medium scenario provides some guidance for possible species mixes for forest industries that could address these age class distribution concerns.

7
STATEWIDE IMPLICATIONS: 7 MILLION CORD ANNUAL HARVEST

This section of the study describes the modelling assumptions used, and the outputs from the highest level of harvesting modelled which is termed the *high* level of harvest. This scenario was developed specifically in response to the FSD requirement to assess the consequences of a level of harvest that approximated the estimated maximum annual volume of timber production. This level was intended to provide an upper bound to the analysis and accordingly should not be viewed as a viable option or *target* being considered for a future level of forest industry development.

As with the previous two sections, this section is intended to provide an understanding of what was harvested and why; what effects this had on the forests and their associated resources and values as defined in the FSD issues of concern; and lastly, what mitigations should be used to ameliorate the significant adverse impacts that result from this level of timber harvesting and forest management activity.

A substantial amount of additional background information was provided in section 5 (base level scenario) which is not repeated in this section. The *changes to the levels and types* of impacts projected to occur at the high level of harvesting are contrasted with those discussed under the base and medium levels of timber harvesting and forest management activities.

This section draws heavily on information and analyses presented in the GEIS technical and background papers. The papers set out in greater detail the methodology used and also identify the limitations of the methodology and the data used to undertake the analyses.

7.1
Description of Harvesting Activities

7.1.1
Underlying Assumptions

The high scenario differs from the base and medium scenarios because it is *supply driven* not *demand driven*. The surplus volumes by species and location at the end of the medium scenario were used to identify opportunities for new industries to be developed to make use of these resources. These opportunities may not represent prudent investments and these developments should not be construed as suggesting that such developments are feasible in any sense other than certain volumes of resources might be available.

To achieve the high scenario harvest level, the existing USDA Forest Service ASQ constraints that were used in modelling the base and medium scenarios had to be relaxed. Also, the base and medium scenario assumptions regarding the shift of 25 percent of the aspen demand to other hardwoods was required (see section 5.1.1). Table 7.1 describes the assumed roundwood consumption levels by species group and market for all scenarios.

7.1.2
Covertypes and Species Harvested

Table 7.2 summarizes the output from all scenarios that describes the total acres, acres uncut, acres clearcut once in 50 years, acres clearcut twice, acres thinned but never clearcut, acres thinned and clearcut for both the southern and the northern study regions, and the state as a whole. These data indicate that approximately 10.5 million acres of timberland would be harvested under the high scenario over the next 50 years. Conversely, adding the area of productive land *not cut* to the productive land *not considered* in the scheduling model, shows that a total of 4.3 million acres of timberland *would not* be harvested over this same period under this scenario. In addition, the 1.9 million acres of reserved and unproductive forest acreage (not included in table 7.2) would not be disturbed by harvesting. This means that under the high scenario 10.5 million acres would experience some form of harvesting and 6.2 million acres would not be harvested over the 50-year study period. By comparison, the corresponding values for the medium scenario are 8.6 and 8.4 million acres; while those for the base scenario are 7.2 and 9.5 million acres.

Table 7.3 shows the acreage harvested and not harvested by covertype under the high scenario. Much of the harvesting activity is concentrated in the aspen and other hardwood covertypes in the medium and high scenarios. However, the high scenario shows a trend towards increases in the area harvested for nearly all covertypes.

Notable increases in acres harvested by covertype for the high versus the medium scenario included: Jack pine (182,600); black spruce (123,000); balsam fir (123,500); tamarack (188,600); oak-hickory (102,800); elm-ash-soft maple (202,200); maple basswood (310,800); and paper birch (206,600).

Breakdown of Harvest Volumes by Product Group
Table 7.4 summarizes the scheduled harvests for products within each group for the northern and southern regions of the state.

Table 7.1. Comparison of assumed roundwood consumption levels by species group and market for the three harvest scenarios (thousands of cords per year).

Species Group / Market	Period 1 (1990 - 1999)			Period 2 (2000-2009)			Periods 3-6 (2010-2049)		
	Base	Medium	High	Base	Medium	High	Base	Medium	High
Aspen									
Bemidji	572	572	572	522	522	522	435	435	450
Brainerd	256	256	256	260.1	287.1	287.1	216.75	239.25	300
Cook	210	210	210	182.7	182.7	182.7	152.25	152.25	300
Duluth	506	532	532	454.5	531	531	378.75	442.5	450
Grand Rapids	433	433	433	390.6	467.1	467.1	325.5	389.25	400
I. Falls	415	415	415	412.2	412.2	412.2	343.5	343.5	400
subtotal	2,392	2,418	2,418	2,222.1	2,402.1	2,402.1	1,851.75	2,001.75	2,300
Spruce-fir									
Brainerd	70	70	70	70	100	100	70	100	150
Duluth	220.5	220.5	220.5	219.5	379.5	379.5	219.5	379.5	400
Grand Rapids	115.5	115.5	115.5	118.5	163.5	163.5	118.5	163.5	300
subtotal	406	406	406	408	643	643	408	643	850
Pine									
Bemidji	159	159	159	188	188	188	188	188	370
Duluth	151	171	171	153	218	218	153	218	370
I. Falls	111	111	111	98	98	98	98	98	260
subtotal	421	441	441	439	504	504	439	504	1,000
Northern Hdwds									
Bemidji	83	83	83	147	147	147	234	234	400
Brainerd	190	190	190	226.9	229.9	229.9	270.25	277.75	600
Cook	51	51	51	79.3	79.3	79.3	109.75	109.75	250
Duluth	93	171	171	145.5	414	414	221.25	502.5	550
Grand Rapids	61	61	61	112.4	120.9	120.9	177.5	198.75	400
I. Falls	48	48	48	94.8	94.8	94.8	163.5	163.5	250
subtotal	526	604	604	805.9	1,085.9	1,085.9	1,176.25	1,486.25	2,450
Total, North	3,745	3,869	3,869	3,875	4,635	4,635	3,875	4,635	6,600
Southern Region									
Red oak sawlogs	50	50	50	50	65	70	50	65	70
Other wood	250	250	250	250	300	330	250	300	330
Total, South	300	300	300	300	365	400	300	365	400
Total, Statewide	4,045	4,169	4,169	4,175	5,000	5,035	4,175	5,000	7,000

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 7.2. Summary of original timberland acres clearcut and/or thinned for three timber harvesting scenarios, 1990–2040.

Action Category*		Base Scenario			Medium Scenario			High Scenario		
		North	South	Total	North	South	Total	North	South	Total
1	Total Timberland			14,773,400			14,773,400			14,773,400
2	Not Considered			1,356,500			1,356,500			1,356,500
3	Considered	12,409,900	1,007,000	13,416,900	12,409,900	1,007,000	13,416,900	12,409,900	1,007,000	13,416,900
4	Not cut	5,591,300	652,200	6,243,500	4,217,100	582,800	4,799,900	2,416,600	535,100	2,951,700
5	Clearcut once	5,775,300	320,700	6,096,000	6,931,200	376,900	7,308,100	8,182,900	408,800	8,591,700
6	Clearcut twice	846,000	0	846,000	970,200	0	970,200	1,353,000	0	1,353,000
7	Thinned but not clearcut	197,300	34,100	231,400	291,400	47,300	338,700	457,400	63,100	520,500
8	Thinned and clearcut	2,100	19,900	22,000	7,300	37,400	44,700	17,700	46,500	64,200
9	Total not cut, sum (2+4)			7,600,000			6,516,400			4,308,200
10	Total cut, sum (5-7)			7,173,400			8,617,000			10,465,200

Source: Jaakko Pöyry Consulting, Inc. (1992a).

**Not considered* are those plots representing young stands, old growth or areas assumed not available and therefore not considered for harvest in the period 1990-2040. *Considered* are those plots representing stands that are available and in terms of age, etc., feasible to consider for harvest during the 50-year study period. Action category 8, thinned and clearcut, is included in the clearcut once category.

Table 7.3. Projected timberland acres harvested and not harvested by initial FIA covertype under the high scenario (1990-2040).

Forest Type	Clearcut Once	Clearcut Twice	Thinned	Total Acres Harvested	Total Acres	Acres Never Harvested	Harvest Acres as % of Total Acres	Harvest Acres as % of Total Harvest	Forest Type Acres as % of Acres
High Scenario									
Jack pine	337,100	18,300	11,100	366,500	446,600	80,100	82.1	3.5	3.0
Red pine	218,900	23,800	17,000	259,700	354,700	95,000	73.2	2.5	2.4
White pine	43,100	5,500	0	48,600	68,600	20,000	70.8	0.5	0.5
Black spruce	748,600	39,700	50,100	838,400	1,349,900	511,500	62.1	8.0	9.1
Balsam fir	556,900	60,500	47,100	664,500	809,200	144,700	82.1	6.3	5.5
Northern white cedar	101,800	13,400	7,600	122,800	648,400	525,600	18.9	1.2	4.4
Tamarack	298,400	0	9,100	307,500	719,400	411,900	42.7	2.9	4.9
White spruce	46,900	1,700	2,900	51,500	91,700	40,200	56.2	0.5	0.6
Oak-Hickory	622,900	0	53,900	676,800	1,124,700	447,900	60.2	6.5	7.6
Elm-Ash-Soft maple	550,900	2,300	60,200	613,400	1,124,600	511,200	54.5	5.9	7.6
Maple-Basswood	772,800	700	66,100	839,600	1,470,200	630,600	57.1	8.0	10.0
Aspen	3,382,000	1,038,300	144,600	4,564,900	5,242,200	677,300	87.1	43.6	35.5
Paper birch	638,800	18,400	29,200	686,400	819,000	132,600	83.8	6.6	5.5
Balsam poplar	272,600	130,400	21,600	424,600	504,200	79,600	84.2	4.1	3.4
Total	8,591,700	1,353,000	520,500	10,465,200	14,773,400	4,308,200	70.8	100.0	100.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 7.4. Scheduling model harvest summary for the northern region under the high scenario, (thousands of cords per year).

Product Group	Component	Period 1990-99	2000-09	2010-19	2020-29	2030-39	2040-49
a) Northern Region							
Aspen	Aspen pulp	1,277.1	1,344.9	1,441.3	1,665.5	1,653.7	1,639.9
	Aspen saw	1,120.9	1,043.1	816.4	578.0	611.8	635.4
	Total	2,398	2,387.8	2,257.9	2,243.4	2,265.6	2,275.2
	Target	2,418	2,402.1	2,300	2,300	2,300	2,300
Spruce-fir	S-fir pulp	247.4	345	399.9	373.1	399.8	352
	S-fir saw	160.3	301.6	443	474.8	441.5	474.7
	Total	407.6	646.4	842.8	847.9	841.3	826.7
	Target	406	643	850	850	850	850
Pine	Pine pulp	92.4	130.9	239.5	245.2	286.4	394.4
	R&W saw	281.5	233.5	487.2	512.2	466.1	218.9
	Other saw	65.7	140.1	265.8	236.3	219.5	360.7
	Total	439.6	504.6	992.5	993.7	971.9	974.1
	Target	441	504	1,000	1,000	1,000	1,000
N. Hardwoods	Pulp	453	761.3	1,498.5	1,412.3	1,371.1	1,338.1
	R Oak saw	43.8	59.7	257.9	172.6	80.5	46.4
	Other saw	108.9	266	647.8	776	875.8	884.2
	Total	605.6	1,087.1	2,404.1	2,360.8	2,327.3	2,268.8
	Target	604	1,085.9	2,450	2,450	2,450	2,450
All Groups	Total	3,850.8	4,625.9	6,497.3	6,445.8	6,406.1	6,344.8
	Target	3,869	4,635	6,650	6,600	6,600	6,600
b) Southern Region							
Red oak	Sawlogs	49.9	70.6	68.5	71.6	66.7	70.8
	Target	50	70	70	70	70	70
Other wood	Various	249.6	330.5	328.8	334.8	329.8	333.8
	Target	250	330	330	330	330	330
All Groups	Total	299.5	401.1	397.3	406.6	396.5	404.6
	Target	300	400	400	400	400	400

Source: Jaakko Pöyry Consulting, Inc. (1992a).

7.1.3
Harvesting by Ownership

As discussed in section 2.3.1 the second model runs assumed that allocation of timberlands to be harvested was constrained by assumed levels of availability by ownership category. These constraints reflect agency existing and prospective policies and land management practices as well as past trends in availability for ownerships with no articulated policies. Table 7.5 shows the total area harvested from timberlands on each ownership under the three scenarios.

The projected harvesting activities by ownership must be considered in the context that the GEIS is not a *planning* document and that the harvesting scenarios are not meant to predict that specific stands will or will not be harvested. The scenarios were developed as a tool to determine how much of the forest would have to be harvested statewide to meet the supply target specified in the FSD. In this case, 7 million cords per year. The emphasis is on *statewide*, as this is the level of analysis that the GEIS is directed toward.

The data in table 7.5 shows that with the ASQ constraints removed, the two national forests assumed far larger roles in meeting timber demand than under either of the two earlier scenarios. In percentage terms, the proportion of the harvest taken from the national forests more than doubled under the high scenario when compared with the medium scenario. In acreage terms, the area harvested was approximately tripled. The area harvested on the other ownerships also increased significantly, but dropped in percentage terms reflecting the increased level of harvesting on the national forests.

7.1.4 Spatial Distribution

Table 7.6 describes the level of harvesting by ecoregion for all scenarios. Figure 7.1 shows the plots harvested during the first ten-year period, and figure 7.2 shows the total number of plots harvested under the high scenario. Comparison of the output from all three scenarios shows that the largest increases are projected to occur in ecoregion 4. In that ecoregion, an additional 889,600 acres are projected to be cut under the high scenario when compared with the medium scenario. In contrast, the jump from base to high scenarios in ecoregion 4 was close to 1.7 million acres. Notable increases between the medium and high scenarios for the other ecoregions include increases of 214,600 acres in ecoregion 1, nearly 335,200 in ecoregion 2, an increase of 188,800 in ecoregion 3 and up by 144,700 in ecoregion 5.

Table 7.5. Original acres harvested by ownership by scenario, second runs, 1990-2040.

	Scenario						Timberland	
	Base		Medium		High			
Ownership	Acres Harvested	Percent	Acres Harvested	Percent	Acres Harvested	Percent	Total Acres	Percent
Chippewa National Forest	160,200	2.23	170,200	1.98	451,800	4.32	567,200	3.84
Superior National Forest	349,500	4.87	352,100	4.09	991,000	9.47	1,253,900	8.49
Miscellaneous federal	53,700	0.75	62,900	0.73	82,800	0.79	197,700	1.34
Native American	171,200	2.39	193,800	2.25	234,500	2.24	490,600	3.32
State	1,296,900	18.08	1,741,400	20.21	1,958,400	18.71	3,077,900	20.83
County and municipal	1,612,800	22.48	1,924,700	22.34	2,057,800	19.66	2,505,600	16.96
Forestry industry	451,400	6.29	561,200	6.51	597,900	5.71	751,300	5.09
Other private	3,077,700	42.90	3,610,700	41.90	4,091,000	39.09	5,929,200	40.13
Total	7,173,400	100.00	8,617,000	100.00	10,465,200	100.00	14,773,400	100.00

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 7.6. Original forest acreage and timberland acres cut and not cut by ecoregion and scenario, 1990-2040.

	Ecoregion							Total
	1	2	3	4	5	6	7	
Total forest land acres	3,372,000	2,023,700	903,000	8,172,900	934,700	637,200	666,300	16,714,800
Reserve/unproductive	509,600	973,900	36,300	359,800	24,400	17,300	20,100	1,941,400
Timberland acres (1-2)	2,862,400	1,049,800	871,700	7,813,100	910,300	619,900	646,200	14,773,400
Acres not cut, base	1,566,000	619,200	546,900	3,447,300	629,200	408,200	378,200	7,600,000
Acres cut, base	1,296,400	430,600	319,800	4,365,800	281,100	211,700	268,000	7,173,400
Acres not cut, medium	1,207,500	566,800	413,100	2,668,600	567,800	364,400	363,200	6,156,400
Acres cut, medium	1,654,900	483,000	453,600	5,144,500	342,500	255,500	283,000	8,617,000
Acres not cut, high	992,900	231,600	224,300	1,779,000	423,100	330,700	321,600	4,308,200
Acres cut, high	1,869,500	818,200	642,400	6,034,100	487,200	289,200	324,600	10,465,200

Source: Jaakko Pöyry Consulting, Inc. (1992a).

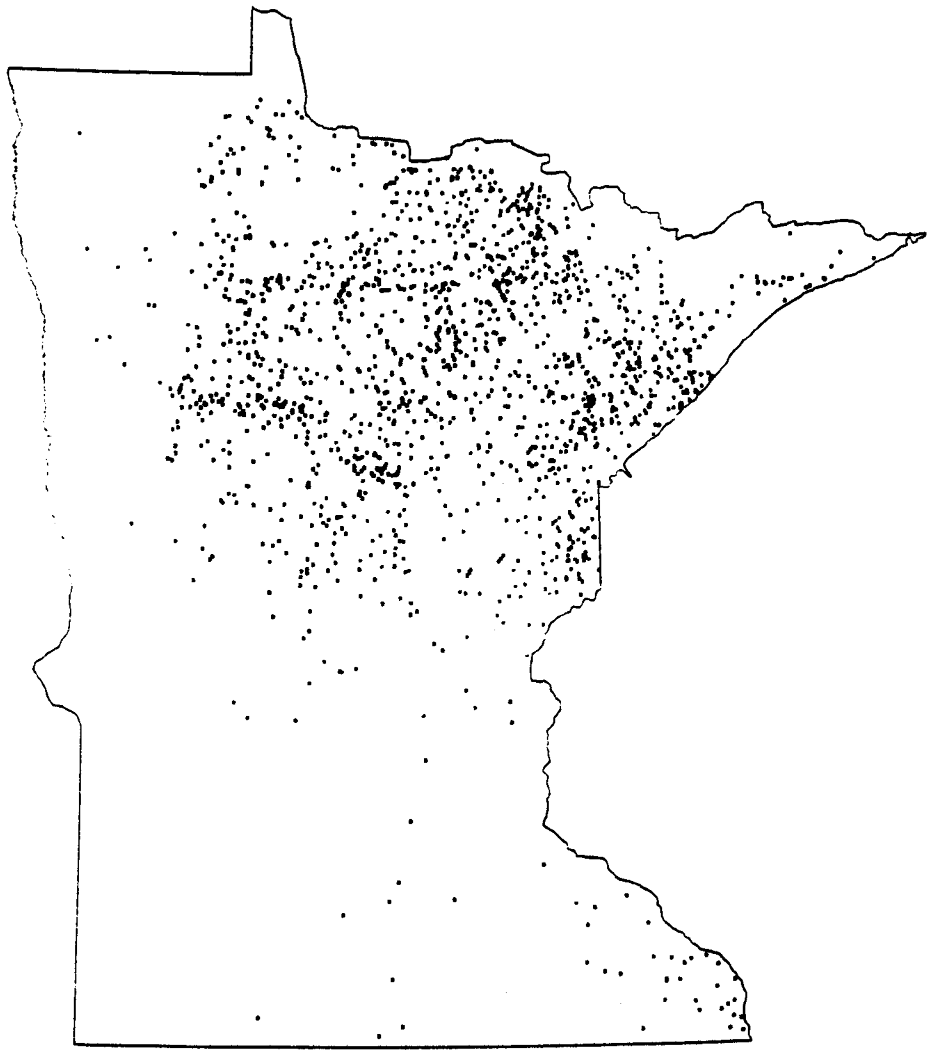

Figure 7.1. Location of high scenario harvested plots for 1990-2000.

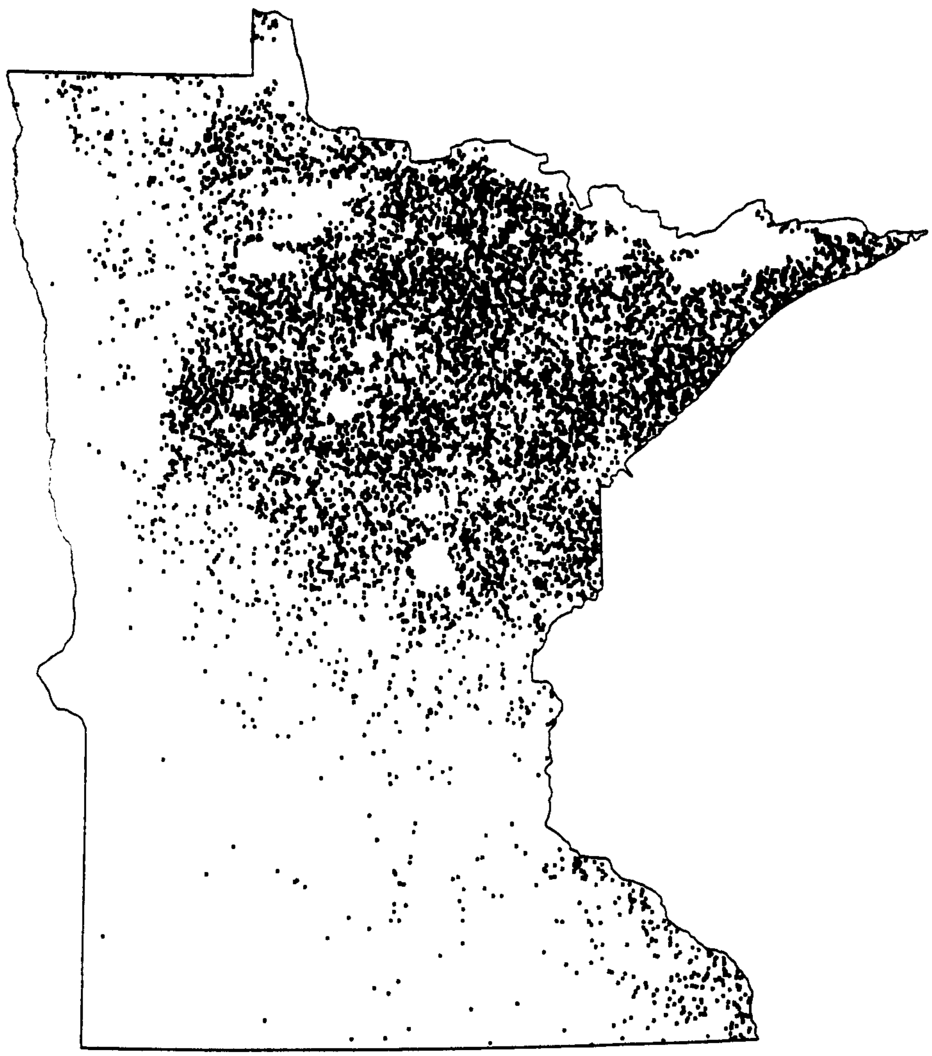

Figure 7.2. Location of all high scenario harvested plots, 1990-2040.

The increased harvests on national forests accounts for the large increases seen in ecoregions 2 and 4. Other increases can be explained by a move into less productive covertypes that were not economically attractive under the demand levels specified in the base and medium scenarios.

7.1.5 Temporal Distribution

The patterns describing the distribution of harvesting activities across the state under the high scenario showed distinguishable differences from those projected to occur under the base and medium scenarios. The main differences were an increasing intensity of harvesting within the national forest lands. However, harvesting activities were still spread across the state. As discussed in section 5.1.5, the well-developed road transport network makes most timberland accessible for harvesting.

7.1.6 Relationship to Long-term Sustainable Timber Removal

Based on a long-term sustained yield analyses similar to the techniques used by the MNDNR (see section 5.1.6 for details of methodology), virtually all timberlands would be required to yield a level of harvest that still falls over 1.5 million cords below the targeted 7 million cords level. This indicates that the 7 million cord level is not sustainable in the long-term unless there are significant increases in the levels of investment in forest management.

These results suggest that an annual harvest level of 5.5 million cords is the maximum that could be sustained. However, as described in section 5.1.6, this conclusion is subject to several important assumptions.

The high level of harvest is still below the estimated maximum level of tree and forest growth potential. However, harvest levels above 5.5 million cords appear sustainable only if (1) the loss of forest land projected in the north is halted, (2) substantial investments in forest management are made to improve productivity, and (3) such investment includes the site specific and other mitigations needed to mitigate otherwise significant impacts. Also, such harvest levels would probably also require continued relaxation of the U.S. Forest Service allowable sale quantities on the two national forests in Minnesota (as was assumed for the high scenario).

7.2 Characterization of Future Forest Resource Conditions

Forests, as with any living entity, change over time irrespective of human intervention. In addition to these natural changes, human activities such as harvesting can also change the forests. The GEIS has been structured to identify the key characteristics that are likely to change; to project the extent of these changes under the three levels of harvesting; and to examine the implications of such changes for the identified issues of concern.

This section describes the projected changes to these key characteristics that occur as a consequence of harvesting at the 7.0 million cord level, as well as those associated with the background levels of change that would occur over a 50-year period. The characteristics discussed include age class, acres under different covertypes, abundance and diversity of tree species within covertypes, and structural changes in the patterns of forest cover.

7.2.1 Forest Area and Covertype Abundance

Forest Area
These data were independent of harvest level and therefore, the discussion in section 5.2.1 is also relevant to the high scenario.

Covertype Acreages
Table 7.7 describes the projected covertype acreages for timberland, reserved, and unproductive forest land. Table 7.8 compares the base, medium, and high scenarios. The key projected changes for timberlands as a consequence of the level of harvesting projected under the three scenarios are:

- The jack pine type continues to decline in acreage, due to both succession to other types and with increased harvesting (from 307,400 for the medium scenario to 272,600 acres for timberland in the high scenario).
- The red pine covertype on timberland increases by approximately 80,000 acres, but the increase is less than for the medium scenario. The increase appears due more to retention of that long-lived species and succession than to planting or natural regeneration.
- The white pine covertype on timberland declines from the acreage under the base and medium scenarios.
- The acreage in the black spruce covertype declined from 1990 to 2040 with subsequent gains to the tamarack and aspen covertype acreages. However, the timberland acreage increased slightly in the high scenario as compared to the medium scenario.
- The balsam fir acreage for timberland declined from 1990 to 2040 from 1,012,500 to less than 600,000 acres under the high scenario. The aspen covertype appears to be a major recipient of that acreage.
- The northern white cedar type acreage appears to increase slightly over the study period and across the harvest scenarios.
- The acreage of tamarack appears to increase slightly over the study period for the medium and high harvest scenarios.
- The white spruce covertype acreage decreases as harvesting level increases, however, it is higher than that for 1990 for all harvest scenarios.

Table 7.7. Forest type acreage (as determined by GEIS covertype algorithm) for timberland, reserved, and unproductive plots under the high scenario, 1990 and projected 2040, statewide (thousand acres).

Forest Type	1990				2040			
	Timberland	Reserved	Unproductive	Total	Timberland High Scenario	Reserved	Unproductive	Total High Scenario
Jack pine	487.1	125.9	1.2	614.2	272.6	56.2	1.2	330.0
Red pine	350.6	78.6	0.9	430.1	433.2	87.7	.9	521.8
White pine	137.3	9.7	1.3	148.3	120.2	32.6	1.3	154.1
Black spruce	1,320.8	129.6	527.5	1,997.9	957.8	88.3	547.5	1,593.6
Balsam fir	1,012.5	117.0	21.9	1,151.4	589.6	72.9	18.5	681.0
Northern white cedar	322.4	8.2	37.3	367.9	370.6	8.5	40.7	419.8
Tamarack	696.2	7.9	118.1	822.2	701.7	6.9	118.2	826.8
White spruce	137.0	43.9	0	181.0	158.2	106.7	0	264.9
Oak-Hickory	1,288.0	13.6	14.0	1,315.6	1,354.1	18.6	18.8	1,391.5
Elm-Ash-Soft maple	1,564.2	64.9	33.4	1,662.5	1,721.5	95.4	35.2	1,852.1
Maple-Basswood	1,301.8	30.6	2.1	1,334.5	1,255.2	34.8	2.1	1,292.1
Aspen	4,496.0	358.1	33.9	4,888.0	5,730.0	393.5	36.8	6,160.3
Paper birch	1,179.3	109.7	6.1	1,295.1	741.7	123.6	6.5	871.8
Balsam poplar	480.1	15.4	10.6	506.1	473.0	14.5	9.5	497.0
Nonstocked	0	0	0	0				
Other	0	0	0	0				
Total	14,773.4	1,113.1	828.3	16,714.8	14,879.4	1,140.2	837.3	16,857.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Table 7.8. Forest type acreage for timberland and all forest plots under the base, medium, and high scenarios, 1990 and projected 2040, statewide (thousand acres).

Forest Type	1990		2040					
	Timberland	Total	Timberland Base Scenario	Timberland Medium Scenario	Timberland High Scenario	Total Base Scenario	Total Medium Scenario	Total High Scenario
Jack pine	487.1	614.2	329.6	307.4	272.6	387.0	364.8	330.0
Red pine	350.6	430.1	452.4	454.4	433.2	541.0	543.0	521.8
White pine	137.3	148.3	141.0	136.0	120.2	174.9	169.9	154.1
Black spruce	1,320.8	1,997.9	1,001.2	945.4	957.8	1,637.0	1,581.2	1,593.6
Balsam fir	1,012.5	1,151.4	657.4	598.4	589.6	748.8	689.8	681.0
Northern white cedar	322.4	367.9	360.9	370.4	370.6	410.1	419.6	419.8
Tamarack	696.2	822.2	678.7	704.4	701.7	803.8	829.5	826.8
White spruce	137.0	181.0	227.9	202.7	158.2	334.6	309.4	264.9
Oak-Hickory	1,288.0	1,315.6	1,370.2	1,322.3	1,354.1	1,407.6	1,359.8	1,391.5
Elm-Ash-Soft maple	1,564.2	1,662.5	1,744.0	1,714.8	1,721.5	1,874.6	1,845.5	1,852.1
Maple-Basswood	1,301.8	1,334.5	1,460.2	1,368.6	1,255.2	1,497.1	1,405.5	1,292.1
Aspen	4,496.0	4,888.0	5,238.7	5,496.5	5,730.0	5,669.0	5,926.8	6,160.3
Paper birch	1,179.3	1,295.1	803.4	806.2	741.7	933.5	936.4	871.8
Balsam poplar	480.1	506.1	413.7	451.8	473.0	437.7	475.8	497.0
Nonstocked	0	0						
Other	0	0						
Total	14,773.4	16,714.8	14,879.4	14,879.4	14,879.4	16,857.0	16,857.0	16,857.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

- Oak-hickory covertype acreage appears to increase over 1990 for all harvest scenarios.
- Elm-ash-soft maple covertype acreage increased substantially over 1990 for all scenarios, in part due to forest area increase in the southern portion of the state.
- Maple-basswood covertype acreage increased for the base scenario, then declined slightly for the high harvest level.
- Aspen covertype acreage on timberlands appears to increase 16.5, 22, and 27 percent over its initial extent (4,496,000 acres) for the base, medium, and high scenarios, respectively, considered over the 50-year study period. However, interpretation should recognize that several other covertypes, notably paper birch and balsam fir, have stands with high proportions of aspen that could, by a slight change in species composition or the algorithm for determining that, be called aspen. Likewise, much of the aspen acreage is mixed and could change slightly and be reclassified as paper birch, balsam fir, jack pine, etc.
- The paper birch covertype appears to decline by several hundred thousand acres as harvesting level increases. However, as with aspen, many acres are composed of mixed species. Consequently, while the acreage classified as *paper birch covertype* has changed, the overall species composition change of the original areas was probably less than the covertype area change would suggest. Aging of this type is a factor contributing to succession to other species.
- The balsam poplar covertype acreage declined with the base scenario and then increased to near original conditions with the high harvesting level.
- When the harvesting level increased from the base to the medium scenario, covertype acreage for timberland declined for eight covertypes. When the harvesting level increased from the medium to the high scenario, five of these eight continued to decline and three others also declined. Six covertypes showed an increase in acreage from the medium to the high scenario (black spruce, northern white cedar, oak-hickory, elm-ash-soft maple, aspen, and balsam poplar).
- Projections for reserved and unproductive forests were unchanged from those noted for the base scenario.

Overall, results suggest that future covertype area *is* sensitive to the level of harvesting and that the response is either species or covertype specific.

7.2.2 Covertype Size and Age Class Structure

Summaries of age classes from 1977-2040 for all harvest scenarios are shown in table 7.9. Forest development indicates the average age of six covertypes continued to increase over 1990 despite the harvesting that took place under the high scenario during that period. The other eight covertypes show trends of reducing average ages. The drop in the average age of the aspen covertype from the present 41 years to 28 years is a significant change.

Table 7.9. Average stand age by covertype and harvest scenario for timberland 1977-2040.

	Average Age of FIA Plots*				
			2040		
Forest Type	1977	1990	Base	Medium	High
Jack pine	42	48	77	69	42
Red pine	43	44	54	54	41
White pine	73	80	104	102	87
Black spruce	46	59	89	61	50
Balsam fir	42	46	82	71	58
Northern white cedar	82	97	116	106	94
Tamarack	52	57	99	85	55
White spruce	33	42	90	82	76
Oak-Hickory	63	69	78	71	63
Elm-Ash-Soft maple	56	56	86	75	60
Maple-Basswood	61	58	90	80	58
Aspen	38	41	34	33	28
Paper birch	49	58	92	81	61
Balsam poplar	39	41	33	31	31

Source: Jaakko Pöyry Consulting, Inc. (1992a). Projected ages for stands not clearcut were determined by adding 50 years. See appendix 2, table 2.2 for more detail.
* weighted by acreage.

These changes are even more pronounced when compared with the outputs from the base and even medium scenarios. Because the age class distributions include the areas of timberland designated as *not available*, which includes old growth and other areas assumed to be unavailable, and ERF and other silvicultural constraints, the average ages on those designated as *available* will tend to be skewed to the lower end of the range. Thus the average age is the result of combining two increasingly different types of stands. The change in the aspen covertype is particularly important because much of Minnesota's forests are comprised of this covertype.

Changes in age class structure will have important implications for many other values of the forest. Certain characteristics only begin to be expressed after forests reach certain stages. These stages have been recognized for most covertypes, and specific management objectives have been developed. Section 5.2.2 discussed these stages and the consequences for the base level of harvesting.

The implications of the trend for average age under the high scenario is reflected in table 7.10, which shows recruitment of stands into old forest and old growth forest.

Table 7.10. Area of old forest for 1990 and projected to 2040 for the base, medium, and high harvest scenarios, all forest lands (acres).*

Forest type (threshold age)	Current 1990	Base Scenario 2040	Medium Scenario 2040	High Scenario 2040
Red pine (120)	21,200	107,496	110,344	96,944
White pine (120)	12,300	91,674	87,743	73,643
Black spruce (120)	157,800	614,219	471,636	436,736
White cedar (120)	60,000	225,600	211,569	183,990
Tamarack (120)	73,000	299,604	268,390	156,307
White spruce (90)	27,400	211,815	185,720	149,583
Oak-Hickory (120)	51,400	342,702	293,044	241,232
Elm-Ash-Soft maple (120)	69,400	483,185	416,120	295,024
Maple-Basswood (120)	37,000	404,502	344,407	181,618
Jack pine (70)	115,100	244,518	207,612	99,269
Balsam fir (70)	304,000	452,468	335,385	256,276
Aspen (70)	467,500	982,911	961,039	837,726
Balsam poplar (70)	24,900	76,629	74,129	73,029
Paper birch (70)	324,400	643,809	559,835	352,494

Source: Jaakko Pöyry Consulting, Inc. (1992a,e).
* Acreages are those determined from GEIS covertype algorithm.

Despite the increased harvesting under the high scenario, more old forest and old growth forest is projected to be present in 2040 than 1990 for all covertypes except jack pine and balsam fir. The drop in jack pine is due to successional changes on reserved lands, and the nearly 50,000 acre drop in balsam fir is not very meaningful because most balsam fir stands greater than 70 years old in Minnesota are infected with spruce budworm.

7.2.3
Tree Species Abundance and Diversity

Tree species composition changes can occur in the form of species composition within a covertype, often related to stand age or stage of development, and in terms of covertype acreage. Table 7.11 presents a summary of species composition in 1990 and that projected to occur in 2040 for all scenarios across all covertypes.

Table 7.11. Summary of projected tree species composition for 1990 and 2040 for base, medium, and high harvest scenarios on timberlands for the second runs (thousands of trees ≥1.0 inch dbh).*

Species	1990	2040		
		Base	Medium	High
Ailanthus	39	15	14	13
American hornbeam	14,419	12,049	12,500	11,521
American basswood	192,090	191,702	184,698	176,313
American elm	150,006	147,215	146,216	148,778
Apple	386	430	509	641
Balsam fir	979,317	863,263	849,201	796,018
Balsam poplar	266,466	283,080	314,295	358,967
Bigtooth aspen	73,184	82,074	88,197	97,201
Bitternut hickory	8,044	8,573	8,590	9,880
Black ash	527,482	662,467	640,214	607,040
Black cherry	35,429	46,605	48,805	52,004
Black locust	455	133	129	135
Black maple	154	125	101	82
Black oak	710	792	735	799
Black spruce	1,039,098	911,752	769,542	686,000
Black walnut	2,289	2,222	2,277	2,443
Black willow	5,702	4,721	5,453	6,373
Boxelder	66,672	82,430	81,689	83,114
Bur oak	190,446	183,028	186,455	189,174
Butternut	2,941	4,442	4,235	4,409
Chokecherry	33,848	36,689	39,035	42,337
Eastern cottonwood	2,735	2,272	2,340	2,363
Eastern redcedar	14,051	17,977	19,194	20,913
Green ash	86,474	79,551	80,027	84,869
Hackberry	14,714	14,842	14,054	13,220
Hawthorn	8,810	8,922	9,476	11,435
Ironwood	117,990	130,328	134,496	143,275
Jack pine	164,593	93,530	98,865	126,646
Ky. coffee tree	445	142	143	157
Mountain ash	1,497	3,273	3,122	2,366
Mountain maple	105,825	115,557	107,763	89,360
N. white-cedar	386,818	615,904	530,282	416,061
Northern pin oak	5,975	5,541	5,865	6,465
Northern red oak	111,893	97,402	97,153	97,435

Table 7.11. (continued)

Species	1990	2040 Base	2040 Medium	2040 High
Other hardwood	41,155	32,342	27,419	20,636
Paper birch	570,934	440,801	459,276	461,745
Peachleaf willow	489	642	678	706
Pincherry	13,140	16,541	17,905	19,499
Ponderosa pine	398	387	434	795
Quaking aspen	1,986,789	2,730,630	2,930,033	3,418,737
Red maple	290,717	223,765	237,572	249,212
Red mulberry	988	985	1,172	1,532
Red pine	97,800	107,691	112,701	132,128
River birch	185	1,682	1,660	1,408
Rock elm	1,572	1,881	1,609	891
Scotch pine	1,630	1,123	1,346	1,746
Shagbark hickory	9,145	11,075	11,376	12,691
Siberian elm	399	391	562	699
Silver maple	9,552	8,890	8,239	7,550
Slippery elm	23,016	27,284	27,220	27,155
Striped maple	463	397	370	367
Sugar maple	283,728	266,355	243,789	213,820
Swamp white oak	454	1310	1,118	776
Tamarack	361,461	299,180	306,991	291,762
White ash	2,494	2,835	2,936	2,701
White oak	10,058	11,377	10,607	10,519
White pine	29,566	29,709	29,298	23,520
White spruce	78,620	76,604	77,665	73,822
Wild plum	5,331	5,361	5,824	6,953
Yellow birch	11,746	20,882	19,500	14,772
Grand Total	8,442,827	9,029,168	9,022,970	9,283,949

Source: Jaakko Pöyry Consulting, Inc. (1992a).
* The numbers in the 1990 column differ from those for the first runs because the second runs used the GEIS rather than the FIA covertype algorithm.

The ownership constraints and mitigations used in the projections appear to have been very effective in moderating changes in species statewide. This is evident for upland, lowland, and riparian species. Changes, as a percent of 1990 values, are small for most species. Black spruce shows a major decline of 34 percent below 1990 tree numbers. The paper birch covertype also shows a decline of nearly 20 percent. The projected 72 percent increase in aspen tree numbers is a combination of the lower average age (and hence numbers of trees per acre) of these stands and projected increases in the area under the aspen covertype.

Because most species are found in many covertypes, results across covertypes are emphasized here. The pattern was also found to be similar for trees with a girth, or dbh, of $\geq$4.5 inches.

Section 5.2.2 discussed the difficulty of determining whether or not a reduction in the conifer component of aspen stands would occur. Concern for this possibility is greatest at the high level of harvest.

7.2.4 Forest Fragmentation

The assessment of forest fragmentation is qualitative, not quantitative. Therefore, no specific acreage totals could be developed.

As discussed in section 5.2.4, fragmentation of forests changes the structural diversity of forested landscapes and can affect biodiversity. When compared with the base scenario, the distribution of timber harvesting and forest management activities *at the statewide level* is not expected to change under the high scenario, except that the intensity of harvesting on national forests was projected to increase significantly following lifting of the ASQ constraints. This change, as well as the requirement to harvest most stands assumed to be available, means the patterns of harvested and unharvested stands at localized levels will change. Therefore, at any time there will likely be more sites affected by harvesting in any given landscape. In addition, as previously noted the average age of most covertypes will not increase as much under the high scenario as was projected to occur under the base or medium scenarios (see section 7.2.2). This will affect *within forest* fragmentation or the juxtaposition of forests of different covertypes and stand ages on the landscape.

7.3 Physical Resource Impacts

Harvesting activities will change aspects of the physical or nonliving environment including forest soils and water resources (water quantity and quality). The consequences of timber harvesting and forest management activities for these resources were discussed at length in section 5.3 in reference to the base level scenario. The *type* of impact will likely not change with the changes in the level of harvesting. However, the *area affected* will change with increasing levels of harvesting. Impacts on these resources tend to be related linearly to the area harvested. This is particularly so for soil impacts. Therefore, the information presented in section 5.3 is not repeated. The significant impacts under the high scenario are fully assessed in section 7.6.

7.4 Biological Resource Impacts

7.4.1 Plant and Animal Species Abundance and Diversity

Animals

This section compares changes to animal populations projected under the base and medium level scenarios with those under the high scenario. As discussed in section 5.4.1, timber harvesting and forest management activities can alter the habitat value of stands for these various species and species groups. A wide range of habitat factors can change as a consequence of harvesting. Changes in these factors can either reduce or enhance habitat values with the potential to then impact populations of animals accordingly.

There are two key factors affecting the habitat value of forests that are of relevance to wildlife populations, that are likely to change as a consequence of timber harvesting and for which statewide data were available. These factors are stand tree species mix and the age or size classes of these trees. Based on these factors, the direction and magnitude of population change in each animal species of interest can be estimated by examining projected acreage of forest types and size classes.

Section 7.2 provided a characterization of the future forest condition under the high scenario, and contrasted this with that projected under the base and medium scenarios. The major differences between the medium and high scenarios are fewer acres reaching older age classes, more acres affected by harvesting, and an increase in aspen covertype acreage.

In addition, the reduction in the average ages of the aspen and balsam poplar covertypes would also have an impact on stand composition and therefore the habitat values for some species. These changes will increase habitat values for some species and will diminish values for others. As discussed in section 5.4.1, nearly all species projected to increase under this scenario are early-succession species that have considerable habitat outside of forests (open areas, brushland, etc.).

The major emphasis in assessing wildlife impacts was at the ecoregion level and results are developed in section 7.6.4. However, for illustration, table 7.12 describes the general direction of projected population levels by harvest scenario. Statewide over the 50-year study period, 97, 94, and 72 percent of the total number of species are projected to remain stable or increase under the base, medium, and high scenarios, respectively. The number of species projected to decrease in population level ranges from 5 in the base scenario to 48 under the high scenario.

Table 7.12. **Number of species of interest that are projected to decrease by 25 percent or more, remain stable, or increase by 25 percent or more, statewide on all forest lands by harvest scenario.***

Species Group (number of species)	Decreasing			Stable			Increasing		
	Base	Med.	High	Base	Med.	High	Base	Med.	High
Small Mammals (22)	0	2	4	21	19	16	1	1	2
Large Mammals (5)	0	0	0	5	4	4	0	1	1
Birds (138)	5	8	43	111	106	61	22	24	34
Herps (8)	0	1	1	6	5	6	2	2	1
All (173)	5	11	48	143	134	87	25	28	38

Source: Jaakko Pöyry Consulting, Inc. (1992f).
* *Stable* is a change of less than 25 percent.

Endangered, Threatened, or Special Concern Species

Animals. The assessment of changes to wildlife populations as a consequence of timber harvesting and forest management activities is centered on changes to habitat. Two species were projected to decline under the base, medium, and high scenarios: Red-shouldered Hawk and Louisiana Waterthrush. An additional species that would be adversely impacted under the high scenario is the pine marten.

Plants. The threat of disturbance and/or damage to a population of rare plants will increase as the area of the state subjected to harvesting increases. This is because the forest dependent rare plant species of Minnesota are typically poorly adapted to trampling types of injury. Most (except for the one tree species listed) are of small stature and easily broken. Any harvest that would allow heavy equipment to drive through a population of any rare plant species would cause impacts. Therefore, the high level of harvest would likely cause additional impacts that are proportional to the additional area affected by harvesting.

The lack of data concerning these species and the level of resolution of the GEIS analysis precluded quantification of these impacts

7.4.2 Aquatic Ecosystems

As the level of harvesting increases, it is reasonable to conclude that harvesting activities that remove or alter forest cover and other types of forest management activities will increase within any given watershed. The differences are likely to be marginal for most watersheds. These activities can have wide ranging effects on waterbodies and the plants and animals that live within them. These changes are therefore likely to be proportional to the area affected. The general discussion of impacts on aquatic ecosystems under the base scenario (section 5.4.2) adequately characterizes the *types* of impacts likely under the medium scenario. The *extent* of aquatic ecosystems that experience these impacts will increase under the medium scenario when compared with the base scenario.

7.4.3 Riparian Corridors

The relationship between the level of harvest and the type and extent of likely impacts under the base and medium scenarios that was described under aquatic ecosystems would similarly apply to riparian corridors which are the strips of land and associated plant communities that are located adjacent to waterbodies. When compared with the base and medium scenarios, the high scenario would likely affect additional areas with the same types of impacts.

7.4.4 Forest Insect and Disease Concerns

As discussed in section 5.4.4, the risk to a forest stand of a pest attack or infestation (susceptibility) and the likelihood of damage if an attack occurs (vulnerability) are frequently related to stand age and the incidence of multiple entries into a stand may also increase risk.

The possible effects of an increase in timber harvesting and associated management practices on forest health in Minnesota include changes in the proportion of susceptible/vulnerable age classes, and the incidence of multiple entry harvesting operations.

The timber harvesting activities projected under the high level scenario shows the aging of the forest as was described for the base level and the majority of covertypes show a decrease in average age as compared to 1990.

The high level of harvesting clearly reduced the area in the older age classes and will tend to reduce the incidence of many insect pests and diseases that are favored by older forests. Insect species in this category include spruce and jack pine budworm and two-lined chestnut borers. In addition, diseases such as white trunk rot of aspen are also likely to be reduced. Other diseases including cankers and decay of upland hardwoods and oak wilt will probably decrease in the short-term but may ultimately increase.

In contrast, the incidence of insect pests, such as white pine weevil, are likely to increase as a consequence of the high level harvests. This is due to an increase in acreage of susceptible younger stands. The incidence of some diseases are also likely to increase, including *Diplodia* shoot blight and canker, and *Scleroderris* canker of red pine.

7.5
Socioeconomic Resource Impacts

7.5.1
Outdoor Recreation Opportunities

Timber harvesting will likely have an impact on the quality of the recreational experience and on the number of hours of recreational activity at a given site. These impacts are related to the recreational user's visual perception and the attractiveness of the forest setting. Some of the impacts are long-term while others are short-term and/or subject to change from forest growth and dynamics on that site or over a broader context or area. Section 5.5.1 discussed the nature and extent of likely impacts.

Table 7.13 describes the harvesting extent by recreational opportunity classes. Harvesting at the high scenario would subject 69.5 percent of the timberland plots to harvesting which compares with the 50.4 and 59.2 percent of plots projected to be harvested under the base and medium scenario. Harvesting beyond the year 2040 would tend to concentrate on the accessible and productive plots harvested in the first 50 years. However, additional acres would likely need to be harvested to achieve sustainability in the long-run.

7.5.2
Aesthetics and Visual Quality

Given the constraints and mitigations assumed on state and federal lands, there appears to be a tendency to harvest areas of high visual sensitivity at a lower rate than areas of moderate to low sensitivity. The converse was found on private lands (see table 7.14).

Timberlands not in federal or state ownership do not have VMGs in place and therefore, there is a stronger likelihood of adverse impacts on these lands. Under the base scenario 38 percent of nonfederal and nonstate owned timberland plots were projected to be impacted. By comparison, under the medium scenario 44 percent are projected to be impacted. Under the high scenario, 48.1 percent are projected to be impacted.

In terms of dynamics over time under the high scenario, the forests of Minnesota in 2040 would look similar to the present. Ownership constraints and mitigations that preclude certain areas from clearcutting would increase

Table 7.13. Distribution of FIA forest and timberland plots and plots projected to be harvested, by ownership and ROS class for the base, medium, and high scenarios, 1990–2040.

ROS Class	Total number of plots, all forest	Total number of timberland plots	Percent of timberland plots by ROS class	Number and (percent) of timberland plots harvested by ROS class					
				Base Scenario		Medium Scenario		High Scenario	
				State/federal lands	Other lands	State/federal lands	Other lands	State/federal lands	Other lands
Primitive	425	53	.4	8 (15.1)	15 (28.3)	10 (18.7)	15 (28.3)	12 (22.6)	23 (43.4)
Semiprimitive nonmotorized	1,306	876	7.2	150 (17.1)	173 (19.7)	211 (24.1)	201 (22.9)	316 (36.1)	217 (24.8)
Semiprimitive motorized	3,409	3,074	25.4	529 (17.2)	925 (30.1)	691 (22.5)	1,119 (36.4)	1,003 (32.6)	1,185 (38.5)
Roaded natural	5,232	5,049	41.7	662 (13.1)	2,121 (42.0)	777 (15.4)	2,428 (48.1)	1,081 (21.4)	2,611 (51.7)
Rural	3,107	3,030	25.0	140 (4.6)	1,366 (45.1)	158 (5.2)	1,548 (51.1)	179 (5.9)	1,779 (58.7)
Urban	57	36	.3	1 (2.8)	18 (50.0)	1 (2.8)	19 (52.8)	2 (5.6)	20 (55.6)
All classes	13,536	12,118	100.0	1,490 (12.3)	4,618 (38.1)	1,848 (15.2)	5,330 (44.0)	2,593 (21.4)	5,835 (48.1)

Table 7.14. Percent of FIA timberland plots projected to be harvested (1990–2040) by visual sensitivity rank and by ownership (excluding primitive, semiprimitive nonmotorized, and urban ROS classes).

Visual Sensitivity Rank	Percent of timberland plots harvested by visual sensitivity rank					
	Base Scenario		Medium Scenario		High Scenario	
	State/federal lands	Other lands	State/federal lands	Other lands	State/federal lands	Other lands
High	10.4	49.6	11.3	56.0	18.9	62.0
Moderate	11.4	44.5	12.3	50.4	19.6	56.0
Low	12.7	37.3	15.2	43.7	20.4	47.6
Very low	13.0	32.5	17.5	38.5	21.4	41.2
All ranks (high to very low)	12.1	39.6	14.6	45.7	20.3	50.0

the area of older forest in many cases. Under the high scenario, the future forest would have an average age like that of today for most covertypes.

However, the oldest ages, given 50 years of growth, would be greater than found today for many areas. It follows that average tree size, which is an important component of attractiveness, would be similar to conditions today for most covertypes. The covertypes that would be adversely impacted are those subject to substantial harvesting including aspen, balsam fir, balsam poplar, and black spruce.

7.5.3 Unique Cultural and Historical Resources

Heritage resources can be divided into five main categories which include: cultural landscapes, standing structures, archaeological sites, cemeteries, and traditional use sites. These were discussed under section 5.5.3. The impacts on archaeological sites are closely linked to the likelihood of impacts on soil physical structure. As discussed above, the types of impacts are likely to stay the same irrespective of the level of harvesting; however, the area affected will increase and thus the number of sites will also increase.

The predicted maximum number of sites affected under the high scenario would be 142,000 sites up from the 121,000 predicted to be affected under the medium scenario. It must be stressed that these estimates are the maximum values.

Traditional Use Sites are locations which have been historically used by one or more groups of people for some type of activity. They may lack the physical evidence of artifacts or structures, and are often characterized by plants, animals, and/or topography which are of cultural and religious significance to Native Americans. The impacts on these sites could not be quantified.

7.5.4 Economic Impacts

Economic impacts were measured in terms of changes in employment, personal income, and the level of output for various sectors of the state economy and for the regions directly affected by the modeled increases in timber harvests. The impacts for the high scenario are summarized in table 7.15.

Statewide economic model (IMPLAN) projections indicated that the high level of timber harvest and forest industry expansion would produce approximately 35,100 additional jobs in the state, an increase of 1.7 percent over the baseline level of employment. Of this, about 25,400 jobs (72

Table 7.15a. Minnesota—employment. Increase in number of jobs above baseline employment.

IMPLAN sector	Baseline Employment	Medium Scenario Direct Effect	Medium Scenario Indirect Effect	Medium Scenario Total* Effect	Medium Scenario Percent of Base	High Scenario Direct Effect	High Scenario Indirect Effect	High Scenario Total Effect	High Scenario Percent of Base
Sectors Contributing Most to Employment									
461 Other Wholesale Trade	114,921		750	871	1		3,783	4,412	4
463 Other Retail Trade	213.626		67	574	0		320	2,958	1
160 Logging Camps and Log	2,016		488	489	24		2,007	2,008	100
188 Paper Mills, Except Building	8,252	352	0	352	4	2,812	0	2,812	34
491 Eating and Drinking Pla	109,412		95	323	0		478	1,663	2
448 Motor Freight Transport	34,880		197	218	1		995	1,102	3
456 Electric Services	12,116		173	192	2		873	976	8
470 Real Estate	54,807		45	155	0		226	800	1
504 Hospitals	47,838		0	152	0		0	793	2
446 Railroads and Related	8,732		135	138	2		684	698	8
490 Accounting, Auditing an	17,615		105	133	1		527	674	4
24 Forestry Products	1,386		131	132	10		551	559	40
74 Maintenance and Repair	14,951		108	118	1		540	593	4
480 Personnel Supply Services	19,810		69	104	1		347	529	3
464 Banking	23,073		53	96	0		264	493	2
467 Insurance Carriers	29,417		24	96	0		122	495	2
465 Credit Agencies	23,161		43	91	0		218	465	2
503 Doctors and Dentists	25,632		0	82	0		1	427	2
482 Management and Consu	14,406		68	82	1		342	414	3
508 Colleges, Universities	19,806		31	80	0		158	410	2
Total	795,857	352	2,582	4,477	1	2,812	12,436	23,281	3
Selected Forest Products and Forestry Sectors									
27 Landscape and Horticul	8,827		44	49	1		173	199	2
199 Paperboard Containers	8,002		21	23	0		105	117	1
26 Agricultural, Forestry	3,293		12	15	0		52	64	2
22 Forest Products	75		6	6	7		24	24	32
161 Sawmills and Planing Mills	941		10	10	1	247	56	316	34
170 Wood Pallets and Skids	193		4	4	2		19	19	10
164 Millwork	6,579		2	2	0		10	11	0
172 Wood Products, N.E.C.	1,459		2	2	0		9	11	1
23 Greenhouse and Nursery	844		0	3	0		2	13	2
173 Wood Containers	213		1	1	1		7	7	3
Total	30,426	0	102	115	0	247	457	782	3
Total, All Sectors in Minnesota	2,085,517	352	3,788	6,752	0	3,059	18,424	35,094	2

Note: Sectors 160, 446, 464, 27, 161, 172, and 23 adjusted to reflect IMPLAN revisions in the North region. Units are number of jobs above baseline employment.
* Total refers to direct, indirect and induced effects.

Table 7.15b. Minnesota—employee compensation. Increase in employee compensation above baseline compensation ($ millions).

IMPLAN sector	Baseline Compensation	Medium Scenario: Direct Effect	Medium Scenario: Indirect Effect	Medium Scenario: Total* Effect	Medium Scenario: Percent of Base	High Scenario: Direct Effect	High Scenario: Indirect Effect	High Scenario: Total Effect	High Scenario: Percent of Base
Sectors Contributing Most to Employee Compensation									
461 Other Wholesale Trade	3,413.14		22.28	25.87	1		112.35	131.04	4
188 Paper Mills, Except Building	380.22	16.19	0.01	16.20	4	129.35	0.06	129.41	34
463 Other Retail Trade	3,356.52		1.06	9.02	0		5.04	46.47	1
456 Electric Services	455.54		6.49	7.23	2		32.82	36.68	8
446 Railroads and Related	384.95		5.86	6.04	2		29.73	30.64	8
160 Logging Camps and Log	23.13		5.60	5.61	24		23.03	23.05	100
448 Motor Freight Transport	775.02		4.38	4.83	1		22.10	24.48	3
504 Hospitals	993.51		0.00	3.16	0		0.00	16.46	2
503 Doctors and Dentists	873.74		0.01	2.79	0		0.05	14.54	2
467 Insurance Carriers	845.22		0.70	2.76	0		3.51	14.23	2
491 Eating and Drinking Places	919.33		0.80	2.71	0		4.02	13.98	2
74 Maintenance and Repair	314.84		2.27	2.49	1		11.37	12.50	4
464 Banking	547.90		1.23	2.29	0		6.17	11.70	2
465 Credit Agencies	562.50		1.05	2.20	0		5.31	11.29	2
516 U.S. Postal Service	471.69		1.36	2.15	0		6.86	10.97	2
454 Communications, Except	508.30		0.90	1.97	0		4.53	10.12	2
488 Legal Services	452.03		0.94	1.82	0		4.71	9.32	2
482 Management and Consu	318.38		1.50	1.81	1		7.56	9.16	3
77 Ammunition, Except For	246.09		1.73	1.74	1		8.74	8.78	4
521 Other State and Local	180.14		1.35	1.75	1		6.82	8.92	5**
Total	16,022.19	16.19	59.52	104.44	1	129.35	294.78	573.74	4
Selected Forest Products and Forestry Sectors									
199 Paperboard Container	317.08		0.82	0.92	0		4.16	4.64	1
27 Landscape and Horticulture	116.23		0.56	0.62	1		2.19	2.50	2
24 Forestry Products	1.89		0.18	0.18	10		0.75	0.76	40
26 Agricultural, Forestry	29.32		0.11	0.13	0		0.47	0.57	2
161 Sawmills and Planing Mills	9.64		0.16	0.16	2	3.85	0.86	4.73	49
164 Millwork	205.29		0.06	0.07	0		0.30	0.35	0
170 Wood Pallets and Skids	2.34		0.05	0.06	3		0.27	0.28	12
193 Paper Coating and Glaz	159.20		0.04	0.05	0		0.19	0.24	0
172 Wood Products, N.E.C.	31.03		0.04	0.05	0		0.19	0.24	1
173 Wood Containers	4.42		0.03	0.03	1		0.15	0.15	3
Total	876.44	0	2.05	2.26	0	3.85	9.53	14.46	2
Total, All Sectors in Minnesota	43,230.86	16.19	84.42	146.38	0	133.20	418.87	790.41	2

Note: Sectors 188, 160, 521, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the North region. Units are employee compensation above baseline compensation ($ millions).
* Total refers to direct, indirect and induced effects.
** Less than 5.0 percent, but rounded up to 5 percent.

Table 7.15c. Minnesota—TIO. Increase in TIO above baseline TIO ($ millions).

IMPLAN sector	Baseline TIO	Medium Scenario Direct Effect	Medium Scenario Indirect Effect	Medium Scenario Total* Effect	Medium Scenario Percent of Base	High Scenario Direct Effect	High Scenario Indirect Effect	High Scenario Total Effect	High Scenario Percent of Base
Sectors Contributing Most to TIO									
188 Paper Mills, Except Building	1,568.1	611.2	0.3	611.4	39	3,062.1	1.3	3.063.4	195
461 Other Wholesale Trade	7,288.6		47.6	55.3	1		239.9	279.8	4
456 Electric Services	2,814.1		40.1	44.7	2		202.8	226.6	8
160 Logging Camps and Logging	126.9		30.7	30.8	24		126.3	126.4	100
470 Real Estate	7,710.1		6.3	21.9	0		31.8	112.6	1
463 Other Retail Trade	7,933.6		2.5	21.3	0		11.9	109.8	1
457 Gas Production and Distribution	885.0		13.5	15.2	2		68.2	76.9	9
448 Motor Freight Transport	2,147.4		12.1	13.4	1		61.2	67.8	3
235 Petroleum Refining	1,038.0		11.4	13.1	1		57.3	66.0	6
446 Railroads and Related Se	758.6		11.6	11.9	2		58.6	60.4	8
469 Owner-Occupied Dwelling	4,111.2		0.0	11.2	0		0.0	58.1	1
491 Eating and Drinking Place	3,676.8		3.2	10.8	0		16.1	55.9	2
74 Maintenance and Report O	1,058.5		7.6	8.4	1		38.2	42.0	4
467 Insurance Carriers	2,397.2		2.0	7.8	0		10.0	40.3	2
504 Hospitals	2,003.4		0.0	6.4	0		0.0	33.2	2
24 Forestry Products	65.7		8.7	8.8	13		31.1	31.5	48
464 Banking	1,476.6		3.4	6.2	0		16.9	31.5	2
454 Communications, Except R	1,523.5		2.7	5.9	0		13.6	30.3	2
521 Other State and Local Go	550.1		4.4	5.6	1		22.0	28.8	5
503 Doctors and Dentists	1,596.1		0.0	5.1	0		0.1	26.6	2
Total	50,729.5	611.2	208.1	915.0	2	3,062.1	1,007.3	4,568.1	9
Selected Forest Products and Forestry Sectors									
199 Paperboard Containers A	1,123.6		2.9	3.2	0		14.7	16.4	1
27 Landscape and Horticulture	238.4		1.2	1.3	1		4.7	5.4	2
161 Sawmills and Planing Mills	47.8		0.9	0.9	2	21.9	4.9	26.9	56
26 Agricultural, Forestry, F	88.1		0.3	0.4	0		1.4	1.7	2
22 Forest Products	4.7		0.3	0.4	7		1.4	1.5	32
164 Millwork	710.9		0.2	0.2	0		1.0	1.2	0
193 Paper Coating and Glazing	657.4		0.2	0.2	0		0.8	1.0	0
170 Wood Pallets and Skids	8.6		0.2	0.2	2		1.0	1.1	13
172 Wood Products, N.E.C.	95.2		0.1	0.1	0		0.6	0.7	1
195 Die-cut Paper and Board	546.5		0.1	0.1	0		0.5	0.6	0
Total	3,521.2	0.0	6.4	7.0	0	21.9	31.0	56.5	2
Total, All Sectors in Minnesota	140,462.7	611.2	297.0	1,059.5	1	3,084.0	1,451.2	5,324.1	4

Source: IMPLAN runs 08/21/92. Jaakko Pöyry Consulting, Inc. (1992h).
Note: Sectors 188, 160, 24, 521, 464, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the North region. Units are increase in TIO above baseline ($ millions).
* Total refers to direct, indirect and induced effects.

percent) would be added within the northern region. The high level of timber harvest would produce an estimated $800 million (in 1985 dollars) in additional employee compensation in the state, an increase of 1.8 percent. Of this, $560 million (69 percent) would be in the north region. Finally, the high level of timber harvesting would produce an estimated $5,300 million (in 1985 dollars) of increased TIO in the state, an increase of 3.8 percent. Of this, $4,600 million (87 percent) would occur in the north region.

7.5.5 Land Management Organization Service Delivery

In order to meet the increased consumption being considered for the high scenario, forest landowners will need to increase their level of timber sales. Harvest levels would have to increase by 75 percent over the base scenario to meet the high scenario. Such increases could have substantial impacts on public forest land management agencies. The high level of harvest would require more planning and supervision, capital expenditures on roading and investments in replanting. Additional income would also be generated. These changes would be reflected in an increased workload for personnel and a need for additional budget allocations.

Projections of the timber volumes harvested from various land ownerships over time were made with the assumption that timber harvests would be constrained and/or mitigated by environmental, aesthetic, socioeconomic, and other concerns. The *constrained or mitigated projections* reflect major existing land use policies and practices.

The potential impacts of increased timber harvesting on forest management organizations in the state under these constraints are summarized below.

Timber harvests from the national forests in Minnesota are projected to decline by roughly 10 to 15 percent from the current level of harvest under both the base and the medium scenarios. Under the high scenario, timber harvests are projected to more than double current harvest levels within two decades. This would undoubtedly require more resources in terms of personnel and funds to handle the increased planning and administration of timber sales.

Constrained projections of timber harvest from MNDNR lands indicate little change from current harvest levels during the first decade under both the base and medium scenarios. The high scenario projects an increase in timber harvest from state lands of more than 50 percent above current levels during the second and subsequent decades. This would require a substantial increase in support for timber sale planning and administration.

Sales of timber from county lands are projected to increase during the first decade over current levels under the high scenario. Subsequently, sales would increase to more than double current levels and then decline slightly by the fifth decade. This large immediate increase in timber harvest would have a major impact on county forest management, and would require substantial increases in funding and personnel to handle the increased timber sale activity while meeting environmental and aesthetic constraints.

Constrained projections of timber harvests from forest industry lands indicate that timber harvests would remain roughly at current harvest levels during the first two decades for all three scenarios, followed by sharp increases during the third and fourth decades, and a substantial decline during the fifth decade.

Timber harvests from Native American lands are projected to rise considerably for the base and medium scenarios and especially for the high harvest level. Such large increases in timber harvests under the high scenario would require substantial increases in funding and personnel to plan and administer sales, and to avoid environmental degradation.

Constrained projections of timber harvests from other private lands indicate a substantial rise in timber harvest under all three scenarios during the first two decades and continue to do so for the high scenario. Achieving these increases in timber harvests from other private lands will require considerable timber sale and land management assistance from forest industry and the state and federal government if potential environmental and aesthetic degradation is to be avoided or minimized.

7.6
Identification of Significant Impacts

Criteria were developed and used by the study groups to assess the significance of impacts projected to occur at each level of harvesting. The criteria and relevant background information are reproduced in full in appendix 1.

The following lists the criteria and presents the significant impacts that are projected to occur at the high level of harvesting. Where meaningful, these impacts are compared with those projected to occur under the base and medium scenarios. The significant impacts have been drawn from the assessments in the technical papers. Criteria have been grouped under the same headings as were used in section 5.

7.6.1
Forest Resources - Extent, Composition, and Condition

The criteria in this section were used by the Maintaining Productivity and the Forest Resource Base, Forest Health, Wildlife, and Biodiversity study groups to identify projected significant changes in the extent, composition, and condition of Minnesota's forest resources.

These criteria cover a wide range of issues ranging from the size of the forests to their genetic makeup. Impacts on federal- and state-listed species of special concern, threatened, or endangered or their habitats were assessed for plants in this section and for animals under the wildlife section following.

Changes to Minnesota's Forests - Size and Composition of Forest Land Base (public and private)

> An impact is considered significant if it is projected that there will be cumulative over the 50-year study period:
> • A change of 3 percent in the size of the total Minnesota forest land base.
> • A change of 3 percent in the area of timberland (commercial forest land) available for wood production.
> • A change of 7 percent in the area of the total forest land base by ecoregion.
> • A change of 7 percent in the area of timberland by ecoregion.

The estimated trends by ecoregions were presented in section 5.6.1. Since changes in forest area is projected to be independent of the level of harvest, the analysis presented in this section also describes the significant impacts for the medium scenario.

Projecting estimates of forest area change are always difficult and can seem exaggerated. However, the history of forest clearing, regrowth, harvesting, and reservation here and in other regions, notably from Wisconsin to New England to Europe, suggests changes can be large and rapid. Additionally, the U.S. and state population is expected to grow substantially over the period to 2040.

Changes to Minnesota Forests - Patterns of Forest Cover in Areas of Mixed Land Use

> An impact is considered significant if noncontiguous forested tracts or patches less than 300 acres in size are projected to experience clearcutting of more than 20 percent of the tract or patch in any one decade.

Statistics on the regrowth of the oak and elm-ash-cottonwood forest types common to agricultural regions suggest that forest cover is returning to ecoregions 5, 6, and 7 quite rapidly on a percentage basis. However, even the large percentage increases estimated for the next 50 years would just return these regions to the forest acreage levels of the 1950s. Additionally, the concentration of oak-hickory in older age classes (see appendix 8, Jaakko Pöyry Consulting, Inc. 1992a) coupled with currently high harvest levels could negatively affect the overall habitat value of existing forest patches. Given the small average stand sizes in this covertype and these ecoregions and the projected acreage of harvested stands by scenario, it is evident that this is occurring and that it is a significant impact. However, data limitations in this study preclude the ability to document it on a site-specific basis.

The covertypes likely to be present in such patches (i.e., oak-hickory and elm-ash-soft maple) show increased levels of harvesting under the high scenario when compared with levels projected under the medium scenario. Data presented in table 7.3 indicates that approximately 305,000 more acres were harvested under the high scenario than were harvested in the oak-hickory and elm-ash-soft maple covertypes under the medium scenario. Intuitively, greater impacts on these resources are likely as the area harvested increases.

These changes in forest patterns have implications for several mammal species as well as forest interior birds occurring largely or entirely in these more developed portions of the state. Note that significant declines were projected for several species in ecoregions 5, 6, and 7. The projected significant impacts on these species discussed in the following section can be assumed to be closely related to this criterion, i.e., further fragmentation of remnant forest patches. Some of the species in question are: gray and fox squirrels, Ovenbird, Cerulean Warbler, and Yellow-throated Vireo. The Red-shouldered Hawk, a species of special concern, will be significantly impacted if further fragmentation of forest cover in mixed land use regions of the state occurs.

Changes to Minnesota Forests—Tree Species Mix

An impact is considered significant if projected gross changes in the relative proportion of any tree species exceeds 25 percent for the respective covertypes over the 50-year planning period.

The harvesting scenarios would affect the age class structure and thereby the species composition of Minnesota's forests. Under the changes projected at the high level scenario the following tree species are projected to experience significant adverse impacts, black spruce, black locust, black maple, and other hardwoods.

Future covertypes appear to be sensitive to the level of harvesting, both in retaining covertypes and in favoring change to other species. Results are clouded because of an imprecision in determining forest covertypes both now and in the future. This imprecision is due in large part to the mixed species composition of Minnesota's forests. However, results suggest the high level of harvesting will contribute to a continued decrease in area of the jack pine, balsam fir, and paper birch covertypes beyond that projected for the medium scenario. However, some of these changes are a consequence of successional changes as stands age, and are not due to harvesting per se. Furthermore, because many stands have very mixed species composition, some of these changes will not necessarily drastically change the vegetation at a regional level or on specific sites. Instead, a major species may simply become less abundant or be reduced to a minor species on a particular site.

Minor Tree Species

Minor tree species are an important component of biodiversity. In many cases they are species near the edge of their range, or are species that simply are not abundant within their range.

The analysis of stem numbers for the high level timber harvesting scenario in the year 2040 reveals that Kentucky coffeetree would be significantly impacted (>25 percent reduction in stem number) for all three scenarios. Additionally, rock elm would be significantly impacted in the high scenario. Also, in the judgement of the study group, significant impacts on honeylocust, yellow oak, and sycamore (if investigation shows it to be native) are likely under all three levels of harvesting.

Reduction of Conifer Component in Aspen Stands

As discussed in section 5.2, the issue of retention of conifers in aspen stands cannot be resolved due to a lack of data. Therefore, it is not possible to predict whether conifers will be lost in short rotation or other harvest of aspen (and therefore whether the significance criterion is triggered). However, if such a reduction in conifer component were to occur, the impact on biodiversity would be significant and proportional to the level of harvest.

Changes to Minnesota Forests - Age Class Structure.

> **An impact is considered significant if the projected replacement age class structure of forests, by covertype, at the end of the 50-year planning period, is insufficient to provide replacement of mature stand acreage (i.e., sustainability of forest communities).**

This criterion requires examination of age class structures at the end of the 50-year study to assess the feasibility of relatively short-term sustainability. Upon doing so it is apparent that the replacement age class structure for timberland appears deficient for paper birch in all three scenarios. This covertype remains unbalanced through the study period because of its current age class structure imbalance. Thus, this covertype is considered to exhibit a significant impact.

Results show increased or stable acreages for white pine, northern white cedar, and white spruce as compared to the present. White cedar is projected to have a very low harvest so the concerns are not a direct consequence of harvesting. Concerns regarding white pine center on the very limited acreage under this covertype. It is likely that much of that acreage increase referred to above is due to covertype definition or determination procedure or succession from other covertypes. Thus, concern for the present or 1990 acreage remains.

The area of old forest of all covertypes is expected to remain stable or increase substantially (see table 7.10). The exceptions are a 14 and 16 percent decline for jack pine and balsam fir, respectively.

Old growth forests.

> An impact is considered significant if there is projected to be any net loss of area of forest meeting the DNR definition for old growth by covertype by ecoregion over the 50-year study period.

Timber harvesting per se, will have no significant impact on old growth in upland forest types since each candidate stand and future old growth stand is assumed to be either officially reserved or officially released for harvest after the appropriate administrative procedures. However, some areas of old growth may be harvested if they are not identified by an inventory. To add to that concern, we note that considerable acreage of lowland conifer stands that meet old growth age criteria is projected to be harvested under the high scenario.

Forest species - genetic variability.

> An impact is considered significant if there is projected to be a loss of genetic variability in forest plant or animal species as measured by:
> 1. a reduction or isolation of habitat or communities supporting a species, or
> 2. a reduction of geographic ecotypes such that a species now present as a viable population disappears or is approaching extirpation from any ecoregion.

The genetic factors relevant to the criterion were discussed in section 5.6.1. These factors cannot be quantified and as a consequence, the details provided in that section are not repeated. The base, medium, and high scenarios differ in several ways that are relevant to forest genetics. The rise in harvesting operations projected under the medium and high scenarios will increase the likelihood that a particular stand would be harvested at some period and also increase the number of harvested stands within a given landscape.

The increased likelihood that a site will be harvested will increase the chances that plants will be physically disturbed or destroyed. Similarly, the increase in harvesting operations at a landscape level will likely increase the degree of fragmentation. Both increase the likelihood of significant impacts, but to an unknown degree.

Federal- or state-listed plant species of special concern, threatened, or endangered or their habitats.

> An impact is considered significant if any harvest or forest management activity is projected to diminish the habitat and disturb a species listed as of special concern, threatened, or endangered (either federal or state).

In general, the forest dependent rare plant species of Minnesota are poorly adapted to trampling types of injury. With the exception of the one tree species on the list, all species are of small stature and easily broken. Operation of harvesting equipment can significantly impact populations of rare plant species within areas harvested. The lack of knowledge regarding the locations of rare species in the state makes it impossible to undertake a more quantitative analysis. In any case, the comparatively coarse level of resolution of the model output would preclude such an analysis.

Table 7.6 in section 7.1.4 shows that the aggregate area harvested under the high scenario will increase by 21 percent when compared with the medium scenario, and that the additional harvest will be spread across all the ecoregions. Therefore, the high scenario will likely result in additional (but unquantified) impacts above those projected to occur at the base and medium levels of harvesting.

Forest Health—change in susceptibility or vulnerability

> An impact is considered significant if projected changes to the forest and activities undertaken lead directly or indirectly to changed susceptibility (risk of an outbreak/infection) or vulnerability (damage if an outbreak occurs) to more than 10 percent by area by covertype.

All timber harvesting and forest management activities affect forest health; all have impacts. Those impacts range from nearly none (where the management activity is minimal) to very significant (where major changes are brought about in the forest). That continuum of impacts is impossible to treat in any quantitative sense so a threshold must be established to aid in communication. Impacts that are greater than that threshold merit attention; impacts below the threshold are not large enough to justify further consideration.

Certain assumptions were made as part of the analysis of significant impacts on forest health. In particular, it was assumed that the MNDNR pest management guidelines and other guidelines would be followed by all ownerships. If the guidelines are not followed, impacts of harvesting on the health of Minnesota's forests could be more severe. The following assess the significant impacts projected to occur under the high level harvesting scenario.

Aspen-birch forest type group. The area of the aspen-birch forest type group more than 40 years old would be reduced by more than 10 percent when comparing the final age class distribution projected at the high harvest level with the existing distribution. This change will alter the susceptibility and vulnerability of this forest type group to outbreaks of specific insect and disease pests. This change is similar to that experienced under the medium level of harvesting and the consequences would also be similar. These include a reduction in vulnerability to forest tent caterpillar; and a reduction in susceptibility to white trunk rot and hypoxylon canker (if disease control guidelines are followed). In addition there is a risk of an increase in Armillaria root rot.

Black spruce forest type group. The substantial increase in the level of harvest in black spruce forest type group under the high scenario is projected to increase the acreage in age classes less than 40 years old by more than 10 percent, and the area over 60 years old would decline by more than 10 percent in the year 2040. These changes are likely to decrease the incidence of root and butt rots caused by *Inonotus tomentosus* which become more prevalent in stands older than 60 years. Therefore, this is a significant positive impact and in direct contrast to the significant negative impact projected to occur under the base level harvesting.

Lowland conifers forest type group. Under the high level of harvest, the area of lowland conifers less than 40 years old is projected to increase by more than 10 percent, while the area older than 60 years is projected to decrease by more than 10 percent. Impacts on balsam fir stands are as discussed under spruce-fir below. For the remaining species, whether significant changes in harvest intensity are likely to change susceptibility or vulnerability of lowland conifer stands to insect and disease pests is unknown.

Lowland hardwoods forest type group. The area of lowland hardwoods forest type group less than 40 years old is projected to increase by more than 10 percent under the high scenario. This is a substantial change from that projected to occur under the base scenario. In addition, the area in the more than 60-year-old age class would decrease by more than 10 percent. Although this represents a major decrease in extent of the 60-year-old-plus age class, there are relatively few major pests that are likely to be affected by changing the level of harvest in lowland hardwood types.

Pine forest type group. Changes would be 10 percent or less under the high scenario. Such change is similar to that projected under the base scenario. Incidence of *Diplodia* shoot blight and canker and *Scleroderris* canker on young (<40 years old) red pine may increase if the areas replanted to red pine are not carefully chosen. Both of these pests are not major problems on older red pine so the projected increase in area of pine more than 40 years old should not have a significant effect on disease incidence in older red pine. There is a potential for an increase in diseases such as needlecasts and gall rust as nursery seedlings are planted to replace the trees that have been harvested.

Lophodermium needlecast on red pine and gall rust of jack pine are two diseases that can be introduced into the field on infected nursery stock.

An increase in area of older pine forest type group may increase the amount of pine that is less vigorous and less able to resist Ips beetles following damage by wind, lightning, flooding, defoliation, or pathogens. Incidence of Ips may therefore increase.

At the high harvest levels, harvested white pine stands are projected to be replaced by younger stands which are more susceptible and vulnerable to white pine weevil. Therefore, this is a significant adverse impact. The increase in younger white pine could increase the incidence of white pine blister rust, especially if white pine is regenerated in northern Minnesota.

Spruce-fir forest type group. In contrast to the projections under the base level of harvesting, the area of spruce-fir forest type less than 40 years old is projected to increase by more than 10 percent under the high harvesting level, and the area more than 40 years old would decrease by more than 10 percent at that level. The overall decrease in tree age within this forest type group will decrease vulnerability and susceptibility of stands to budworm damage. Probability of wildfire should decrease since mortality, breakage, and windthrow that follow budworm outbreaks will decrease. Therefore, this is a significant positive impact and an important change from the base scenario.

The decrease in area of older spruce-fir forest type group will lead to an decrease in the level of susceptibility and vulnerability of these species to trunk, root and butt rots and can be considered a significant positive impact.

Upland hardwoods forest type group. The area of upland hardwoods forest type group less than 40 years old is projected to increase under the high harvest level, and the area more than 60 years old would decrease by more than 10 percent.

Under the high harvest level, the area of younger trees will increase. Younger trees are generally more vigorously growing and have more starch reserves than older trees. They are therefore less affected by drought and other environmental stress and presumably less susceptible to severe damage by two-lined chestnut borer. The reduced susceptibility of the younger trees will be offset by an increase in the area of older forest.

Clearcutting stands of upland hardwoods forest type group should reduce the incidence of decay in the mid-term (10 to 50 years) and cankers in the short-term (< 10 years) as decayed and cankered trees are removed from the stand. However, selection and shelterwood cuts are often preferred methods of regenerating stands of upland hardwood forest type groups. If some type of multiple entry harvest is chosen, the chances of wounding residual trees increases; the incidence of decay and cankers is also likely to increase. Thinning and other stand entries are projected to increase substantially in stands of upland hardwood forest type. Hence the overall impact of increased harvesting is a likely increase in decays and cankers.

Under the high level timber harvest, a medium-term (10 to 50 years) decrease in the incidence of oak wilt is expected if clearcutting is the method of harvest. Clearcutting would eliminate oak wilt pockets within the clearcuts. Multiple stand entries may tend to injure oak, and make them more susceptible to infection. Given that multiple entry harvest will predominate, the amount of oak wilt is therefore projected to increase (with high uncertainty of prediction).

7.6.2 Soil Resources

Nutrients

An impact is considered significant if nutrients removed and/or redistributed during harvest and followup activities are not replaced over the term of the projected rotation.

Impacts of the high level of harvesting were assessed by determining the area of each covertype that was harvested on each soil. More area of aspen-birch was harvested than of any of the other types; aspen-birch is also the dominant covertype in the state. Similarly, the extent of harvesting was greatest on well-drained medium-textured soils; that is also the dominant soil type in the state.

Harvest of merchantable bole did not remove either nitrogen nor phosphorus beyond their rates of replenishment. Areas at risk for loss of calcium are most closely associated with harvest of aspen-birch and upland hardwoods, on both medium- and, especially, coarse-textured soils. Thus under the high scenario, the area at risk for nutrient loss increased compared to the base scenario. The increased calcium loss is primarily associated with increased harvest of upland hardwoods. As a result, over 7.0 million acres are at risk of calcium loss under the high scenario. Increased harvest of black spruce on organic soils, and increased harvest of most species on coarse-textured soils under the high scenario, leads to an increase of about 0.5 million acres at risk for magnesium loss (up to a total of 4 million acres). Finally, increased area at risk for potassium loss is also associated with increase in harvest on coarse-textured soils, leading to a small increase in area at risk for potassium loss.

Compaction and Related Disturbances

An impact is considered significant if the proportion of the harvest unit projected to be moderately to severely compacted/puddled exceeds the following threshold proportions:

- 5 percent on highly sensitive sites;
- 10 percent on moderately sensitive sites; and
- 20 percent on sites with low sensitivity.

The analysis of significant harvest unit impacts under the high scenario indicates they were most frequent on the well-drained medium-textured soils, which are the most common soils in the state, and the poorly-drained medium and poorly-drained fine soils which have the lowest strength.

Harvesting

The following figures are the cumulative results for the 50-year study period assuming the high level harvesting scenario and the seasonal distribution of harvesting activities outlined in the Silvicultural Systems background paper (Jaakko Pöyry Consulting, Inc. 1992m). Approximately 7 million acres of timberlands on mineral soils would be harvested statewide during the study period. The significance criteria would be exceeded on harvesting units representing an area of just in excess of 1,240,000 acres. The area devoted to haul roads in order to extract the timber means an additional 90,000 acres would be significantly impacted.

The impact assessment indicated that increased levels of timber harvesting will invariably lead to increased amounts of compaction and related disturbance. The significance criteria were exceeded by both mechanical and hand-felling operations on moderately and highly sensitive sites. It was estimated that about 25 percent of the area within moderate sensitive sites would be negatively affected by equipment trafficking for both harvesting configurations. The portion of highly sensitive sites that are negatively impacted could increase to about 30 percent for hand-felling operations and 55 percent for mechanical felling operations.

These results reflect the seasonal harvesting distribution on all soil types within each ecoregion. Limiting timber harvesting to specific seasons on individual soils or sites could greatly affect the impact assessment. The MNDNR and some counties are starting to implement these practices on upland sites in addition to the long standing use of these practices on organic soils.

Soil Erosion

> An impact is considered significant if the rate of soil loss is projected to exceed the limits prescribed by the U.S. Soil Conservation Service expressed as:
>
> $$\text{rate} > T$$
>
> where T varies between 1-5 (tons/ac/yr)

Surface erosion rates exceeded T values on less than 1 percent of the area harvested, and this significant impact was predominantly limited to well-drained soils which exist on steeper slopes.

These results represent the total area impacted over the 50-year planning period. The analyses indicated that significance criteria would be exceeded only in moderately and heavily trafficked areas (skid trails) within harvest units and on haul roads. Also, significant impacts were concentrated in well-drained mineral soils which is to be expected since they are the soils with steepest slopes.

Under the high level of harvest, about 45,000 acres within harvest units would develop erosion rates that exceed T values. Accelerated erosion caused by skidding and felling activities would exceed T values on less than 1 percent of the total area harvested during the 50-year period.

The greatest erosion rates were estimated to occur in ecoregion 6. This ecoregion has the steepest slopes (averaging 45 percent in many areas). The southern portion of the state also has the highest rainfall intensity. It was estimated that initial erosion rates could exceed 14 ton/ac/yr in some areas in ecoregion 6. Initial rates rarely exceeded 5 ton/ac/yr in other ecoregions.

If an area equal to 1 percent of the harvest area were utilized for haul roads on mineral soils, T values would be exceeded on an additional 10,000 acres under the high level of harvest. These totals indicate that erosion rates would be exceeded on about 8 percent of the haul road area.

Erosion associated with haul roads would occur at faster rates than erosion within harvest units. This is a function of the more complete removal of surface protection and smoothing of the ground surface in haul roads. The analyses indicated that maximum initial erosion rates in haul roads could approach 100 ton/ac/yr in some areas.

As stated in section 5.6.6, the effects of timber harvesting and forest management activities on mass movements were not quantified. The greatest potential for mass movements would occur in areas with steep slopes such as the Coulee region of southeastern Minnesota (in ecoregion 6) and areas with shallow soils over bedrock (ecoregions 2 and 3). However, there is currently no evidence suggesting that mass movements are currently a major problem in forested portions of Minnesota.

7.6.3
Water Resources and Aquatic Ecosystems

These criteria were applied to identify significant impacts affecting water resources and aquatic ecosystems.

Lakes, rivers, streams, and wetlands - level of sedimentation/nutrient loading.

An impact is considered significant if timber harvesting and associated management activities are projected to cause changes in the level of sedimentation and/or nutrient loading of waterbodies such that more than 25 percent of monitoring observations following harvest exceed the 85th percentile of preharvest or reference conditions.

Lakes, rivers, streams, and wetlands - runoff.

An impact is considered significant if projected timber harvesting and associated management activities cause changes that result in greater than 60 percent of a *Minor Watershed*[1] to be in a *disturbed condition*[2] at any time.

[1]Minor watersheds as defined in MNDNR 1979 Watershed Map.

[2]Disturbed condition is defined as cleared land or regenerated forest younger than age 15 years.

Lakes, rivers, streams, and wetlands/peatlands - aquatic ecosystems.

> An impact is considered significant if timber harvesting and forest management activities are projected to result in changes to one or more aquatic ecosystem variables such that:
>
> a. more than 25 percent of observations exceed the 85th percentile of preharvest or reference conditions for the following variables:
>   - sediment levels,
>   - water nutrient levels; or
>
> b. peak streamflows more than double or if minimum flows fall below the *7Q10*[3] level; or
>
> c. more than 25 percent of observations exceed the 85th percentile or fall below the 15th percentile of preharvest or reference conditions for
>   - *aquatic community structure, community function, or fish populations*[4].

Application of the above criteria to the water resource impacts projected to occur at the high scenario indicates that the effects of timber harvest at the ecoregion level will not cause impacts that will exceed the thresholds specified in the criteria.

However, there will be a series of changes in the landscape and in the water resource. Most of those changes will be relatively local and relatively short-term in scale. Timber harvest which is accomplished in compliance with Minnesota BMPs will have significantly fewer local water resource impacts than will timber harvest in the absence of BMPs. Therefore, the increased harvesting under the high scenario is likely to increase the number of sites affected, but will not change the types of impacts that were projected to occur under the base scenario.

7.6.4 Wildlife Populations

These criteria were used to determine the significance of impacts of projected changes in wildlife populations.

[3] The 7Q10 designation is a measure of the lowest flow for any 7-day period within any 10-year interval, and is widely used to protect water quality. Other methods for which significance criteria could be developed (e.g., wetted perimeter, Tennant's method, Instream Flow Incremental Methodology) would be more appropriate in representing fish habitat values.

[4] Specific variables to be measured might include kinds and numbers of organisms, rates at which the community processes energy or nutrients or the populations of fishes. The specific variables to be measured will be chosen by scientists assessing any given timber harvest operation(s).

Forest dependent wildlife - habitats.

An impact is considered significant if the available habitat of a species is projected to be changed by 25 percent in any ecoregion.

Table 7.16 summarizes the wildlife species showing significant negative impacts by this criteria and the next one involving species of special concern, threatened, or endangered or their habitat. Ninety-one species, about 53 percent of all wildlife species included in the analysis, were significantly impacted over the 50-year study period under the high scenario. Most species impacted significantly under this scenario were also impacted under the base and medium scenarios; for some of these the number of ecoregions in which the impacts occurred was higher under the high as compared to the base and medium scenarios.

No large mammals would be significantly impacted under the medium scenario. Eight small mammal species would be impacted under the high scenario. Species impacted included northern flying squirrel; gray, fox, and red squirrels; lynx; porcupine; pine marten; and fisher. The number of bird species impacted by the high scenario increased to 78, which is up from the 69 under the medium scenario and 39 under the based scenario. Species projected to be adversely impacted include all owl species, most woodpecker species and many warbler species.

Small mammals: The eight small mammals adversely impacted include gray and fox squirrels which are associated with mature oak forests. The northern flying squirrel requires large tracts of forest to maintain stable populations and may be adversely affected by forest fragmentation. Beaver are projected to be impacted for one decade in two ecoregions. However, the projected decline in this species must be viewed against a trend of population increases elsewhere. The remaining species showing negative impacts, lynx, porcupine, pine marten, and fisher, occupy a variety of covertypes and impacts on these species may reflect an overall reduction in the area of mature forests in these covertypes.

Birds: Impacts on riparian species were projected to be the same under the high as for the base and medium scenarios. Ten conifer dependent species were projected to declining populations under the high scenario, up from two under the medium scenario. Sixteen hardwood dependent species under the high scenario compared with six under the medium scenario.

Several times as many interior and mature forest bird species are projected to be negatively impacted under the high scenario as under the medium scenario. In addition, Spruce Grouse would be negatively impacted statewide and in ecoregions 1, 2, and 4 compared with a negative impact on ecoregion 4 only under the medium scenario.

Table 7.16. Species significantly negatively impacted on all forest lands under the base, medium, and high levels of harvest using criterion 8 (≥5 percent statewide decline for a species listed as endangered, threatened, or special concern) and criterion 11 (≥25 percent decline in any ecoregion). Numbers in parentheses indicate ecoregions with a projected decline ≥25 percent. Double x (xx) shows those species with a ≥25 percent decline statewide, plus all species affected by criteria 8.

Species	Species Significantly Impacted		
	Base	Medium	High
Small- and medium-sized mammals:			
Beaver	x (2,6)	x (2,7)	
Northern flying squirrel	x (5)	x (3,5)	xx (3,4,5)
Porcupine			xx (3,4,5)
Pine marten			xx (1,3,4)
Fisher			x (3,4,5)
Gray squirrel	x (4,7)	xx (4,6)	xx (1,4)
Fox squirrel	x (4,7)	xx (4)	xx (4,5,6)
Red squirrel			x (3,4)
Bobcat	x (3)	x (3)	
Lynx	x (3)	x (3)	x (3,4)
Birds			
Spruce Grouse		x (4)	xx (1,2,4,)
Green-backed Heron	x (3,6)	x (6)	x (6)
Sharp-shinned Hawk		x (3)	xx (3,4)
Cooper's Hawk	x (4)	x (1,4)	xx (1,4)
Northern Goshawk	x (4)	x (4)	xx (1,3,4)
Red-shouldered Hawk	xx (4,5,6)	xx (4,5,6)	xx (4,5,6)
Broad-winged Hawk		x (4)	xx (1,3,4)
Merlin		x (4)	xx (3,4)
Eastern Screech-owl	x (4)	x (4)	x (4)
Great Horned Owl		x (4)	x (1,3,4)
Barred Owl		x (6)	xx (1,3,4,5,6)
Great Gray Owl	x (3)	x (3)	x (3,4)
Long-eared Owl		x (3,4)	xx (3,4)
Boreal Owl		x (3,4)	xx (3,4)
Northern Saw-whet Owl		x (3)	xx (3,4)
Whip-poor-will	x (7)	x (7)	x (7)
Red-headed Woodpecker		x (3,4)	x (1,3,4)
Red-bellied Woodpecker			x (4)
Yellow-bellied Sapsucker		x (4)	xx (1,3,4)
Hairy Woodpecker	x (6)	x (3,6)	x (3,6)
Black-backed Woodpecker		x (3,4)	x (3,4)

Table 7.16. (continued)

Species	Species Significantly Impacted		
	Base	Medium	High
Northern Flicker	x (2)	x(2)	
Pileated Woodpecker	x (6)	x (1,6)	xx (1,3,4,5,6)
Olive-sided Flycatcher			x (3)
Eastern Wood Pewee	x (4)	x (4)	xx (1,3,4)
Yellow-bellied Flycatcher			x (3,4)
Acadian Flycatcher	x (6)	x (6)	xx (5,6)
Least Flycatcher			xx (1,3,4)
Eastern Phoebe	x (2)	x (2)	x (2)
Great Crested Flycatcher			xx (1,3,4)
Gray Jay	x (3)	x (3)	x (3,4)
Blue Jay		x (4)	xx (3,4)
American Crow			xx (1,3,4)
Common Raven		x (4)	xx (3,4)
Black-capped Chickadee			xx (1,3,4)
Boreal Chickadee	x (3)	x (3)	x (3,4)
Red-breasted Nuthatch			x (1,3,4)
White-breasted Nuthatch		x (4)	xx (1,3,4)
Brown Creeper		x (4)	xx (2,3,4)
Golden-crowned Kinglet		x (3)	xx (3,4)
Ruby-crowned Kinglet		x (3)	x (3,4)
Blue-gray Gnatcatcher		x (4)	xx (4)
Eastern Bluebird	x (2)	x (2)	
Veery			x (1)
Swainson's Thrush	x (3)	x (3)	x (3,4)
Hermit Thrush			xx (3,4)
Wood Thrush		xx (4)	xx (3,4)
Gray Catbird	x (2)	x (2)	
Brown Thrasher	x (2)	x (2)	
Solitary Vireo		x (3,4)	xx (3,4)
Yellow-throated Vireo	xx (4,6)	xx (1,4,5,6)	xx (1,4,5,6)
Red-eyed Vireo		x (6)	xx (1,3,4)
Tennessee Warbler			x (3,4)
Nashville Warbler			x (3)
Northern Parula			xx (3,4)
Yellow Warbler	x (2)	x (2)	
Magnolia Warbler	x (3)	x (3)	x (3)

Table 7.16. (continued)

Species	Species Significantly Impacted		
	Base	Medium	High
Cape May Warbler		x (3)	x (3,4)
Black-throated Blue Warbler			xx (3)
Black-throated Green Warbler		x (4)	xx (2,3,4)
Blackburman Warbler			xx (3,4)
Pine Warbler		x (1,3)	xx (1,3,4)
Bay-breasted Warbler		x (3)	x (3)
Cerulean Warbler	x (6)	xx (6)	xx (5,6)
Black-and-white Warbler			x (5)
American Redstart			x (1)
Ovenbird	x (6)	x (4,6)	xx (1,3,4)
Louisiana Waterthrush	x (7)	x (7)	x (7)
Connecticut Warbler	x (3)	x (3)	x (3,4)
Common Yellowthroat	x (2)	x (2)	
Hooded Warbler	xx (6)	xx (6)	xx (5,6)
Wilson's Warbler	xx (2)	xx (2)	
Yellow-rumped Warbler	x (3)	x (3)	x (3,4)
Northern Cardinal		x (4)	x (4)
Indigo Bunting			x (1)
Scarlet Tanager	x (6)	x (4,6)	xx (1,3,4,5,6)
Chipping Sparrow			x (3)
Song Sparrow	x (2)	x (2)	
Lincoln's Sparrow	xx (1,2,3,4)	xx (1,2,3,4)	xx (1,2,4)
Dark-eyed Junco	x (3,4)	x (3)	x (3)
Common Grackle	x (2)	x (2)	
Northern Oriole	x (4)	xx (4)	xx (1,3,4)
Purple Finch	x (3)	x (3,4)	x (3,4)
Red Crossbill		x (3)	x (3,4)
White-winged Crossbill		x (3)	x (3,4)
Pine Siskin	x (5)	x (1,3,4,5)	xx (1,3,4,5)
American Goldfinch	x (2)	x (2)	
Evening Grosbeak		x (3)	xx (3,4)

Table 7.16. (continued)

Species	Species Significantly Impacted		
	Base	**Medium**	**High**
Amphibians and Reptiles:			
Ringneck snake	x (1)	xx (1,3,4)	xx (1,3,4)
Eastern newt			x (1,4)
Red-backed salamander			x 91)
Wood frog			x (3)
Spring peeper			x (3,4)

Source: Jaakko Pöyry Consulting, Inc. (1992f).

Herps: The ringneck snake was the only species showing adverse impacts statewide under the medium and high scenarios. However, five species show significant adverse impacts in at least one ecoregion, compared with one under the base and medium scenarios.

The changes for some species also translate into 25 percent or more declines on a statewide basis. These are summarized in table 7.13 in section 7.4.1. Statewide, 48 species would decline by 25 percent or more; that is more than four times the number adversely affected under the medium scenario. The statewide declines include three species that are of special concern, endangered, or threatened (Red-shouldered Hawk, Louisiana Waterthrush, and pine marten).

Federal- or state-listed wildlife species of special concern, threatened, or endangered or their habitats.

> An impact is considered significant if any harvest or forest management activity is projected to diminish the habitat and disturb a species listed as of special concern, threatened, or endangered (either federal or state).

For analysis, a decrease of 5 percent or more in habitat or population index statewide was interpreted to be a significant impact.

The same significant impacts are projected to occur for the Red-shouldered Hawk and Louisiana Waterthrush under the high scenario as occurred under the base and medium scenarios. Additionally, the pine marten is significantly impacted under this criterion.

In addition to the direct assessments of population change assessed above, two other criteria were used to identify impacts on key habitat factors for some species. These criteria and the assessments of significance are discussed below.

Forest dependent wildlife - habitats (lowland conifers).

An impact is considered significant if, by ecoregion, net loss of patches of mature lowland conifer between 10 and 200 acres is projected to exceed 25 percent of total patches over the 50-year study period.

In regions where great expanses of lowland conifers, particularly black spruce, predominate on the landscape, protection of this covertype is not as critical to wildlife as where the type occurs as isolated patches. The increased demand for black spruce under the high scenario will likely increase pressure on this covertype.

Forest dependent wildlife - food species.

An impact is considered significant if, by ecoregion, the projected rate of removal of tree species that provide vital food for wildlife, (oaks, hickories, and mountain ash), exceeds their projected rate of replacement.

A number of species such as the grey and fox squirrels projected to have significant declines under the high level harvest rely on mature oak forests for food and cavity resources. Three factors that were part of the output will provide some guidance as to landscape scale changes to some of these species. The covertype area and age variables allow an interpretation of very broad change in the availability of these resources. In addition, the number of trees by species on timberlands was also projected.

The projected area changes in the oak-hickory covertype (table 7.8 section 7.2.1) shows that the area of this covertype is projected to increase slightly over the 50-year period, probably reflecting projected increases in the area of forest in the southern ecoregions. The average age of this covertype is projected to decline slightly from the present 69 years to 63 years under the high scenario (table 7.9 section 7.2.2). This is 15 years less than that projected under the base scenario.

The projected numbers for food tree species (from table 7.13, section 7.2.3) show increases under the high scenario compared to the base scenario. It should be stressed, however, that the numbers include all trees larger than 1-inch dbh. Trees this small would not provide food resources, hence these figures should only be used to gauge broad trends. Species showing increases over current levels include mountain ash, bitternut hickory, black oak, white oak, swamp white oak, and butternut. Those showing stable or slight increases/decreases included black walnut, bur oak, and northern pin oak. Northern red oak was projected to show a decline of approximately 15 percent for all three scenarios.

Forest species - genetic variability.

An impact is considered significant if there is projected to be a loss of genetic variability in forest plant or animal species as measured by:
1. a reduction or isolation of habitat or communities supporting a species, or
2. a reduction of geographic ecotypes such that a species now present as a viable population disappears or is approaching extirpation from any ecoregion.

As discussed previously, fragmentation is likely to increase as a consequence of increased harvesting projected to occur under the high scenario. The range of species previously listed under the base scenario are likely to be more affected under this level of harvesting than was the case under the base level. The importance attached to change affecting individual species can be assessed by weighing several factors including the overall size of the population, the distances involved, and particularly the mobility of the animal. Thus, birds would probably be least affected and herps would be most vulnerable, particularly those that are not likely to disperse along major streams and rivers. Some species show genetic variability over their range whereas others have a more homogeneous genetic makeup. Information on this is essentially lacking, so this discussion must be confined to generalities. This issue is fully discussed with regard to plants in the Biodiversity technical paper.

In general, when fragmented populations at or near the boundaries of a species range are in jeopardy, it suggests that genetic loss is much more likely than where the same amount of local loss occurs well inside the geographic range of a species. Minnesota, with its great diversity of forest and climatic types, includes the distributional limits of many wildlife species—including cases of northern, southern, eastern, and western edges of species' distributions. Thus, among midwestern states, Minnesota has an unusual number of cases where the edges of a species' genetic variability might be jeopardized. Species with significant predicted impacts from timber harvesting that reach the edge of their range in the state include: black bear, fisher, pine marten, northern flying squirrel, fox squirrel, red squirrel, woodland jumping mouse, lynx, Great Gray Owl, Boreal Owl, and red-backed salamander.

7.6.5
Recreation and Aesthetics

Changes to Minnesota forests - Patterns of forest cover in predominately forested areas-forest roads

> An impact is considered significant if there is projected to be development of permanent forest roads in areas meeting the criteria for either of the following Recreation Opportunity Spectrum (ROS) categories:
> - unroaded primitive areas.
> - semiprimitive nonmotorized areas.

The two ROS classes used in the criterion are defined as:

Primitive.—An area three or more miles from all maintained roads or railroads and which has an unmodified natural environment. There can be evidence of foot trails, or recreational use. Structures in use are rare. Contact with humans is rare and chances of seeing wildlife are good. Example: BWCAW. Approximately 3 percent of total forest land and 0.4 percent of timberland in Minnesota meet these criteria.

Semiprimitive nonmotorized.—An area one-half to three miles from all maintained roads or railroads, but which can be close to primitive roads or trails used only occasionally. Modifications to the environment are evident, such as old stumps from logging, but are not apparent to the casual observer. Structures in use are rare. Human contact is low and chances of seeing wildlife are good. Example: Recently undisturbed state lands. Approximately 9 percent of total forest land and 7.2 percent of timberland meet these criteria.

A permanent forest road is defined as a formed road that is graveled or paved and is maintained in a trafficable condition (as distinct from being allowed to revegetate). The criterion is intended to identify changes in the pattern of disturbance to the least disturbed areas of the unreserved forest lands. The ROS criteria assess levels of disturbance, particularly roads. The criterion was applied to northern counties that are predominantly forested (see table 7.17).

Harvesting and the development of roads needed to access timber from forests within these categories of lands is indicative of an increased level of disturbance. Improved access provides opportunities for additional use by people who depend on motorized access. This will likely displace a proportion of existing users and will impact animals that are adversely affected when the level of human contact increases.

Table 7.17. Distribution of FIA timberland plots and percent of plots projected to be harvested in primitive and semiprimitive nonmotorized ROS classes, by physiographic class under the base, medium and high scenarios.

ROS Class	Total number of plots	Percent of timberland plots harvested by scenario and ownership*											
		Base Scenario				Medium Scenario				High Scenario			
		State/federal lands		Other lands		State/federal lands		Other lands		State/federal lands		Other lands	
		dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet
Primitive	53	11.3	3.8	20.7	7.6	13.2	5.6	21.5	6.8	17.0	5.6	26.4	17.0
Semiprimitive nonmotorized	876	10.8	6.3	15.3	3.9	12.1	12.0	17.3	5.6	17.4	18.7	17.8	7.0

* See table 5.19 for total number of plots harvested by scenario.

According to the criterion used, only plots harvested on dry sites constitute significant impacts to primitive and semiprimitive nonmotorized recreation opportunities. The criterion specified for use in assessing impacts on primitive class lands further requires identification of those areas designated unroaded *primitive* lands and *semiprimitive nonmotorized* lands, where construction of permanent forest roads is projected.

Under the high scenario, 43.4 percent of the 53 timberland plots designated as primitive and dry are projected to be harvested and therefore significantly impacted. Additionally, 35.2 percent of the 876 timberland plots designated as semiprimitive nonmotorized are projected to be significantly impacted. These impacted plots correspond to 5.4 and 23.6 percent of all forested plots in the primitive and semiprimitive nonmotorized ROS classes, respectively. Based on the criterion, no significant impacts occur when plots in the "wet" physiographic classes are projected to be harvested. These plots would be accessed when the ground is frozen and therefore are assumed not to require permanent roads.

Forest Recreation and Aesthetics

> An impact is considered significant if VMGs are not used in the planning and execution of projected timber sales for visually sensitive areas.

The criterion refers to VMGs, which are planning tools used by the federal and state ownerships to reduce visual impacts. Significant impacts can be avoided where visual planning is used to identify *where* and *how* harvesting and associated forest operations should take place, i.e., road location and design, use of buffers, size and shape of cut, and slash and debris disposal practices.

Harvesting can reduce the aesthetic experience for subsequent users, therefore limiting the recreation value of harvested areas and the adjacent unharvested areas. However, harvest operations and associated roading can also create additional recreation opportunities of a more developed type.

Visually sensitive forested areas recognized in this criterion can include such areas as those adjacent (within one-fourth mile) to water (lakes and rivers), important tourist and recreation areas, and along recognized tourist access routes. The criterion assumes that significant impacts occur where harvesting operations take place in visually sensitive areas on lands where owners do not practice formalized visual management planning. For example, the USDA Forest Service has had formalized VMSs in place for a long time. Other ownerships, including MNDNR Management Region 2 and Beltrami County, are in the process of developing and applying guidelines.

Typically, other ownerships do not have formalized systems in place. Hence, while in some cases efforts are made to reduce visual impacts on a site by site basis, impacts can still occur when viewed from a wider context.

The certainty of the impact is dependent on the degree to which visual planning is used in timber sale layout and BMPs are adhered to in the execution of the harvesting and postharvest closure of the site. Impacts can extend into the medium-term depending on the circumstances.

Based on the interpretation of the significant impact criterion, significant visual impacts occur when timber harvesting and forest management activities do not follow VMGs. Analysis found that 74.1 percent of the timberland plots harvested under the high scenario would not be treated according to VMGs and these are therefore judged to be significantly impacted.

7.6.6
Unique Cultural and Historical Resources

> An impact is considered significant if heritage resources including cultural landscapes, structural remains, archaeological remains, Native American traditional use sites are destroyed; or cemeteries are disturbed.

The following maximum levels of significant impacts are predicted for each type of heritage resource, based on the interpretation of *destroyed* and the types of impacts discussed in section 5.5.3, and estimated likelihood of impacts under the high scenario in section 7.5.3. There is insufficient data to assess, even qualitatively, the extent that these sites will be impacted. Significant impacts are likely to occur and the relative number of impacts will increase as the level of harvesting increases.

Archaeological and Cemetery Sites
Based on the analysis presented in section 5.5.3, the predicted *maximum* number of sites to be destroyed is shown in table 7.18.

The actual numbers of sites affected can be confidently predicted to be less than these totals. However, because of the nature of the assumptions used to generate these estimates, it is not possible to quantitatively assess the effect of most of these assumptions. The only data that can be quantified are the projected acres that are harvested on national forest. Preharvest surveys detect most sites on these lands and therefore it is valid to assume that no impacts occur. The figures in table 7.18 reflect this reduction. However, it is not possible to set a lower bound on these estimates.

Table 7.18. Predicted maximum number of archaeological and cemetery sites to be destroyed in ecoregions 1 to 6 under the base, medium, and high harvesting scenarios.

Harvest Scenario	Number of Sites Destroyed	
	Number	Percent of Total Predicted Sites Affected*
Base	100,000	52
Medium	116,000	61
High	142,000	75

Source: Jaakko Pöyry Consulting, Inc. (1992g).
*The total number of sites predicted in ecoregions 1 to 6 (see section 2.3) is approximately 190,000.
Note: excludes impacts on USDA Forest Service lands.

Traditional Use Sites

As discussed in section 5.5.3, traditional use sites will be impacted. However, the extent cannot be quantified, as these sites have not been inventoried. Thus, significant impacts on these sites are likely to increase with the level of harvesting.

7.6.7 Economics

Regional economics - changes in economic parameters.

An impact is considered significant if there is projected, for each region (north, south, and metro), a change in the following economic parameters by economic sector over 50 years:
- output - ± 5 percent
- employment - ± 5 percent
- income (wages and salaries) - ± 5 percent

Section 6.6.7 describes the methodology used to estimate economic impacts. The significance criterion outlined above assesses the significance of the economic impacts projected to as a consequence of the high level of harvesting. The factors assessed include employment, employee compensation, and TIO. Applying this criterion to the economic impacts generated by the high scenario indicated that significant positive impacts are projected to occur in all of the top twenty economic sectors in the northern region of Minnesota and in five sectors in the state as a whole. In the southeast region, only two sectors are projected to have significant positive economic impacts. No significant impacts are projected to occur in the metro and southwest regions, because no forest industry expansion was projected to take place in these regions.

Significant Economic Impacts in the North Region

The expansion of the timber industry under the high scenario was projected to occur in the pulp and paper industry and in sawmills. This level of harvesting was projected to have significant positive economic impacts in terms of employment, employee compensation, and TIO within the northern region.

Nearly all of the north region's economic sectors showed significant increases in economic activity and employment (5 percent or more) as the result of high scenario expansion.

All but one of the top twenty sectors and eight of ten selected forest products and forestry sectors showed significant increases in employee compensation in the north region. Overall, the projected increase in employee compensation for all sectors of the north region was significant.

All of the top twenty sectors showed significant increases in TIO, with the Paper Mills (sector 188), Logging (sector 160), and Forestry Products (sector 24) sectors showing the largest percentage gains. Overall, the top twenty sectors together showed a significant 42 percent gain in TIO. Six of the forest products and forestry sectors showed a significant gain in TIO. When all economic sectors in the north region are considered, the projected increase in TIO was significant.

Expansion of the Paper Mills sector (188) resulted in a significant 195 percent gain in TIO. It generated a 34 percent increase in employment and employee compensation. These employment and employee compensation increases were easily significant under the criteria established for this analysis.

Significant Economic Impacts in the Southeast Region

Expansion of the sawmill industry was projected for the southeast region under the high scenario. This expansion caused significant increases in the sawmills and logging sectors. However, the overall employment, compensation and TIO increases for the region were not significant.

Significant Economic Impacts for the State of Minnesota

The projected expansion of the timber industry would result in significant increases in employment, employee compensation, and TIO for many sectors in the north region, especially under the high scenario. However, the increases for the state as a whole were less significant. At the high level of timber harvest, only five of the top twenty sectors contributing most to employment gains in Minnesota had projected increases that were significant (5 percent or greater), and three of these were sectors related to forestry or forest products. Only three of the top ten forest products and forestry sectors (22-Forest Products) indicated a significant increase in employment statewide. Among the top twenty sectors contributing most to employee compensation, four showed a significant increase. Only three of the selected forest products and forestry sectors showed significant gains in employee compensation. Table 7.19 shows those sectors of Minnesota's economy with significant (5 percent or greater) increases in employment, employee compensation, and TIO resulting from the medium and high scenarios.

Overall, total output in the state's economy increases by about a billion dollars under the medium scenario and by over five billion dollars under the high scenario. In each case, about 60 percent of the total increase occurs in the paper sector. Almost all of the direct impacts occur in the paper sector. The output of the paper sector increases by 39 percent under the medium scenario and by 195 percent under the high scenario. The logging sector increases output by 24 percent under the medium scenario and doubles under the high scenario. Impacts are measured relative to the base scenario; therefore, there are no impacts resulting from the base scenario.

Impacts on Forest Management Activities
The changes to management agencies caused by an increase in the level of harvest will not trigger the significance criterion as this was developed to assess impacts by sector at a regional scale. Precise estimates are not available for the additional funding and personnel that might be required by federal, state, and county land management agencies to meet future increase in timber harvests. However, additional resources will need to be committed by state government and the counties to implement the harvest level and mitigations recommendations.

Impacts on Recreation and Tourism
It was not possible to directly link increased timber harvesting with changes in recreation activities. In addition, it was not possible to develop linkages between the level of harvesting and the levels of tourism activities or expenditure patterns. As a consequence, it has not been possible to quantitatively assess how the increased timber harvesting levels considered would economically impact the sectors identified in the FSD. In the absence of quantitative assessments it is not possible to trigger the significance criterion.

7.6.8 Summary of Significant Impacts

The high scenario significant impacts identified in sections 7.6.1 to 7.6.7 are the same as those listed in section 5.6.8 as explained in section 6.6.8. The difference between scenarios is in the degree or scale of impacts rather than in the type of impact. The high scenario in most cases showed more significant impacts in terms of acreage and/or species impacted than the base

Table 7.19. Economic sectors in Minnesota with significant increases in employment, employee compensation, and TIO due to increased levels of timber harvesting under the medium and high scenarios. (Direct, indirect, and total impacts, in employment [jobs] and in millions of dollars.)

IMPLAN Sector	Baseline TIO	Medium Scenario				High Scenario			
		Direct Effect	Indirect Effect	Total* Effect	Percent of Base	Direct Effect	Indirect Effect	Total* Effect	Percent of Base
Sectors with significant increases in employment (jobs)[a]									
160 Logging Camps and Logging	2,016		488	489	24		2,007	2,008	100
188 Paper Mills, Except Building	8,252	352	0	352	4	2,812	0	2,812	34
456 Electric Services	12,116		173	192	2		873	976	8
446 Railroads and Related	8,732		135	138	2		684	698	8
24 Forestry Products	1,386		131	132	10		551	559	40
22 Forest Products	75		6	6	7		24	24	32
161 Sawmills and Planing Mills	941		10	10	1	247	56	316	34
170 Wood Pallets and skids	193		4	4	2		19	19	10
Total, all sectors in Minnesota	2,085,517	352	3,788	6,752	0	3,059	18,424	35,094	2
Sectors with significant increases in employee compensation ($ millions)[b]									
188 Paper Mills, Except Building	380.22	16.19	0.01	16.20	4	129.35	0.06	129.41	34
456 Electric Services	455.54		6.49	7.23	2		32.82	36.68	8
446 Railroads and Related	384.95		5.86	6.04	2		29.73	30.64	8
160 Logging Camps and Logging	23.13		5.60	5.61	24		23.03	23.05	100
521 Other State and Local	180.14		1.35	1.75	1		6.82	8.92	5**
24 Forestry Products	1.89		0.18	0.18	10		0.75	0.76	40
161 Sawmills and Planing Mills	9.64		0.16	0.16	2	3.85	0.86	4.73	49
170 Wood Pallets and Skids	2.34		0.05	0.06	3		0.27	0.28	12
Total, all sectors in Minnesota	43,230.86	16.19	84.42	146.38	0	133.20	418.87	790.41	2
Sectors with significant increases in TIO (any scenario) ($ millions)[c]									
188 Paper Mills, Except Building	1,568.1	611.2	0.3	611.4	39	3,062.1	1.3	3,063.4	195
456 Electric Services	2,814.1		40.1	44.7	2		202.8	226.6	8
160 Logging Camps and Logging	126.9		30.7	30.8	24		126.3	126.4	100
457 Gas Production and Distribution	885.0		13.5	15.2	2		68.2	76.9	9
235 Petroleum Refining	1,038.0		11.4	13.1	1		57.3	66.0	6
446 Railroads and Related	758.6		11.6	11.9	2		58.6	60.4	8
24 Forestry Products	65.7		8.7	8.8	13		31.1	31.5	48
521 Other State and Local	550.1		4.4	5.6	1		22.0	28.8	5
161 Sawmills and Planing Mills	47.8		0.9	0.9	2	21.9	4.9	26.9	56
22 Forest Products	4.7		0.3	0.4	7		1.4	1.5	32
170 Wood Pallets and Skids	8.6		0.2	0.2	2		1.0	1.2	13
Total, all sectors in Minnesota	140,462.7	611.2	297.0	1,059.5	1	3,084.0	1,451.2	5,324.1	4

Source: Jaakko Pöyry Consulting, Inc. (1992h).

[a]Sectors 160, 446, 464, 27, 161, 172, and 23 adjusted to reflect IMPLAN revisions in the north region. Units are number of jobs above baseline employment.

[b]Sectors 188, 160, 521, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the north region. Units are employee compensation above baseline compensation ($ millions).

[c]Sectors 188, 160, 24, 521, 464, 27, 161, 170, and 172 adjusted to reflect IMPLAN revisions in the north region. Units are increase in TIO above baseline ($ millions).

* Total effect in industry output includes direct, indirect, and induced (not shown) increases.

** Less than 5.0 percent, but rounded up to 5 percent.

and medium scenarios. In some cases, for example soil nutrient losses, the effect was closely related to the acreage harvested. However, in other cases, notably wildlife impacts, there was a large increase in the number of significant impacts.

7.7 Recommended Mitigation Strategies

The strategies developed to mitigate significant impacts projected to occur at the high level of harvest (7.0 million cords per year) will include those developed to mitigate the significant impacts identified at the base (4 million cord) and medium (4.9 million cord) levels of harvest. For most covertypes, the difference among the three scenarios is related to the intensity of harvesting activity at the landscape level. *The types of site level impacts will be unchanged and, therefore, the same mitigations will be required; although, mitigations would typically need to be applied to more area than under the base scenario.* For example, the area of harvest units expected to be significantly impacted by compaction was approximately 840,000 acres under the base scenario, 1,050,000 acres under the medium scenario and 1,240,000 under the high scenario. Therefore, the same mitigation strategies would have to be applied to an additional 190,000 acres to mitigate significant impacts under the high scenario as compared to the medium scenario.

In addition, the same mitigations applied because of significant impacts identified at the base and medium levels may also mitigate other impacts projected to occur at the high level of harvest. For example, the intensity of harvesting in a covertype projected under the base level may have resulted in projections of significant impacts on a single squirrel species; while under the medium scenario, the more intensive harvesting in the same covertype may have resulted in significant impacts on two additional squirrel species and two bird species. The same mitigation strategy, e.g., retain cavity and mast trees may mitigate all impacts.

Similarly, more intensive harvesting at the landscape level will not change the types of impacts; however, the *need* for mitigations will likely increase with increasing intensity of harvest. Hence, the strategy to develop a connected landscape, and the principles guiding development of that strategy remain the same at all three levels of harvest; however, the need for this mitigation increases as the level of harvest increases and the degree of human induced change in the landscape increases.

The rate of harvest over the 50-year study period will also affect the level of impacts. This is particularly the case with mitigations that depend on information being gathered. Information on the locations and ecology of plant species classified as endangered, threatened, and special concern is a good example. Stands harvested without that information increase the likelihood of impacts. Therefore, the more stands harvested before the information becomes available, the greater the impacts.

Therefore, the strategies presented in section 5 for the base scenario will apply to the mitigations required under the high scenario. However, these mitigations will often need to be applied to more areas or there is greater urgency to them.

7.7.1 Recommended Strategies Development

The criteria and process for developing recommended mitigation strategies was described in section 5.7.1.

7.7.2 Recommended Strategies

This section identifies the strategies developed to mitigate significant impacts projected to occur at the high level of harvest (7.0 million cords per year). These strategies, many of which reflect the mitigation measures developed in the technical papers, have been combined and modified where required in order to achieve multiple objectives and resource protection goals. Mitigation strategies that would improve the standard of forest practice in Minnesota but do not directly mitigate significant impacts are also presented.

The strategies recommended to address significant impacts at the high level of harvesting are presented under three categories which reflect their main focus:

1. site-level responses;
2. landscape-level responses; and
3. forest resources research.

The actual mitigations recommended for each of these categories were listed in section 5.7.2.

7.7.3 Effectiveness at Mitigating Significant Impacts

The following section discusses the relative effectiveness of the proposed strategies as mitigations for the significant impacts projected to occur under the high scenario.

1 Impact
Projected significant loss of forest area in ecoregions 1, 3, and 4
Reduce the area of forest converted to nonforest land uses: The process of land use conversion is independent of the level of harvesting. The proposed strategy seeks to influence NIPF ownership to maintain forested land under forest cover, irrespective of their management objectives for the land. The effectiveness and feasibility of this mitigation strategy was discussed in section 5.7.3 and those findings apply as well to the high harvest scenario.

2 Impact
Projected harvesting affecting patterns of forest cover in areas of mixed land use
These impacts would affect species that depend on the features of mature forest and forest interior species. The following strategies will mitigate these impacts.

Maintain patches of forest intact in areas of mixed land use: By reducing use of clearcutting silvicultural systems, linking patches, and augmenting existing patches of forest.

Mitigations to maintain populations of forest interior species and the Red-Shouldered Hawk will need to maintain forest interior conditions in remnant patches. Large (>300 acre) blocks of mature forest will likely have to be retained with only periodic disturbance to maintain the most sensitive species.

Effectiveness: If applied at a regional scale this mitigation strategy will likely be effective at mitigating impacts by maintaining these important habitats. The increased level of harvest is projected to be mainly within northern ecoregions which are not the focus of the mitigation strategy.

Feasibility: As discussed in section 5.7.3, the feasibility of this strategy is heavily dependent on NIPF owners adopting the constraints on management of their forests.

Retention of large blocks of forest with constraints on the amount of disturbance is less likely to be successful because this aspect of the strategy will likely require cooperation of more than one NIPF landowner. As more landowners become involved the likelihood of **all** owners cooperating will decrease. Purchase of these blocks for inclusion in the state's reserve system is likely the most effective means to achieve this mitigation.

3 Impact
Projected changes to tree species mix
Projected changes to tree species mixes in the state's forests are likely to result from changes in the age class distributions of covertypes as well as

from direct impacts on minor tree species. The strategy depends on several distinct elements which are discussed below.

Monitor the age class structure and covertype structure of the state's forests and their patterns across the landscape: This mitigation would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Complete the MNDNR county biodiversity inventory: This mitigation would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Conduct an inventory of old growth forests across all ownerships: This would not mitigate impacts directly, but would contribute information to assist decisions on other mitigations. Specific guidelines for managing the identified sites would have to be developed for USDA Forest Service, MNDNR, and county-managed lands.

Maintain desired age class distributions for each covertype: Offers the prospect of modifying the tree species mix by insuring that there are adequate numbers of stands present in the state that are likely to provide suitable conditions for the full range of species.

Maintain desired covertype distribution: This provides for maintenance of tree species mix by management to achieve acreage goals by covertype. The available tools include harvesting and a range of silvicultural practices that favor certain species and covertypes. In some areas, restoration of forest cover by planting or enrichment may be appropriate. In other situations minimal disturbance might be effective to allow natural succession.

Effectiveness: The mitigation strategy would likely be only moderately effective and would require long periods to achieve even detectable change. Because harvesting is the only practical tool available for these landscape scale manipulations there are inherent constraints on the range of covertypes that will likely be manipulated. Typically changes will be focussed on covertypes dominated by the more commercial species. The projected increases in demand for some species such as black spruce and balsam fir will assist in efforts to balance age classes. Stands of other noncommercial covertypes and those within reserved forests will likely continue the trend towards older age classes. Use of other tools such as fire and special silvicultural systems would likely be very expensive and confined to important stands.

Feasibility: The mitigation is moderately feasible as the major public ownerships have policies to maintain biodiversity. The other ownerships typically have no clear management objectives in this area and are less likely to direct their management to achieve these goals. Therefore, the mitigation would be focussed on the major public owned forests

4 Impact
Projected changes in the age class structure of paper birch
This was the only covertype projected to have significant changes to the age class distribution. The following elements comprise the mitigation strategy for this covertype.

Monitor age class and covertype structure of the state's forests and their patterns across the landscape: This would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Conversion of older stands to young stands to balance the age class structure: Would require that old stands be harvested and new stands regenerated.

Effectiveness: If a proportion of older stands could be replaced by younger stands the mitigation would be effective.

Feasibility: The mitigation is only moderately feasible because the covertype is not a sought after commercial species and is difficult to regenerate once stands become too old to reliably stump sprout. The major public ownerships will likely undertake limited regeneration programs but these will likely be inadequate to balance the age class distribution.

5 Impact
Projected harvesting affecting genetic variability of plant or animal species
Harvesting is projected to lead to further fragmentation of the forest and to impact outlier populations of some species and some plant communities. The following elements make up the mitigation strategy to mitigate these impacts.

Complete the MNDNR county biodiversity inventory: This would not mitigate impacts directly but would contribute information that would allow informed decisions to be made concerning other mitigations.

Develop blocks of ERF: Would promote additional diversity of covertype condition and would provide habitat for species dependent on mature/older forest. ERF policies are likely to be confined to the major public ownerships.

ERF and riparian corridors would maintain many opportunities for transfer of genetic materials between separated populations of forest plants and animals. In the northern ecoregions where public ownerships dominate ownership patterns, remnant old growth is preserved and ERF policies are being implemented. In the southern part of the state, the riparian zones will be the most important vectors for genetic transfer.

Modified silvicultural systems: Such as use of uneven-aged and thinning for harvesting and retention of key habitat requirements would likely maintain conditions that are suitable for many of the species likely to be significantly adversely impacted.

Effectiveness: Combinations of these mitigations will likely be effective at reducing significant impacts by providing a range of age classes in each covertype and linkages for transfer of genetic material.

Feasibility: The major public ownerships have mandates to manage for biodiversity. However, application of these mitigations within forests managed by ownerships other than the major public landowners is likely to be mixed and will depend on owners' objectives. Consequently, the mitigation is rated at low to moderate feasibility. It will likely be more feasible in the north and less feasible in the south of the state.

6 Impact
Projected harvesting affecting federal- or state-listed species of special concern, threatened or endangered or their habitats
Impacts affecting populations of these species of plants and the communities that contain them are interpreted to occur as a consequence of harvesting because little is known of their locations. The significant impact criterion threshold was set at any diminution or disturbance of habitat or populations of these species. Projected increases in levels of harvesting, particularly in ecoregions 3 and 4, will increase the risk that such impacts will occur, especially under the high scenario.

The mitigation strategy directed towards maintaining genetic variability discussed previously will likely mitigate these significant impacts.

Complete the MNDNR county biological survey: There is a strong likelihood that populations of these species and the communities which support them will be disturbed and diminished under circumstances where the occurrences of these species remains unknown. Therefore, significant impacts are likely to be higher in areas that have not been surveyed by the MNDNR county biological survey.

Concern for completion of an old growth inventory, as noted in section 5, increases with the level of harvesting.

Effectiveness: The effectiveness of the strategy is highly dependent on access to information on the occurrences of these species and the communities that support them. Consequently, the rate at which harvesting occurs is an important factor. The increased level of harvesting under the high scenario means that during any given period, approximately 21 percent more timberland will be harvested than under the medium scenario. Therefore, to maintain the risk of impacting these species it will be necessary as a minimum to greatly increase the rate at which the survey is done. Planning based on information available from this program would enable the locations of these populations to be noted and harvesting redirected. The effectiveness of the strategy relies largely on increasing the funding and staffing allocated to the MNDNR county survey.

Feasibility: The strategy is likely to be moderately feasible subject to adequate funding being provided to complete the biodiversity survey.

7 Impact

Changes in the susceptibility and vulnerability of covertypes to forest health risks

Impacts were interpreted based on projected changes to age class distributions and circumstances where multiple-entry harvesting systems were to be used. The changes in forest health projected to occur primarily reflect the increasing age of stands in the noncommercial covertypes on timberlands and all covertypes within reserved lands. The mitigation strategy is aimed at developing statewide plans to handle pest outbreaks and to modify the equipment and techniques used in multiple-entry harvests. The following outlines the elements of this strategy.

IPM strategies: Will assist to mitigate impacts associated with major outbreaks such as gypsy moth. Planning such as advocated under this mitigation will allow a more rapid response and therefore will likely reduce the level of impact experienced.

Modify equipment and practices for use in multiple entry harvesting operations: Will likely reduce the incidence of damage to residual stems and will therefore reduce the incidence of pests and diseases that are associated with wounds. This will have particular application in the south of the state.

Maintain desired age class distributions for each covertype: Will allow the prospect of reducing the proportion of susceptible and vulnerable covertypes on ownerships with wood production objectives.

Effectiveness: The mitigation strategy is likely to be moderately effective at providing the basis for reducing the scale of damage caused by major outbreaks of pests, particularly pests such as gypsy moth. The localized impacts caused by damage to retained stems would likely be reduced if the mitigations to equipment and practices were introduced.

Feasibility: The strategy is likely to be moderately feasible subject to participation by the major stakeholders in the process of developing IPM strategies. Adoption of new harvesting equipment and techniques will likely be of moderate feasibility subject to provision of assistance to undertake trials and subsequently, to loggers willingness to make the investments needed to replace equipment.

8 Impact

Projected harvesting affecting site nutrient capital

Nutrient losses above estimated levels of replenishment were projected to occur for several combinations of covertype/soil type/harvesting practices. The increased harvesting projected to occur under the high scenario will increase the requirement for this mitigation by increasing the area of timberland projected to be significantly impacted. These significant impacts can be mitigated by changing the length of rotations and the harvesting methods used. The following strategy has been developed to mitigate these impacts.

Retain or redistribute slash within the cutover: Will maintain the nutrients contained in the leaves (needles) and branches within the cutover. This can be achieved either by favoring use of equipment that retains slash at the site where the tree was felled; or, slash from landings can be redistributed using existing equipment. Development of systems that could undertake partial or full bark removal in the cutover would also greatly aid nutrient retention.

Manage a proportion of stands under ERF guidelines: Would extend the period for nutrient replenishment prior to the next harvesting operation.

Effectiveness: The mitigation of retaining or returning slash and (if feasible) bark within the cutover is likely to be a very effective strategy for reducing nutrient loss. Longer rotations are also effective by allowing natural processes to replenish the nutrients lost in harvest or in site preparation. The duration is long-term, but effectiveness is reduced with time as species reach advanced ages and become less vigorous and more susceptible to forest health problems.

Feasibility: In some cases the strategy can be implemented relatively easily. However, overall feasibility will depend upon operational and technical constraints, particularly on the harvesting technique, the equipment available, and to some extent the season of harvesting as it facilitates removal of bark. Equipment to remove branches and bark at the stump is currently operational overseas. In the long-term, feasibility should be high. Return of slash to a site from a landing or elsewhere would also be similarly effective and long-term. Its feasibility would be affected by the added cost of another pass of equipment over the site and the potential compaction and puddling associated with such an activity. Returning material in winter would minimize the latter effect. The duration of the effect is long-term.

The feasibility of applying longer rotations is problematic for short-lived species and benefits diminish with time as nutrient levels return to preharvest levels. Under the high scenario, substantial acreage would need to be under short rotation.

9 Impact

Projected harvesting affecting soil physical structure

Compaction and puddling is projected to most frequently impact well-drained medium-textured soils (the most common soil in the state) and poorly-drained medium- and fine-textured soils. The likelihood of impacts is affected by the extent of roading, type of equipment, and the season of harvest. The following describes the mitigations that comprise this strategy.

Develop landscape-based road and trail plans: This strategy would involve planning and coordination between ownerships to develop landscape-based road and trail plans. The plans would cover development of new roads, long-term access needs and closure policies.

Modify times of equipment operation to minimize compaction: Is intended to reduce the occurrence of compaction by identifying susceptible sites and limiting operations on those sites to periods when the risk of compaction is lowest.

Effectiveness: If fully implemented, the strategy would likely be moderately effective at mitigating the significant impacts.

Feasibility: Development of landscape-based plans would require a leadership role to initiate the process and to coordinate responses from other ownerships. The MNDNR is the agency best placed to undertake this role. This strategy is feasible given the existing MNDNR responsibilities to produce an inventory of state forest roads under the MFRMA of 1982. In addition, the number of ownerships likely to be developing new roads in the more remote areas is limited. The cost of adopting this mitigation would center on the additional planning that some ownerships would have to undertake to participate in the process. Additional costs would also be incurred by the MNDNR in coordinating and compiling inputs from others.

Constraints on equipment operation during susceptible periods will require assessments of site susceptibility at an operational scale if preventative measures are to be effective. In most areas, soil maps and other tools are *not* available at the stand or harvest unit scale. Confirmation of site susceptibility will require on-the-ground inspection by natural resource professionals. This will likely require additional training and staffing of forest management organizations. The MNDNR, USDA Forest Service, and possibly the larger counties and forest industries are best equipped to undertake this mitigation. It is unlikely that planning and assessments on NIPF lands would reach this level of sophistication and consequently this mitigation is unlikely to be feasible on these lands.

The feasibility of imposing seasonal restrictions on harvesting on some soil types or delaying operations that are already underway would likely be constrained by the financial hardship to loggers that would likely happen as a consequence of these actions. In addition, these restrictions may interfere with the continuity of supply to some mills. The feasibility will therefore also be constrained by the flexibility of forest industries delivery schedules.

10 Impact
Projected harvesting causing accelerated erosion from forest roads
Forest roads are the primary sources of accelerated erosion from harvested areas. The mitigation strategy aimed at reducing compaction will also mitigate erosion impacts.

The key elements of the above strategy that will mitigate accelerated erosion impacts include adherence to BMPs: consistent road closure policies; and reducing the length of road constructed while improving the standard of design, construction, and maintenance.

Effectiveness: These mitigations will reduce the amount of poor standard forest roads that are likely to cause erosion. If applied throughout the state this strategy would provide moderately effective mitigation of the impact.

Feasibility: The main erosion problems in the state occur in the southeast where there is less likelihood that these measures will be adopted because of the predominance of NIPF lands in this region.

11 Impact
Projected changes in the populations of forest dependent wildlife
Projected changes to wildlife populations were based on changes in the amount and quality of likely habitat within the known ranges of each species or group of species. The mitigation strategy is intended to:

- identify and protect important habitats;
- provide a range of age classes within each covertype in particular to maintain habitat features of old and old growth forests;
- maintain patches of forest in areas of mixed land use;
- provide a landscape with connections necessary for movement of animals among separated populations;

- modifications to harvesting practices to maintain within cutovers some of the key habitat needs for animals dependent on features of mature forests; and
- distribute logging slash to provide cover for small animals in clearcuts.

The following discusses each element of the proposed mitigation strategy and assesses the overall effectiveness and feasibility of the strategy.

Complete the MNDNR county biological survey: The information from the survey is essential to identify important habitats for forest dependent species. Earlier comments on the importance of the rate of harvesting and its relation to the speed of the survey also apply here.

Conduct an inventory of old growth forests across all ownerships: This information is important to identify habitat for species dependent on old growth forests.

Develop blocks of ERF: Would promote additional diversity of covertype condition and would provide habitat for species dependent on mature/older forest. ERF policies are likely to be confined to the major public ownerships. ERF and riparian corridors would maintain many opportunities for movement of animals between separated populations.

Maintain patches of forest intact in areas of mixed land use: By reducing use of clearcutting silvicultural systems, linking patches, and augmenting existing patches of forest. This mitigation strategy incorporates aspects of mitigations including management of riparian corridors and use of uneven-aged silvicultural systems in those patches that are harvested. Large (>300 acre) blocks of mature forest will likely have to be retained with limited disturbance to maintain populations of the most sensitive species, especially the Red-Shouldered Hawk.

Modify silvicultural systems to maintain key habitat components: Such as use of uneven-aged and thinning systems as substitutes for clearcutting where appropriate, i.e., in certain covertypes that can be managed using these systems.

Redistribute slash across the cutover: Would maintain cover for small mammals in cutovers following clearcutting.

Effectiveness: Maintenance of key habitat requirements and slash spreading would likely be moderately effective at maintaining habitat for adversely impacted species in those covertypes harvested using clearcutting systems. Mitigations that substitute uneven-aged silvicultural systems for clearcutting will likely be effective at maintaining suitable habitat conditions for species dependent on elements of mature forests, but would likely provide moderate to low levels of mitigation for species dependent on forest interior conditions and limited disturbance.

ERF, old growth, and connected landscapes would provide habitat for species dependent on old forest and forest interior species. The focus of these mitigations is likely to be in the northern half of the state because of the pattern of ownership. These mitigations are less likely in the south because of predominantly NIPF ownership. Maintenance of large patches of unharvested forest in these areas will likely be moderately effective at maintaining populations of forest interior species present in the south.

Feasibility: Modifications to maintain key habitat features are widely practiced on lands by the major public ownerships and are being introduced by some counties. Introduction of these mitigations to NIPF and industrial lands will likely be dependent on the costs associated with their adoption, the owner's awareness of the need for these mitigations, and the willingness of loggers to implement the mitigations at an operational level.

Replacement of clearcutting with uneven-aged silviculture systems is actively being undertaken by the major public landowners as part of their ERF programs. In addition, these systems are likely to be used on NIPF lands in the south of the state. This is because the covertypes and range of products sought in the south are more suited to these systems.

ERF and old growth are likely to be feasible on public lands in the northern part of the state. These measures are consistent with the mandate given these ownerships. The feasibility of maintaining large blocks of forest in the south is less likely because of the problems associated with coordinating uniform management with more than one owner as were discussed previously.

Similarly, connecting corridors of ERF would be more feasible in the north, where there are large contiguous blocks of public ownership. Given that a sizable portion of the landscape is going to be managed as ERF anyway, the cost of ERF corridors might be modest, since corridors might simply be a different spatial arrangement of ERF—some of it in strips instead of all in blocks. ERF corridors would likely be infeasible in the south, due in large part to the high cost of purchasing easements across private lands in areas that are intensively farmed. As a consequence, riparian corridors will probably always provide the major habitat linkages in the southern part of Minnesota.

The overall strategy is likely to be moderately successful at mitigating impacts on those species projected to be significantly impacted. The need for it increases under the high scenario as compared to the base and medium harvest levels.

12 Impact
Projected harvesting affecting populations of the Red-shouldered Hawk, Louisiana Waterthrush, and pine marten
These are the only animal species listed as a federal or state species of special concern, threatened, or endangered. The Red-shouldered Hawk and pine marten are projected to be significantly impacted because of harvesting in larger patches of forest. The pine marten is found in a variety of mature forest types in the northern part of the state where such habitat exists in large blocks.

The strategies discussed under impact 11 which seek to mitigate impacts on all significantly impacted wildlife populations includes all the elements likely to benefit these species. Developing blocks of ERF, maintaining linkages between patches of remnant forest or old growth via connected landscapes, and maintaining patches of forest intact in areas of mixed land use are the three strategies discussed under impact 11 most likely to benefit the Red-shouldered Hawk and pine marten.

13 Impact
Projected harvesting affecting patterns of mature lowland conifer stands
Patches of mature lowland conifers are important habitat, particularly in those parts of the state where lowland conifers occur as small isolated patches within more extensive upland forests. The strategy is intended to maintain such stands as an ongoing part of the landscape. The substantial increases in the volumes of lowland conifers projected to be harvested under the high scenario will likely increase the need for this mitigation. The following describes the proposed elements of this strategy.

Retention of conifer patches in clearcut stands: Is part of existing federal and state management guidelines. This mitigation would require that these patches be excluded from harvests on other ownerships that are primarily directed at obtaining upland species.

Effectiveness: If applied, the mitigation would maintain these habitat elements within cutovers in predominantly upland stands.

Feasibility: The mitigation is straightforward and could be easily applied at an operational level. The major public ownerships already undertake elements of this mitigation in their current management strategies guidelines, particularly for deer management. It is less likely that NIPF and industrial owners will adhere to these guidelines because the retention of conifers could present a real cost. The level of compliance will likely reflect the value of the species retained.

14 Impact
Projected harvesting affecting the availability of food producing trees
The loss of food producing trees such as oak and hickory were projected to impact species such as the gray and fox squirrels that rely on mature oaks to provide food and shelter (cavities). The following mitigations make up the strategy directed at maintaining these habitat features.

Clearcutting with residuals: Will retain mature food producing trees in those covertypes that include such trees as part of the species mix. This mitigation would favor retention of trees such as oak, hickory, mountain ash, and cherry. Federal and state management guidelines favor retention of these trees on the major public timberlands.

Effectiveness: This mitigation would preferentially maintain these important habitat elements in areas subjected to clearcutting. Retention of these trees would be moderately effective in sustaining populations of animals dependent on food from these trees.

Feasibility: The feasibility of this mitigation is dependent on ownership. The state and federal lands are likely to forgo the revenues possible from sale of these trees (especially oak). In contrast, the mitigation is less likely to be feasible on NIPF and industry owned lands and on many county managed lands as these owners are less likely to forgo the revenues. In addition, operations on these lands are less likely to be planned to maintain these habitat features prior to harvesting.

15 Impact
Projected harvesting in the absence of VMGs on visually sensitive areas
Timber harvesting and forest management activities that occur within the visual catchment of resorts or other outdoor recreation facilities are projected to cause significant impacts on aesthetic values where VMGs are not used. The mitigation strategy is aimed at developing (1) VMGs that can be applied as a minimum standard for all timberlands, and (2) coordinated planning of future road and trail development and closures.

Develop landscape-based road and trail plan: This would provide opportunities for a broad audience to learn about and affect the visual aspects of forest settings.

Development and promotion of VMGs for use on all timberlands: This would reduce the level of visual impact likely to occur as a consequence of harvesting related activities on ownerships that do not use VMGs.

Effectiveness: This strategy would provide a moderate level of effectiveness at reducing the likelihood of conflicts between the forest products industry and the tourism/recreation resort industry.

Feasibility: There is already some dialogue between resort owners and timber producers regarding timber harvesting, travel corridors, and the visual catchment of resorts. A variety of options are available that range from a cooperative agreement with the landowner to limit logging and/or to use VMGs if logged to purchase of visual easements.

16 Impact
Projected development of permanent roads in primitive and semiprimitive nonmotorized areas
Harvesting is projected to result in the development of permanent roads in primitive and semiprimitive nonmotorized areas. Doing so affects these sites by changing the recreational opportunities present and restoration to the original opportunities is by definition not possible. The problem is intensified by increased harvesting in the high scenario as compared to the base and medium scenarios.

Develop landscape-based road and trail plan: This would improve the chances for minimizing roads and trails that would change recreational opportunities on the more primitive sites and ensure that a variety of recreation opportunities are maintained across ownerships.

Develop guidelines for management road construction: Would provide for protection of recreational values and use in primitive and semiprimitive nonmotorized areas which are managed for timber production.

Effectiveness: In addition to the above noted benefits of road and trail planning for resort operators, such plans would provide the overview needed to develop an understanding of where primitive and semiprimitive nonmotorized recreational opportunities exist and might exist in the future. Coordination between ownerships is important to the success of this planning. Use of nonpermanent roads and VMGs can reduce the degree and period over which impacts persist.

Feasibility: These alternatives are potentially feasible subject to cooperation of the major timberland ownerships. However, this will require leadership by the MNDNR as the most appropriate agency to initiate and oversee the planning and development of nonpermanent road guidelines and their implementation. This planning and the development and implementation of guidelines would have long-term benefits.

17 Impact
Projected harvesting affecting unique cultural and historical resources
Harvesting is projected to significantly impact a range of archaeological, cemetery, and traditional use sites used by contemporary Native Americans.

Provide adequate resources to maintain the state listing of known sites: This would allow the state archaeologist to discharge current responsibilities to maintain an important reference describing the occurrences of sites in the state; and to provide a leadership role in developing a better understanding of the state's heritage resources. This mitigation is not linked to timber harvesting but extends to all land uses that involve soil disturbance.

Increase the proportion of harvests undertaken during winter: Reducing soil compaction by changing the season of harvest for susceptible soil types will likely mitigate some impacts as frozen soil will not experience the levels of compaction that would occur during other seasons.

Development of a landscape-based road and trail plan : This would provide opportunities for traditional users to comment on roading issues during the planning phase. This could help avoid conflicts.

Effectiveness: This strategy would provide a low level of effectiveness at mitigating the significant impacts projected to occur.

Feasibility: The feasibility of these mitigations is likely to be relatively low, due to the low priority given these resources by the majority of ownerships.

7.7.4
Cumulative Unmitigated Significant Impacts

The mitigation strategies described in the previous section will likely mitigate many of the significant impacts projected to occur under the high level of harvesting. This section identifies the cumulative unmitigated impacts that are likely to remain despite implementation of the mitigation strategies.

Loss of Forest Area and Timberlands

There is a strong likelihood that the area of forest in the north of the state will continue to decline. The area of timberlands will continue to decline as a consequence of the loss of forest area and the increased area of forest managed primarily for nontimber values. These reductions will exacerbate constraints on wood supply at the high level of harvesting. Increasing the productivity of the acres that remain available for harvest is achievable and could offset any losses of timberland acreage over the long-term.

Changes to Age Class and Covertype Structure

The levels of harvesting projected to occur under the high level of harvesting will improve the balance in the age class distributions for several of the species and/or covertypes that are currently underutilized from a timber production perspective and were showing marked shifts towards older age class distributions. The shift will be towards younger age classes. However, despite this reversal in the trend to older age classes, the projected age class distributions at the end of the study period show the acreage of old forest will be similar or greater than what exists today for most covertypes. This is because there are areas that have been excluded from harvest where forests will continue to mature. Also, for some covertypes, the volumes harvested are less than the net increment in volume over the study period.

Changes to the paper birch covertype were assessed as being the only significant impact under the relevant age class criterion. However, there is a projected increase in the aspen covertype acreage at the apparent expense of conifer covertypes. That would be mitigated only by allowing natural succession to conifer covertypes, retention of conifers in harvested stands, and regeneration of harvested aspen stands by planting conifers or other practices that favor conifer establishment on a large-scale. This situation argues for covertype goals and practices to achieve them over the long-term.

Incidence of Pests and Diseases

The likely increase in the vulnerability and susceptibility of some covertypes to impacts from pests and disease is closely linked to the age class changes discussed above. Despite the effectiveness of an IPM plan, some impacts cannot be mitigated for the reasons set out above. The incidence of losses to pests and disease will likely be less under the high scenario as compared to the base or medium scenarios because of the trend to younger and generally less susceptible and vulnerable stands.

Impacts on Biodiversity

The lack of knowledge concerning the distributions and specific populations of endangered, threatened, and special concern species will likely lead to ongoing and increased frequency of localized impacts on these species as a consequence of timber harvesting operations. In the absence of this data, impacts on these categories of plants will continue and likely increase over the levels of impacts under the base and medium scenarios.

Populations of the Red-shouldered Hawk, Louisiana Waterthrush, and pine marten will likely be maintained under the proposed mitigations, although there is some uncertainty due to inadequate knowledge of the precise habitat requirements of these species.

Impacts on Forest Soils

More acres will be affected by losses of nutrient capital under the high as compared to the base and medium scenarios. Similarly, more acres will be compacted and experience accelerated rates of erosion. The projected increase incidence of these impacts increases the importance of mitigation strategies to minimize their occurrence.

Erosion from roads and other compacted areas will likely increase under the high scenario as compared to the base and medium levels of harvesting.

Improved road design, construction, maintenance, and consistent road closure policies will also become more important practices. Increased erosion can have subsequent impacts on water quality, though mitigations can be effective at reducing the risk of these secondary impacts occurring.

Impacts on Archaeological and Cemetery Sites
Uncertainty regarding the locations of these sites and their vulnerability to damage means that impacts will continue except on timberlands owned by the USDA Forest Service, on timberlands not available for harvesting, and on the comparatively high proportion of other lands where operations are conducted when the ground is frozen.

Impacts on Traditional Use Sites
Improved liaison between forest managers and Native American groups regarding future roading plans will likely reduce but not eliminate the incidence of impacts on these uses. The high scenario will greatly increase the importance of this liaison.

Loss of Primitive and Semiprimitive Nonmotorized Recreation Opportunities
Roading in these areas will likely reduce the areas of primitive and semiprimitive nonmotorized recreational experiences that are potentially available in the state. The consequences of this loss cannot be accurately gauged because the amount of use within these areas and the number of users affected is not known. Use of VMGs and the development of a coordinated road and trail plan will become imperative under the high scenario.

Impacts on Motorized Recreational Uses
Harvesting in visually sensitive areas without VMGs will adversely impact existing users of these sites. The maturing of many areas of forest, including formerly harvested areas, will likely provide new or replacement opportunities for these recreational activities. However, population growth and increased harvesting under the high scenario will exacerbate the problems of providing for this use.

Impacts on the Tourism and Travel-based Industries
The inability to quantify the linkages between the level of harvest and its consequences for the tourism industry means the likelihood of unmitigated impacts cannot be ascertained. However, it is likely that more resorts will be more adversely impacted by visually obtrusive harvesting operations within their viewshed or along access routes under the high scenario as compared to the base and medium level of harvesting. Use of VMGs will likely reduce the area adversely impacted and duration of impacts and will become imperative under the high scenario if conflicts over timber harvesting and resource management are to be avoided.

7.8 Conclusions

The harvesting projected to occur at the high level (7.0 million cords) is only marginally feasible over the study period given existing and likely future land management policies and practices. However, this scenario exhibits less margin for error in projection model accuracy and associated assumptions than the base and medium scenarios. In addition, impacts on soil productivity, wildlife habitat, and aesthetic values are more severe than for the base and medium scenarios and thus the effectiveness of mitigations in maintaining these and other characteristics and values is unlikely. The following paragraphs discuss the degree of certainty in these conclusions and implications.

Estimated timberland area changes and assumptions of timberland availability by ownership play a crucial role in the feasibility of this scenario. Loss of timberland acreage as projected or lesser availability of timberland for harvest without compensating investment to improve productivity contribute to making this scenario infeasible. The importance of these assumptions is underscored by the fact that feasibility was only achieved with substantial (25 percent) substitution of other species for aspen and relaxation of ASQs for the two national forests in Minnesota. Further, introduction of these assumptions caused changes to the forest different and beyond those projected to occur under the base and medium scenarios.

As with the base and medium scenarios, localized impacts will continue and increase, despite the introduction of proposed mitigation strategies. These impacts will increase and be most evident on NIPF lands as a consequence of likely lower standards of planning and supervision of field operations compared to large ownerships with professional staffing. However, if fully implemented across all ownerships, the previously identified mitigations would reduce both the likelihood and frequency of significant impacts that might degrade the long-term sustainability of the state's forest resources. The exception is the projected reductions in the nutrient capital of some low productivity sites. As discussed previously, the consequences of these reductions will need to be carefully monitored.

The high level of harvesting is still below the level of sustainable yield as defined from the standpoint of tree and forest growth potential. However, the high scenario harvest level fell over 1.5 million cords per year short of being sustainable over the long-term in a timber production sense given assumptions about ownership constraints, mitigations, etc. In other words, the growth and yield potential needed to achieve the 7.0 million cords per year level over the long-term is only achievable with substantial investment in practices that would improve productivity. Thus, at the current levels of productivity investments, the maximum long-term sustainable harvest level appears to be about 5.5 million cords per year. Also, at this level of harvesting there is little flexibility available to meet timber supply demands while making provision for nontimber values. Importantly, if some of the impacts cannot be effectively mitigated, then the 5.5 million cord level would not be sustainable as described in this study. Further, the increased pressure on the resource to meet these varied demands means that investments to increase productivity of timberlands would become essential if a higher than 5.5 million cord level of harvest were to be achieved. These investments could increase the productivity of stands to meet harvest levels and also allow more area to be used for other activities. However, such investment is a long-term strategy that must consider satisfying nontimber values in execution.

Harvest levels above 5.5 million cords per year appear sustainable only if, in addition to effective mitigation of impacts, (1) the loss of forest land projected in the north was halted, and (2) substantial investments in forest management are made to improve productivity. Such harvest levels would require long-term investments. Additionally, such harvest levels might require the USDA Forest Service allowable sale quantities on the two national forests to be relaxed.

As with the base and medium scenarios, there will be constraints in the supplies of aspen during the middle of the modelled period. The base and medium scenario projections assumed that 25 percent of the demand for this species would be transferred to northern hardwood species. However, that shift cannot be sustained indefinitely. Widening the range of acceptable species to more closely reflect the mixed species stands found in Minnesota increases management flexibility and possibly reduces the area that has to be harvested by reducing the amount of potentially usable wood fiber left on harvested sites.

The proposed mitigations will require a leadership role to oversee their development and application. At present, there is no agency with the authority for such responsibility extending across ownerships to discharge these responsibilities. In addition, the current diverse ownership patterns and associated objectives means that there are no broad-based direction or goals for a future forest condition being set within the state. Direction and goal setting clearly becomes extremely important with the high level harvest scenario.

Future forest industry developments should be directed towards industries that can utilize species that have the capacity to sustain high levels of harvesting. This includes covertypes that continue to show unbalanced age class distributions at the end of the high scenario study period. The assumed timber demand used to prepare the high scenario provides some guidance for possible species mixes for forest industries that could address these age class concerns.

The high scenario level of harvesting seems unlikely to be achieved. The statewide coordination across ownerships required at this level of harvest is doubtful. The considerable negative consequences for production of nontimber values from the forests, the extent of required mitigations, and cost of timber produced means that achieving widely satisfying results would be very difficult.

8
SUGGESTED STRATEGIC PROGRAMMATIC RESPONSES

The nine technical and, to some extent, the five background GEIS papers provide a wide range of specific mitigation strategies that address those impacts identified in sections 5, 6, and 7 as significantly adverse. These strategies to mitigate the impacts projected to occur at three distinct levels of statewide timber harvesting activity were developed separately in the technical papers to address specific issues related to timber harvesting (e.g., impacts of timber harvesting on wildlife habitat). The GEIS integrates those separate analyses and recommendations to address all key issue areas identified for analysis in the FSD in a unified manner.

The integrated mitigations identified in sections 5 to 7, and summarized in appendix 4, vary considerably in terms of their focus and the functional role they play in protecting and enhancing the state's forest resources. However, three general categories of mitigations are evident. These are:

- site-level responses;
- landscape-level responses; and
- forest resources research.

Site-level Responses

Site-level mitigations are those considered to be tactical (i.e., they are typically specific on-the-ground land practices designed to reduce and/or eliminate environmental problems associated with harvesting or forest management). Included in this category are measures such as filter strip retention in riparian areas, alternative methods for disposal/distribution of slash in a harvested area, consideration/retention of biomass (e.g., snags) during harvest, and timber sale design modifications to reflect nontimber considerations (e.g., wildlife, aesthetics). These practices are quite identifiable and focused on achieving specific resource objectives (e.g., 100-foot vegetative filter strips adjacent to waterbodies or wetlands).

Landscape-level Responses

The second category of mitigation strategies that surfaced through the GEIS study process is that defined here as coordinated approaches for addressing resource management concerns that arise from accumulation of site-level impacts. Such mitigations do not specifically relate to certain practices on a given harvest site, but rather encompass geographically large areas spanning multiple ownerships, and serve to address landscape-level forest resources goals. Unlike tactical mitigations that are often realized in a relatively short period of time simply through alternative harvesting and/or management practices, these more complex mitigations will often take an extended period of time to implement and require the cooperative and coordinated efforts of many different land managers. Examples of such mitigations include modification of age class and/or covertype structure for an ecoregion which, when aggregated, can serve as statewide goals to achieve wildlife habitat, biodiversity, timber production, or forest protection objectives.

Forest Resources Research
A third general category of mitigation strategies identified in sections 5 to 7 is that which addresses gaps in the current level of understanding about forest ecosystems and their interactions with other important resource-dependent variables. These forest resources research strategies will not, by themselves, mitigate the significant impacts projected to occur. However, they will provide resources managers and policymakers with better information regarding specific resource characteristics and trends. This information, in turn, will allow new or more effective management strategies to be developed to address the area of concern. The forest resources research mitigations presented in the preceding sections focus on the: collection of baseline data; establishment of monitoring programs to identify trends in resource conditions; and development of research programs aimed at providing better understanding of interactions and linkages between various elements of the forest environment and its management. In addition, research aimed at improving efficiency of wood utilization is important to all scenarios considered.

The GEIS identifies a variety of mitigation recommendations at each of the three alternative levels of statewide timber harvest. However, while such tactical mitigations are extremely important and useful study outcomes, the GEIS also serves the broader purpose of providing direction on the types of policy or programmatic strategies the state should consider to effectively address the recommended mitigations.

There are a number of ways in which the recommendations identified in the technical and background papers can be transformed and brought forward as strategic policy recommendations. The key focus was on integrating the various mitigation options into a comprehensive set of policy strategies that can readily be identified as the centerpiece for an implementation program. The remainder of this section presents these broad policy strategies, and an overview of forest resource-based research strategies and administration mechanisms needed to implement the site- and landscape-level policy strategies.

8.1
Suggested Site-level Policy Responses

Strategies in this category are intended to modify operational procedures used in planning, and executing timber harvesting and forest management activities on an individual site.

8.1.1
Goals and Objectives

The goals and objectives for suggested site-level policy responses are simple and straightforward. They should:

- incorporate all site-level mitigation strategies recommended in the final GEIS;
- apply statewide to all ownerships to the extent legally and practically possible;
- ensure that the issue of cost effectiveness is given key consideration;
- consider the need to maintain the integrity of private property ownership rights while;
- informing all property owners of their statewide responsibilities for resource protection; and
- provide for ongoing research and special interest groups' input and, as appropriate, develop processes for subsequent clarification and/or modification of these practice standards.

8.1.2
Major Policy Elements and Considerations

Many of the recommended mitigations developed in the technical papers and included in this document address specific objectives. This study has also discussed the mechanisms that are currently available to address these recommendations. One of the most important is the Minnesota voluntary BMPs program, which is basically aimed at water quality.

While recognizing the utility of a voluntary water quality BMPs program, the GEIS has identified the need to expand it to incorporate a broader recognition of forest resource values through an array of prescriptive timber harvesting and forest management practices. Consequently, the GEIS study recommends Minnesota adopt a comprehensive forest resources practices program that advances acceptable practices for maintaining and enhancing these values beyond that possible with the effective, but narrow, water quality BMPs program.

Other States' Experiences
Several other states have adopted a comprehensive timber harvesting and/or forest management practices programs. In fact, as of 1991, ten states had implemented some form of a comprehensive forest practices law, and three states have laws that form a defacto regulatory system on forest management and harvesting practices (Ellefson and Cheng 1993, in press). The states covered by these legislative approaches (further discussed in appendix 4) are as follows:

- comprehensive forest practices states
  - Alaska
  - California
  - Connecticut
  - Idaho
  - Maine
  - Massachusetts
  - Nevada
  - New Mexico
  - Oregon
  - Washington

- defacto forest practices states:
  - Florida
  - Maryland
  - Montana

Key Considerations
Irrespective of the type of guidelines or regulatory structure for prescribing acceptable timber harvesting practices a state is contemplating, there are several important factors that need to be considered. The Society of American Foresters (SAF), a national organization of forest resource professionals, has articulated many of these considerations in a recent position statement on forest practice regulations (SAF 1989). Note that the SAF neither advocates nor opposes the public regulation of private forest practices. Rather, the SAF presented criteria to assess the likely effectiveness of such regulation. These are criteria for sound ideas that should be considered in examining alternative mechanisms to affect timber harvesting or forest management practices. A complete discussion of these principles is included in appendix 4. In brief, they collectively emphasize the following:

- regulate only to enhance, not to deplete;
- balance regulatory costs with benefits, be efficient;
- cover all interested publics and landowners;
- base all efforts on science, not anecdote;
- recognize forest variability, flexibility; and
- the need for monitoring, clarity, fairness, responsiveness, and responsibility.

Clearly forest practice regulations are but one way to sustain forest productivity and protect environmental quality. Although they may express a broad public intent to achieve this objective, they should not be assumed to do so by virtue of intent alone. The effectiveness of forest practice regulations depends on their impact. Their impact depends on landowners' responses to them, and rarely can these responses be expected to follow directly from the regulatory intent (SAF 1989).

8.1.3
Policy Recommendation for Minnesota

The background work for the GEIS has generated a family of site-level strategic mitigation recommendations. The material in section 4 illustrates that the existing framework to address these recommendations is adequate in theory. However, it can be limited to too few resources of landowners in practice. The GEIS study team therefore recommends that the site-level recommendations be collectively considered in a coordinated and more encompassing *state comprehensive Forest Resources Practices Program* (FRPP). Such a program would be aimed at a common set of practices and guidelines across ownerships to provide a consistent framework for coordination of separate landowners' mandates and policies.

FRPP
Such a program would serve as an umbrella structure for the implementation of a wide range of specific management prescriptions that have been identified as necessary, and whose impacts are beneficial to important forest resource values. These management prescriptions could include guidelines that address the following activities associated with timber harvesting and recognized in the GEIS as desirable approaches to mitigating adverse impacts:

- timber sale design and layout to incorporate nontimber concerns (visual BMPs);
- methods for the disposal/redistribution of slash and other woody biomass;
- pest management, using the MNDNR's pest management guidelines;
- establishment and management of riparian corridors;
- BMPs for water quality;
- biomass retention (e.g., inclusion of snags);
- harvest and management practices, thinning, clearcutting, etc.;
- postharvest reforestation practices;
- types and methods of road construction;
- managing for visual/aesthetic objectives;
- managing for protection of unique historical/cultural resources; and
- traffic control/site amelioration to minimize compaction.

8.1.4
Practices Compliance and Support Mechanisms

The SAF principles mentioned in this section and detailed in appendix 4 serve as a guide for this major policy initiative. A central issue is determining the most efficient and appropriate means of effectively implementing these practices once they are developed. Possible alternatives for implementing these practices include the following.

Mandatory Compliance
Detailed rules and regulations are developed to prescribe how timber harvesting and forest management activities should be conducted. Mechanisms for reviewing compliance, and penalties for failure to comply with such rules would be part of the formal regulations. Appropriate mechanisms for monitoring and evaluation would be created.

Voluntary Guidelines
An alternative way to implement a comprehensive set of forest practices is through a voluntary compliance structure, much like the current BMPs in Minnesota. Under such a program, loggers and land managers would be offered opportunities for educational and training programs, appropriate technical/financial assistance, and other incentives to encourage application of desired logging practices. Public resource management agencies would play an important role in encouraging voluntary compliance with these practices.

Certification
Another tool to help implement a series of forest practices prescriptions is certification of loggers, forest operators, and foresters. Certification would likely help ensure that these affected groups are aware of current expected practices and are competent in their implementation. Establishing such a certification (or licensing) program before any member of these groups can operate in Minnesota is one way of influencing monitoring and checking compliance over the aforementioned forest practices prescriptions. In any case, participation in educational programs is essential for continued competency in conducting the desired practices and as a condition for continued certification.

Procurement Contracts
A final option listed here is for woodusing industries to require compliance with a code of practice (COP) as a condition of wood supply contracts. Under such a program, Minnesota's forest industries would endorse a COP developed under the FRPP. The COP would be incorporated into wood supply and forest management agreements, with noncompliance treated as a breach of contract conditions. This would link in with logger, forester, and forest worker certifications, which should be based on both required educational and demonstrated field training results. Those who do not comply with the COP risk financial losses as well as a loss of their certification/license to operate in the forests of Minnesota. However, under current state and federal laws such a program would likely lead to the determination of an employer/employee relationship between independent logging contractors and the landowners and wood using industries with whom they do business. Thus, care should be taken in the development and implementation of this option.

Suggested Approach for Minnesota
The GEIS recommends the following implementation steps be associated with adoption of the new FRPP:

- The FRPP should initially be voluntary. However, it must also clearly consider incorporating the following elements:
  - logger, forest operator, and forester certification or licensing programs;
  - statistically sound monitoring and evaluation of compliance activities. If compliance falls below a specified threshold, mandatory compliance rules should then be considered (including therein authority, costs, data needs/availability, and available resources) for the area out of compliance;
  - wood purchasing industries will be encouraged to adopt a forest operators/loggers COP that is congruent with forest practices guidelines. This COP would then be introduced into all forest operators/loggers contracts to ensure statewide standard compliance; and
  - the state should work with its own agencies and departments, the counties and the USDA Forest Service to develop financial and technical assistance and incentives programs for private landowners, operators, and loggers to encourage adherence to the practices prescriptions.

8.1.5
Administrative, Personnel, and Financial Requirements

The recommended organizational structure for implementing the recommended FRPP is discussed in section 8.4.

Development of a comprehensive set of forest resource practices prescriptions/standards should reflect broad-based inputs. However, administration of the FRPP must be assigned to a single body with the sole responsibility for implementing, monitoring, and enforcing approved practices.

With regard to personnel and finance, the GEIS process is too general to develop specific recommendations. Nonetheless, the state should carefully review the history of the ten states with full practices programs, as well as the three with defacto programs. The experience of these states should serve as a guide. As shown in appendix 4, Montana spends less than $100,000 per year on a voluntary program driven by a unique *intent to* notification process requirement, while California spends over $10,000,000 annually on a mandatory one. Additionally, staffing for review and enforcement of threatened or endangered species concerns may also need to be considered.

Minnesota should carefully consider the criteria suggested in the SAF position statement and maintain a very watchful eye on both staffing and monitoring/compliance costs. Mechanisms, such as timber or processing taxes, or surcharges on recreation facilities, will ultimately need to be considered as possible mechanisms to finance such a comprehensive timber harvesting program or FRPP designed to meet only the absolute minimum requirements to mitigate site-level timber harvesting and forest management impacts.

8.2 Suggested Landscape-level Policy Responses

Landscape-level responses were defined as those typically being broad-based solutions to address the cumulative effects of individual site-level practices which require extensive planning and cross-ownership coordination to achieve intended regional or statewide objectives. This will be a difficult task due to the widely varying mandates and objectives of the various landowners statewide. However, without this effort, there will be no way to ensure the best possible results.

8.2.1 Goals and Objectives

The goals and objectives for suggested landscape-level policy responses are similar to those for the site-level responses. They should:

- incorporate all landscape-level mitigation strategies recommended in this study;
- apply statewide across all ownerships to the extent legally and practically possible;
- be simple, straightforward, and cost effective;
- consider the conflicting nature of diverse forest lands and forest land owners;
- involve all landowner groups to the maximum extent possible;
- be responsive to new data and information to ensure flexibility for change when needed; and
- create the environment to develop a common foundation (*not necessarily uniform*) for statewide resource management and planning objectives to the maximum degree possible.

8.2.2 Major Policy Elements and Considerations

Some of the key recommended mitigation strategies developed in the technical papers that are carried forward in this document have relatively broad objectives that transcend forest land ownership boundaries. Typical examples would be:

- to balance age class and covertype structure statewide;
- to develop and institute a statewide road and trail plan;
- to fully implement an integrated forest health program; and
- to maintain patches of forest intact in areas of mixed land use (and ownership) by reducing use of clearcutting, linking patches, etc.

The consideration of mitigation strategies that transcend ownership boundaries and owners' objectives is clearly difficult under any circumstances. To the degree Minnesota's forest resources decisionmaking structure is presently diverse and complex, this can be even more difficult. Currently, the state does not appear to have a system that will generate a common foundation for statewide forest resources and resource management goals and objectives. As stated in section 4.8:

> "... To the degree that the USDA Forest Service, the NIPF group, the counties, the MNDNR, and other interested parties, such as the forest products industry, conservation groups, the tourism and resort industry, etc., cannot go forward under well-articulated and common visions and goals, guidelines, and directions, the state's forest resources run the risk of inadequately providing for the values and services needed by society."

To meet this challenge, leadership is needed to develop this common foundation.

8.2.3 Policy Recommendation for Minnesota

The GEIS study team recommends that to successfully mitigate, in advance, unacceptable *landscape-level* impacts from timber harvesting and forest management activities, a statewide *Sustainable Forest Resources Program* (SFRP) should be adopted as the basis for a common statewide foundation. The study team realizes that other activities, such as the MNDNR regional planning, the Lake States Assessment, etc., are in progress. However, this is not enough. These efforts need to be coordinated and combined for effectiveness and efficiency where possible. This is the best road to a common and more effective statewide foundation.

SFRP

This initiative would provide a broad, landscape-level focus on managing Minnesota's forest resources for a variety of outputs and objectives as has been discussed in several technical papers. The basic objective of this SFRP would be to establish a structure and mechanism statewide for systematically identifying existing forest resource conditions; evaluating these conditions in light of past forest resource trends; determining desired future forest resource conditions; identifying and developing specific strategies necessary to achieve those desired future forest resource conditions; and providing feedback to assess the success in achieving those objectives are determined.

In contrast to existing forest or land use planning efforts conducted by federal, state, and county agencies, the SFRP would identify and set goals for desired future forest resource conditions that *transcend ownership boundaries*. In addition, the temporal requirements associated with achieving these goals would likely be longer-term than existing individual planning efforts.

The SFRP would provide a systematic way to direct forest management towards the achievement of broad, landscape-level forest resource conditions and goals. In doing so, the program would be supported by the following major activities:

- *Identifying present and past forest resource conditions.* The first requirement in establishing a landscape-level approach to resource management is to develop a sound understanding of existing resource conditions and emerging trends. Such information is essential to recognizing how the resources have changed over time, what variables have influenced this change, and the likely direction these changes will take in the future. Doing so, however, requires the acknowledgement that it is impossible to monitor and evaluate all forest resource attributes. Instead, the focus needs to be on identifying the key parameters that reflect the broader health of the forest resources and their ability to function together as an ecosystem.
- *Identifying future forest resource condition goals.* The focus of this activity would be to determine what forest resource goals are both desirable and realistically achievable. The future contribution of Minnesota's forests to forest biological diversity, economic development, and forest health and productivity are examples of areas that need precisely defined goals. This would be done through incorporation of a broad-based interest representation. It is very important to define these goals in such a way that they can be realistically achieved. For example, a goal to maintain or advance the level of biological diversity would need to be articulated in the form of desired future forest age class and covertype structure.
- *Management alternative formulation and implementation.* Once broad, landscape-wide forest resource goals are established, specific management strategies need to be formulated to achieve these goals. The success of the SFRP depends on the cooperative and coordinated effort of the different forest resource management organizations to develop comprehensive strategies, recognizing their respective individual politics

and programs. A commitment is needed from these organizations to conduct their activities such that the landscape-level goals are defined and addressed. The strategies developed need not necessarily be identical among forest resource management agencies, but they must be complementary.

- *Monitoring and evaluation.* Another key to the success of a SFRP is ensuring that forest resource characteristics are monitored and periodically evaluated to identify the degree to which the desired future forest resource goals are, in fact, being achieved. The specific characteristics to be monitored will be closely linked to the desired future forest resource attributes identified in the second step. Performance results from periodic monitoring and evaluation will be a useful tool for making appropriate modifications to specific management practices and goals.

8.2.4 Administrative, Personnel, and Financial Requirements

The recommended organizational structure to help create and implement a successful Minnesota-wide SFRP is covered in section 8.4. However, some broad comments regarding administrative structure, personnel, and financial issues are noted here:

Administration Requirements
Administratively, a single entity should create and coordinate the implementation of the SFRP. This administrative body must be assigned both the responsibility and the authority to achieve this task on an *agency basis*. This administrative body *should have no line management responsibilities (day-to-day vested interests) for on-the-ground program implementation,* but it should be held accountable for the effective development, organization, and coordination of the program.

Personnel Requirements
The human resources need for this task should mostly come from existing natural resource units in public and private agencies and organizations. A successful SFRP can be achieved by redirecting these existing human resources to a new approach, rather than by layering an entire new personnel structure onto the already existing one(s). The only area of new staff support would be to the newly appointed administrative body, where some additional human resources will likely be required. These requirements are discussed in appendix 4.

Financial Requirements
As noted previously, for the most part this program will be organized by redirecting existing public and private resources rather than creating duplicative systems and funding needs. The major new financial issues will

be centered around an annual budget for the modestly staffed administrative body. This is discussed more completely in appendix 4.

Like the recommended FRPP, the SFRP will need to be self-funded on a long-term basis or its viability, objectivity, and flexibility will be jeopardized. A variety of funding source options are potentially available, but forest resources use or consumption levies should be considered as a primary source to generate the funding. This approach will be in the best long-term interest of the primary forest user groups, as it will internalize the cost of a SFRP to those with a vested interest in protecting, managing, and using the state's forest resources. This will, in turn, help to keep the entire effort simple and straightforward. The GEIS study team fully realizes this is easier said than done, but the principles are still sound. Further analysis of funding is beyond the scope of this study.

8.3 Suggested Forest Resources Research Strategic Responses

Forest resources research strategies in this category are intended to: obtain the information needed to undertake strategic and operational planning; monitor both short and long-term forest resource changes occurring at the landscape- and site-level; and provide a foundation of scientific information that can be used in developing technically sound forest resources management and planning policies and programs. The specific responses considered (from section 5.7.2) are:

- monitor the age class and covertype structure of the state's forests;
- complete an inventory of the state's biodiversity features;
- conduct an inventory of old growth forests across all ownerships;
- develop and fund a research program to investigate the effects of timber harvesting and forest management activities on the tourism and travel industry in Minnesota; and
- upgrade and maintain a listing of known archaeological, historical, and traditional use sites in the state.

These strategies tend to parallel findings of the recent study of forest resources research by the National Research Council (1990). This study called for strengthening five broad research areas:

1. the biology of forest organisms;
2. ecosystem function and management;
3. human-forest interactions;
4. wood as a raw material; and
5. international trade, competition, and cooperation.

Note that the GEIS recommended responses in section 5.7.2 are related to biophysical forest attributes and human forest interactions. As such, these strategies relate to areas 1 to 3 above. The GEIS did not focus scopewise on issues associated with 4 and 5. However, the full spectrum of research needs identified in appendix 4 does encompass these nationally identified areas.

Section 4 of this document outlines the existing organizations with responsibilities for forest resources research in Minnesota, as well as their current programs and initiatives. This study has also demonstrated three very important realities with respect to the importance and availability of information on Minnesota's forest resources:

- the GEIS process has been totally dependent on previously conducted forest resources research;
- the GEIS process has required a very significant amount of well-founded research in order to respond credibly, factually, and objectively to the FSD key issues; and
- while substantial and relevant research information was readily available for GEIS-related work, the GEIS process clearly identified the need for significantly enhanced research to comprehensively address all FSD key issues.

8.3.1
General Focus For Future Forest Resources Research

In addition to recognizing specific shortcomings in the current status of information relating to Minnesota's forest resources, the GEIS study process underscored the need to focus future resources research efforts to address the following information needs:

Multidisciplinary Considerations
Past research efforts have often focused very narrowly on specific, segmented areas of forest resources. As a result, research involving a broad cross-section of scientific disciplines from the biological, physical, and social sciences was seldom conducted. However, as resources management moves towards a more integrated and broadscale, landscape-level approach that involves interdisciplinary problem solving, the research needed to support this approach must also take on a parallel direction.

The GEIS study is an excellent demonstration of how to better understand and evaluate the interactions, interrelationships and interdependencies among various systems of the state's forest resources. Future research efforts must also be broadened to recognize these linkages from an ecosystem-level perspective. This will involve collaboration among a wide variety of natural resources disciplines.

Spatial and Temporal Dimensions
The GEIS exemplifies the utility of conducting forest resource assessments that consider broad-scale dimensions of time and space. The statewide scope and 50-year planning horizon generated levels of understanding not previously known about the interactions between various levels of timber harvesting and their effect on a variety of forest resource characteristics. As was discovered through this study, however, few data sets exist to meet the information needs of such analysis.

Public demand for a better understanding of how today's actions will affect forest resource values over long periods of time will continue to increase. Improved information and systems technology will allow forest resource managers to respond more efficiently by improving their ability to incorporate more forest resource information in their decisionmaking. Future forest resources research must broaden its scope to consider larger geographic scales and longer planning horizons than have been treated in the past.

Forest Resources Management Linkages
Scientists must continue to strengthen links between forest resources research outcomes and forest resources management practices. Rapid changes in technology regarding forest resources management and utilization suggest such links are essential if practitioners are to be more responsive in developing management techniques and principles are scientifically based.

Investment and Response Linkages
In order to cover these four concepts, Minnesota must have a well-designed and coordinated forest resources research program. Existing research focus is sporadic in terms of targeting needs for specific issues, providing cross-landowner interaction, and in coordination of statewide forest resources research programs. In short, a coordinated approach is needed to ensure the best possible advancement of strategies to mitigate potential impacts of timber harvesting and forest management.

8.3.2 Goals and Objectives

The research program required to cover the four broad information needs identified in the previous section should have an overriding goal to *meet both existing and future gaps in the level of understanding needed to properly manage Minnesota's forest resources over time.*

Furthermore, the appropriate research program will need to be carefully linked to both the FRPP (site-level responses and needs) and the SFRP (landscape-level responses and needs). In this light, the research program's objectives should be to:

- provide the scientific basis for development, refinement, and monitoring of forest practices and policies appropriate at the statewide level;
- develop an understanding of how timber harvesting and forest management affect landscape-level ecological processes and functions;
- ensure that timber harvesting and forest management in Minnesota are state-of-the-art;
- ensure that the information needed to guide policy development and monitor its effectiveness is available to decisionmakers;
- provide a structured way to set its own research priorities, undertake specific tasks, and to disseminate the results to appropriate end users; and
- be responsive to changing demands in information needs required by forest resource professionals and policymakers.

8.3.3 Research Program Considerations

The long-standing history of cooperative agreements between the USDA Forest Service NCFES and the UofM College of Natural Resources was noted in section 4.5. Also discussed were the roles of the UofM MAES and MES, as well as the NRRI in Duluth.

The resulting availability of formal research efforts has been constructive and provided important input to forest resources management in Minnesota. However, existing research organizations and cooperative agreements are not enough, as was determined during this study. In fact, the GEIS technical papers (and sections 5 to 7 of this report) have identified where required information was lacking, as well as possible areas for improving existing practices in order to achieve better mitigation results. These considerations can serve as part of the charge for implementing a fully-coordinated and focused statewide research program. Examples of research initiatives that could be included as foundation steps for this program are (a comprehensive list of all major research initiatives identified in the GEIS process is included in appendix 4):

- to develop a better understanding of timber harvesting and forest management impacts on ecosystem functions and processes;
- to provide the scientific basis for setting and refining desired age class and covertype goals to meet biological diversity objectives;
- to identify the full role of forest soils and their various conditions in forest resources productivity in Minnesota;
- to determine the interaction between the level of timber harvesting and forest management activities and the tourism/outdoor recreation industry;
- to develop management techniques and impact assessments for forest pests;

- to identify and evaluate low impact timber harvesting techniques and technologies applicable to Minnesota;
- to identify potentially complementary forest industries for Minnesota; and
- to fulfill some of the monitoring functions identified under the harvesting practices and SFRP.

8.3.4
Identified Research Program Overview

To meet the previous identified research program goals and objectives, and effectively deal with the other issues raised here, the GEIS study team offers the following recommendations with regard to a research program:

- to effectively and efficiently address the research needs, goals, and objectives for Minnesota, the state must assume the central role for coordinating the development of a comprehensive cross-landowner, statewide *Forest Resources Research Program* (FRRP);
- the administrative responsibility for coordinating the statewide FRRP should be assigned a single administrator. This assignment should allow for the utilization of existing systems and organizational structures wherever possible;
- the FRRP will need to be responsible for at least the following:
  - identifying research needs and establishing priorities and coordination among agencies for actual research work, with a focus on ecosystem and landscape-level research;
  - identifying and tracking all ongoing forest resource-related research, information dissemination, effectiveness, and funding issues;
  - encouraging collaborative programs and projects aimed at new technology development for more effective forest resources management;
  - facilitate methodologies and systems for database development, sharing, and application across species such as databases that allow for common ecological classification system and/or analyses;
  - develop methodologies for effective monitoring programs for scientific purposes, FRPP compliance needs, and cross-landowners and agencies forest resource administrative effectiveness;
  - foster research that is based on scientific principles of measurement, assessment and evaluation;
  - develop approaches to ensure administrative effectiveness across all landowners and agencies through good coordination and cooperation; and
  - develop a mechanism that generates a five-year statewide research program based on needs and priorities of the FRPP and SFRP. Also critical will be consideration of funding availability and mechanisms, institution/agencies available resources and talents, and cross-landowners' goals and objectives.

- the statewide FRRP should also become the driving force for extension, technology transfer, and continuing education activities, both current programs and those to be developed in cooperation with the MES. These educational efforts are viewed as essential to the acceptance and implementation of GEIS recommendations.
- The GEIS study team further recommends the establishment of a Minnesota Applied Forestry and Harvesting Program within the statewide FRRP and in coordination with the MES. The program would be jointly administered by the MNDNR and the MES and would:
  - be the basis of certification/licensing for employment and subcontract work in forest areas for all landowners and agencies in Minnesota as required by the COP;
  - integrate forest management, harvesting, and other forest multiresource subjects into a comprehensive extension education program; and
  - be supportive of the needs of the FRPP and SFRP.

This focus on coordination in research programs recognizes that data and research results useful to the GEIS has come from many sources in the state, from other research programs around the country, and from other countries. Within the state it is important to recognize the MNDNR Fish and Wildlife Division's research efforts, the Natural Heritage Program, and the Country Biological Survey as important contributors and parties to coordination. Additionally, by virtue of their progress in many areas of forest protection, management, and harvesting research, contacts and scientist exchanges with forestry research programs in Canada and Scandinavia are especially encouraged.

8.3.5 Administrative, Personnel, and Financial Requirements

The research program will operate in the overall statewide structure embodied and outlined in section 8.4. One of the FRRP administrator's first assignments would be to detail the initial administrative and staffing requirements required for the first five-year plan, including its education components. Some of the broad concepts that should be considered are that:

- existing organizations and mechanisms should be utilized to the maximum extent possible;
- subsequent new resource needs should first be appended to existing structures; and
- new structures be created only as a last resort.

As with the other GEIS recommended programs, self-funding should be used as much as possible. Heavy reliance on state general revenues would be likely to subject the research program to relatively frequent statewide budgetary debates. This could be destructive to a statewide research program *which must have a stable, long-term focus and direction.*

To move toward as much funding independence as possible, the new research program should focus on the following:

- existing federal formula research funds and competitive grant programs;
- current state funds earmarked for natural resources research issues; and
- direct stakeholder support.

However, for long-term financial support sufficient to address the GEIS identified needs, the state should pursue securing alternative self-funding sources that relate to forest resources use or access, which are addressed in general terms in appendix 4.

8.4
Possible Administrative and Organizational Structures

Previous parts of this section discussed and outlined three major strategic program directions that need to embody implementation of the mitigation recommendations discussed in sections 5 to 7. These are the:

1. FRPP;
2. SFRP; and
3. FRRP.

The purpose of the remainder of this section is to outline a range of possible administrative and organizational structures that could be used in Minnesota to implement these three major strategic program recommendations. Included in this discussion will be the consultant's recommendation as to which arrangement would be the most effective in administering and implementing these three programs.

8.4.1
Characteristics of Effective Administrative Mechanisms

The long-term effectiveness of the strategic program recommendations will depend, to a large degree, on the administrative structures determined to have responsibility for their administration and implementation. There are a variety of administrative mechanisms and institutional structures that could be used to implement the FRPP, SFRP, and FRRP. Many of these already exist in Minnesota's public government infrastructure. The nature and substance of these three strategic program directions suggest there are obvious advantages and disadvantages associated with assigning responsibility of administering these programs to a particular organization. As the state begins to examine processes for implementing these recommendations, certain attributes stand out as being important characteristics of agencies or organizations assigned this implementation responsibility. Thus, the chosen administrative structure should:

- provide opportunities for representative stakeholders of Minnesota's forest resources to provide input on development and implementation of the FRPP, SFRP, and FRRP;
- provide an environment that fosters interagency coordination on forest resource matters of mutual concern;
- have defined opportunities and procedures for providing public input, as well as defined processes for incorporating this input into decisionmaking processes;
- be empowered to fully carry out its responsibilities commensurate with the overall objectives of the three strategic programs;
- be recognized as the focal point that can provide input to legislative and executive branches on statewide forest resource policy matters;
- be recognized within the state as the organizational entity with the authority to implement the strategic program recommendations;
- have adequate staff and financial resources to fully accomplish each program's stated objectives;
- have the technical, administrative, and professional expertise to fully implement the three recommended programs;
- have defined processes for ensuring accountability from the various affected interests in achieving each program's stated objectives;
- have defined processes for fully implementing these programs in a manner that ensures cost and organizational efficiencies;
- consider the need to maintain the integrity of private property ownership rights; and
- have the authority and responsibility for implementing these programs which are not in conflict with existing laws or rules or other existing agency policies or programs.

8.4.2
Alternative Mechanisms for Implementing Strategic Program Recommendations

The GEIS study team recognizes that the ultimate decision for determining the appropriate place and administrative structure for implementing the three broad strategic programs recommended in the GEIS will occur outside the parameters of this study. This reality not withstanding, the study team felt the GEIS has the responsibility for identifying possible administrative structures that should be considered in subsequent discussions of how best to implement the recommendations contained in this study, as well as suggesting a preferred structure.

The following discusses four such mechanisms/structures in the context of general strengths and weaknesses that would support or hinder their ability to effectively implement the FRPP, SFRP, and FRRP. Of these four, three currently exist in Minnesota. The last mechanism discussed, a Minnesota Board of Forest Resources, does not presently exist and would have to be established. These four are by no means the only alternatives available to Minnesota—many others exist. Their inclusion here illustrates the breadth of options available that could be used to administer these programs.

Minnesota EQB

One possible administrative structure for implementing the three strategic programs is the Minnesota EQB. As the state's executive branch board responsible for coordinating statewide environmental policy, the EQB could serve as the repository for administering the three strategic program recommendations. Given the current structure, operation and responsibilities of the EQB, the following observations regarding the appropriateness of the EQB as the administering agency for the strategic program recommendations are made.

Strengths/Advantages

The EQB:

- is an established environmental policy board that reflects many of the characteristics and serves many of the functions that would be needed to administer the three program recommendations;
- currently plays a major role in coordination of state environmental policy;
- represents a broad cross section of interests reflecting different agency and citizen perspectives regarding natural resources and environmental policy;
- currently has the jurisdiction to address and coordinate natural resources issues that affect different agencies/organizations; and
- provides citizen access to environmental and natural resources decisionmaking through its well-developed and articulated policies and operating procedures.

Weaknesses/Disadvantages

However, the EQB historically:

- has focused primarily on pollution and land use/development issues, and thus its experience in dealing with natural resources issues, including forestry, has been quite limited;
- has and will continue to maintain a wide area of topical responsibilities, which will in turn limit its ability to focus consistently and in the required degree on the three strategic programs;
- has responsibilities that affect other levels of government beyond the state, primarily through administration of the state's Environmental Review Program. However, it may not be perceived by nonstate

government entities as having the responsibility (or authority) to coordinate development of statewide forest resources policy;
- has limited staffing and additional staff support would be needed if the EQB were assigned responsibility for implementing the three strategic program recommendations; and
- has functioned on enabling legislation that does not recognize many of the functions that would be needed to fully implement these programs, for example, in coordinating research and administering a voluntary forestry practices program.

MNDNR

As the agency responsible for resource management responsibilities on state forest lands, the MNDNR and/or its Division of Forestry is another possible organization that could administer the FRPP, SFRP, and FRRP. Reflecting this agency's organizational structure, mission, and responsibilities for resource management, the following observations are presented regarding the appropriateness of the MNDNR to administer these programs.

Strengths/Advantages

The MNDNR:

- currently has substantial professional resources management expertise in a variety of disciplines related to forest resources management (e.g., forest management, wildlife, recreation);
- has responsibility for managing a significant portion of the state's forest land base, and in response has developed numerous policies and programs directed at managing this resource;
- utilizes many of the resource planning activities in the department which are consistent with the general direction and intent of the SFRP;
- has experience in developing voluntary forest practice guidelines (i.e., BMPs), including coordinating two field audits on compliance with these practices;
- has previously established working relationships with many of the organizations that would be involved in implementing the three recommended programs (e.g., research); and
- has created linkages with different research units in the state and region, which would help support administration of the FRRP.

Weaknesses/Disadvantages

The MNDNR:

- is not explicitly empowered to serve as a coordinator for developing forest resource policies and/or goals on lands other than those that are state-owned;

- has processes for citizen access to resources management decisionmaking within the MNDNR that are sometimes perceived as being not well developed or articulated;
- is perceived by certain segments of the public as being too closely aligned with industrial interests to objectively carry out the provisions embodied in the three recommended programs;
- lacks authority for implementing research programs; and
- given its specific line responsibilities for statewide forest resources, as the administrator of the three strategic programs, the MNDNR would effectively become its own monitoring agency, which would likely create significant potential for conflicts as well as questions of credibility.

MFCC

The MFCC was established in the late 1970s at the request of the USDA Forest Service to serve as an informal means of bringing together various stakeholders to discuss common forestry problems, and develop cooperative solutions to these problems. There are currently 28 members on the MFCC. In general, membership to the MFCC can be characterized as including the state's public land management organizations, natural resources education and research institutions, professional forestry associations, and wood products industry interests. At present, MFCC meetings are held quarterly. Given its current structure and function, the following observations can be made regarding the opportunities for assigning GEIS implementation responsibility to the MFCC.

Strengths/Advantages

The MFCC:

- has many interests associated with forest resources management already represented on the MFCC;
- has had some success in coordinating forestry-related activities, including research and extension programming; and
- is represented with considerable natural resources professional and technical expertise.

Weaknesses/Disadvantages

Conversely, the MFCC:

- is strictly a voluntary committee, and as such it is not recognized in law, or otherwise as having authority to provide the administrative functions or decisionmaking authority needed to implement the three recommended strategic programs;
- does not have the support staff necessary nor the funding mechanisms to implement the program recommendations. Also, administrative and support staff responsibility is currently provided in-kind by the MNDNR's Division of Forestry;

- does not have a membership that reflects the broader stakeholder representation that is suggested as being needed to incorporate balanced input in implementation of the FRPP and SFRP; and
- does not have well-developed processes for citizen access and participation in MFCC discussions.

Minnesota Board of Forest Resources
A fourth alternative administrative structure for implementing the FRPP, SFRP, and FRRP is creation of a Minnesota Board of Forest or Natural Resources. Such a board would provide the focal point around which all other administrative and organizational structure suggestions would flow.

In general, the functional responsibilities of the board should include the following:

- serve as the primary state entity for coordinating all forest resources issues, policies, plans, and programs;
- serve as the primary advisory body on forest resources issues to the executive and legislative branches of the Minnesota state government;
- design, implement, administer, and be responsible and accountable for the FRPP, SFRP, and FRRP; and
- work with both the executive and legislative branches of government to secure funding, and implement the organizational structures required to meet its mission.

If such a board were created, several general observations can be offered regarding its ability to serve as the administrative structure for implementing the FRPP, SFRP, and FRRP.

Strengths/Advantages
Creation of such a board would:

- establish a formal mechanism for developing and implementing *statewide and mutually-agreeable* resource goals;
- legitimize the authority for developing and implementing these statewide resource goals;
- address an identified problem of the need for better coordination among forest managers and owners in addressing certain forest resource issues of mutual concerns;
- provide a new opportunity for obtaining broad stakeholder representation in implementing the GEIS's strategic program recommendations;
- generate a well-defined access point for public input/response to resource management decisions;
- establish a focal point for addressing statewide forest resources issues and developing policy responses; and

- provide an opportunity to foster integrated management of the various uses of forest resources.

Weaknesses/Disadvantages
At the same time, such a board could:

- interfere with MNDNR, county, and federal management authority, management direction, and decisionmaking processes;
- with a small number of stakeholders, disenfranchise special interests not represented on the board;
- if limited to forest resources, set a precedent for creation of other state "resource" boards; and
- deter from its objective of achieving integrated resources management if it is too narrowly centered (e.g., a timber or a wildlife focus).

8.4.3
Recommended Administrative Structure for Implementing Strategic Program Recommendations

Given the relative strengths and weaknesses of the four alternative administrative mechanisms discussed in the context of implementing the FRPP, SFRP, and FRRP, the GEIS study team recommends a Minnesota Board of Forest Resources be established. The potential for a broader natural resources board also exists, but that is beyond the scope of this study. At this juncture, a forest resources board is viewed as embodying more of the desirable characteristics identified in section 8.4.1, relative to the other three administrative structures discussed. As envisioned by the study team, a Minnesota Board of Forest Resources would serve as the umbrella structure under which the three strategic program recommendations identified in this section would have the highest potential to be jointly and successfully implemented.

Other new vehicles besides a forest resources board are possible. Possibilities may evolve from several environmental/natural resource agency reorganization bills in the legislature, the Governor's Commission on Reform and Efficiency, or the Governor's Sustainable Development Initiative. The state could also adopt a forest resources commission or council, or create an expanded forest resources committee. Each of these options will have different characteristics and potentials for success, depending, of course, on the basic charter given the selected body. The primary differences among boards, commissions, councils, and committees are explained in appendix 4, section 8. However, if the administrative agency for these programs is going to reflect many of the desirable characteristics described in section 8.4.1, the GEIS study team's recommendation is that Minnesota establish a state board of forest resources. A more detailed description of suggested key characteristics and considerations of a forest resources board are presented in section 9 of appendix 4.

8.5
Implementation Considerations

The GEIS process, underway now for over three years, was a focused exercise to collect a tremendous amount of baseline data on Minnesota's forest resources condition, and make judgements about how timber harvesting affects these conditions. Recommendations to address specific resource concerns, as well as broader strategic policy responses, have also been identified. Now that this baseline assessment is complete, follow-up efforts need to ensure that, to the extent desirable and practical, the recommendations put forward in this assessment are implemented to their fullest. In doing so, three specific tasks are suggested:

1. GEIS information dissemination;
2. administrative responsibility assessment; and
3. supporting program development.

8.5.1
GEIS Information Dissemination

Many of the tactical recommendations identified in sections 5 to 7 can begin to be implemented on public lands directly by the land management agencies through changes in their operational procedures and policies. To facilitate this process, the GEIS study team suggests, to the extent possible, efforts be undertaken to disseminate the information and findings of the GEIS to the state's land management organizations. While many of the mitigations suggested in the GEIS are being carried out in varying degrees by these organizations, a comprehensive outreach program is needed to fully inform land managers of the study's findings and recommended modifications to existing management practices. In addition, educational efforts should be directed at disseminating the findings and recommendations of the GEIS to the 130,000 NIPF owners, as they are collectively responsible for managing nearly one-half of the state's forest land base. Workshops, seminars, and other like forums are suggested as appropriate vehicles to disseminate the GEIS findings and recommendations. This outreach effort should be a lead component of the education effort described in section 8.3.4.

8.5.2
Assigning Administrative Responsibility—Strategic Program Recommendations

Successful implementation of the three strategic program recommendations will require assigning administrative responsibility for program development. While the FRPP, SFRP, and FRRP efforts could be developed independently, the GEIS study team believes a forest resources board is the appropriate administrative structure for implementing these initiatives. As such, the team views creation of a forest resources board as paramount to effectively developing these three major policy initiatives concurrently.

Therefore, as a means of implementing the strategic policy responses presented in this section, the GEIS study team recommends the initial focus should be on establishing a state board of forest resources. Being the recommended umbrella under which the site and landscape-level strategic policy and forest resources research initiatives are largely carried out, it is essential this organizational structure be created in advance of the other policy initiatives. Only after a forest resources board is created can these other strategic policy responses be developed and fully implemented.

In an effort to advance the concept of a forest resources board, the GEIS study team suggests the creation of an ad hoc task force with broad representation that includes both legislative and executive branches of government. This task force should be charged with (1) agreement on the key mission, authority, functions, and structure of such a forest resources board; and (2) preparation of draft legislation that would create a Minnesota Board of Forest Resources.

Should the state choose to use other organizational structures (e.g., EQB, MNDNR) for administering the three strategic programs identified, efforts need to be undertaken to assign the receiving agency with the appropriate authority and resources necessary to establish full program implementation. Such could include revising existing laws, or modifying organizational structures to accommodate this responsibility.

8.5.3 Supporting Program Development

A number of systems will need to be developed to support full implementation of the three strategic program recommendations. Although briefly discussed in the context of specific programs earlier in this section, supporting systems need to be thoughtfully developed in the context of the FRPP, SFRP, and FRRP. Key among these are the following:

- *Educational programs* will need to be developed to inform landowners, resource managers, and loggers of the various elements and practices embodied in the FRPP. Given the recommended voluntary nature of the FRPP, a thorough assessment of existing programs needs to be conducted and a comprehensive outreach programming strategy developed.
- *A range of technical assistance programs* will need to be considered to provide landowners with assistance in managing their lands for a variety of forest values. A number of technical assistance programs currently exist in both the public and private sector. A comprehensive review of these programs needs to be carried out to determine the gaps or

inconsistencies in existing technical assistance programming, and identify desirable modifications to such programs or the development of new ones that would support successful implementation of the GEIS's three strategic program recommendations.

- *Existing cost-share and other financial assistance programs* also need to be examined in the context of supporting full implementation of the FRPP, SFRP, and FRRP. Similar to the need to conduct a review of existing technical assistance programs, financial assistance programs need to be critiqued with the same goal of identifying existing program deficiencies. A key consideration in determining whether to augment existing programs or develop additional financial incentives for forest landowners is the effectiveness of such efforts in achieving desirable land management practices and forest resource outputs.
- *Professional education programs* will be paramount to providing the needed training to the state's existing and future natural resource professionals. Such programs should recognize the need to develop broad, interdisciplinary curricula that incorporate a wide variety of training opportunities in the physical, biological, and social sciences related to natural resources and environmental management.
- *Continuing education for resource professionals* will also be needed to ensure that resource professionals are exposed to state-of-the-art management techniques and technological innovations as they become available. This information exchange will become increasingly important as management direction responds to new management philosophies and directions (e.g., landscape management) that incorporates new paradigms.
- *Scientific monitoring programs* are critically important to serving as the mechanism by which the FRPP and SFRP are effective in meeting their intended goals. As such, comprehensive programs need to be designed to provide the necessary feedback information regarding overall program effectiveness at accomplishing its stated goals. In designing these scientific monitoring programs, consideration needs to be given to existing monitoring and evaluation efforts, as well as to determining the appropriate administrative responsibility for their implementation.
- *Research programs* will be central to the long-term success of the FRPP and SFRP. As such, research needs should be communicated to the research community via publications and conferences as the FRRP is being developed in order to move basic concepts forward.

8.5.4 Implementation Timeliness

A final thought on implementation is appropriate. The GEIS study team also strongly suggests that processes to implement these recommendations begin immediately. Public interest in management and protection of Minnesota's forest resources has grown tremendously in the last few years. The GEIS study process characterized many of the important forest resource issues, and has provided focus to the debate about the extent of problems or concerns, as well as how to effectively deal with them. Given this momentum, the study team believes successful implementation of the study's recommendations will be enhanced by their timely consideration by the appropriate policymakers.

9
OBSERVATIONS BY THE CONSULTANT

The GEIS study process has raised the public's level of understanding about Minnesota's forest resources and expectations for follow-up. The study is also a model for other states or units of government pondering the rising interest in their forest resources. In light of this, the following comments may be helpful, as they are aimed at improving the understanding of the process and improving the process itself.

9.1
Objectivity

The study team, like many others, began this project with individually held beliefs. However, the team also made a commitment to objectivity. That commitment forced the team to develop an appreciation of the technical and philosophical concerns and points of view germane to all aspects of the study. That objectivity is clearly demonstrated in the GEIS. As the study concludes, the subject will return to the realm of politics but with an increased level of understanding. The following sections discuss some concerns as the consideration of Minnesota's forest resources moves to the next phase.

9.2
Interpretation of Significance

When interpreting the study results, certain definitions and the process should be kept in mind. Significance was a concept defined by the study process itself. This was based on knowledge of the type of changes that might take place as a result of timber harvesting and forest management activities, and judgement on the importance of change of certain levels of magnitude. These results, in turn, have influenced recommendations for mitigations. Additionally, impacts were often judged significant by ecoregion, but the number of such geographic breakdowns can influence the number of results subsequently found significant. Whether the subject is economic or ecological impacts, increasing the number of breakdowns generally leads to an increase in the number of significant impacts. It also follows that the more ecoregions where a result is noted as significant, the greater the likelihood that the situation is widespread. Conversely, fewer breakdowns usually means fewer significant impacts.

9.3
Minnesota's Forests in a Global Context

Minnesota's air, water, diversity of plant and animal species, and other resources do not belong to Minnesota alone. These resources are both shared and important well beyond the state's boundaries. Moreover, actions in Minnesota can have positive or negative impacts on the environment outside its borders. Nor does Minnesota's resources management operate in a vacuum. There are many outside factors that will influence policy here. For these reasons, consideration of global consequences of proposed local actions and/or policies regarding natural resources, and vice versa, are extremely important.

Two interdependent issues are paramount: biodiversity and the social and economic health of society. The biodiversity analyses in this study indicate that few species in Minnesota are imperiled by current timber harvesting and forest management practices. Minnesota is in a position to avoid a future decline in biodiversity by introducing some mitigation strategies that are relatively minor, compared to what would be needed in the future if forest biodiversity is not considered at this time. Forest management in Minnesota may even be able to partly compensate for problems elsewhere, for example, with migratory bird species.

What is needed is, in fact, a balancing act—Minnesota must manage for biodiversity yet avoid treating its other resources in such a protective manner that resource supply problems and their consequences are exported to other states and countries less prepared to deal with those problems. Minnesota's forests, and all U.S. forests are an important source of raw materials. Driven by concerns for survival of specific plant and animal species as well as entire ecosystems, lawmakers, agency administrators, and others are continually increasing both the number and scope of constraints under which land managers must operate—especially when it comes to raw materials extraction or consumption. The effects of these constraints are likely to directly impact raw materials availability and cost, and indirectly, materials selection as well as regional environmental impacts.

Environmental implications of materials production have only recently begun to receive serious attention. However, the gathering of raw materials through forest harvest operations and managing the forests for timber production is viewed negatively by many. A narrow statewide-only consideration of materials and environmental impacts lacks the broadscale, global thinking that realistically examines the raw materials options available to society. Instead, the tendency has been to look at raw materials gathering operations in isolation, and to compare the environmental impacts of such operations with those of not mining or not harvesting. Not surprisingly, in this narrower context, findings usually showing the environmental impacts of doing nothing are less than the impacts of timber harvesting or forest management activities. The problem is that this kind of comparison is not very meaningful, since doing nothing is often not a realistic alternative.

Additionally, science is not always advanced enough to ascertain the real consequences of doing nothing. There may, in fact, be environmental impacts of doing nothing at a given point in time. Raw materials demanded by society must come from somewhere. Note that:

- populations are increasing significantly in both developing and developed nations;
- because of increasing population, needs for industrial raw materials worldwide are likely to double or triple in the next century;
- Minnesota and the U.S. are net importers of almost all categories of materials used in construction and in production of durable and nondurable goods;
- transferring raw material gathering activities to regions outside Minnesota or U.S. borders through materials imports does not necessarily mean that environmental impacts have been eliminated—they may have just been shifted elsewhere. Furthermore, substitution for wood often leads to other significant and negative environmental impacts, not the least of which are likely attributable to large demand increases for primary energy associated with substitute raw materials gathering and processing.

It is a matter of concern that the subjects of biodiversity and timber supply and their regional and global implications were not more fully developed in the FSD; however, there was a practical need to limit the scope of the FSD to ensure a manageable process and study. Nevertheless, these additional concerns should be considered in the future.

9.4 Additional Study Areas

The study team noted that impacts from human activities other than timber harvesting and forest management often had far more profound effects on the environment than timber harvesting and forest management activities. Among those activities are agriculture and urban development. In the areas of water quality and biodiversity, these two areas of activity have enormous cumulative impacts. In some cases they were more pervasive than timber harvesting and forest management activities, and served to defeat many mitigations developed for forests in this study. Consequently, it is recommended that these two areas receive consideration for GEIS examination in the near future.

Additionally, the sum total of all the mitigations suggested here is substantial and is likely to have a negative impact on the economies of private forest management. This is especially true in comparison to competing urban and agricultural land use. The consequence may be reductions in timber supply, reduced levels of forest management, or simply loss of forest land to development or agriculture. Clearly, the state will need to consider economic incentives to level the economic playing field across land uses or forest management and many forest resource values will suffer. Consequently, it is recommended that the area of incentives receive careful examination in research and state policy formulation.

9.5 Study Process

This study is a potential model for the breadth and depth of its treatment of forest resources, timber harvesting, and forest management. However, in retrospect the study was limited by an unrealistic timeframe. This came about from several sources: (1) the full funding and therefore scoping of the study was delayed, (2) the advisory committee took a much more active role in study direction than was anticipated, and (3) more time was required than planned for data collection and synthesis, including interaction among study groups. Additionally, the process did not provide for full development of policy aspects of the study.

9.6 Concluding Remarks

The Minnesota GEIS study took three years to complete. The final GEIS report represents a significant milestone in the efforts to bridge the needs for forest fiber production and consumption and a vibrant, healthy forest environment. However, the GEIS study is only one step in the establishment of a working system for bridging these needs. The next step rests with the people of the State of Minnesota. With the proper initiative, this potentially very constructive process will continue unimpeded.

10
LIST OF ACRONYMS

ACP	Agricultural Conservation Program
ASCS	Agricultural Stabilization and Conservation Service
ASQs	allowable sale quantities
ATV	all terrain vehicle
BIA	Bureau of Indian Affairs
BMPs	best management practices
BWCAW	Boundary Waters Canoe Area Wilderness
CARTD	Center for Applied Research and Technology Development
CED	Center for Economic Development
CEQ	Council on Environmental Quality
CETA	Cooperative Employment and Training Act
CFCs	chloroflourocarbons
COP	Code of Practices
CRP	Conservation Reserve Program
CWE	Center for Water and Environment
dbh	diameter at breast height
EIS	Environment Impact Statement
EPA	Environmental Protection Agency
EQB	Environmental Quality Board
ERF	extended rotation forest
FHM	forest health management
FIA	Forest Inventory and Analysis
FIP	Forestry Incentives Program
FRPP	Forest Practices Program
FRRP	Forestry Research Program
FSD	Final Scoping Document
GCMs	global circulation models
GEIS	Generic Environmental Impact Statement
GFDL	Geophysical Fluid Dynamics Laboratory (a GCMs)
GIS	geographic information system
GISS	NASA Goddard Institute for Space Studies (a GCMs)
IPM	integrated pest management
LCMR	Legislative Commission on Minnesota Resources
LMIC	Land Management Information Center
MACLC	Minnesota Association of County Land Commissioners
MAES	Minnesota Agricultural Experiment Station
MES	Minnesota Extension Service
MFCC	Minnesota Forestry Coordinating Committee
MFRMA	Minnesota Forest Resource Management Act
MFRP	Minnesota Forest Resources Plan
MAI	mean annual increment
MPIRG	Minnesota Public Interest Research Group
NCFES	North Central Forest Experiment Station

NEPA	National Environmental Policy Act
NFMA	National Forest Management Act
NIPF	nonindustrial private forest
NRRI	Natural Resources Research Institute
OMG	old magazines
ONP	old newspaper
OSB	oriented strand board
OWP	office wastepaper
PSL	parallel strand lumber
RI	recurrence interval
RIM	Reinvest in Minnesota
ROS	Recreation Opportunity Spectrum
RPA	Resources Planning Act
RVs	recreational vehicles
SAF	Society of American Foresters
SFRP	Sustainable Forestry Program
SIP	Stewardship Incentives Program
SWCD	Soil and Water Conservation Districts
TIO	total industrial output
UGLBC	Upper Great Lakes Biodiversity Committee
UofM	University of Minnesota
VMGs	visual management guidelines
VMS	Visual Management System

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APPENDIX 1

Preferred Mitigation Strategies

1.1
Mitigation Alternatives Criteria

The significant impacts identified in sections 5, 6 and 7 are those likely to occur at the three levels of harvesting if management practices including selected mitigations are applied as described for the second model runs. The impacts also include exogenous factors such as land use change. The significance criteria identify those impacts that exceed threshold levels and therefore require a mitigative policy response. The technical papers identify the range of possible mitigations that could be applied to address these significant impacts. In addition, significant impacts which cannot be mitigated are also identified. This appendix describes criteria for selecting preferred mitigation alternatives.

A variety of strategies can mitigate against adverse impacts of timber harvesting and forest management and exogenous factors affecting the resource. The final criteria document (Jaakko Pöyry Consulting, Inc. 1991c) describes how such strategies would be identified and selected.

Framework for analyzing mitigations and selecting preferred mitigation strategies
Criteria for selecting strategies are drawn from the final criteria document noted above and reproduced below:

Based on an analysis of mitigation alternatives identified, preferred mitigation strategies will be selected by considering in relative terms:
1. the effectiveness at mitigating the identified significant impacts;
2. the beneficial effects on other resource values;
3. the adverse effects on other resource values;
4. the physical, biological, administrative (implementation and oversight), financial (costs, public and private, direct and indirect), and social (ability to organize, support and effect implementation) feasibility; and
5. the probability of success and duration of success.

In practice, the verbal and written input from the Advisory Committee on the potential mitigation strategies led to acceptance, rejection and/or refinement of the potential strategies. These results were then approved by the EQB and comprise the strategies considered and evaluated in detail. Additionally, for this analysis the above criteria were grouped as follows:

1. *Effectiveness* addresses a mitigation strategy in terms of its ability to either avoid or reduce the identified impacts.
2. *Feasibility* addresses the likelihood that the mitigation strategy can be implemented, based on existing or future economic, social, biophysical, or administrative constraints.
3. *Duration* of mitigation can best be scored into four classes: 1=long-term—greater than 50 years and irreversible; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
4. *Concomitant effects* refers to those strategies that have the potential to significantly affect other resources. It is clearly fallacious to consider that any forest management practice will only affect a single resource; forests are intricately interacting ecosystems, and each practice affects many resources.
5. *Probability of success*, though not tabulated explicitly in the following tables, is a combination of effectiveness, feasibility and duration with minimal negative concomitant effects. The strategies identified as highly effective, highly feasible, of long duration and with minimal negative concomitant effects are assumed to have the greatest chance of success in the long-term.

These criteria were then applied to the various mitigation strategies for the purpose of comparison among them and to help determine preferred mitigation strategies.

1.2 Mitigation Strategies

The rankings of mitigation strategies with respect to the above criteria have been grouped by impact or impact area and are presented below. This presentation pulls together impacts and corresponding consideration of mitigation strategies from all the GEIS technical papers.

1.2.1 Evaluation of Specific Strategies

The impacts or impact areas treated here are:

- loss of forest statewide and by ecoregion;
- loss of timberland statewide and by ecoregion;
- patterns of forest cover in areas of mixed land use;
- tree species mix;
- age class structure;
- forest health;
- soil nutrients;
- soil compaction;

- soil erosion;
- wildlife populations;
- maintenance of biodiversity;
- water resources and aquatic ecosystems;
- primitive and semiprimitive nonmotorized recreation opportunities;
- aesthetic resources;
- cultural resources; and
- economics and management.

Individual strategies corresponding to these impacts are ranked and discussed below. Explanations of the ranks for these mitigation strategies are provided in the discussion.

IMPACT—Loss of Forest Statewide and by Ecoregion
Two possible mitigation strategies are considered for the impacts of loss of forest land. These are summarized in table 1.1.

Table 1.1. Evaluation of mitigation strategies for minimizing negative impacts of loss of forest land on forest productivity and the forest resource base. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (+)[b]
Reduce loss of forest area - northern ecoregions	2	2	2	Wildlife (+)
- southern ecoregions	2	3	2	Wildlife (+)
Increase rate of forest establishment	2	2	1	Biodiversity (+)

[a] 1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Measures to reduce the area of forest land converted to other land uses seek to discourage landholders from converting forest land to other forms of land use. Such conversions will likely take place almost exclusively on private lands. Therefore, any initiatives that seek to limit or control uses must be framed in ways that recognize private property rights, including the rights of owners to use their land for its highest economic use. There are a variety of policy instruments that are available at the federal, state and local level. The effectiveness of these policy instruments to compete with economic forces varies considerably across the state. They are likely to be less effective and/or more costly closer to major urban areas, where the value of the land for other purposes increases. Conversely, in the northern part of the state, these instruments will likely be more effective where they are applied as the unit value of land decreases. Overall, the alternative is rated as being moderately feasible. This is because most of the conversion from forest to other land uses is occurring in the north of the state. However, there are limited stocks of nonforest land in this region. Therefore, *any* change in land use in this part of the state will likely reduce the area of forest land. Changes brought about under this mitigation are likely to persist over the medium-term.

Increasing the rate of forest establishment can reduce the net loss of forest lands. There are a range of federal and state government incentives to promote reforestation activities on private lands. These programs are not necessarily aimed at increasing the area of forest *per se* but do achieve this as a side effect of efforts to reduce the area of cropland or to reduce soil losses. The effectiveness and feasibility of this mitigation will likely be governed by the degree to which the objectives of these existing reforestation programs could be achieved while at the same time meeting the age class and covertype changes identified as being desirable. If funds do not become available through these programs, the feasibility of this alternative is likely to be constrained by the comparatively low returns from independent forest plantation enterprises. Low returns are unlikely to motivate private growers to expand their area of forest. Where forest is established, the duration of the effect is long-term.

Preferred Mitigation(s)
Both potential mitigations are likely to be moderately effective, but reducing the loss of forest land allows use of a variety of policy instruments tailored to the situations that require them. Thus it is the preferred mitigation. However, interest in establishing new forests will continue and should be encouraged, especially where environmental protection needs are evident, such as in riparian areas.

IMPACT—Loss of Timberland Statewide and by Ecoregion
Four possible mitigation strategies are considered for the impacts of loss of timberland. These are summarized in table 1.2.

Increasing the afforestation rate for selected covertypes would decrease the net loss of timberland as described in the previous section.

No net loss of timberlands would maintain the area of timberlands available for timber production. This policy may be effective in maintaining the land base; however, this is only one part of the timber supply equation. The productivity of timberlands is equally important. Therefore, while this alternative is appealing in its simplicity, it would be of limited effectiveness. This alternative is also not likely to be highly feasible because of budget constraints applying to the major state and federal agencies. None of these agencies has active timberland acquisition programs, although some land exchanges continue. The forest industries are the in the best position to give effect to this mitigation, and are also the most likely to benefit.

Table 1.2. Evaluation of mitigation strategies for minimizing negative impacts of loss of timberland on forest productivity and the forest resource base. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (+)[b]
Increase afforestation rate for selected covertypes	2	2	1	Biodiversity (+)
No net loss of timberlands policy	3	3	1	
Increase utilization of harvested stands	2	2	1	Economics (+) Soils (-) Wildlife (-) Biodiversity (-)
Increase productivity	1	2	1	Biodiversity (-)

[a] 1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Increasing utilization would raise per acre yields thereby avoiding the need to increase the area harvested to obtain additional wood. This mitigation could be achieved by using more of each stem harvested by reducing minimum top diameter and log length specifications of logs; and by changing production processes to accept the range of species available from the forest rather than only a proportion of the species available; or by redesigning products to meet design needs or product standards using less raw material. The feasibility of this alternative is dependent on the ability of the forest products industry to adapt to changing input specifications while remaining competitive with other domestic and international competitors. Additionally, such utilization would need to be cognizant of concerns about soils and wildlife habitat. Proposed new industries are moving in this direction; retrofitting existing industries will be more difficult. The benefits from this alternative would be long-term.

Increasing productivity of existing and future stands will likely be a more effective way to maintain future resource security than reliance on gross area. There are many ways to increase productivity of timberlands. Regeneration to full stocking levels and site-species matching are the two most readily implemented on a statewide scale. However, achieving fully stocked stand conditions and the matching of species to sites could adversely affect biodiversity. This is because, to achieve maximum productivity in one stand, trees that are important to biodiversity, such as minor tree species, and trees with cavities, take up space, water, and nutrients that would otherwise go to trees that produce usable timber. This mitigation would be feasible, as much can be achieved by changing the way harvesting is done, and by improved site survey and planning. Additionally, some practices could be expensive to the extent of reducing feasibility. The focus of this mitigation is on private lands where the standards of planning and management can be most improved. Improving these standards, and therefore productivity, is feasible using a combination of landowner education and wider ranging BMPs that include good harvesting practices likely to maximize regrowth success. This alternative would provide long-term mitigation.

Preferred Mitigation(s)
There is considerable difference in establishing a no net loss policy and actually implementing it with appropriate funding. Consequently, increasing utilization and productivity are the preferred alternatives. However, increasing productivity will require a commitment to management investments on a large-scale over long-term horizons.

IMPACT—Patterns of Forest Cover in Areas of Mixed Land Use
Two possible mitigation strategies are considered for the negative impacts of patterns of forest land. These are summarized in table 1.3.

Table 1.3. Evaluation of mitigation strategies for minimizing negative impacts of patterns of timberland on forest productivity and the forest resource base. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (+)[b]
Reduce site specific impacts	2	2	1	Biodiversity/ Wildlife (+)
Acquisition of key patches	1	2	1	Biodiversity/ Wildlife (+)

[a] 1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Reducing site specific impacts would involve thinning or uneven-aged management where feasible, and limiting harvesting and especially harvesting of small portions of any given tract in any one decade. Since most such lands are in private ownership, education, incentive and assistance programs would likely be most cost effective. Regulation of practices is an alternative, but likely a very expensive alternative, due to the scattered ownership. In reality, partial cutting, as opposed to clearcutting, is feasible and the most common practice in such regions. The impacts are likely to be long-term, but subject to the vagaries of changing ownership.

Acquisition of key forest patches is a strategy most appropriate to patches that are very important as habitat and to the connectivity of habitat. Easements or purchase may both be useful. In the case of wetlands, precedents provide experience with the approach and suggest it is feasible and effective. A practical limitation is the availability of funding.

Preferred Mitigation(s)
Both strategies can be effective and feasible, depending on program funding. Both should be pursued to encompass a large area in a cost-effective manner.

IMPACT—Tree Species Mix
Four possible mitigation strategies are considered for the impacts of loss of timberland. These are summarized in table 1.4.

Table 1.4. Evaluation of mitigation strategies for minimizing negative impacts of tree species mix on forest productivity and the resource base. Rankings for effectiveness and feasibility from 1 =high to 3 =low, and for duration from 1 =long- to 4 =very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (+)[b]
Alter age class structure	1	1	1	Biodiversity (+)
Alter species composition	1	2	1	
Enrichment of species composition on private lands	2	2	1	Forest Health (+) Biodiversity/ wildlife (+)

[a] 1 =long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Altering stand age class structure in many cases affects stand age-related species composition for both trees and understory vegetation. This mitigation is very feasible and could be coordinated with the existing extended rotation forest programs of the MNDNR and USDA Forest Service. Since changes in age class structure would be implemented through harvesting, manipulation of large numbers of stands would be a long-term process.

Altering tree species composition could also be achieved by varying harvesting and silvicultural practices. This mitigation relies on development of guidelines for management of types to promote desirable species or to effect covertype changes. These mitigations would logically apply to public ownerships which have a mandate for managing to promote biodiversity at a state or national level. This mitigation is very feasible and could be coordinated with the existing extended rotation forest programs of the MNDNR and USDA Forest Service. Manipulation of stands to effect species or covertype changes would necessarily be a long-term process. The feasibility of this alternative would be constrained by the ability to obtain funds for this purpose. It is unlikely that the costs of such conversions could be justified by returns from timber production alone. The contribution of such stands to maintenance of biodiversity and provision of other values would make these expenditures by public ownerships more justifiable.

Changing species composition would require wider application of existing species site matching guidelines. Application of these guidelines would be effective at preventing offsite planting. The MNDNR, USDA Forest Service, larger counties and forest industries lands typically already implement these guidelines. Therefore, increasing the use of guidelines is feasible assuming the MNDNR takes a leadership role to promote their use by NIPF ownerships via existing extension services. This mitigation would have significant positive impact on forest health. Once established, the forests will provide long-term benefits.

Enrichment of species composition can be effective, especially on public lands. It can be used to create a change in covertype or simply to enrich a stand. Difficulties are matching species regeneration requirements with site conditions and dealing with herbivory. Also, establishing meaningful enrichment over a large area would require substantial management investment over a long time period. For private ownerships, success would require a range of incentives, technical expertise and a clear description of the benefits for other purposes such as aesthetics, wildlife food or habitat, etc.

Preferred Mitigation(s)

Altering the age class distribution through harvesting is the preferred mitigation. Where that is not sufficient to achieve covertype or species composition goals, alteration of species composition directly is appropriate. Enrichment is the most expensive approach and likely to be limited by practical considerations to only a few species and site conditions.

IMPACT—Age Class Structure

Only one possible mitigation strategies was considered for the impacts of age class structure on forest productivity and the resource base. This mitigation is summarized in table 1.5.

Balancing age classes is technically feasible; however, in practical terms it depends on markets and/or management investments to fund implementation. Such investments are most likely to develop for species with commercial value. This balance also needs to be considered in the context of desired species composition for the forest and long-term goals for that. The task is complicated by the varied forest land ownership. Depending on the forest type and existing age class distribution, the process will invariably affect some wildlife species positively and some negatively.

Table 1.5. Evaluation of mitigation strategies for minimizing negative impacts of forest age class structure on forest productivity and the forest resource base. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (+)[b]
Balance the age class structure	2	2	2	Wildlife (+)

[a] 1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.

[b] Effects that are noted are those with potential to *significantly* affect another resource.

Preferred Mitigation(s)

Balancing age classes in conjunction with changes in species composition is the preferred approach.

IMPACT—Forest Health

These criteria were then applied to the various mitigation strategies for the purpose of comparison among them and to help determine preferred mitigation strategies. A variety of strategies can mitigate potential adverse impacts of timber harvesting and forest management activities on forest health. A comparison of the strategies considered is summarized in table 1.6.

Monitoring and if required manipulating the proportion of forest type groups that are maintained in susceptible and/or vulnerable age classes would be an effective way to anticipate medium- and long-term changes in the incidence of certain pest outbreaks. The age class structure of a forest can only be changed over the medium- to long-term. It is therefore important to have a clear understanding of trends as early as possible to allow the maximum time to effect changes. While the alternative would be of value in the medium-term, because of the time necessary it would be of marginal effectiveness in the short-term. The alternative is feasible in that the data needed to undertake such analyses are periodically available, as are the tools needed to derive the relevant information. If implemented, this mitigation would provide a long-term benefit.

Changing harvesting equipment is potentially an effective mitigation that would reduce the incidence of pests that benefit from damage of retained trees. As discussed previously, logging contractors in Minnesota are typically small and therefore are unlikely to have the resources to experiment or to readily adopt new types of equipment that would involve extensive operator training. However, if a regional perspective is adopted, with support from other stakeholders including forest industries and major ownerships, then the alternative will be feasible. The benefits would extend from towards the end of the short-term to the long-term.

Table 1.6. Evaluation of mitigation strategies for minimizing negative impacts of timber harvesting on forest health. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative(-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Monitor and/or manipulate age class distribution	2	2	1	Productivity (+)
Changing harvest equipment	1	2	1	Economic (-); Soils (+)
Worker training	1	1	1	Economic (+)
Monitor pests	1	1	1	
Develop IPM strategies	1	1	1	
Increased research	1	2	1	
Increase use of pest management guidelines	2	2	1	

[a] 1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Worker training is an effective way to mitigate impacts caused by damage to retained trees. This is a comparatively inexpensive alternative that also has significant benefits in terms of worker safety and compliance with BMPs. Benefits can be realized in the short-term and would extend to the long-term.

Strategies to monitor forest pest problems are an effective way to give forest managers more time to react to likely pest problems and also a better appreciation of the extent of the problem. Both are crucial pieces of information when choosing between alternative management responses. This mitigation alternative is feasible. This alternative would provide long-term benefits.

Development of IPM strategies for major existing and likely pests would be effective by allowing a faster and more focussed response than would likely occur if plans to deal with pest outbreaks are formulated during or immediately prior to an outbreak. This alternative would be most effective if linked to the monitoring programs set out in other alternatives. The mitigation is potentially very feasible assuming that a body is convened to develop this initiative. The benefits of this initiative would extend from the short-term to the long-term.

Increased research, to gather knowledge concerning the most serious pests would be effective. Some research may lead to *blind alleys*, but other work would be likely to have high payoff. This strategy would be feasible but depends on availability of funds to carry out the work. Mitigations developed from this strategy would be long-term.

Increased use of pest management guidelines, especially by those ownerships who do not currently have access to this information, would be moderately effective. The effectiveness of the guidelines would be limited due to problems caused by the lack of professional judgement that may be required. It is also only moderately feasible because of the difficulties of disseminating the information to landowners in the NIPF category. It would be more feasible to educate loggers and other field staff. The duration of the mitigation would be short- to long-term.

Preferred Mitigations
The mitigation strategies set out above are not mutually exclusive and there is no strategy that is preferred as the strategies presented each tackle a slightly different angle of the forest health problem. As described above, all are moderately to highly effective and feasible and all would provide long-term benefits.

IMPACT—Soil Nutrients
A variety of strategies can mitigate potential adverse impacts of timber harvesting on soil nutrients. A comparison of the strategies considered is summarized in table 1.7.

Dormant season harvesting retains material on the site, but its effectiveness is limited to the case of full-tree harvesting of deciduous trees. It is feasible for upland covertypes and its duration is long-term. It is not very effective at reducing nutrient loss because a relatively small proportion of nutrients are in the foliage of those deciduous species whose harvest tends to most seriously deplete site nutrients, and conifer species retain foliage all year.

Retaining or returning material on the site is an example of a very effective strategy for reducing nutrient loss. In some cases it can be implemented relatively easily. However, overall feasibility will depend upon operational and technical constraints, particularly on the harvesting technique, the equipment available, and to some extent the season of harvesting as it facilitates removal of bark. Equipment to remove branches and bark at the stump is currently operational for Eucalypts in Australia. In the long-term feasibility should be high. Return of slash to a site from a landing or elsewhere would also be similarly effective and long-term. Its feasibility would be affected by the added cost of another pass of equipment over the site and the potential compaction and puddling associated with such an activity. Returning material in winter would minimize the latter effect. The duration of the effect is long-term.

Table 1.7. Evaluation of mitigation strategies for minimizing negative impacts of timber harvesting on soil nutrients. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative(-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Dormant season harvest	3	2	1	
Retaining material	1	2	1	
Longer rotations	2	2	1	Forest Health (-)
Species conversion	2	2	2	
Appropriate site preparation	1	2	1	
Fertilization	2	3	3	Water Quality (-)
Partial harvest	3	1	2	
No harvest	1	3	1	Biodiversity (+) Water Quality (-)

[a] 1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Longer rotations are effective by allowing natural processes to replenish the nutrients lost in harvest or in site preparation. The duration is long term, but effectiveness is reduced with time as species reach advanced ages and become less vigorous and more susceptible to forest health problems. Older stands are generally more susceptible to a variety of insects and diseases when compared to younger stands of the same species. Thus this mitigation may negatively affect the forest health issue area. Feasibility is problematic for short-lived species and benefits diminish with time as nutrient levels return to preharvest levels.

Species conversion, though moderately effective and initially appealing, would incur considerable cost because it primarily involves converting sites from nutrient-demanding species (aspen and upland hardwoods) to early-successional nutrient-conserving species (jack and red pine). This conversion would require substantial inputs for site preparation, seeding or planting, etc. Alternatively, allowing natural succession to replace aspen stands would lead to either upland hardwood or spruce-fir stands. Like aspen, these stands retain relatively large quantities of nutrients in aboveground tree components. Species conversion would also require overt action at nearly every rotation to maintain the effect, whereas the effect of such measures as retaining material and appropriate site preparation would continue well-beyond a single cycle. This is especially true if those latter practices were adopted as standard procedures.

Appropriate site preparation techniques are useful and can be implemented relatively easily, and they are often less costly than more adverse (i.e., heavy-handed) techniques. The effect of such measures would also continue well beyond a single rotation. This is especially true if such practices were adopted as standard procedures.

Fertilization is a strategy that corrects or replaces nutrients that are lost. It is effective, but only for short periods. It would require repeated applications during a rotation or within cutting cycles to maintain the positive effect, thus raising questions about feasibility and costs. It is an expensive technique. Additionally, the practice could have adverse (negative) impacts on other resources, notably water quality.

Partial harvest, whether by thinning or all-aged management, only reduces the nutrient depletion associated with a single stand entry. Over the long-term, equivalent volumes of products would be removed from a site and hence equivalent amounts of nutrients. It is therefore a feasible practice, but is of limited effectiveness. Its duration, similarly, would be only of medium term.

No harvest is another potential management strategy on sites with both very low nutrient capital and rates of replenishment. Because nutrients are not removed, this method is effective and long-term. If the management goal is wood production, however, this technique is not feasible and is equivalent to nonmanagement. Unharvested stands may positively contribute to management goals that are associated with old-growth. Because nutrients will ultimately leach from systems that do not have net volume growth, this strategy may have negative impacts on water quality.

Preferred mitigation(s)
Retaining material is the mitigation with the greatest chance for success in minimizing negative impacts of timber harvesting on soil nutrients. Thus it

is the preferred mitigation. However, each of the mitigations may be useful, depending on site specific and operational circumstances. The least successful mitigation applied on a broad scale would appear to be fertilization.

IMPACT—Soil Compaction

A variety of strategies can mitigate potential adverse impacts of timber harvesting on soil compaction. A comparison of the strategies considered is summarized in table 1.8.

Table 1.8. Evaluation of mitigation strategies for minimizing negative impacts of timber harvesting on soil compaction. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long-term to 4=very short-term. Concomitant effects refers to potential positive (+) or negative(-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Identify sites that are potentially susceptible to equipment impacts	2	2	1	Economics (-)
Limit equipment operation to periods of high soil strength	1	2	1	Economics (-)
Concentrate equipment trafficking	2	2	1	
Traffic on top of surface organic residues	2	2	1	Forest Health (-)
Use high flotation equipment	2	2	1	
Employ aerial yarding systems preparation	1	3	1	
Change type of equipment used to fell trees	2	2	1	Economics (-)
Develop long-term transportation plan	2	2	1	Wildlife (+) Recreation (+)
Develop site disturbance guidelines	1	2	1	
Ameliorative measures	2	2	1	Economics (-)
No harvest	1	3	1	Biodiversity (+) Water Quality (-)

[a] 1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.

[b] Effects that are noted are those with potential to *significantly* affect another resource.

Identifying sites that are potentially susceptible to equipment impacts would be an expensive and time consuming process if applied to all Minnesota sites. This limits its feasibility, as this work would have to be done in advance of harvesting.

Limiting equipment operation to periods of high soil strength is the most effective mechanism of minimizing compaction and related disturbances when ground-based equipment is used. Its feasibility is somewhat limited because it requires careful monitoring by natural resource professionals and may cause economic hardship to operators and some mills.

Concentrating equipment trafficking can effectively reduce the areal extent of site disturbance, though high levels of compaction and other disturbances can occur in areas that are trafficked. It may force operators to travel greater distances when skidding, which can reduce their productivity.

Trafficking on top of surface organic residues can protect the soil surface from equipment impacts for one or two equipment passes, provided the residues form a relatively continuous mat. This practice loses its effectiveness after the first several passes because the organic residues are broken down or displaced. Operators may be reluctant to operate on top of slash because it may get caught up in their equipment or slow them down.

Using high flotation equipment may be partially effective in reducing site disturbances. Previous research is not conclusive regarding the benefits of this type of equipment. Feasibility is limited because of the high cost of this equipment.

Employing aerial yarding systems would eliminate most, if not all, of the soil disturbances. However, the feasibility of these systems is very low in Minnesota because of their high cost and the low value of most forest products in Minnesota. A possible exception is in the southeast where the high species value and the steep topography may justify the introduction of cable systems. Their feasibility is further limited because there is currently no infrastructure to support these systems in Minnesota.

Change the type of equipment used to fell trees is potentially feasible for a proportion of harvesting operations. The feasibility of this alternative is limited by the ability to alter decisions on equipment choice that are made by loggers.

Development of a long-term transportation plan would effectively minimize the area disturbed by forest haul roads. It would require coordination between forest management organizations to implement properly.

Developing site disturbance guidelines would effectively limit the amount of disturbance on individual sites. Additional research would most likely be required to establish and document allowable disturbance limits. Also, it would take considerable debate to evaluate the pros and cons of voluntary versus mandatory guidelines. Creation of guidelines would require additional human resources to monitor their implementation and effectiveness.

Ameliorative measures such as discing and subsoiling may restore porosity in some areas. These practices are most effective on medium- and coarse-textured soils, particularly when compaction is limited to specific areas such as landings, skid trails, and haul roads. Tillage would be less effective on fine-textured soils because of the difficulty in pulling implements through these soils and the clodiness that can result. An additional concern of tillage is the potential damage that can be done to aspen roots which can reduce regeneration of this important species. Finally, all operators may not have access to the equipment necessary to perform these types of operations.

No harvest is another potential management strategy on sites sensitive to equipment impacts. If the management goal is wood production, however, this technique is not feasible and is equivalent to nonmanagement.

Preferred mitigation(s)
Limiting operations to periods of adequate soil strength, concentrating equipment trafficking, and development of long-term transportation plans are the preferred mitigation strategies. These are all potentially feasible under current conditions, though they would require the commitment of additional resources to planning and management. They would effectively reduce compaction and related disturbances.

IMPACT—Soil Erosion
A variety of strategies can mitigate potential adverse impacts of timber harvesting on soil erosion. A comparison of the strategies considered is summarized in table 1.9.

Constructing water bars can effectively divert overland flow from steeply sloping skid trails. Water bars can be constructed with the blades of standard harvesting equipment. Some training would be required to ensure proper construction techniques and spacing.

Revegetating or mulching bare soil areas effectively reduces erosion rates in steeper topography. These areas most commonly develop along roads, skid trails, and landings. This would require additional expense and training for individuals not traditionally involved in road construction operations.

Proper road engineering is an integral component to minimizing erosion wherever overland flow can accumulate on or adjacent to roads. The technology is available to accomplish this goal; however, it requires careful training and additional expense for individuals not traditionally involved in road construction operations. Vehicle safety and haul speed must always be considered during road design.

Table 1.9. Evaluation of mitigation strategies for minimizing negative impacts of timber harvesting on soil erosion. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative(-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Construct water bars	1	1	1	Water quality (+)
Revegetate and or mulch areas of exposed mineral soil	1	2	1	Water quality (+)
Proper road engineering	1	2	1	Water quality (+)
Close roads after use	2	2	1	Water quality (+) Recreation (-)
Operator training in road design and construction	2	2	1	Water quality (+) Economics (-)

[a] 1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Closing roads after harvest will allow them to revegetate and decreases the chances of additional disturbances by vehicles when the roads are wet. This technique is most feasible for temporary roads that are constructed with minimal effort and end at log landings. The effectiveness of this technique can be significantly reduced by the continued use by off-road vehicles, which can retard revegetation and cause additional rutting, leading to rills and gullies.

Operator training in road design and construction is required to properly construct roads. Such training is particularly useful when building roads in steep topography or adjacent to rivers and streams. Such training would require an additional commitment of human resources.

Preferred mitigation(s)
Proper road engineering, revegetating bare soil areas, and closing temporary roads after harvest are the preferred mitigation strategies. These activities

would reduce soil erosion along forest roads and major skid trails, the major areas where erosion problems caused by forest management activities occur. The additional expense incurred in implementing these measures would lead to important and long-term reductions in erosion problems.

IMPACT—Maintenance of Biodiversity

Maintenance of biodiversity in managed forests is a very complex process, often with several mitigations necessary for a single impact, and multiple effects of each mitigation. A summary of the significant impacts, and effectiveness of each strategy, as judged by the study group (table 1.10) provides a useful starting before evaluating the feasibility of each mitigation (table 1.11).

Table 1.10. Effectiveness of mitigation strategies relevant to each significant impact, from 1=high to 3=low. Empty box= little or no effect.

Significant Impact	Mitigation										
	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	5.10	5.11	5.12
Decline of old growth swamp conifer forest	1	2	2	1							1
Likely decline of hemlock, yellow oak, honeylocust, sycamore, Kentucky coffeetree and rock elm	1	1								1	
Potential loss of conifers in mixed-species stands		1				1			1		3
Decline of tree species near the range edge	1	1	1	2	3		1			2	2
Decline of rare communities	1			2	1	1	3			2	2
Effects of fragmentation on forest herbs	3	2	1	2							3
Effects of fragmentation during climate change		3	1								2
Deer browsing	3			1							1
Potential displacement of native species by hybrids								1			1
Decline of rare plants species	1	1	1	2	1	1	3	3	3	1	3
Decline of red-shouldered hawk	1	1	1	3							
Decline of Pine marten	1	1	1	1					1		

Key for tables 1.10 and 1.11:

Mitigation (numbered according to presentation in technical paper on biodiversity):

- 5.2 Inventory
- 5.3 Extended Rotation Forest
- 5.4 Connected Landscape
- 5.5 Biodiversity Maintenance Areas
- 5.6 Prescribed Burning
- 5.7 Return of Red and White Pines, and Upland White Cedar
- 5.8 Favor Tree Species Near the Edge of Their Range
- 5.9 Careful Use of Exotics and Hybrids
- 5.10 Retain Conifers in Mixed-Species Stands
- 5.11 Careful Harvest Near Rare Species and Communities
- 5.12 Resolution of Conflicting Management Goals

Table 1.11. Evaluation of mitigation strategies for minimizing negative impacts of timber harvesting in biodiversity. Number of impacts mitigated shows how many of the total 13 potential negative impacts identified above would be helped by each strategy. The number of impacts highly mitigated is the number of impacts that received a 1 in table 1.10. Feasibility is ranked from 1=high to 3=low, and for duration from 1=long to 4=very short term. Rankings apply only to those impacts indicated in table 1.10. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD, other than those considered in this paper (genetic variability, biodiversity, old growth and old forests, endangered, threatened and special concern species). Blank means no significant concomitant effects expected.

Mitigation Strategy	# Impacts Mitigated/ highly mitigated	Feasibility Physical/Administrative/ Financial			Duration	Concomitant Effects
5.2	9/7	1	1	2	2	Forest Wildlife (+)
5.3	9/6	1	1	1	1	Recreation, Esthetics (+), Forest Health (-)
5.4	7/6	2	2	2	1	Forest Wildlife (+)
5.5	8/3	2	3	1	1	
5.6	3/2	2	2	2	1	Forest Wildlife (+)
5.7	3/3	1	2	3	1	Forest Wildlife, Recreation and Esthetics (+)
5.8	3/1	1	1	2	1	
5.9	2/1	1	1	1	1	
5.10	3/2	2	1	2	1	
5.11	4/2	1	2	2	1	
5.12	9/3	1	3	1	3	

Inventory (5.2) is probably the most effective overall strategy at this time, because there is a need to simply identify occurrences of rare species and communities, and old growth so that forest managers can adapt harvest plans. Not all points on the landscape are equally important to protection of biodiversity. For example, small temporary wet areas within forests or stands used as stopovers by migratory song birds may contribute resources necessary for survival of many species at key times. Such natural features need to be inventoried. In the absence of complete inventory in the state's northern forest lands, many effects of harvesting on rare species and communities will be due to accidental harvest of sensitive areas. A complete inventory of biodiversity features of the state's forests would require a substantial investment of time and money over the next decade. Inventory alone is not sufficient to protect biodiversity; there need to be guidelines for management of rare features identified by inventory. However, inventory is the *starting point for protection of biodiversity.*

Optimizing timber harvest while guaranteeing preservation of statewide biodiversity requires, without question, uniform statewide information on existing and previous biota, without regard to current land ownership or jurisdiction. If the presence of a species or a whole biotic community is an objective of long-range planning within our state, then the current geographic status of those entities becomes a prerequisite to any planning strategies, to say nothing of implementation, however that may be directed.

Extended Rotation Forests (5.3) are effective overall because they directly help mitigate a large number of potential effects of harvesting on biodiversity. Extended rotation forests do not remove lands from the timberland base, yet they help provide many of the features of old growth forests over relatively large areas. The second run harvesting scenarios included 20 percent extended rotation forest on state and federal lands, and showed that a high yield of timber and pulpwood is still possible.

Generally, with increasing intensity of forest harvest, there is increased short-circuiting of plant succession and the development of structural diversity. Extended rotation forests assure the continued presence of large tree gaps, dead wood, and the species that depend on them, without being designated old growth and removed from the base of timberland. Extended rotations can mimic the natural rotation period for Minnesota forests more closely. Intensive management, with shorter rotations, is compatible with biodiversity, as long as other portions of the landscape are managed with extended rotations.

Connected Landscapes (5.4) are very effective at reducing the effects of fragmentation, without reserving large contiguous blocks of forest. They can be achieved by changing the spatial pattern of harvest, not the amount of harvest. However, it would be difficult to work out plans for the corridors, which would require interagency cooperation. The connected forest corridors would be managed under extended rotation forest guidelines, which would count as part of the recommended ERF forest percentage in the state or under uneven-aged management guidelines where appropriate.

By creating corridors for plant and animal species migration, this strategy would be the most cost effective way of allowing Minnesota's forest to respond to future climate change. Genetic variation in Minnesota generally occurs along a cline correlated with climate, from southwest to northeast. It is important not to disrupt the genetic spatial structure of forest trees by harvesting. Paleoecology shows that the climate has always been changing and this will continue, whether or not human-caused global warming occurs.

Tree populations must be able to respond to changing climate, and gene flow and seed movement should be allowed to occur from southwest to northeast. Also, in all ecoregions except the border lakes (ecoregion 2), old growth forests are probably too isolated to allow exchange of genetic material among old growth species.

Biodiversity Maintenance Areas (5.5) in Minnesota's northern conifer forests are very effective at reducing effects of fragmentation, by providing examples of a landscape that is managed for timber harvest, but with a natural spatial pattern. This means very large clearcuts to mimic the largest size (>10,000 acres) of natural disturbances in Minnesota. Administrative and physical feasibility of these large clearcuts is moderate to low, because a large area within one administrative unit would have to be dedicated permanently to a biodiversity maintenance area. However, the financial feasibility is high because the mature forests within the area count as part of the total extended rotation forest in the state.

Reduction of deer browsing and grazing in biodiversity maintenance areas will allow combinations of species, interactions among species, and physiognomic structure of the forest to develop as they would under natural conditions. Conditions of low deer numbers already exist in the BWCAW, so that a biodiversity maintenance area is not necessary in ecoregion 2. Other suitable areas with low deer numbers may also exist and be revealed if mitigation 5.2 is carried out.

Prescribed Burning (5.6) is very effective for mitigating two impacts: the loss of rare fire dependent communities and the rare species that live in them. The physical feasibility varies a lot within the state, but is high in remote areas and low in heavily populated areas where there is potential liability for escaped fires. Financial feasibility is moderately low because prescribed burning is labor intensive with little or no gain in timber production results.

Return of Red and White Pines and Upland White Cedar (5.7). Many people would like to see more red and white pine on the landscape. The strategy outlined in the introduction for stopping the loss of biodiversity is to maintain the natural function of the forest landscape, including the balance of covertypes. It is difficult for the forest landscape of Minnesota to function naturally when a covertype once occupying 3.5 million acres now occupies only slightly over 400,000 acres. The physical feasibility for restoring these species is very high—there is a lot of suitable aspen forest within which the conifer component could be increased. However, the financial feasibility for replanting is low (about $127.00/acre), unless the species are restored by leaving individuals of currently existing seed sources during harvest.

Favor Tree Species Near the Edge of Their Range (5.8). Trees that are near the edge of their range are often poor competitors against other species that are in optimal habitat. To maintain their populations in the state, they should be retained in forest management—except in cases where it is known that their populations are stable or increasing.

The feasibility of this strategy is high because guidelines for leaving seed trees of the affected species/regions is all that is required.

Careful Use of Exotic and Hybrid Tree Species (5.9) will be very effective in preventing future loss of biodiversity due to displacement of native species by exotics. The physical, financial and administrative feasibilities are all high because this is a preventative strategy. Currently there is not a widespread problem. All that is required is development of guidelines for future purchases of exotic and hybrid stock.

Retain Conifers in Mixed-Species Stands (5.10). This strategy would be very effective in reducing the potential biodiversity effects of having a large proportion of the state or one ecoregion in one covertype, such as aspen. A substantial conifer component allows aspen stands to be used by many wildlife species and plants. Administrative feasibility is high, but economic feasibility is only moderately high because there would be some reduction in the amount of aspen pulpwood harvested per acre.

Careful Harvest Near Rare Species and Communities (5.11) is extremely effective at mitigating impacts of harvest on biodiversity. It is necessary in the case of most endangered, threatened or special concern species. The physical feasibility is high, but administrative and economic feasibility is only moderate because some the large number of species and communities would require many guidelines and some potential timber harvest would be lost.

Resolution of Conflicting Management Goals (5.12) would help managers look at biodiversity in a landscape context, rather than on a species-by-species basis. The most effective part of the strategy would be that it would help managers plan harvests to avoid future conflicts. Resolution of conflicting management goals is physically very feasible, and does not cost much since most managers are already involved with planning and continuing their education throughout their career.

Preferred Mitigations
Inventory of significant biodiversity features within Minnesota's forest lands, combined with a permanently ERF-connected landscape, restoration and retention of conifer cover, and careful harvesting near rare communities and plant species would appear to be the combination most suited to overall protection of biodiversity statewide. This combination has some positive ameliorative effect on all significant impacts of harvesting identified, except

the potential effect of exotic and hybrid species. The main disadvantage is the physical and administrative difficulty of establishing a connected landscape. This is because these mitigations would have to be heavily concentrated on public forest lands, which may not always have the spatial extent or complex of communities needed. Also, all public agencies as well as interested private landowners would have to coordinate their efforts to an unprecedented degree. However, reducing fragmentation is biologically of overwhelming importance.

All of the mitigation strategies for biodiversity that were identified will be useful under some circumstances. The last strategy—resolution of conflicting management goals—would be the most useful way to develop a policy to determine when each mitigation should be applied.

IMPACT—Wildlife Populations

Extended Rotation Forests
Effectiveness: Species Mitigated
A variety of small- and medium-sized mammals (including red-backed voles, all species of tree squirrels, fisher and pine marten) would benefit most from older forests on the landscape. Bobcat, lynx, snowshoe hare and northern flying squirrel would also benefit from older lowland conifer forests, and deciduous forests where conifers are appearing in the understory. An upland deciduous forests may contain plentiful food for hares, but without cover-providing low conifer, hares cannot exist due to predation vulnerability.

White-tailed deer would benefit only to the extent that scattered lowland conifer stands in the north are preserved in a mature stage, and that some northern hardwood stands grow long enough to develop a conifer component of fir and spruce for cover. Moose, while favored by good acreages of young regenerating aspen, also do well in very old forests where the canopy is opening to permit a well-developed shrub layer of mountain maple, hazel and dogwoods. However, this stage of forest aging might more likely fall under old growth. Moose also seek conifer cover in summer and winter to avoid extremes in temperature.

Wherever oak mast is a critical resource to some mammals, particularly deer, bears, and squirrels, longer rotation is important. The importance of this feature is inversely proportional to the abundance of the oaks, so greatest priority should be applied in the northern regions where oaks become a minor part of forest composition. In general, most tree species are more prolific in seed/mast/fruit production at an age older than that normal for early timber harvest.

Many bird species projected to be significantly impacted by harvesting are associated strongly with mature forests, including Barred Owl, Long-eared Owl, Boreal Owl, Pileated Woodpecker, Black-backed Woodpecker, Yellow-bellied Sapsucker, Red-shouldered Hawk, Red-breasted Nuthatch, and Scarlet Tanager.

A variety of forest-floor herps are favored by old forests in that they require deep shade, a deep layer of moist leaf litter, and a good distribution of woody debris that is characteristic of the accumulations of dead material over many decades. These include all forest salamanders, the wood frog, milk snake, and eastern hognose snake. In addition, forest mice and shrews in many cases depend heavily upon small and large decomposing woody debris for cover and for sources of food. In turn, this benefit favors the avian and mammalian predators of these small mammals.

Silvicultural Methods Other Than Clearcutting
Clearcutting with Residuals
Effectiveness: Species Mitigated
Deer, moose, snowshoe hare, and pine marten will use the inclusions as cover from heat, cold, or predators while still having access to the emergent forage in the clearcut. Black bears will use conifer shade in summer while feeding on berries in clearcuts. A variety of birds will use the snags for nesting when cavities develop, including Tree Swallows, Northern Saw-whet Owls, Eastern Bluebirds, and most woodpecker species. Other birds use the snags for territorial singing perches, including Golden-winged Warbler, American Robin, and Chestnut-sided Warbler. Raptors use the snags for hunting perches—the Red-tailed Hawk, Kestrel, and Northern Saw-whet Owl.

Selective Cutting
Effectiveness: Species mitigated.
This mitigation will minimize reduction in important features of older forests needed by some small- and medium-sized mammals, amphibians, and reptiles in all ecoregions. It will favor black bears in the north by producing small openings where fruits, such as raspberries, will flourish, as well as herbaceous plants that sought in spring, while the selective pattern retains mast-producing, mature trees plus ample shade. This pattern will favor deer year-round throughout the state, by leaving thermal cover while producing temporary patches of forest herbs and of shrubs that provide summer and winter browse with high quality summer and winter forage. The deer would still need access to herbaceous openings. In the north, moose would be favored as well as deer, although the quantities of forage they require will not be provided as well as by clearcuts. Snowshoe hares will also be favored if some low conifer for security is present.

Where forests dominated by oaks are cut in this manner rather than by clearcutting, all mast-dependent species will be favored, particularly fox and gray squirrels, bears, deer, and Wood Ducks.

A wide variety of forest birds that would otherwise disappear from clearcut stands will remain in the select cuts. Forest raptors can often be protected by reserving a few acres around each nesting site. Apparently the Red-shouldered Hawk may not tolerate this level of disturbance. More data are needed to determine the extent to which it will tolerate forest cutting and at what times.

Ruffed Grouse will be partly favored, particularly if some aspen arises in the openings created by the cutting; however, numbers will not be as great as in small clearcuts. Woodcock will be favored in sites where soil is moist enough to provide their invertebrate food sources.

More Mast and Other Food Producing Trees
Effectiveness: Species Mitigated
Among small mammals, this mitigation is most applicable to the impacted squirrel species analyzed, and to forests in the southern and central portion of the state (including all of ecoregion 4).

The productivity and survival of white-tailed deer and black bear are higher, all other habitat features being equal, when good supplies of mast are available; this is true wherever the range of these large mammals overlaps with the range of oaks. In northern Minnesota, where oak stands are relatively rare, individual bears sometimes travel over 10 miles just to feed on acorns in the fall. The Wood Duck and the Wild Turkey are both mast-eating birds that will benefit from protection of the producing trees. In the case of the wood duck, the oaks used are generally in a riparian setting.

Berry trees are used by the Pine Grosbeak, Brown Thrasher, all thrushes, Evening Grosbeak, Cedar Waxwing, Bohemian Waxwing, Ruffed Grouse, Scarlet Tanager, Rose-breasted Grosbeak, and Northern Oriole; as well as by all tree squirrels, black bears, and red and gray foxes.

It is assumed that federal and state policy will regulate the harvest of the oak type, but the majority of the state's oak forests lie outside these ownership jurisdictions. Existing oak stands should be identified and managed so as to maintain the mast resource as a primary objective. Special silvicultural standards are needed to incorporate protection of key berry-producing species.

Retention of More Trees With Cavities
Effectiveness: Species Mitigated
As pointed out in the species accounts (section 2), studies in Illinois have shown that forests inhabited by gray squirrels contained a minimum of 6 cavity trees/ha (about 2.4 trees/acre); southern flying squirrels use a large number of tree cavities during each night's activity as escape sites, feeding stations, and resting areas. This mitigation should be applied over all Minnesota ecoregions, but for mammals it may be especially critical within the range of the gray squirrel, projected to be heavily impacted under all harvest scenarios.

Many bird species are dependent upon cavities for nesting, and a number of overwintering songbirds, such as Chickadees, require cavities for thermal protection in cold weather. Tree-cavity nesters range through all forest types and stand sizes; some species prefer lone trees in openings, hence the importance of cavity-snags on edges and within clearcuts. Cavity nesters in Minnesota forests include Owls—Boreal, Barred, Screech, and Northern Saw-whet; Woodpeckers—Red-headed, Red-bellied, Downy, Hairy, Three-toed, Black-backed, and Northern Flicker; Black-capped and Boreal Chickadees; Red-breasted and White-breasted Nuthatches; Eastern Bluebird; Tree Swallow; and several ducks—Common Goldeneye, Common and Hooded Mergansers, and Wood Duck.

Retention of Slash
Effectiveness: Species Mitigated
Slash retention should be applied statewide to benefit small mammals, such as the red-backed vole, shrews, and deer mice. This material also aids herps, such as the wood turtle, that begin to use clearcuts with early development of the shrub layer and increased soil-moisture retention. Although slash retention may not increase use of recent clearcuts by these animals substantially, presence of slash in older regenerating stands is an important habitat feature for these animals. Another important function of slash is the creation of a favorable subnivean substrate for small mammals, including predators and prey. The structure of slash—particularly branches with limbs—prevents packing of snow thus allowing extensive travel-ways, cover and foraging sites for mice, shrews, and weasels. The larger dimension slash including whole, unlimbed trees provides subnivean security for larger mammals such as snowshoe hares and pine marten. This habitat attribute is particularly critical in large clearcuts where wind otherwise compresses snow so as to impede subnivean movements.

An important effect of adequate slash cover for small mammals is provision of prey for such mammalian carnivores as foxes, and, in the north, pine marten and fisher. As discussed in the pine-marten account, snags, blowdowns, deadfalls, and slash comprise critical substrate, not only for supporting prey but also for the mobility and security-cover of the marten itself. Likewise, increased densities of small- and medium-sized mammals serve to increase prey for forest raptors, many of which are relatively tolerant of some forest clearing as long as suitable nest trees are left. Raptors affected here include the Red-tailed Hawk, Kestrel, and Goshawk; and many owl species found in forested areas throughout the state.

Because adequate food is promoted through slash retention, this tends to offset, in part but not entirely, some potential negative impacts of clearcutting on raptors.

Logging practices which leave large amounts of scattered slash and some larger logs will greatly reduce the impact of harvesting on herps. Although not all species are known to use slash, some species, such as the milk snake, wood turtle, blue-spotted salamander, redback salamander, eastern newt, boreal ringneck snake, eastern hognose snake, wood frog, and spring peeper will benefit.

Because BMPs do not apply to small or temporary wetlands and ephemeral streams, they should be modified or expanded to include protection of these wetlands from slash piling or other disturbances. Application of this BMPs modification should include instructions on recognizing such wetlands during dry periods and particularly during winter, when a considerable amount of harvest occurs.

Retention of More Conifers
Effectiveness: Species Mitigated
Mitigations directed at retaining conifer forest cover, conifer inclusions in mixed stands, and conifer understories are related to a very long list of birds of northern Minnesota. Many songbirds and raptors—either breeding in or migrating through the forested north—are associated with conifer cover.

Isolated patches of conifers are known to enhance the use of harvested areas by pine marten, at least during winter, and conifers are an important component of mature forest habitat for this species. The red squirrel, one of the prey for the pine marten, is strongly tied to spruce and cedar forests.

White-tailed deer and moose use conifer cover in northern Minnesota during winter because of the reduced wind chill and lower, less crusted snow cover within conifer stands. While research is being carried out on how conifer cover relates to survival of wintering deer in the north, according to the harvest model, the reductions of mature conifers are extensive enough under the high harvest scenario that mitigations would be required immediately. It is assumed that federal and state forest management guidelines for retaining lowland conifer for wildlife will be sufficiently effective for all federal and state lands, and to some extent, county lands. However, much of the harvesting will be on other ownerships. Therefore, the recommendations for mitigation include the reservation of plots of mature conifers, with northern white cedar having the highest priority, followed by white spruce, balsam fir, jack pine, red and white pine, and finally black spruce. The mitigation also includes extension of the rotation ages of clearcut forests to permit emergence and maturation of some conifers. These mitigations apply primarily to ecoregions 1, 2, 3, and the northern half of 4.

Conifer presence is important for moose, probably most critically in summer when, without deep conifer-shaded and moist-soil stands, the animals would be stressed by the heat of midsummer. Moose in winter also are more often found in the proximity of conifer clumps, even as they forage in open shrub vegetation. Retention of lowland black spruce, plus some types of jack pine, is critical to the Spruce Grouse.

Regionwide inventory and composition targets need to be developed to develop conifer-retention approaches that are truly effective in protecting habitats of so many northern Minnesota species. For relatively uniform habitat maintenance over the entire region, guidelines need to be applied at the level of a reasonably localized unit, perhaps the township, as was chosen here for analyzing projected impacts on deer in the north. Starting with the estimated percent conifer found on the 1990 FIA plot, this level could be used as a guide for pursuing a no-net-loss target for every township. While it may appear that the program is directed primarily towards deer, the effects would indeed impact a very broad spectrum of birds and mammals.

Retention of conifers will mitigate the adverse impacts of harvesting to bird species associated with mixed coniferous-hardwood or totally conifer covertypes. This is especially true for conifer inclusions within hardwood stands in ecoregions 1 through 4. Wildlife species that would be partially mitigated by this measure include most of those that are associated with conifer trees in otherwise hardwood-dominated forest covertypes and include Sharp-shinned Hawk, Swainson's Thrush, Red-breasted Nuthatch, Golden-crowned Kinglet, Ruby-crowned Kinglet, Northern Parula, Pine Warbler, Yellow-rumped Warbler, Chipping Sparrow, and Pine Siskin.

In addition to retention of conifers, it is also important to consider plantings designed in such a manner to increase conifer cover and inclusions.

The wood turtle, ringneck snakes, and red-backed salamander are associated with mixed species stands and would benefit from retention of conifer inclusions within aspen forests.

Spatial Patterns of Cutting
Large clearcuts and large patches of mature conifer forest.
Effectiveness: Species mitigated
The very large clear cuts will favor moose in the early stages; when mature, if they are eventually large patches of conifer, then they will favor such conifer interior birds as the Three-toed Woodpecker and mammals such as the pine marten.

Retaining relatively large tracts of mature forest in ecoregions 4, 5, 6, and 7 will potential mitigate harvesting impacts on the gray squirrel and all forest interior birds in that part of the state: Pileated Woodpecker, Acadian Flycatcher, Cerulean Warbler, Black-and-white Warbler, Ovenbird, and Scarlet Tanager. Much of this mitigation is related to reducing nest parasitism by the Brown-headed Cowbird, also an edge species. In addition, large areas of continuous, mature forest are required to mitigate negative impacts on forest raptors, especially the Red-shouldered Hawk and possibly the Goshawk.

Travel corridors
Effectiveness: Species Mitigated
Corridors will be particularly important to the pine marten, red squirrel, flying squirrel, and red-backed vole year round, and to deer and snowshoe hares in winter. In southern and central Minnesota corridors through larger cuts will serve tree squirrels and flying squirrels.

Riparian Corridors
Effectiveness: Species mitigated
The wider buffer will mitigate negative effects of harvesting on most herps as well as on birds such as the Prothonotary Warbler, Louisiana Waterthrush, Northern Waterthrush, and Cerulean Warbler, the habitat problems for which are concentrated mainly in the southern portion of the state. In the north, occasional exceptions to restricting harvest from stream edges will maintain favorable habitat for the beaver which requires young, emergent deciduous trees, mainly aspen; the beaver in turn creates extensive habitats through impoundments for birds, mammals and herps.

Protection of Sensitive Sites
Effectiveness: Species mitigated
This mitigation is aimed at species such as the Massasauga, timber rattlesnake, five-lined skink, and lined snake, which are too rare for analysis of habitat abundance in this paper. This mitigation is already in place for rare birds such as the Bald Eagle. Similar mitigations, tailored to the needs of each rare species, are necessary to preserve other species which may not be as publicly visible as the Bald Eagle.

Reduce Use of Herbicides
Effectiveness: Species Mitigated
Black bears, deer, moose, snowshoe hares and many bird species are highly dependent on the browse and fruit produced by many shrubs on conifer plantations. Birds whose hatchlings depend on insects from the herb or low shrub layers in plantations may be impacted from the reduction of this food source. All frogs and salamanders may be negatively impacted by the use of herbicides. However, since herbicide use is very limited in Minnesota's forests, this mitigation is not expected to produce major results.

Preferred Mitigations
Determination of preferred mitigation strategies for impacts of harvesting on wildlife is a complex process. Each of the mitigations strategies identified provides partial mitigation for a number of significant impacts, and concomitantly, each impact is mitigated by several strategies. In addition, each mitigation strategy, if implemented, affects the outcome of the other strategies. Also, some of the mitigations have long been in place and others just recently been implemented to some degree.

All of the identified strategies are of long-term duration, all are quite feasible physically, and all are very effective under certain circumstances. Financially, all of the mitigation strategies identified require administrative guidelines that would also cost time and money during preparation of timber sales. In addition, the cost of actually growing and harvesting timber would be higher, because most of the strategies, such as extended rotation forest, retention of mast trees and changes in spatial patterns of cutting would reduce timber production and require less intense harvest over a larger area or harvest over a longer time or at greater expense.

Concomitant effects of the mitigation strategies identified would be virtually all positive for biodiversity, and extended rotation forests would have a positive effect on soil nutrient balance and aesthetics. Retention of conifers and silvicultural methods other than clearcutting would also have a positive effect on recreation and aesthetics. Three mitigation strategies (extended rotation forests, retention of slash and retention of trees with cavities) may have negative effects on forest health and productivity in some cases.

The simplest way to determine which strategies are preferred is to find a combination of a few strategies that partially or wholly mitigate the maximum number of significant impacts identified in this paper. The mitigations that appear of greatest relevance to a broad spectrum of animals are *Retention of Conifers*, particularly for northern Minnesota, and *Protection of Riparian Zones*, particularly in southern and western Minnesota. The next two most important mitigation strategies appear to be *Extended Rotation Forest* and *Spatial Patterns of Cutting*. These four strategies in combination appear to provide some mitigation for a majority of significant impacts identified. However, all of the mitigations will be useful in certain cases.

The second runs of the harvest scenarios incorporated increases in forest area in all ownerships in the southern part of the state and decreases in forest area in private ownership in the northern part of the state. The results of this analysis could differ markedly with different area change estimates for several species of birds and mammals. In the southern part of the state, the projected increase in forest area ameliorates the effects of harvesting, while the projected decrease in forest area in the north exacerbates the negative impacts of harvesting. Therefore, the mitigation strategies in the MPFRB Technical Paper aimed at reducing the loss of forest area by ecoregion would also work well in conjunction with the mitigation strategies identified by the wildlife study group.

For sound economic policy and environmental management, it is not wise to consider applying the mitigation recommendations above in an isolated or generic manner. Rather, they need to be applied in relation to an understanding of regional wildlife and biodiversity problems and in conjunction with the potential of different land ownerships to contribute differentially to both protection of wildlife and production of timber products.

To implement regional, cross-ownership wildlife management and protection, a uniform data base on habitats and populations must be developed as the first step, as discussed in the Biodiversity Technical Paper. Such an inventory system must be far more uniform in coverage and comprehensive in parameters measured than any regional system now in place or being planned within the forested part of the state. Among other attributes, such a system must have a spatial dimension, so that landscape patterns are recorded at scales and with attention to relationships that are dictated by the needs of various animal species.

Under comprehensive regional wildlife habitat inventory and conservation planning, the need for any of the specific mitigations described above will be prioritized in terms of sites, timing, and funding allocations. The overall objective of such coordination will be an optimization of efforts and expenditures for protecting the state's forest wildlife and minimizing the risk of critical habitat loss.

IMPACT—Water Resources and Aquatic Ecosystems
There are no significant impacts on water quality or fisheries resources predicted at the ecoregion level.

However, there are numerous site specific impacts that are predicted to affect third order and smaller watersheds. These impacts include:

- increases in annual water yield and peak snowmelt runoff;
- increases in stream dissolved ions;
- where BMPs are not used, affected streams will experience increased sediment loads and light levels and decreases in CWD inputs and stream fish populations (ecoregions 1, 4, 6); and
- even where BMPs are used, small watersheds will experience localized impacts including increased nutrient and sediment loads, and changed structure and functional rates of aquatic communities.

There are two general strategies that might be followed to reduce localized water resource impacts: improved watershed management and increased effectiveness of BMPs. In the first instance, several suggestions are presented below for increased coordination among agencies and increased monitoring and enforcement of water resource management and BMPs implementation. These suggestions will be most effective over relatively large areas (i.e., will affect multiple locations in which BMPs might be used). Second, several suggestions are presented which are intended to improve the effectiveness of individual BMPs on the ground (i.e., to increase the degree of protection afforded a given water resource from any specific application of BMPs). In combination, these two mitigative strategies would counteract all of the negative water resource changes predicted to result from forest harvest in Minnesota, at any of the three harvest scenarios modelled in this GEIS.

STRATEGIES TO IMPROVE WATERSHED MANAGEMENT

For the proposed levels of harvesting, and on an ecoregion basis there are no specific mitigative measures that can be specified. However, there are measures to prevent or avoid adverse impacts on the quantity of streamflow on a watershed-specific down to site-specific basis. The cumulative effects of widespread changes in forest cover over time and over specific watersheds should be monitored. The following are ways this might be achieved.

1 Integrated Watershed Management

Timber harvesting plans in Minnesota should consider the watershed areas affected and the initial (existing) forest cover and should ensure that for third order watersheds or larger, reductions in percentage of forest cover by large increments (20 to 30 percent of area) over any given 10- to 15-year period should be avoided. Such changes can lead to increases in stormflow peaks and volumes that can create conditions favorable to more frequent flooding for events with recurrence intervals of less than 30 years. Integrated watershed management programs, such as these recently implemented in several Minnesota counties, would further reduce any possible negative hydrologic impacts.

2 Measures to Accommodate Increased Flows
Harvesting plans should incorporate an understanding of increases in peak discharges when designing road culverts and other water conveyance systems immediately downstream from clearcuts to avoid over bank flow and accompanying streambank erosion and sedimentation associated with such flood events. First and second order watersheds that experience clearcuts of >60 percent are expected to show a doubling of peak discharges associated with recurrence intervals less than 30 years. All ownerships and/or purchasers of stumpage should be encouraged to plan harvests, including roading.

3 Evaluation of Changes in Snowmelt Peak Discharge
For operations within watersheds with persistent snow cover during the winter, harvesting plans should evaluate expected changes in annual snowmelt peak discharge. From a watershed perspective, the opportunity exists to exert beneficial effects as well as to avoid significant increases in snowmelt peak discharges. The only information needed is the existing level of forest cover and the proposed change in forest cover with planned harvests. The figure in Verry et al. (1983) (Jaakko Pöyry Consulting, Inc. 1992d) should be used for this evaluation.

4 Clearcut Area in Lowland Conifers
Extensive clearing of large, contiguous areas of lowland conifers (peatlands) should be avoided where: (1) there is a small mineral soil upland component in the watershed, and (2) there is a receiving stream that is sensitive to reductions in streamflow during dry periods. Clearcuts of 30 to 50 acres in most such watersheds will have little effect on low flows.

STRATEGIES TO PROTECT FISH POPULATIONS
1 Monitoring of a Sample of Timber Harvesting and Forest Management Activity Sites
The MNDNR Division of Fisheries and MPCA should be notified of timber harvest activities in advance and for a sample of harvesting operations to allow them to assist in the assessment of impacts. Many landowners will harvest with minimal impact if they understand the implications of various actions. Clearly, implementation of and compliance with BMPs will be the most important factor in protecting the fisheries resource as timber harvest increases. In addition, full implementation of MPCA regulations should, in theory, prevent any negative impacts on any of the coldwater resources. However, it is unlikely that MPCA can effectively educate the public to fully enforce regulations or even pursue complete compliance. To ensure protection of the resource and to reduce impacts, better coordination among MPCA, and MNDNR Fisheries, Ecological Services, Waters and Forestry divisions is needed. Limited efforts have been made in Minnesota to monitor the effects of timber harvest, to determine their effects on water quality and fisheries and/or to conduct public education campaigns to ensure minimal

impact and compliance with BMPs. In addition, the complete lack of computerized monitoring databases makes monitoring and assessment of these activities difficult and makes large-scale predictions, such as those attempted in this report difficult and tenuous.

Several additional factors should be considered in developing monitoring procedures. The percentage of an ecoregion's resource affected should be as important as total resource affected. Regions with few resources may be more affected by a level of impact than regions with many lakes or miles of stream. The persistence of impacts should also be considered; for example, small reaches of several different streams being affected each year are probably less important than if these impacts occurred on the same stream or drainage basin. Reversibility will also be important; no irreversible impacts (e.g., loss of acid neutralizing capacity in northeastern trout lakes) were identified, but continued monitoring is needed to ensure these do not occur.

2 Development of Pesticide Use Protocols

If increased use of herbicides and insecticides occurs, procedures should be developed to educate users and regulate pesticide use to prevent their entry into receiving waters. No impacts associated with herbicides and insecticides have been assumed because there appears to be little current use of these tools. A recent agreement between MNDNR and the forestry community on pesticide management further suggests little future impact (i.e., mitigated agreement on use of pesticides on forested lands).

3 Monitoring of Populations of Aquatic Species of Special Concern

Aquatic species of special concern should be explicitly included within monitoring programs. While the analysis conducted did not indicate that any of these species would be endangered, monitoring would provide advance warning of potential problems.

STRATEGIES TO INCREASE EFFECTIVENESS OF MINNESOTA BMPS

A set of mitigations that can reduce and ameliorate potential timber harvest impacts have been identified and are presented in the following section. Protective measures are the preferred approach. However, in the event that protective and educational measures fail, several restorative strategies are suggested. As with any management strategy, proper assessment and the use of adaptive management (i.e., understanding and adapting management to current, local conditions) (Walters 1986, Orians 1986) are the best approaches. Timber harvests should be monitored and management strategies altered if so indicated.

1 Water Quality Mitigations

As noted in the Minnesota BMPs manual, control of sediment from harvest activities requires a specific site assessment of probable problem areas. Some situations will require more mitigative actions than others. It is uneconomical to prescribe a specific mix of practices without an evaluation of the particular logging site. Assigning specific practices at the ecoregion scale is unrealistic. In this section, mitigative features are paraphrased from the Minnesota BMPs Manual. Mandatory enforcement of these BMPs would probably increase compliance and would also carry significant increases in administrative costs (Ellefson 1992).

Document possible threats to water quality associated with all timber sales, including potential access problems. Effective planning represents the single most important feature of successful BMPs implementation. Timber harvest activity need not impact Minnesota's water resources when risks are properly assessed before cutting the first tree. Acknowledgement of potential problems can lead to active problem avoidance.

Establish a minimum 25-foot filter strip along all intermittent and permanent streams, lakes, rivers and wetlands. Wider strips should be used as slope, slope length and soil erodibility increase. Filter strips or buffer zones between areas of soil disturbances and water trap dislodged soil particles before they enter streams, lakes, rivers and wetlands as sediment. Filter strips are vegetative zones open to restricted harvest activity. Minimizing disturbance of the litter layer and underlying mineral soil in the filter strip remains top priority. Width of a particular filter strip along both intermittent and permanent streams, lakes, rivers and wetlands varies with percent slope and slope length, as well as soil erodibility. The general rule applied states that necessary width is equal to 25 feet plus 2 feet for each percent rise in slope between the soil disturbance, including roads and the waterbody in question.

Establish a minimum 25-foot filter strip width along all temporary and permanent roads near waterbodies. Roadways should not parallel a waterbody within the 25-foot limit. Roadway placement in areas of higher slope and soil erodibility reflects the greater erosive potential of these areas and places roadways a greater distance from water (c.f., design examples in the Minnesota BMPs Manual). Forest roads, both temporary and permanent, require planning to reduce total new mileage created while incorporating existing routes to meet the goal of minimal stream and wetland crossings. Proper road design minimizes road slope to grades of 1 to 2 percent where feasible; grades in excess of 10 percent should be avoided, unless care is taken to provide drainage and avoid discharge directly from road surfaces to waterbodies.

Prevent unmitigated crossing of all permanent streams at any season and of streams large enough to have open water during winter. Minnesota's forests contain many streams, lakes and wetlands; timber harvest in these areas inevitably requires roadway water crossings. Careful planning reduces this number of water crossings substantially. Mitigated water crossings significantly reduce water quality impacts relative to unmitigated crossings. Planned crossings incorporate projected use patterns (e.g., duration of use) and other natural features (e.g, stable banks or high rock content) to reduce the amount of input and limit the amount of sediment transported within the stream itself resulting from use of the crossing. The BMPs Manual discusses this topic extensively, including crossing preferences, bridge and culvert design, bridge and culvert construction and materials and proper drainage techniques. This action regards both planning and crossing activities which are restricted exclusively to low water periods as mitigative acts. Crossings should occur at right angles to the stream. Permanent crossings require approved bridges and culverts meeting the minimum requirements stated in the BMPs manual. These structures should be designed to withstand low frequency storm events (i.e., $\geq$50 year RI). Water crossings should be constructed of nontoxic materials and allow proper drainage without disrupting fish migration.

Prevent use of soil in drainage and stream crossings, including those of temporary nature. Emphasize placement of winter road crossings in level areas. Prevent organic material placement and require removal of temporary winter crossings in areas where slope >3 percent. Winter roads access between 40 and 50 percent of each year's timber harvest sites. Travel is currently restricted on these roads during spring breakup. Use of these winter roads during spring thaw can impact water quality, particularly in wetland areas. The BMPs manual recommends that culverts or bridges be used when the expected duration of a crossing exceeds five years. Crossings should use native log materials when there is no alternative to crossing frozen water.

Prevent direct drainage of diverted water into lakes, streams or wetlands. Water should be drained into a filter strip of appropriate width for the slope and distance to water of the site. Roadway drainage constitutes a serious concern in reducing effects of harvest activity on water quality. Roadways designed to reduce erosion exhibit construction techniques such as grade rolls or dips, open-top culverts, cross drains and lead-off ditches. These techniques reduce the sediment carrying capacity of roadway runoff by reducing velocity.

Attain full implementation of the recommendations in the Minnesota BMPs Manual or increased emphasis placed on excavation and drainage components of roadway construction. Road construction creates situations where soil is exposed which may end up as sediment in nearby lakes, streams, rivers and wetlands. Proper planning reduces the probability of erosion. The BMPs manual lists actions to be followed in clearing, excavation, surfacing, drainage, soil protection and maintenance phases of roadway construction. Full implementation of these construction features ensures that a minimal amount of source material will be associated with harvest roads. This includes careful placement of debris in a manner not impeding water flow, careful shaping and stabilization of borrow pits to avoid problems with nearby water, installation of drainage structures on roads as soon as possible and considering armoring culvert inlets and outlets to reduce bank and channel erosion where necessary. Roadway surfacing with appropriate materials should be emphasized in high slope areas. Stabilization of exposed soil surfaces with grasses or sod should be mandatory.

Placement of a barrier across roads considered inactive, along with signs stating road closure; establish water bars in areas of road grade of >5 percent. Undertake followup inspections of roadway surfaces to ensure basic compliance with aims of the BMPs. All roads require some measure of maintenance, including debris removal from road surfaces and drainages. Traffic should be limited to associated harvest management activity wherever possible, particularly during spring thaw and wet periods. Ruts, holes and washouts require periodic attention and proper materials to reduce the chance of reappearance.

Improve education of recreational users of forested lands to sensitize these individuals to potential impacts on water quality and the role they can play to avoid water quality degradation including prevention of unmitigated stream crossings with recreational vehicles. Postharvest recreational vehicle activity on both permanent and temporary roads can extend the period of disturbance associated with some roads far beyond the time of tree removal, particularly where harvest roads allow new access to water.

2 Fish Habitat/Population Mitigations

The following modifications to Minnesota's BMPs manual will increase the probability that the local scale integrity of the riparian corridor is preserved and that significant site-specific impacts to water quality and the ecology of aquatic ecosystems are avoided.

Extend rotation of timber harvest. Harvest can lead to water resource impacts through exposing soils to precipitation and other climatic influences. Extended rotations would reduce the total percent of a watershed which is deforested during any time period. Longer rotations would thus mitigate some cumulative water resource impacts.

Timber harvesting and forest management activities within the filter strip should be kept to a minimum to prevent alteration of organic matter input timing, quantity and quality; alteration of CWD inputs to the stream channel; and changes in angular canopy density. BMPs guidelines recommend the establishment of a filter strip to prevent movement of sediment, nutrients and organic debris into an adjacent waterbody. However, no mention is made of managing the filter strip to maintain litter and CWD inputs to an adjacent waterbody. At a minimum, selected large (dead or live) trees should be left in the riparian zone to ensure a long-term input of CWD to the channel.

BMPs guidelines recommend that shade trees be left adjacent to a trout stream to minimize changes in temperature associated with harvest activities and management within a filter strip. This guideline is insufficient to protect stream temperature regimes. Only designated trout streams are mentioned within the guideline. Many designated trout lakes exist within Minnesota and many of them have tributary streams which are not designated trout streams. Clearly, this practice does not protect designated trout lakes or streams which are fed by streams that are not designated trout streams. In addition, no real management strategies are recommended. Questions such as: *What kind of shade trees? How is minimize defined?* are not addressed. Water quality statutes state that natural temperature regimes within designated trout waters may not change (i.e., *no material increase*) or a water quality standard will have been violated.

Removal of harvest slash and debris from temporary and intermittent drainages is necessary to prevent excessive loading during storm events. BMPs guidelines recommend that harvest slash and debris should be pulled away from waterbodies to prevent loadings of unstable organic matter to a stream or lake. However, no mention is made of temporary or intermittent drainages. Most organic matter loading to streams and lakes occurs during storm runoff events.

Enforce State Water Quality Standards. In many forest harvest situations, local violations of state water quality standards occur. These are rarely detected or enforced due to limits in staff and resources among state water quality agencies.

Implement stratified statewide monitoring of pre-, during and postlogging condition of a subset of streams and lakes. This should include public and private lands and at least four ecoregions (e.g., 2, 3, 4 and 6). Variables should include physical habitat, temperature and flow, water quality and fish population/community structure, including nongame fish.

In addition, the following ameliorative actions are available to mitigate impacts to fish populations at a particular site, or to another site as a resource trade-off.

- *Supplemental or reintroductory stocking of fish into disturbed systems.* When possible, stocked fish should come from local or indigenous sources to minimize genetic impacts and diseases. This should only be used as a means to restore populations in circumstances where preventative measures have failed to maintain fish stocks. It should not be viewed as a routine procedure.

- *Installation of stream habitat improvement structures or habitat enhancements.*

STRATEGIES TO INCREASE COMPLIANCE WITH BMPS

As discussed in section 1.5, compliance with BMPs in Minnesota is generally high for all ownerships. Increased compliance would further reduce the site specific impacts identified in section 5. The following are methods that could be used to increase the level of compliance, as well as the standard of compliance.

1 Mandatory Compliance with BMPs

The State of Minnesota could mandate compliance with BMPs for all timber harvesting and forest management activities and for all ownerships. Although field audits of BMPs compliance indicate relatively widespread use, this option could further improve the level of compliance, and would likely improve the standard of planning on those ownerships that currently do little planning in advance of roading and harvesting operations. Adoption of this option would necessitate development of a new regulatory framework to oversee operations to ensure compliance. Similar bodies in other states have carried significant administrative costs (Ellefson 1992).

2 Education and Training Programs

The State of Minnesota could develop an extension program to provide education and technical advice to increase the level of compliance with BMPs; and the standard of compliance. BMPs and associated techniques are comparatively new to Minnesota (LCMR 1989). Despite this, the level of compliance is typically high. This option is aimed at increasing the level of compliance by making landowners, supervisors and loggers aware of BMPs; and equipping them with the skills to effectively implement BMPs in the field.

3 Industry Specifications

Forest industries could make compliance with BMPs a contract clause in any agreements to supply stumpage or to undertake contract logging that they enter into with logging contractors. This approach, which has recently been adopted by some of Minnesota's forest products companies, could be backed by appropriate monitoring and penalties. This option places the onus on forest industries to increase compliance with BMPs on lands used to supply their stumpage intake. The mitigation recognizes that industry demand is the focus for timber harvesting and forest management activities; that industry is involved at an early stage in many operations; and that the ability to withdraw from purchasing wood or engaging a particular logger provides a strong incentive for compliance. The effectiveness of this requirement should be analyzed to determine its workability.

IMPACT—Primitive and Semiprimitive Nonmotorized Recreation Opportunities

Three strategies have been put forward to mitigate potential adverse impacts of timber harvesting on primitive types of recreation opportunities. A comparison of these strategies is summarized in table 1.12.

Explanations of the ranks for these mitigations are as follows:

Landscape-based road and trail plan.—This alternative would be very effective. It would provide a fundamental planning tool that would allow coordination between ownerships to insure that primitive and semiprimitive nonmotorized recreation opportunities are adequately provided for. The alternative has high feasibility assuming the MNDNR fulfills the leadership role. It would provide benefits over the medium- and long-term.

Table 1.12. Evaluation of mitigation strategies for minimizing significant negative impacts of timber harvesting and forest management activities on recreation opportunities. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Landscape-based road and trail plan	1	1	2	Biodiversity(±) Tourism (+) Water quality (+)
Nonpermanent road construction	2	2	1	Biodiversity (+) Water quality (+) Soils (-)
VMGs for primitive types of recreation opportunities	1	2	1	Biodiversity (+) Tourism (+) Water quality (+) Soils (-)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to 10 years; 4=very short-term—less than 2 years.
[b]Effects that are noted are those with potential to *significantly* affect another resource.

Nonpermanent road construction.—An effective way to maintain primitive kinds of recreation opportunities on primitive and semiprimitive nonmotorized timberland plots that are primarily managed for timber harvesting. This option may not be feasible because use of nonpermanent roads may not be readily accepted as an alternative to conventional techniques to put in permanent roads. Disturbance to soils may also be greater where nonpermanent roads are used in dry physiographic areas. Long-term benefits could accrue.

Developing VMGs for primitive and semiprimitive recreation opportunities.—A highly effective way of retaining primitive kinds of opportunities in areas that will be harvested. VMGs, especially if used in conjunction with nonpermanent roads, give attention to the important social attributes and long-term benefits associated with primitive recreation opportunities. However, VMGs prescribed in the technical report (e.g., removal of slash) may run counter to prescriptions found in the Forest Soils technical report (Jaakko Pöyry Consulting, Inc. 1992e). The latter could limit the feasibility of some of the VMGs. Benefits would be short- to medium-term.

Preferred Mitigation(s)

The mitigations are not mutually exclusive and if used in combination would mitigate the identified significant impacts and would therefore retain primitive opportunities in the long-term.

IMPACTS—Aesthetic Resources

Several strategies have been developed to mitigate the potential adverse impacts of timber harvesting on forest aesthetics. A comparison of these strategies is presented in table 1.13.

Explanations of the ranks for these mitigations are as follows:

Visual Sensitivity Rank I Timberlands

Develop a buffer zone where harvesting is prohibited in visual sensitivity rank I timberlands.—While a desirable alternative for its effectiveness as a way to maintain recreation opportunities currently existing within the zone, may not be as feasible nor of as long-lasting a duration as might be desired. In the long-run, prohibiting any kind of forest management may diminish existing recreation opportunities found in semiprimitive motorized, roaded natural, and rural ROS classes.

Develop a buffer zone where special harvest practices are permitted on visual sensitivity rank I timberlands.—A desirable alternative, especially for semiprimitive motorized, roaded natural and rural ROS classes. Timber harvesting practices that would be allowed would be those designed to enhance existing recreation opportunities managed for within these zones. Maintaining these types of opportunities should be possible in the short-, medium- and long-terms.

Develop VMGs for resort areas.—While somewhat effective and feasible for resorts, it would do nothing to maintain recreation opportunities outside these areas. It would maintain recreation opportunities in the short-, medium- and long-terms for areas adjacent to resorts.

Table 1.13. Evaluation of mitigation strategies for minimizing significant negative impacts of timber harvesting and forest management activities on forest aesthetics. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effect (±)[b]
Visual Sensitivity Rank I Timberlands				
Inventory visual sensitivity rank I timberlands	1	2	1	Soils (+) Tourism (+) Economics (-) Water quality (+)
VMGs for use in visual sensitivity rank I timberlands	1	2	1	Soils (+) Tourism (+) Economics (-) Water quality (+)
Alternative 1 guidelines	1	3	1	Tourism (+)
Alternative 2 guidelines	2	1	1	Biodiversity (+) Soils (+)/(-) Tourism (+) Forest health (-)
Visual Sensitivity Ranks II to IV				
Develop VMGs for resort areas	2	2	1	Tourism (+)
Develop VMGs for all forest lands under all ownerships	1	2	1	Biodiversity (+) Soils (+)/(-) Tourism (+) Forest health (-)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to 10 years; 4=very short-term—less than 2 years.
[b]Effects that are noted are those with potential to *significantly* affect another resource.

Visual Sensitivity Ranks II to IV

Develop VMGs for all timberlands in visual sensitivity ranks II to IV under all ownerships.—This alternative would address maintaining visual quality and recreation opportunities for all ownerships on all forest lands. It would be effective, would address needs in the short-, medium- and long-terms and, although it would probably be expensive to implement, the costs are not expected to be prohibitive. The state is already moving in this direction so the feasibility of this alternative is, to some extent, validated. This approach would also ensure that resort interests were addressed.

Preferred Mitigation(s)
The preferred mitigations would be a combination of developing VMGs for all forest lands under all ownerships for visual sensitivity ranks II through IV and developing a buffer zone where special harvest practices would be permitted on visual sensitivity rank I timberlands. Guidelines have been outlined in table 8.2 (Jaakko Pöyry Consulting, Inc. 1993) for implementing VMGs for visual sensitivity ranks II through IV. Both mitigations have the potential to maintain visual quality and recreation opportunities on and around the timberlands impacted by harvesting.

IMPACT—Cultural Resources

Table 1.14. Evaluation of mitigation strategies for minimizing negative impacts of forest harvesting on historical and cultural resources. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative(-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Statewide Coordination and Leadership				
Upgrade and maintain state listing of known sites	1	1	1	
Collecting information	1	2	1	
Predictive models	2	3	1	
Site protection protocols	1	1	1	
Education programs	2	1	1	
Location of Sites Prior to Harvesting				
Locate traditional use sites/modify access	2	2	1	
Preharvest surveys	1	2	1	Economic (-)
Modified Harvesting Equipment and Practices				
Harvest when soil strength high	2	3	2	Economic (-)
Lower impact equipment and practices	3	3	2	
Lower impact site prep practices	2	2	2	Water Quality (-)

[a] 1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

1 Statewide Coordination and Leadership

Upgrading and maintaining the state listing of known sites is of fundamental importance to the effective protection of the cultural and historical resources. Access to information on the location of sites, the numbers of similar sites and the information within the sites is essential for informed decisionmaking and planning as well as for research purposes. This alternative is therefore likely to be very effective, feasible and will provide lasting benefits.

Collecting information on cultural resource and traditional use sites will increase understanding of the location and nature of these sites and will form the basis for more informed decisionmaking regarding these values. Hence, while this information will not afford any protection, it is a necessary prerequisite for being able to develop appropriate strategies. This alternative is achievable, subject to appropriate funding and the cooperation of Native American people.

Development of predictive models will likely improve the ability to identify areas with an increased likelihood of finding certain types of sites. These models can focus survey efforts and prioritize areas for survey. Therefore, where reliable models can be developed, they will form the basis for more informed decisionmaking regarding the survey needs and survey success. The feasibility of these models is limited because of the lack of data in many areas upon which to base such models. Therefore, while this information will not afford any protection, it is a necessary prerequisite for being able to develop appropriate strategies. This alternative is achievable subject to appropriate funding and the cooperation of Native American people.

Development of site protection protocols is an effective way to insure that identified sites are handled in the most appropriate manner to ensure protection, particularly during harvesting and subsequently for longer periods. This alternative is feasible. Drafting these protocols should be straightforward, subject to the participation and cooperation of all interested groups. Where the measures are employed, the duration of the effect is long-term.

Education programs can assist by increasing awareness of the values and significance of cultural and historic resources; and ways to protect those values. The effectiveness and feasibility of this option are linked by the need to identify the means to develop and disseminate information. This could most appropriately be done in conjunction with existing extension networks. This alternative is feasible. The duration of the effect is long-term, assuming that education programs are ongoing.

2 Location of Sites Prior to Harvesting

Consideration of Traditional Use patterns in roading plans is an effective way to reduce potential conflicts between forest managers and Native

American people, primarily on public and reservation lands. This alternative is feasible and should be aided by the data collection identified above. The duration of the effect is long-term.

Preharvest site survey is currently employed on USDA Forest Service lands. This has been an effective mitigation where it is used, assuming located sites are dealt with appropriately (see below). The feasibility of this alternative is dependent on which ownership is being considered. It is currently unclear as to whether state and county land managers are legally required to actively survey timber sales for heritage sites before logging commences.

Private landholders are currently under no compulsion to undertake surveys although incorporation of Shoreland Regulations into county zoning regulations may require this.

The cost of surveys represents another potential constraint to the feasibility of this alternative. Costs have been estimated at approximately $3.00 per acre for large areas and $4.00 per acre for smaller size blocks. Despite these constraints, the increasing recognition given to these resources on public and private lands means this alternative is of moderate feasibility. Once located, sites can be accorded long-term protection.

3 Modified Harvesting Equipment and Practices

Modifications to harvesting equipment and practices are the least effective options. These options can mitigate impacts only in the sense that the risk of impacts is reduced under some circumstances. The degree to which risks are reduced on an individual site depends on factors as varied as operator behavior and prevailing weather conditions. There is no way to determine the success of the mitigation. Measures to increase or reallocate the area harvested during winter, when conditions would be within the range specified, would be difficult to specify and implement. The task of identifying candidate areas, monitoring conditions and supervising operations would require significant resources. The conflict between the need to harvest wet sites under these same conditions is also likely to reduce the feasibility of this option. Lastly, additional harvest during the winter months would require additional investments in equipment and personnel during the winter months but less for remaining periods. This would disrupt employment patterns and require significant new capital investments.

Therefore, while this alternative has varying effectiveness, its feasibility is uniformly low. Duration of benefits from this option are likely to be medium-term, as new impacts would be likely each time an area was harvested.

Preferred Mitigation(s)
Development of the leadership and coordination role in the handling of cultural and historical resources at the statewide level is of fundamental importance. There are several state agencies and bodies that could possibly handle this role, including the MNDNR, Minnesota Historical Society and the Office of the State Archaeologist. Of these, the Office of the State Archaeologist has the most direct responsibilities with respect to these resources and therefore should assume this role. The services and advice that could be provided will increase the likelihood of success for other mitigations. Therefore, these alternatives must be considered the highest priority. Of the remaining alternatives, those that seek to identify and or prevent impacts from occurring are preferred over those that seek to reduce the risk of impacts by changing equipment and practices without first identifying sites. This is because the latter type of mitigations only reduce impacts on certain categories of sites and do not eliminate the risk of damage to those categories of sites that can benefit. However, each of the mitigations may be useful, depending on site specific and operational circumstances.

IMPACT—Economics and Management
No significant impacts were identified, hence no mitigations are required at the base level of harvesting.

APPENDIX 2
Covertype Determination Methodology and Implications and Age Class Distributions

In making projections, it was not possible to project the FIA forest type classification. Consequently, a simpler forest type classification algorithm was developed—one that approximated the FIA classification and that could be projected. In doing to, it became evident that several covertypes, notably white pine, northern white cedar and white spruce were *very* sensitive to the algorithm used. These are among the most mixed covertypes (in terms of species composition) and thus understandably sensitive in classification. Because of differences between the FIA and the GEIS-specific algorithm, both are shown for 1990 in table 2.1. Subsequently, acreage projection tables are developed using the GEIS algorithm only. This avoids confusion in the interpretation of changes from 1990 forward.

Table 2.1. Forest type acreage for FIA timberland, reserved and unproductive plots for 1990, statewide (thousand acres).

Forest Type	1990			
	Timberland*	Reserved	Unproductive	Total
Jack pine	(487.1) 447.5	(125.9) 131.5	(1.2) 0	(614.2) 579.0
Red pine	(350.6) 301.6	(78.6) 80.4	(0.9) 0	(430.1) 382.0
White pine	(137.3) 63.2	(9.7) 3.8	(1.3) 1.3	(148.3) 68.3
Black spruce	(1,320.8) 1,322.1	(129.6) 126.6	(527.5) 533.7	(1,997.9) 1,982.4
Balsam fir	(1,012.5) 734.3	(117.0) 93.1	(21.9) 12.5	(1,151.4) 839.9
Northern white cedar	(322.4) 680.5	(8.2) 25.1	(37.3) 38.3	(367.9) 743.9
Tamarack	(696.2) 705.1	(7.9) 8.9	(118.1) 110.7	(822.2) 824.7
White spruce	(137.1) 93.8	(43.9) 39.9	(0) 0	(181.0) 133.7
Oak-Hickory	(1,288.0) 1,190.4	(13.6) 9.5	(14.0) 13.4	(1,315.6) 1,213.3
Elm-Ash-Soft maple	(1,564.2) 1,291.5	(64.9) 42.8	(33.4) 33.1	(1,662.5) 1,367.4
Maple-Basswood	(1,301.8) 1,396.7	(30.6) 17.0	(2.1) 0	(1,334.5) 1,413.7
Aspen	(4,496.0) 5,115.4	(358.1) 422.1	(33.9) 30.3	(4,888.0) 5,567.8
Paper birch	(1,179.3) 834.7	(109.7) 94.9	(6.1) 2.1	(1,295.1) 931.7
Balsam poplar	(480.1) 427.7	(15.4) 7.1	(10.6) 8.4	(506.1) 443.2
Nonstocked	(0) 168.9	(0) 0	(0) 43.5	(0) 222.8
Other	(0) 0	(0) 10.4	(0) 1.0	(0) 0
Total	14,773.4	1,113.1	828.3	16,714.8

Source: Jaakko Pöyry Consulting, Inc. (1992a).
*Values in parentheses are 1990 acres as determined by GEIS covertype algorithm.

Table 2.2 describes the age class distributions of forest types for 1990 and the projections to 2040 for timberland, reserved and unproductive forest land. These data should be interpreted with caution because (1) stand age is a difficult variable to measure accurately, and (2) projection and modelling methodologies involved simplifying assumptions about stand aging. Among these are that stands projected for 50 years will then be 50 years older. In reality, remeasurement of stand ages in 50 years may lead to somewhat younger estimates of age as the oldest trees die and are replaced by slightly or even much younger stems.

In these projections, postharvest covertype change was simulated for both (1) conversion by artificial means, and (2) for natural regeneration processes. The latter were developed stochastically based on patterns observed in the FIA data for the period 1977–90. Subsequent to regeneration, all plots were grown by the growth model and periodically evaluated for covertype based on the plurality of basal area by species. This evaluation used the GEIS specific algorithm that approximated FIA covertype classification. Thus, covertype acreage could change with harvest and also later through stand development and succession, i.e., as species composition changed. Some covertypes show the presence of age classes in 2040 that are in excess of the usual lifetime of species comprising that type. In such cases one may assume that stands have become uneven-aged and/or are in the process of succeeding to other species.

Slight differences between figures in this table and those in other tabulations in this document are due to differences in the completeness of FIA test data editing and data handling procdures that evolved as the study progressed.

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected.

Forest Type	Age	Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
		1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Jack pine	5	28,800	11,256	19,840	22,902				
	15	38,600	10,560	9,836	45,100				
	25	27,100	25,419	32,122	59,759				
	35	37,200	20,557	30,125	47,250				
	45	83,700	2,482	1,500	9,791	3,400			
	55	92,900	30,220	28,138	24,558	14,200			
	65	86,200	42,028	35,631	21,377	39,200			
	75	28,500	18,070	17,239	8,577	40,800			
	85	10,300	22,474	17,895	4,034	26,400	4,300		
	95	3,800	44,720	29,960	5,853	7,500	3,400		1,200
	105	3,300	37,737	37,055	6,154		16,200		
	115		39,291	34,205	5,600		21,400		
	125	5,300	15,965	10,803	7,251		10,900		
	135		3,506	2,300	1,200				
	145		1,400						
	155		755	755					
	165								
	175		3,200		3,200				
Total		445,700	329,640	307,404	272,606	131,500	56,200		1,200
Red pine	5	46,600	47,696	42,945	54,773				
	15	40,800	54,504	54,721	73,392				
	25	59,900	38,098	43,601	88,248				
	35	32,200	36,804	44,222	27,649				
	45	36,000	53,924	47,824	54,829	1,600			
	55	21,900	45,876	45,876	47,276				
	65	32,400	36,790	35,990	24,190	1,700			
	75	21,600	39,396	36,640	19,292	9,200			
	85	30,900	23,475	23,875	12,698	7,500			
	95	12,000	12,627	14,727	5,927	16,600	3,400		
	105	12,100	19,727	20,127	2,627	15,300			
	115	1,000	16,000	13,400	5,300	7,300	5,300		
	125	2,100	8,052	8,300	5,800	8,800	9,200		900
	135	1,400	9,629	9,829	3,129	3,600	7,500		
	145		7,315	7,315	5,615	8,800	18,500		
	155		1,300	3,800	1,300		15,300		
	165						7,300		
	175		1,200	1,200	1,200		8,800		
	185						3,600		
	195						8,800		
Total		350,900	452,392	454,392	433,245	80,400	87,700		900

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

		Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
Forest Type	Age	1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
White pine	5	1,900	2,400	2,400	4,500				
	15		7,140	5,494	16,597				
	25		6,303	5,855	10,983				
	35	2,200	6,051	8,851	7,000				
	45	6,300	15,034	15,034	10,054				
	55	7,900	5,559	4,808	5,559				
	65	6,700	4,183	4,183	4,183				
	75	10,700		1,000					
	85	8,400							
	95	5,000	6,000	6,000	1,900	2,000			
	105	8,000	8,355	7,396	5,896		3,400		
	115	2,800	14,732	13,654	6,310		4,100		
	125	3,700	6,034	7,034	4,534			1,300	
	135	1,300	21,233	17,402	12,402	1,800	21,300		
	145	3,700	15,424	14,324	12,424		2,000		
	155		5,994	5,994	4,894				
	165		4,182	4,182	4,182				
	175		6,006	6,006	3,506				1,300
	185		1,100	1,100			1,800		
	195		5,301	5,301	5,301				
Total		68,600	141,031	136,018	120,225	3,800	32,600	1,300	1,300
Black spruce	5	43,900	56,796	125,960	198,033			4,400	
	15	102,200	42,337	105,277	162,570	8,600		153,100	
	25	110,300	27,794	108,225	115,761	1,800		9,900	
	35	91,100	41,080	83,035	58,861	12,700		6,000	
	45	145,300	44,816	34,303	25,301	3,600		13,900	
	55	206,900	36,998	36,998	36,629	13,500		21,200	8,100
	65	172,800	71,224	61,972	58,772	19,800	8,500	30,400	153,100
	75	135,000	73,440	52,257	47,057	21,800		46,500	13,500
	85	110,900	58,600	37,921	32,621	5,100	7,000	18,200	7,300
	95	82,200	84,735	50,289	48,789	25,700	3,600	36,800	15,200
	105	60,400	119,185	78,009	56,958	9,000	7,200	53,800	17,200
	115	24,600	86,159	55,751	35,931	5,000	8,500	33,200	30,400
	125	25,900	69,086	40,906	24,406		14,000	35,300	50,500
	135	10,700	63,573	26,762	16,762		1,700	16,400	18,200
	145	16,800	41,917	17,237	11,837		23,800	54,600	37,800
	155		33,257	13,600	13,500		9,000		54,800
	165		17,500	8,800	7,200		5,000		33,200
	175		13,655	1,200	1,200				36,400
	185		8,500	2,700	1,400				17,200
	195		10,531	4,231	4,231				54,600
Total		1,339,000	1,001,183	945,433	957,819	126,600	88,300	553,700	547,500

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

Forest Type	Age	Timberland				Reserved Acres		Unproductive	
			2040 - 3 Scenarios						
		1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Balsam fir	5	60,600	25,472	40,232	49,584			800	
	15	85,900	41,592	61,974	85,449	3,600		5,500	
	25	68,600	60,918	80,513	114,283	3,400		900	
	35	48,600	38,271	61,372	58,707			900	
	45	121,000	20,456	22,901	44,885	25,100			
	55	194,200	58,238	45,050	40,150	29,900	3,500	2,400	1,900
	65	130,900	40,502	31,931	20,786	19,900			5,500
	75	50,900	32,988	24,231	13,131	1,900	5,200		900
	85	27,500	33,016	16,206	16,106	1,700			2,200
	95	5,300	52,549	24,417	17,317	1,900	10,600	900	1,000
	105	3,800	63,940	35,657	22,906	5,700	19,500	1,100	2,400
	115	4,500	52,149	35,420	20,763		14,700		
	125		31,160	24,660	15,960		7,100		
	135		36,252	27,952	15,052		5,100		2,600
	145	2,600	12,773	7,900	6,600		1,700		900
	155		8,555	7,155	6,455		1,900		1,100
	165		13,000	13,000	10,600				
	175		11,857	14,057	8,657				
	185		7,129	7,120	7,129		3,600		
	195		16,600	16,660	15,100				
Total		804,300	657,377	598,357	589,620	93,100	72,900	12,500	18,500
Northern white cedar	5	3,000	10,851	19,273	33,798			2,800	
	15	12,000	14,523	28,535	46,040	2,100		10,000	
	25	17,600	6,800	16,562	26,512				
	35	9,800	6,244	9,044	6,526				
	45	16,300	2,600	1,100					
	55	28,400	6,055	6,055	6,055			1,000	2,800
	65	29,400	18,152	18,152	18,152		3,100	1,400	10,000
	75	56,000	22,300	20,200	19,100	1,800		3,400	
	85	78,800	9,780	9,780	8,480			1,000	
	95	100,700	15,731	13,931	12,231			3,900	
	105	58,800	27,229	24,429	20,829	3,200		3,500	1,000
	115	63,900	24,106	20,900	18,000	2,300	1,800	4,100	1,400
	125	54,000	30,257	24,557	19,331	5,400			3,400
	135	28,700	20,100	17,800	15,100	8,900		1,600	1,000
	145	85,700	56,835	52,104	41,751	1,400	1,900	5,600	5,000
	155		26,400	25,100	20,800				3,500
	165		20,031	20,031	17,231				4,100
	175		19,351	19,351	18,251				1,300
	185		4,126	4,126	4,126		1,700		1,600
	195		19,400	19,400	18,300				5,600
Total		643,700	360,871	370,430	370,613	25,100	8,500	38,300	40,700

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

Forest Type	Age	Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
		1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Tamarack	5	47,800	17,191	51,174	126,506			1,100	
	15	55,200	17,570	53,483	116,236	3,100		16,800	
	25	85,600	12,840	48,429	66,903			1,100	
	35	63,800	19,150	16,442	31,464			3,200	
	45	53,400	2,957	11,133	16,357			3,400	
	55	73,200	59,154	56,395	54,364			4,700	2,504
	65	86,300	43,045	40,694	31,594		1,100	4,000	18,300
	75	49,800	66,273	56,869	54,160			16,500	1,100
	85	45,200	53,726	46,395	39,864			12,800	3,200
	95	45,300	50,529	42,445	38,545	2,900		7,800	3,400
	105	26,600	57,460	40,960	23,017			15,100	5,800
	115	21,300	64,119	56,482	31,271			6,800	4,000
	125	24,700	46,662	36,704	27,980	1,900		6,100	16,500
	135	3,700	44,575	35,797	10,300			4,500	13,800
	145	20,600	34,685	28,307	1,851		3,900	8,800	7,800
	155		28,202	22,102	2,800				15,100
	165		18,652	18,652	10,200				4,800
	175		21,500	21,500	9,100		1,900		7,300
	185		2,600	2,600	1,100				4,500
	195		17,828	17,828	8,076				10,100
Total		702,500	678,718	704,391	701,688	8,900	6,900	110,700	118,204
White spruce	5	9,600	3,896	7,800	4,400				
	15	4,700	2,600	8,770	12,588				
	25	16,800	4,353	6,710	5,753				
	35	11,100	5,780	6,700	7,780				
	45	16,900	5,545	6,225	6,445	3,500			
	55	13,000	17,355	17,255	15,555	1,700			
	65	7,200	21,879	19,779	18,722	4,700	5,400		
	75	2,100	35,043	30,999	25,999	8,800	5,400		
	85	2,600	15,574	8,653	7,253	7,200			
	95	1,500	24,001	20,601	13,901	9,000	8,800		
	105		28,243	22,137	12,755	1,400	15,400		
	115		31,689	18,231	4,331	3,600	18,300		
	125	2,000	10,300	8,000	3,400		21,800		
	135	1,700	2,182	1,351	4,796		8,900		
	145		11,400	11,400	7,700		13,000		
	155		0	0	0		3,300		
	165		1,400	1,400	1,400		4,600		
	175		3,000	3,000	1,700				
	185		1,700	1,700	1,700		1800		
	195		2,000	2,000	2,000				
Total		89,200	227,940	202,711	158,178	39,900	106,700		

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

		Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
Forest Type	Age	1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Oak-hickory	5	29,000	111,392	129,973	139,096	2,200		800	
	15	19,100	146,988	172,228	211,271				
	25	26,400	130,295	165,269	216,426			1,000	
	35	15,500	76,648	84,517	73,396			200	
	45	95,300	47,770	39.361	68,028	1,700			
	55	183,400	46,664	44,713	50,466		4,177	600	1,887
	65	226,400	22,878	22,878	22,878	4,100		1,900	
	75	154,100	38,117	37,366	38,568	700		1,100	1,348
	85	142,200	33,280	31,349	26,215			3,100	269
	95	99,600	94,749	77,648	71,794		3,505	1,200	
	105	65,700	155,354	129,380	101,235	800	1,078	600	809
	115	15,900	139,493	110,977	109,588		5,527	1,200	2,774
	125	46,900	106,258	85,822	69,233		2,291	1,700	1,100
	135	1,000	67,319	60,430	42,443		943		4,302
	145	3,500	77,408	63,876	63,115				1,618
	155		38,072	31,241	25,405		1,078		809
	165		14,184	12,214	10,507				1,618
	175		23,330	23,330	14,398				2,292
	185								
	195								
Total		1,124,700	1,370,199	1,322,361	1,354,062	9,500	18,599	13,400	18,826
Elm-ash-cottonwood	5	100,400	119,376	183,755	224,734	7,700		6,200	
	15	103,500	117,176	172,423	238,803			3,100	
	25	51,700	113,674	151,428	247,846				
	35	61,700	46,461	63,026	82,743			1,100	
	45	91,700	23,065	17,695	41,354	4,500			
	55	129,000	122,915	120,596	115,123	6,100	13,638	1,800	6,608
	65	197,900	119,525	111,335	115,589	3,400	5,600	4,200	3,100
	75	126,800	61,568	53,788	57,842	4,200	2,643	3,700	
	85	80,100	72,174	56,589	47,153	1,900		1,800	1,100
	95	67,800	129,506	117,825	101,709	7,300	14,143	4,200	
	105	47,900	181,485	142,723	122,672	4,100	14,935		1,800
	115	12,500	192,327	145,963	102,297	1,800	24,064		5,400
	125	18,600	155,766	134,812	86,769		3,600	1,100	4,013
	135	4,100	86,049	77,418	39,137	1,800	3,600	2,600	2,009
	145	14,600	72,998	60,405	31,973		7,300	3,300	14,200
	155		47,443	35,191	20,213		4,100		
	165		16,502	14,600	7,200		1,800		
	175		22,750	18,944	11,259				1,100
	185		9,306	8,551	7,351				2,600
	195		33,949	27,777	21,700				3,300
Total		1,108,300	1,744,015	1,714,844	1,721,467	42,800	95,423	33,100	35,230

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

Forest Type	Age	Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
		1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Maple-basswood	5	79,900	70,242	129,219	231,154				
	15	107,500	85,284	110,531	185,145	1,600			
	25	76,600	68,052	112,632	131,983				
	35	63,000	49,359	50,696	54,944				
	45	137,300	50,828	43,639	47,323				
	55	254,500	71,383	61,097	68,181	7,100	1,022		2,100
	65	261,100	70,844	70,844	71,675	4,500	2,157		
	75	171,300	48,637	42,753	39,993				
	85	142,300	42,342	37,166	38,666	2,800	943		
	95	70,900	105,085	81,550	55,028		4,091		
	105	59,100	169,911	128,042	65,530		11,217		
	115	9,100	230,621	162,862	90,827	1,000	8,513		
	125	21,100	139,832	109,208	52,513		2,300		
	135	3,400	114,355	100,435	54,745		3,148		
	145	7,000	52,191	45,254	19,948				
	155		46,975	41,967	24,176				
	165		11,409	10,578	5,424				
	175		17,389	14,605	8,493				
	185		6,930	6,930	3,697				
	195		8,573	8,573	5,792		1,400		
Total		1,464,100	1,460,242	1,368,581	1,255,237	17,000	34,791		2,100
Aspen	5	753,400	946,143	1,020,427	1,464,253	9,000		4,600	
	15	587,200	901,143	952,862	1,145,248	15,800		3,300	
	25	415,700	850,932	859,931	1,081,590	24,600		1,100	
	35	461,900	1,122,492	1,259,639	1,287,461	12,000		6,000	
	45	761,900	528,134	540,371	21,959	42,400		3,200	
	55	957,700	173,682	169,831	160,506	128,700	8,292	6,900	8,771
	65	791,200	132,292	131,416	125,949	166,800	8,600	1,800	5,674
	75	295,600	76,727	76,727	71,725	17,700	19,578		1,100
	85	110,000	62,580	64,080	59,835	2,300	12,348	1,000	6,000
	95	40,900	99,917	96,031	84,717	900	38,373	2,400	3,200
	105	8,800	157,772	151,793	102,979	1,900	125,995		6,900
	115	3,400	111,537	107,087	80,060		144,782		1,800
	125	4,600	39,043	35,412	23,812		22,813		
	135		20,040	15,514	7,714		4,000		1,000
	145	1,000	5,900	5,000	2,200		2,700		2,400
	155		4,000	4,000	4,000		1,900		
	165		3,106	3,106	3,204		500		
	175		1,100	1,100	1,100		1,800		
	185		900	900	900		1,800		
	195		1,300	1,300	1,300				
Total		5,193,600	5,238,745	5,496,527	5,730,278	422,100	393,481	30,300	36,845

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

Forest Type	Age	Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
		1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Paper birch	5	41,600	40,176	44,327	50,422	1,800			
	15	22,400	61,530	94,334	98,475	1,800		1,100	
	25	23,200	65,209	106,694	174,260	3,600			
	35	22,600	25,973	53,793	70,648			1,100	
	45	96,700	14,702	10,585	57,160	5,300			
	55	200,000	57,068	46,200	33,902	29,300	2,500		
	65	207,400	19,708	15,257	20,977	46,100	1,348		1,483
	75	115,200	23,098	20,198	19,298	5,300	1,800		
	85	35,900	20,700	16,749	13,449		1,400		1,000
	95	27,900	34,606	28,892	14,692	1,700	7,200		
	105	12,300	89,308	71,683	29,371		23,500		4,000
	115	6,400	104,387	73,630	30,070		52,800		
	125	5,000	73,436	65,354	21,361		19,100		
	135		41,875	37,543	21,461				
	145		31,179	27,666	16,443				
	155		22,104	19,504	9,426		3,600		
	165		25,593	22,793	14,931		3,200		
	175		16,268	16,268	12,935		1,800		
	185		9,409	9,409	9,409		3,600		
	195		27,046	25,346	22,991		1,800		
Total		816,600	803,375	806,225	741,681	94,900	123,648	2,100	6,483
Balsam poplar	5	60,200	112,390	122,213	112,253				
	15	61,500	65,947	80,852	96,594	3,500		900	
	25	42,000	63,219	73,580	78,750				
	35	40,200	73,388	80,279	91,648			1,300	
	45	101,300	6,249	4,849	4,849	1,800		3,000	
	55	75,700	18,211	18,211	18,211	1,800		1,000	
	65	67,500	15,562	15,562	15,562		5,200		900
	75	31,100	9,087	9,087	9,087				
	85	6,800	8,586	8,586	8,586				1,300
	95	10,400	22,186	22,186	22,186		1,800		3,000
	105		9,472	9,472	9,472		1,800		2,100
	115		3,412	3,412	3,412		5,700	1,100	
	125		2,655	1,555	1,555				
	135	500							
	145		831	831	831				2,200
	155								
	165		1,400						
	175		1,100	1,100					1,100
	185								
	195								1,100
Total		497,200	413,695	451,755	472,996	7,100	14,500	8,400	9,500

APPENDIX 3

Bird Mitigations

Table 3.1. Mitigation strategies relevant to those bird species projected to be negatively impacted by one or more of the harvesting scenarios.

Species	Mitigation Codes*
Spruce Grouse	1,3,8
Green-backed Heron	1,5
Sharp-shinned Hawk	1,3,8
Cooper's Hawk	1,2,3,8
Northern Goshawk	1,3,8
Red-shouldered Hawk	1,2,3,5,8
Broad-winged Hawk	1,3
Merlin	1,3,8
Eastern Screech-owl	1,2,5,8
Great Horned Owl	1,2,3,8
Barred Owl	1,2,3,8,9
Great Gray Owl	1,3,8
Long-eared Owl	1,2,3,8
Boreal Owl	1,3,8,9
Northern Saw-whet Owl	1,3,8,9
Whip-poor-will	2,3,4,5
Red-headed Woodpecker	1,2,9
Red-bellied Woodpecker	1,2,9
Yellow-bellied Sapsucker	1,3,8,9
Hairy Woodpecker	1,2,3,5,7,9
Black-backed Woodpecker	1,3,8,9
Northern Flicker	4,7,9
Pileated Woodpecker	1,2,3,5,8,9
Olive-sided Flycatcher	3,7,9
Eastern Wood Pewee	1,4,5
Yellow-bellied Flycatcher	1,3,8
Acadian Flycatcher	2,5,8
Least Flycatcher	1,3,8
Eastern Phoebe	5
Great Crested Flycatcher	1,3,9
Gray Jay	1,3,8
Blue Jay	6
American Crow	(low concern)

Species	Mitigation Codes*
Common Raven	1,3
Black-capped Chickadee	1,2,3,9
Boreal Chickadee	1,3,8,9
Red-breasted Nuthatch	1,3,9
White-breasted Nuthatch	1,2,3,9
Brown Creeper	1,3,9
Golden-crowned Kinglet	1,3,8
Ruby-crowned Kinglet	1,3,8
Blue-gray Gnatcatcher	1,2,8
Eastern Bluebird	7,9
Veery	4
Swainson's Thrush	1,3,8
Hermit Thrush	1,3,8
Wood Thrush	1,3,8
Gray Catbird	4,5
Brown Thrasher	4,5
Solitary Vireo	1,3,8
Yellow-throated Vireo	1,2,3,5,8
Red-eyed Vireo	1,2,3,8
Tennessee Warbler	1,3,8
Nashville Warbler	3,4
Northern Parula	1,3,8
Yellow Warbler	4,5 (low concern)
Magnolia Warbler	4
Cape May Warbler	1,3,8
Black-throated Blue Warbler	1,3,4,8
Black-throated Green Warbler	1,3,8
Blackburnian Warbler	1,3,8
Pine Warbler	1,3,8
Bay-breasted Warbler	1,3,8
Cerulean Warbler	1,2,5,8
Black-and-white Warbler	1,2,3,4,8
American Redstart	2,3,4
Ovenbird	1,2,3,5,8
Louisiana Waterthrush	1,2,5,8
Connecticut Warbler	1,3,8
Common Yellowthroat	5 (low concern)
Hooded Warbler	1,2,5,8

Species	Mitigation Codes*
Wilson's Warbler	5
Yellow-rumped Warbler	1,3
Northern Cardinal	4
Indigo Bunting	4,5,7
Scarlet Tanager	1,2,3,8
Chipping Sparrow	7
Song Sparrow	4,5 (low concern)
Lincoln's Sparrow	3
Dark-eyed Junco	1,3
Common Grackle	4,5 (low concern)
Northern Oriole	1,2,3,5
Purple finch	1,2,3,5
Red Crossbill	1,3
White-winged Crossbill	1,3,6
Pine Siskin	1,2,3
American Goldfinch	4 (low concern)
Evening Grosbeak	1,3

*Key
1 = ERF
2 = large patches south
3 = large patches north
4 = uneven-aged/thinning management
5 = riparian corridors
6 = mast trees
7 = clearcut with residuals
8 = connected landscape
9 = retain cavity trees

APPENDIX 4

Suggested Strategic Responses Background Materials

4.1 Introduction

The GEIS suggested strategic responses are presented in section 8 of the main report. The purpose of this appendix is to provide important background materials that together will help create a more complete backdrop for understanding the form and structure of the suggested strategic responses in section 8 of the main report.

The materials covered in this appendix are as follows:

- summary of GEIS mitigation strategies;
- companion states' forest practices experiences;
- forest practices regulations position statement (SAF);
- GEIS identified forest research deficiencies;
- alternative services delivery options;
- public policies and programs participants;
- forest resource policies and programs administration background; and
- Minnesota forest resources administrative structure illustrative example.

4.2 Mitigations Recommendations Summary

The individual study groups' recommended mitigation strategies are displayed in appendix 1. Sections 5 to 7 of the main report discuss the *integrated* recommended strategies across all key issue areas for the three timber harvesting and forest management activity levels. These integrated mitigation strategies were grouped into three general categories:

1. forest-based research;
2. landscape-level responses; and
3. site-level responses.

To help the reader better understand the scope of these integrated strategies, this section of the appendix revisits them and provides a brief descriptive summary from a different perspective. Here they are overviewed based on the *functional* role they play in terms of the following:

- guidance;
- constraints;
- objectives;
- oversight;

- education; and
- research.

4.2.1
Guidance-oriented Mitigation Strategies

A certain subset of the recommended mitigation strategies actually establish guides or guidelines that need to be adhered to:

- limit all harvesting activities in the southern part of Minnesota in riparian corridors 200 feet wide either side of watercourses;
- for the remainder of the state, where shoreline rules do not apply, for riparian zones 100 feet wide along lakes, wetlands, and each river and stream (> third order), limit all harvesting activities;
- construct no permanent roads in ROS classes 1 and 2 areas anywhere in Minnesota;
- limit harvesting in at least 20 percent of the state's timberlands to techniques that will generate ERF conditions;
- restrict harvesting to generate one-half to one mile wide corridors that establish corridors for connected landscapes involving old growth patches, research natural areas, and scientific natural areas;
- develop VMGs, especially in conjunction with nonpermanent roads and visually sensitive areas;
- restrict logging in and around all sensitive sites such as those for eagles rookeries, or other special species identified in sections 5 to 7; and
- develop guidelines for good harvest practices, for applications in statewide harvesting operations where the guidelines begin with and are similar to existing water quality BMPs that are directed at site-level operation and planning.

4.2.2
Constraints-oriented Mitigation Strategies

Select mitigation strategies can be grouped as prescriptions aimed at constraining the type of management activities to those that will mitigate significant impacts where appropriate:

- adhere to a program of site slash retention where as much slash as is physically and economically feasible should be contained as close as possible to the tree stump, except where stand hygiene (e.g., for red pine) dictates otherwise;
- utilize thinning, harvesting, and other silvicultural equipment selected to minimize stand or site disturbance and damage;
- use silvicultural techniques that maintain the integrity of riparian vegetation zones at all times;

- use harvest planning techniques that retain cavity containing trees per requirements for local bird species and other cavity dwelling animals;
- maintain desired age class distributions for each covertype statewide by employing silvicultural techniques aimed at adjusting tree species mix and age distribution to generate the desired balance;
- employed modified silvicultural systems, such as uneven-aged management, thinning or clearcutting with residuals for retention of key habitat types;
- modify times of stand entry to reduce potential for site damage, such as in poor soil moisture periods; and
- select tree species and silvicultural systems best suited to local site conditions.

4.2.3 *Objectives*-oriented Mitigation Strategies

A few key recommended mitigation strategies can be classified as goal setting in nature:

- optimize wood fiber utilization at all levels from the woods to the manufacturing line;
- increase the timber productivity of existing and future stands statewide, especially on NIPF owned lands;
- reduce the area of forest land and timberland converted to nonforest land uses;
- balance age class and covertype structures statewide;
- retain key habitat forest land types, such as riparian areas;
- develop and institute a statewide road and trail plan;
- adopt a statewide IPM strategy; and
- increase proportion of wintertime harvesting activities.

4.2.4 *Oversight*-oriented Mitigation Strategies

Certain significant impacts will not be mitigated successfully without better information and monitoring over time:

- monitor the age class and covertype structure of the state's forests;
- complete the MNDNR county biodiversity inventory;
- provide adequate resources to upscale and maintain the state's listing of known unique cultural and historical and traditional use sites; and
- develop information collection and monitoring programs as the need arises to ensure other mitigation strategies are working (such as for BMPs).

4.2.5
Education-oriented Mitigation Strategies

Effective implementation of certain recommended mitigation strategies will require that companion education type strategies (specifically noted previously or implied) also be pursued:

- develop and implement a comprehensive statewide landowners extension or continuing education program covering the mitigation strategies developed for this GEIS;
- institute a continuing education program for loggers, forest operators and foresters that can be the basis for certification and licensing programs; and
- provide publicly available educational materials to help ensure the public is objectively informed on the issues affecting resource management decisions.

4.2.6
Research-oriented Mitigation Strategies

Knowledge enhancement is a key to both successful mitigation strategy implementation and enhancing or expanding mitigation strategies as needed. A range of research strategies were either previously recommended or their need was implicitly derived. These are developed in detail in section 4.5 of this appendix.

4.3
Companion States' Forest Practices Experiences

Ellefson and Cheng (1993) identified key considerations for any state contemplating the development of a statewide forest practice law. These considerations include the following:

- regulations by governments are harsh public policy tools;
- regulatory programs are becoming more and more common;
- private landowners' careless application of forest practices has stimulated consideration for such regulations;
- the public's interest in natural environments is greatly increased;
- federal environmental laws, policies and regulations (e.g., NEPA, EPA, RPA, etc.) have nurtured states' interest in complementary regulations;
- the public sentiment is moving toward greater accountability;
- local ordinances, rules, guidelines, etc., are proliferating into a jungle of complex mishmash that collectively confound and confuse everyone, including the on-the-ground operators;

- there is a growing interest in the forest as a landscape, that tends to transcend ownership boundaries; and
- there is escalating special interest group pressure and motivation to follow special interest leadership out of group rather than subject matter loyalty.

Furthermore, any comprehensive forest practices program should recognize that for existing programs:

- there seems to be agreement that they have led to improved forest environmental quality;
- most clientele (e.g., loggers, landowners, etc.) do not see the current regulations as overburdensome; and
- landowner and operator compliance rates are high; generally in the 85 to 95 percent range;
- compliance is only slightly better where the regulatory practices are mandatory and there is a thorough companion monitoring and compliance enforcement program; and
- any regulatory program of this type can be costly to both public agencies and private concerns:
  - the 13 states listed previously expended over $30 million in 1991 (see table 4.1) and with staffing of over 400 people;
  - the range of expenditures were from a low of $83,000 for Montana's voluntary program to a high of $10+ million for California's complex mandatory program; and
  - regulation also raises costs to the forest landowner and loggers, via lost harvest, revenues, higher operating costs, and new expenses for the regulatory compliance activities.

Finally, while regulatory approaches to forest management and timber harvesting practices may be needed under certain circumstances, several alternatives to regulation exist. Therefore, both states with enacted regulatory-based forest practice acts/programs as well as those considering such an approach should consider the alternative mechanisms for implementation such as:

- voluntary BMPs (e.g., Minnesota today);
- extension education;
- technical assistance programs;
- financial assistance;
- cost sharing; and
- tax incentives.

Research by Ellefson and Cheng (1993) indicates that of these, technical assistance and regulations are most effective in protecting forest values such as water quality. Almost none of the state administrators contacted felt voluntary programs alone were effective long-term solutions.

Table 4.1. Administrative and enforcement expenditures for state forest practice regulatory programs.

	1991 (thousands $)
Alaska	
Division of Forestry	$ 224
Division of Fish and Game	500
Department of Environmental Conservation	400
California	
Department of Forestry and Fire Protection	$ 8,690
Regional Water Quality Agencies	1,200
Department of Fish and Game	1,000
State Water Resources Board	100
Tahoe Regional Planning Agency	22
Connecticut	
Division of Forestry	NA
Florida	
Regional Water Management Districts	$ 327
Idaho	
Department of Lands	$ 685
Division of Environmental Quality	140
Maine	
Maine Forest Service	$ 340
Maryland	
Chesapeake Bay Critical Areas Program	$1,294
Non-Tidal Wetlands Program	47
Erosion and Sediment Control Program	180
Waterway Access Program	596
Massachusetts	
Division of Forests and Parks	$650
Montana	
Division of Forestry	$ 83
Nevada	
Division of Forestry	$ 1,250
New Mexico	
Division of Forestry and Resources Conservation	$ 217
Oregon	
Department of Forestry	$ 3,300
Department of Environmental Quality	100
Department of Fish and Wildlife	100
Washington	
Division of Forest Practices	$ 6,600
Department of Fisheries	772
Department of Wildlife	660
Department of Ecology	687
Total	$ 30,074

Source: Ellefson and Cheng 1993 (in press).

4.4
Forest Practices Regulations Position Statement

As far as developing whatever program a state believes it should ultimately adopt, key considerations which have been effectively articulated in a recent SAF position on this topic (SAF 1989) should be taken into serious consideration:

" • The SAF neither advocates, or opposes the public regulation of private forest practices in general."

- Where states choose to regulate, "...the society advocates systems on regulation that will enhance rather than deplete forest resources and that reflect the cost of regulation in relation to benefits achieved.
- Forest practices regulation should be authorized by bodies that represent the broad public interest and the full range of forest users.
- Effective forest practices should include the interests of all citizens they are likely to affect.
- Forest-practice regulations should be based on the application of scientific knowledge, forest management principles, and their impacts on landowners' objectives.
- Forest-practice regulations should assure the productivity of forest lands and protect the environment.
- An effective regulatory system should include means to obtain and incorporate the best information about its consequences.
- Regulation of forest practices should recognize variations in forest conditions and forest-derived values within a state.
- To be adaptable, a regulatory system should separate rule-making from legislative functions.
- The regulatory system should place rule-making responsibilities in representative bodies that have direct access to the information they require.
- When several means can achieve the same regulatory goal, a landowner should have the discretion to choose the means that best suits his or her particular circumstances.
- A regulatory system should provide for sound monitoring of its impacts in different physical and social conditions.
- Forest-practice regulations should be clearly applied and enforced with respect to (1) the lands and practices to which they apply; (2) the governmental jurisdictions that exercise authority for them; and (3) the processes through which this authority is exercised and appealed.
- Forest-practice laws and rules should clearly define the land they cover, the terms used, and the standards for acceptable practices.

- If overlapping levels of governmental jurisdiction enact regulations, the precedence among jurisdictions should be clearly established.
- Enforcement must be consistent among ownerships with similar characteristics and for the same ownerships at different times.
- A regulatory system should inform those it affects.
- The authorities and responsibilities for forest-practice regulation should be as unambiguous and as uncomplicated as possible.
- The processes of rule-making and appeal should be readily accessible, responsive, and equitable for all who may wish to use them.
- Forest-practice regulations and related programs should provide incentives that both promote desired private practices and support the viability of the ownerships the regulations are intended to affect.
- A regulatory system should be designed and administered to product incentives that have the greatest net beneficial effect on the forest resources it is intended to improve. The system's capacity to do so should be evaluated in terms of (1) the physical impacts and public responses it produces and (2) the compatibility of other forest policies and programs with regulatory intent.
- Forest-practice regulation should not exceed what a government can finance and staff adequately to satisfy the preceding criteria.
- A regulatory system should provide clear information to the public about the legal and financial costs that regulation of private forest management may entail.

Forest-practice regulations are one means to sustain forest productivity and protect environmental quality. Although they may express a broad public intent to achieve this objective, they should not be assumed to do so by virtue of intent alone. The effectiveness of forest-practice regulations depends on their impact. Their impact depends on landowners' responses to them, and rarely can these responses be expected to follow directly from the regulatory intent"

4.5
GEIS Identified Forest Research Deficiencies Summary

As was noted in the main report, the GEIS has demonstrated three very important realities with regard to forest-based research in Minnesota:

- the GEIS process has been totally dependent on previously conducted forest-based research;
- the GEIS process has required a very significant amount of well-founded research in order to respond credibly, factually, and objectively to the FSD key issues; and
- while substantial and relevant research information was readily available for GEIS-related work, the GEIS process clearly identified the need for

significantly enhanced research to comprehensively address all FSD key issues.

The GEIS identified forest-based research needs are summarized here by the primary GEIS technical areas:

Maintaining Productivity and the Resource Base

- to provide the scientific basis and technical support to developing some of the inventory and monitoring functions identified as needed under the FRPP and SFRP, including more timely and detailed information on nontimber aspects of forests and their development and monitoring of spatial patterns and their implications;
- to provide the scientific basis for setting and refining desired age class and covertype structure goals to meet biological diversity objectives;
- to develop improved forest growth and change models, including ingrowth, regeneration, and succession estimation that provides sensitivity to specific harvesting and ecological conditions on a wide range of sites and ownerships and under varying silvicultural practices;
- to provide improved estimates of the increased yields from various levels of investment in forest management practices;
- to develop improved models and estimates of uneven-aged stand management yields and associated harvest and management costs;
- to improve the utilization data for Minnesota tree species and harvesting practices;
- to develop cost effective regeneration techniques to establish desired species under site conditions exhibiting low levels of disturbance and under existing stands as in the case of enrichment plantings (red and white pine and northern white cedar are priority species for this effort);
- to determine the harvesting spatial patterns at a landscape level that favor timber production and simultaneously achieving biological and aesthetic goals; and
- to examine findings of global change modelling efforts as they relate to Minnesota's forests, including forest change modelling to identify implications and response strategies.

Forest Health

- to monitor forest health to keep abreast of developing problems and trends and to provide for implementation of anticipatory IPM;
- to assess the pattern and rate of spread of pests and diseases from older forests in reserved areas to surrounding timberlands; and
- to improve the understanding of forest health as it relates to wildlife habitat and biodiversity concerns.

Forest Soils

- to document nutrient removals and replenishment rates under various harvesting systems and utilization levels on a range of soil types (including slash and bark retention on site);
- to document on site physical effects (compaction, puddling, etc.) under current and prospective harvesting systems in Minnesota; and
- to identify and quantify the benefits of low impact timber harvesting techniques and technologies; and
- to assess the changes in soil and soil water nutrient content, organic matter and acidity that occurs after covertypes are changed by harvesting practices.

Water Quality and Fisheries

- to assess the effectiveness of BMPs by region in preventing changes in the flux of organic matter, nutrients and light energy to streams, wetlands and lakes;
- to determine cumulative effects of multiple harvests within a watershed with emphasis on harvested area, timing, pattern across the watershed and harvesting practices;
- to assess the effects of reestablishing riparian corridors on stream community structure and function; and
- to develop Instream Flow Incremental Methodology (IFIM) for improving the understanding of water quality impacts.

Biodiversity

- to determine the relationships between covertype, stand age and plant community composition in a site specific and landscape context;
- to determine the effectiveness of connected landscapes concepts for natural dispersal and movement of plant and animal species and to develop cost effective approaches to their implementation;
- to assess harvesting effects on plant community species composition including herbaceous plants and tree species near the edge of their range, with emphasis on the direct physical effects and indirect effects from changing the environment;
- to quantify harvesting effects on endangered, threatened, and special concern species, with emphasis on the habitat factors that lead to change with manipulation, including consideration of population genetics and gene flow; and
- to improve the understanding of the relationship between rotation length, harvesting methods and conifer component of mixed species stands, especially for aspen stands.

Wildlife

- to improve the understanding and models of habitat requirements by species;

- to improve the understanding of species displacement and recovery under various harvesting practices;
- to improve the knowledge of relationships between covertype, stand age, site quality and animal population levels over short and long time periods;
- to improve the understanding of habitat fragmentation impacts on wildlife population levels in both northern and southern Minnesota forests; and
- to determine the effect of harvesting methods on quantity, quality and distribution of coarse woody debris and the role coarse woody debris plays in animal habitats.

Recreation and Aesthetics

- to refine and validate models of recreation and aesthetic value for predicting sensitivity of forested sites and landscapes to harvesting;
- to develop indices of the statewide and regional recreation and aesthetic value and attributes of Minnesota's forest lands for monitoring impacts and changes over time;
- to improve landscape and regional level models of the impact of forest structure and harvesting on recreation activity levels over short and long time periods; and
- to improve estimates of harvesting and road development impacts on the more primitive areas and associated recreational opportunities.

Historical and Cultural Resources

- to develop improved predictive models for site location on timberlands statewide; and
- to develop guidelines for harvesting and management on sensitive sites and landscapes, perhaps by region.

Economics and Management Issues

- to identify and quantify the interaction between the level of timber harvesting and the implications for the tourism and travel/outdoor recreation industry;
- to develop an improved recreation-tourism component for the IMPLAN model for analysis of harvesting impacts and changes on regional economies;
- to improve cost estimates for the mitigations specified in the technical papers and identify who would ultimately pay for these mitigations;
- to identify potentially complementary forest-based industries for Minnesota; and
- to identify appropriate types and levels of incentives to encourage private forest management in light of public and private benefits of such land use.

Harvesting and Silviculture

- to identify and evaluate low impact harvesting techniques and technologies applicable to Minnesota;
- to assess retention of conifers and other minor components of aspen stands with respect to harvesting practices and rotation age; and
- to develop and test silvicultural guidelines for uneven-aged management of forest stands, including those of mixed species composition, for a range of short- and long-term management objectives.

Wood Utilization and Recycling

- to improve technologies for increasing efficiency of wood use;
- to develop new process technology to enhance the suitability of recycled fiber in existing mills;
- to develop technical information for use of a wider array of species in existing and emerging wood and fiber products;
- to determine relationships between silvicultural practices, wood quality, and wood products characteristics; and
- to assess life cycle environmental impacts of alternative raw materials with emphasis on wood-based products

Policy and Administration

- to monitor the extent and administrative effectiveness of implementation of GEIS related recommendations;
- to assess GEIS related public, agency, and clientele understanding of issues, process, and progress; and
- to identify and evaluate refinements to GEIS programmatic approaches as suggested by progress in implementation of study recommendations.

Particularly important in this research is to increase the detail and resolution of models that can provide the prediction and assessment of impacts and the determination of the effectiveness of mitigations.

4.6 Alternative Services Delivery Options

The GEIS study outlines three broad policy directions creating programs for the following:

- forest resources practices program (FRPP);
- sustainable forest resources program (SFRP); and
- forest resources research program (FRRP).

Mechanisms for helping deliver these programs to the public were also briefly addressed in the main document. The purpose of this section is to provide a more comprehensive overview of delivery mechanisms available to the state that need to be considered in terms of the overall administrative and organizational structure recommendations discussed in the GEIS study.

In the book, *Reinventing Government* (Osborne and Gaebler 1992), the authors listed 36 specific, different ways that government can "intervene in the market" for the social good. Although not all 36 will ultimately be applicable to how government might mitigate timber harvesting and forest management impacts in Minnesota, they do represent a wide range of options worthy of consideration for helping deliver the three programs identified above. Table 4.2 presents a summary of these 36 alternative categorized as follows:

- rulemaking;
- monetary incentives;
- action steps;
- information exchange;
- organizational structuring; and
- program incentives.

Table 4.2 also provides a subjective assessment of each alternative in terms of which program(s) (FRPP, SFRP, and/or FRRP) it may apply to and to what degree it may be successful in advancing one or more of the programs in Minnesota.

4.6.1 Rulemaking

The Minnesota government is empowered to legislate, regulate, deregulate, license, and tax. The recommended mitigation strategies and strategic program directions for this GEIS study will, in many cases, require new laws, regulations, licensing programs and taxation policies. Collectively, this group of rulemaking options will be critical for successful development and implementation of the three strategic programs. For example:

- Creating legal rules and sanctions will be the first step in establishing all three strategic programs and their organizational structures as well as their spans of responsibility and authority.
- Regulations (not deregulations) will be a key component of the FRPP and, to a lesser extent, of the SFRP. Regulatory actions are not likely to affect the FRRP.
- The only program to be significantly affected by licensing is the FRPP. This is especially the case for the required licensing and COP components of the FRPP.

Table 4.2. Alternative service delivery options.

Alternative*	Utility for Minnesota's Strategic Programs		
	FRPP	SFRP	FRRP
Rulemaking			
1. creating legal rules and sanctions	1**	1	1
2. regulation or deregulation	1	2	3
3. licensing	1	3	3
4. tax policy	2	2	2
Monetary Incentives			
1. grants	3	3	1
2. subsidies	1	3	3
3. loans	1	3	3
4. loan guarantees	1	3	3
5. rewards, awards and bounties	2	2	2
6. vouchers	3	3	3
7. impact fees	1	1	1
8. seed money	1	3	2
9. equity investments	1	3	2
10. *quid pro quo*'s	2	2	3
Action Steps			
1. monitoring and investigating	1	1	1
2. contracting	1	2	2
3. franchising	1	1	2
4. catalyzing nongovernment efforts	1	1	1
5. convening nongovernment leaders	1	1	1
6. jawboning	3	3	3
7. sale, exchange, use of property	3	2	2
8. restructuring the market	2	2	3
Information Exchange			
1. technical assistance	1	1	1
2. information	2	2	1
3. referral	2	2	3
Organizational Structuring			
1. public-private partnerships	1	1	1
2. public-public partnerships	1	1	1
3. quasi-public or private corporations	3	3	3
4. public enterprise	2	2	2
5. volunteers	2	2	2
6. voluntary associations	2	2	2

Alternative*	Utility for Minnesota's Strategic Programs		
	FRPP	SFRP	FRRP
Program Incentives			
1. procurement	3	3	3
2. insurance	3	3	3
3. coproduction or self-help	3	3	3
4. demand management	2	2	3
5. changing public investment policy	2	2	2

*List from Osborne and Gaebler 1992.
**1=good, 2=low, 3=unknown or not applicable.

- Tax policy legislation or regulation will have potential to impact adequate funding for all three strategic programs. Recall that one of the goals for all three programs is to move them toward self-funding. Tax policies can be crucial in achieving this goal. For example, tax credits for aiding the FRRP would channel revenue toward that program. Use taxes can create funds for administering the FRPP. Revenue sharing tax policies among the state, counties and federal land owning agencies may be needed to effectively advance the SFRP.

4.6.2 Monetary Incentive

The range of monetary incentives noted in table 4.2 will play a variety of roles relative to the recommended three strategic programs. Some examples of how these incentives can help successfully advance the three recommended strategic programs are noted here:

1. Grants will play a critical role in assuring funding for the FRRP, however, their role in the FRPP and SFRP will likely be minimal to nonexistent.
2. Subsidies may be used as incentives for compliance with FRPP regulations, but their use for the FRRP and SFRP seem quite limited.
3. Loans and loan guarantees could become quite helpful in stimulating the introduction of new equipment and technologies aimed at advancing the FRPP, but they will be of little use for the SFRP and FRRP.
4. Rewards, awards and bounties may play a meaningful role for the FRPP, but the focus should be on rewards and awards for good practice, rather than bounties for failure. Also good performances for advancing the SFRP and achieving uniquely helpful results from the FRRP can be stimulated by judicious use of rewards and awards.
5. Vouchers will not likely play a significant role in any of the three strategic programs.

6. Impact fees could play a very unique and meaningful role for all three strategic programs:
   - in the form of penalties for creating adverse impacts not acceptable within the bounds of the FRPP;
   - in the form of revenues from user fee for forest-related activities to help fund the financial needs of the FRPP, SFRP, and FRRP; and
   - in the form of incentives to direct forest uses towards or away from activities that help or detract from efforts to mitigate potential significant impacts.
7. Seed money and equity investments may ultimately support development of technologies and equipment that will help the FRPP. Lesser potential exists here to advance the FRRP, and no real benefit can be seen for the SFRP.
8. *Quid pro quo*, where business interests pay for support services (roads, gates, etc.) for the right to pursue development or resource use could play a role in encouraging compliance with the FRPP. The *quid pro quo* could also be utilized to stimulate adherence to the statewide forest plan developed under the SFRP, such as establishing ERFs in return for certain access rights. No major role for *quid pro quo* is foreseen for the FRRP, at this time.

4.6.3 Action Steps

The action steps listed in table 4.2 will have varying degrees of impact on implementation of the three strategic programs. For example:

1. Monitoring and investigating will play a key role in all three strategic programs. The FRPP will require monitoring to identify practices compliance. Investigation of noncompliance will be necessary to determine scope and remedies. The SFRP and FRRP will likewise benefit from differing degrees of monitoring and investigation to help ensure each program is staying on track. The degree of monitoring and investigating required will be a product of development of the three programs.
2. Contracting and franchising may be the best and most economical course for the state to meet the independent and objective monitoring and investigation needs of the three strategic programs, especially for the FRPP. This approach will allow the functions to be achieved without building an expensive and cumbersome bureaucracy.
3. Catalyzing nongovernment efforts and convening nongovernment leaders will be critical components of the public participation process for each of the three strategic programs. For example, the GEIS process itself has been advanced by the citizen's Advisory Committee and the state's encouragement of statewide stakeholder participation. Similar public

stimulation and involvement will need to be secured for successful statewide implementation of the three subject programs.

4. Jawboning may have a minor role to play in the three strategic programs, but it is not likely to have any real significant impact.
5. Sale, exchange or use of property may have a role in SFRP- and FRRP-related activities, but is not likely to advance FRPP. For example, achieving ERFs may be more possible by developing a pattern of land exchange or property use exemptions. Research may be advanced by establishing research access and sites through property sales, exchange of use agreements.
6. Restructuring the market is a very delicate and controversial tool. It may have application in the FRPP and SFRP areas by helping shift demand to surplus fiber species or away from delicate areas, for example. However, the FRRP will likely need to be utilized to develop the best market restructuring concepts prior to any real move in this direction.

4.6.4 Information Exchange

Availability of the correct information is crucial for successful development and implementation of both the FRPP and SFRP. Without the proper data and knowledge, many aspects of these two strategic programs would simply fail, or not ever exist from the outset. For example:

1. Technical assistance will be required to develop the licensing and COP component of the FRPP. Technical assistance will also be needed to impart education (such as through the MES) to landowners and operators to aid in FRPP compliance. The SFRP will also be dependent on technical assistance at the county level to help ensure the statewide SFRP directions are based on sound ideas and can be pursued by all landowners. Again, the FRRP will be the key source for generation of the technical assistance program support elements.
2. Educational information was identified above as the foundation of the technical assistance program for successful implementation of the FRPP and SFRP. This same type of information will also be an important tool for explaining the three programs' needs, successes, failures and so forth. For example, quality educational information is integrally linked to the monitoring function discussed previously. General information will play a less important role.
3. The referral option will play a modest but at times needed role in pursuing the FRPP and SFRP activities. Landowners can be referred to literature, equipment, technologies, etc., that will help in compliance with the needs of the FRPP. County commissioners can be referred to studies, planning tools, support groups, etc., which will help them with their part of the SFRP and its associated statewide forest management plan.

4.6.5 Organizational Structuring

The family of organizational structuring options displayed in table 4.2 offer the state of Minnesota options for pursuing key aspects of all three strategic programs that may not be possible otherwise. For example:

1. The public-private partnerships in the UofM have much potential to generate research truly focused at the FRPP and SFRP needs over time because of the shared vested interests. New such partnerships may help create techniques for transmitting technical assistance, guiding, monitoring and investigation functions, and even provide enhanced services in the forest environment (such as recreation, or implementation of a statewide road and trial plan, etc.). In the final analysis, complete successful implementation of the FRPP, SFRP and FRRP will require very close partnerships across all key public and private organizations involved with Minnesota's forest-based resources.
2. Public-public partnerships will be essential for all three strategic programs. The state MNDNR, county land commissioners, the BLM and the USDA Forest Service must all cooperate closely in such partnerships or all three programs will likely fail.
3. Quasi-public or private corporations (nonprofit enterprises run by public or private entities) may have a role in this arena, but it must be developed. Presently the role is not envisioned to be significant.
4. Public enterprise has already played a major role historically in Minnesota. The USDA Forest Service and the National Park Service provide for recreational opportunities the private sector cannot. The MNDNR and counties also provide for forest-based public services, but on a more constrained scale. The availability of the public enterprise and its forest resource will continue to play an important role in call three strategic programs over time.
5. Volunteers and voluntary associations can play a meaningful role in all three strategic programs. Professional services (legal, forestry, etc.) volunteers can provide an economic stimulus to better develop and implement all three strategic programs. Voluntary associations can serve as a mechanism to review and advance the SFRP or help evaluate progress in the FRRP. These resources are also likely to be the key to the citizen advisory committee input needed to help guide the FRPP. In a sense, the imagination is the only limit here; the key will be to structure and channel this type of support in a constructive manner across time.

4.6.6 Program Incentives

The program incentives listed in table 4.2 are representative of a broad range of such efforts the state of Minnesota can pursue. Some will have some potential for helping advance the three strategic programs, and others will have only limited potential:

1. Procurement, insurance and coproduction or self-help programs have little potential for the strategic directions being discussed here.
2. Demand management programs can be used to help shift pressure to or away from selected forest resources. For example, heavy user fees on backpacking can reduce the demand for such an activity. High severance fees for harvesting trees over, say, 100 years of age can direct the demand for wood away from older trees and toward younger trees. Viewed in this light, demand management can impact both the FRPP and the SFRP. However, with restructuring the market discussed previously, great care must be exercised here because the *cause-and-effect* relations are very complicated. The FRRP would be a good tool to ensure research is conducted before any such major directions are pursued.
3. Changing public investment policy can encourage or discourage almost any behavior. Higher investments in quality BMPs that are a foundation of the FRPP will help generate a better quality and a more successful FRPP. Grants that encourage public-public participation will advance the SFRP. Providing investment incentives to private firms for financial support of the FRRP will enhance the quality and success of this key strategic program. In a sense, this particular tool offers good policy potential for helping advance all three strategic programs, if well thought out policy steps are taken to stimulate private investment toward the most helpful arenas.

4.6.7 Overall Observation

This appendix section has overviewed a very wide range of alternative service delivery options as they relate to the three GEIS recommended strategic program directions. This range should provide a good foundation for consideration of the types of activities required post-GEIS to help take the strategic program recommendations and turn them into reality. The key here will be to tailor specific service delivery options to the three strategic programs within the foundation of the GEIS recommended administrative and organizational structure.

4.7
Public Policy and Program Participants

The purpose of this appendix section is to illustrate the truly broad sweeping nature of the current groups of participants involved in Minnesota's forest-based public policies and programs. The intent is not to ensure that every single participant is listed, but is to provide a comprehensive illustration. The structure, policies and programs, and current planning and coordination efforts for Minnesota's land managing organizations are discussed in section 4 of the main GEIS document. A more detailed presentation on those matters is contained in the GEIS background paper on Public Forestry Organizations and Policies (Jaakko Pöyry Consulting, Inc. 1992k). As noted in section 4 of the main GEIS document, Minnesota has a comprehensive and complex hierarchy of mechanisms that create the framework for resource management. These mechanisms are encompassed by:

- policies;
- planning;
- coordination;
- programs; and
- public participation.

The aforementioned hierarchy involves the governor's office, select legislative committees, and several agencies, departments, boards and citizen advisory committees at the state level. The counties involve their commissioners, land departments, special committees and citizen oversight and action groups. Through the USDA Forest Service, several other entities are brought into the process:

- USDA Forest Service, Washington office;
- USDA Forest Service, regional office;
- USDA Forest Service Forest Products Laboratory;
- Superior and Chippewa national forests;
- NRRI;
- UofM, College of Natural Resources;
- UofM, MAES;
- UofM, MES;
- public participation groups; and
- the state and federal legal systems.

Numerous other groups also are involved or participate in the resource management process:

- NIPF landowners;
- Native Americans and the BIA;
- forest products industry firms;

- U.S. BLM;
- U.S. Fish and Wildlife Service;
- U.S. EPA;
- U.S. Corps of Engineers;
- MACLC;
- Timber Producers Association;
- Minnesota Association of Soil and Water Conservation Districts (SWCD);
- Minnesota Forest Coordinating Committee;
- Minnesota Resort Association;
- RIM Coalition;
- LCMR;
- Minnesota Forestry Association;
- Minnesota Forest Industries, Inc.;
- Minnesota Public Interest Research Group (MPIRG);
- The Audubon Society;
- Izaak Walton League;
- The Wilderness Society;
- The Sierra Club;
- SAF;
- Minnesota deer hunters, fishing and recreation associations; and
- numerous other technical specialty groups and interested members of the public at large.

4.8
Forest Resource Policies and Programs Administration Background

The GEIS study has examined a very wide range of complex and interdependent natural conditions and forces that collectively have shaped Minnesota's forest resource base. Similarly, this study has also explored the rather complicated political and policy arena that currently provides the administrative and organizational structure that is directed at managing and protecting this forest resource base. Similar to most states, Minnesota's forest resource base policies and programs are spread across a broad range of governmental units, both within and across various governments.

Within such a complicated and interactive environment, effective coordination of all key policies and programs will be essential for meeting often conflicting and always demanding and desirable social objectives. The main body of the GEIS report has, furthermore, described the likely significant impacts of timber harvesting and forest management activities in Minnesota, as well as a family of recommended mitigation strategies.

Subsequently, the GEIS study recommended three statewide strategic programs to allow for the implementation of the recommended mitigations:

- FRPP;
- SFRP; and
- FRRP.

The purpose of this appendix section is to provide some helpful background information that is relevant to the formulation of the overall administrative and organizational structure recommended in the main GEIS report for effective implementation of the three suggested strategic programs.

4.8.1 Alternative Administrative Mechanisms

A recent study (Kilgore and Ellefson 1992), which evaluated administrative mechanisms used by all 50 state governments to deal with forest resource policies and programs, provides some very appropriate food for thought on alternative administrative mechanisms. Governments use a variety of methods for effective administration and coordination of major policies and programs:

- information interagency communications links;
- memorandums of agreement among and between government agencies;
- programs and the processes required to generate and implement multiple resource-oriented statewide strategic plans;
- formal administrative mechanisms assigned responsibilities for programs and broad policies' development (e.g., boards and commissions); and
- reorganization of agencies aimed at stimulating more integrated planning and management.

4.8.2 Perspectives for Forest Resource Issues

Specific administrative structures designed especially for forest resource issues and affairs demand a unique perspective because of the following (Kilgore and Ellefson 1992):

- forest resource issues and affairs are broad in scope and of extensive interest to numerous public agencies—and as such, are extremely difficult to package effectively;
- multiple units and layers of government will be involved in covering forest resource issues and affairs;
- these issues and affairs often lack the presence of one voice within and across governments, which in turn leads directly to ongoing advocacy conflicts;
- the conflicting and contradictory missions of various government units often generate policies that are in conflict with and are contradictory to each other;

- policy development for forest resources is often inefficient due to poor coordination across the wide range of involved government units;
- these issues and affairs often lack quality input from multiple interests, which in turn, makes them too narrow and less useful;
- unified government agencies' postures on forest resource issues and affairs are often lacking, which negatively affects others positive views on such matters; and
- multiple government units often generate very narrowly focused plans that are neither strategic nor comprehensive, which detracts a great deal from the focused attention they need.

Forest resource programs are often organized by the separate natural resource categories that constitute them. As such, they very often then exist within separate units of government. This generates an environment of highly individualistic behavior, with no real requirements to coordinate across the integrated nature of the multiple resource complex.

However, state governments are becoming more and more aware of the importance of better administrative mechanisms that both allow for and stimulate the need to address the involved problems and issues in an integrated manner.

4.8.3
Frequency and Types of Forest Resource Programs

The types of programs that are involved in statewide forest resource matters cover a broad range of subject matters, as is illustrated by table 4.3. The most predominant programs involve NIPF assistance, wildfire suppression and insect disease and control. Interestingly, only five states offer continuing education programs, which seems to go against the grain of offering meaningful long-term NIPF assistance programs.

Success of each state's family of forest resource programs is varied. Often this success is tied to the effectiveness of statewide administrative structures to stimulate or allow for widespread coordination. In most states such coordination is common, but the methods vary from informal task forces for information sharing and formal forestry coordination mechanisms (most states) to use of state planning or finance agencies, the governor's office or simply organizational consolidation (only a handful of states) (Kilgore and Ellefson 1992).

Table 4.3. Programs administered by state forestry organizations, by type and frequency of program, 1989.

Program Type	Percentage of States	Proportion
Nonindustrial Private Forestry Assistance	48	96
Wildfire Suppression	46	92
Insect and Disease Control	45	90
Forest Planning	44	88
Urban Forestry	44	88
Reforestation Programs	43	86
Timber Sale Programs	43	86
Tree Nursery Programs	41	82
Prescribed Burning	39	78
Forest Resource Assessment	36	72
Forest Watershed Management	23	46
Forest Land Acquisition	20	40
Forest Road Development	20	40
Forest Tax Law Administration	19	38
Environmental Education	18	36
Private Forest Regulation	17	34
Forest Recreation Development and Administration	13	26
Environmental Review	12	24
Forestry Research	12	24
Forest Wildlife Management	7	14
Resource Information Systems	7	14
Professional Continuing Education	5	10

Source: Kilgore and Ellefson (1992).

4.8.4
Administrative Mechanisms Overview

Formal administrative mechanisms for forest resource policies and programs are relatively common in state governments. Table 4.4 illustrates that over 60 percent of the states have a forestry board, commission, council, committee or similar mechanism authorized to deal with such policies and programs. Furthermore, 80 percent of these states with formal mechanisms established them through state law (Kilgore and Ellefson 1992).

The membership of these formal administrative mechanisms ranges from 5 to 30 persons, but the average is 11. The majority has 10 members or less. Table 4.5 illustrates that public forestry managers and forest industry representatives are the most often represented groups on such mechanisms. At the bottom of the list are the state planning agencies.

Table 4.4. Formal mechanisms used by state governments to coordinate forest policies and programs, 1989.

State	Coordinating Mechanism
Alabama	Alabama Forestry Planning Committee
Arkansas	Arkansas Forestry Commission Board of Forestry
Florida	Florida Forestry Council
Georgia	Georgia Forestry Commission
Idaho	Forest Practices Act Advisory Committee
Illinois	Forestry Council
Indiana	State Forestry Planning Committee
Kentucky	(name not assigned)
Louisiana	Louisiana Forestry Commission
Maine	Citizen's Forest Advisory Council
Massachusetts	Massachusetts State Forestry Committee
Michigan	Michigan Council on Forest Product Industrial Development
Minnesota	Minnesota Forestry Coordinating Committee
Mississippi	Mississippi Forestry Commission
Missouri	Missouri Forest Resources Planning Committee
Montana	Land Board
Nevada	Board of Forestry
North Carolina	North Carolina Forestry Advisory Council
North Dakota	Forestry Planning Committee
Ohio	Forestry Advisory Council
Oregon	State Board of Forestry
Rhode Island	State Forestry Planning Committee
South Carolina	South Carolina Forestry Commission
Tennessee	Tennessee Forestry Commission
Utah	Board of State Lands and Forestry
Vermont	Forest Resources Advisory Council
Virginia	Forestry Board
Washington	Board of Natural Resources
West Virginia	Forest Management Review Commission
Wisconsin	Natural Resources Board

Source: Kilgore and Ellefson (1992).

Table 4.5. Representation on formal forestry coordinating mechanisms of state governments, by frequency and average number per mechanism, 1989.

Affiliation	Represented		Composite Index of Representation
	Percent of Time*	Average Number	
Public forest managers	52	3.68	1.00
Forest industry	58	2.72	0.82
Citizen members	39	3.41	0.69
Academic and research personnel	42	1.84	0.40
Fish and wildlife managers	45	1.35	0.32
Local elected officials	10	5.33	0.28
Agricultural agencies	35	1.36	0.25
Legislators	10	4.66	0.24
Landowner associations	26	1.37	0.19
Environmental groups	29	1.11	0.17
Trade associations	19	1.50	0.15
Soil and water districts	26	1.12	0.15
Forest land management agencies	13	2.00	0.14
Private forest owners	6	2.00	0.06
Sporting groups	10	1.00	0.05
State conservation agencies	6	1.50	0.05
Livestock industry	6	1.50	0.05
Pollution control agencies	6	1.00	0.03
Society of American Foresters	6	1.00	0.03
Departments of education	6	1.00	0.03
Office of the governor	6	1.00	0.03
Forestry consultants	6	1.00	0.03
State planning agencies	3	1.00	0.02

Source: Kilgore and Ellefson (1992).
* Percent of mechanisms having the noted representation assigned to them.

Of the 31 states with formal forestry administrative mechanisms, only two use the process of public elections for selecting membership on boards or commissions. The other 29 rely on the use of the appointment process, primarily involving executive branch of government through the governor's office. The terms of appointment range from two to nine years, with the typical term being four years.

The responsibilities of these mechanisms cover a broad range of topics. Table 4.6 shows that the most predominant are for:

- policy and program development;
- program oversight and evaluation; and
- long-range and strategic planning.

For the 31 formal state mechanisms, the following displays the entity type to which they are held accountable:

- director or head of the state's lead forestry agency or natural resources department—12 states;
- the governor's office—nine states;
- the state legislature—seven states; and
- the governor's office shared with the state legislature—three states.

Table 4.6. **Primary functions of formal forestry coordinating mechanisms of state governments, 1989.**

Function	Number of States	Proportion (percent)
Policy and program development	18	58
Program oversight and evaluation	17	55
Long-range and strategic planning	16	48
Program evaluation	10	31
Regulation of private forestry	4	14
Information sharing	3	10
Fiscal and budget development	2	7
State forester appointment	1	3

Source: Kilgore and Ellefson (1992).

4.8.5
Major Formal Administrative Mechanisms Form and Function

Generally speaking there are four basic categories of formal administrative mechanisms:

- forestry boards;
- forestry commissions;
- forestry councils; and
- forestry committees.

The data in table 4.7 summarizes several key factors associated with the formation and ongoing functioning of these formal type forestry type mechanisms (Kilgore and Ellefson 1992).

Table 4.7. Major formal coordinating mechanisms for state forestry programs and policies, by selected characteristics, 1989.

Characteristic	Board	Commission	Council	Committee
Number of states using	8	7	7	9
Average size	7.75	9.43	13.6	14.11
Method of selection	A/E	A	A	A
Means of creation	L	L	L	L/Ia
Predominant accountability	G	L	C	C
Primary functions	Pd	Pd	Pl	Pl,D
Relative effectiveness	2nd	1st	2nd	3rd
Influence on ownerships	2nd	1st	4th	3rd

Key: A=appointed, E=elected, L=legislature, Ia=informal agreements, G=governor, C=department head, Pd=policy development, Pl=long-range and/or strategic planning, and D=discussion of forestry issues.
Source: Kilgore and Ellefson (1992).

Forestry Boards

There are eight states that use this form of a formal administrative mechanism for forestry issues and affairs. Interestingly, six are located in the western or southwestern United States. Membership averages eight individuals per board. Two of these boards are open to popular election processes, while the other six are subject to the appointment process.

All eight of the boards were created by legislative action. Four boards report to the governor, one to the state legislature, one to the lead forestry department, and two to no particular entity. Interestingly, these later two are judged to be rather ineffective in providing coordination and administrative leadership. Note also that the low effectiveness ranking of these two "floating" boards lowered the overall effectiveness of the board data reported in table 4.7.

Forestry Commissions

A total of seven states, all in the southern and southeastern United States, have established forestry commissions. The average membership is between nine and ten individuals per commission. All members of these commissions are appointed, with average terms of just over six years.

Similar to forestry boards, all of the commissions were created by legislative action. One commission reports to no particular entity, two report jointly to the governor and the legislature, and four directly to the legislature.

Forestry Councils
Seven states, all in the eastern United States, have established forestry councils. Their membership roles tend to be significantly larger than either boards or commissions, averaging over 13 persons per council.

Their range is quite broad too, covering a spread of from five to 25 members. The typical method of membership is through appointment with an average length of service of about four years.

All state forestry councils were created by legislative action. However, unlike for the boards and commissions which were primarily created in response to some particular major forestry issue, only two councils were created with a similar impetus. Most councils report to the lead state forestry or natural resource agency head.

Forestry Committees
Formal forestry committees are found in nine states. The average membership is 14 individuals, with a range of eight to 30. All committee members in every state are appointed, and few have designated terms. Only two of the committees were established by legislative action.

None of the committees report either to the governor or the legislature. Nearly all report in an advisory capacity to the department head for the lead natural resources or forestry agency. Unlike boards, commissions or councils, committees rarely deal with policy and program matters. They serve primarily as a forum or a vehicle for stimulating coordination of forestry matters of mutual interest.

4.8.6 General Observations

The types of administrative structures available to states to coordinate and implement statewide forest policies and programs are varied and diverse. No one approach has been proven to be the absolute best in meeting all of the various demands of society. At the same time, those states that have made definitive moves toward establishing formal mechanisms to deal with today's myriad of conflicting forest-based issues and affairs have helped create a growing body of practical knowledge from which all interested parties can gain. Some of the keys to success appear to encompass the following:

- legislative creation of a forestry board or commission has distinct advantages over other alternatives;
- membership size should be kept moderate, ranging from 8 to 12 members;
- members should be appointed rather than elected;
- terms vary from 2 to 9 years, with 4 to 6 being common;

- staggered terms are predominant;
- effectiveness is directly tied to accountability;
- typical accountability assignments are either to the state legislature or the governor's office;
- authority to develop and both implement and administer administrative rules will also be crucial for success; and
- longer-term, every interested state will need to be involved in research on the best methodology to pursue in terms of formal forest resources administrative structures due to its highly undeveloped current nature.

4.9
Minnesota Forest Resources Administrative Structure Illustrative Example

One of the key recommendations of the GEIS study displayed in section 8 of the main report is to create a Minnesota Board of Forest Resources. The purpose of this appendix section is to *provide an example to illustrate more clearly the general concept* of a board of forest resources. The general attributes of such a body as envisioned by the study team are as follows:

Charter. The Minnesota Board of Forest Resources will need to be created by legislative action. This will ensure its legal standing and provide the assurance of stability and durability. The enacting legislation will need to address many details related to the full charge of responsibilities, authorities and accountabilities. Many of these matters have been addressed in this section and others have been addressed in appendix 4.

Membership. The Minnesota Board of Forest Resources members should be appointed by the executive branch of the state government, subject to confirmation by the state legislature. Membership terms should be at least four and not more than six years. The terms should be staggered to ensure protection against a one-time change. The membership total should be kept small, in the 8 to 10 range. Every effort should be made to secure balanced representation for all major landowner groups, however, aside from the major landowners (the state, the USDA Forest Service, forest industries, the counties, and the NIPF), no board member should represent a particular interest group or constituency or have any financial interests in any of the state's forest lands.

Appointments to the board need to be based on each individual's professional qualifications, education, experience, knowledge, and interest in forest resource-related issues and subject matters. Care should be taken to avoid appointments based on other criteria. Credibility with the public at large and the state's major landowners will be absolutely essential for the board to be successful. Therefore, individuals appointed to this board should be well-respected *states-people* who have a broad and visionary outlook on how the state's forest resources should be managed and protected.

Leadership. The governor should be charged with nominating a board chairman and vice chairman. Their appointments would be subject to legislative approval. The board chair would be accountable to the governor's office.

Public Input. The quality and social acceptability of the board's actions will frequently depend on the availability and type of public input. Random or disorganized input can be quite disruptive and counter productive. Consequently, the GEIS study team also recommends the creation of a formal Citizens' Advisory Committee to the Minnesota Board of Forest Resources. This citizens' group would function similarly to the GEIS Citizens' Advisory Committee. The formal rules for its establishment and operation should be left to the purview of the board.

Administrative and Staffing Issues. Aside from the board membership itself, additional staffing support will obviously be required. However, with care and creativity, the net impact on the limited budgetary resources of the state of Minnesota can be minimized. An example of this can be found in the California situation where nearly $10 million are spent solely on administration and enforcement of state forest practices regulatory programs, but only $400,000 is earmarked for the board's annual operating budget. The direct staffing assigned to support the California board consists of a full-time assistant executive officer, a program analyst, a management services technician, required clerical support, and a few student interns.

The key is to utilize existing state resources as much as is practically possible. In the final analysis, this will likely require some form of reorganization of the myriad of state entities that have involvement with the state's forest resources in one way or another. One option here is to have the state forester, who is an employee of the MNDNR, serve as the formal technical advisor to the board. This step will help funnel resources of the MNDNR Division of Forestry toward activities that directly support the board's needs. The most important factor to keep in mind here is that the state must set a goal to minimize staffing and costs without undercutting the board's ability to meet its responsibilities.

Funding Considerations. Funding for the board's operations should be provided as much as possible from revenues derived from uses of the forest resources the board is charged to look after. In other words, just like for the FRPP, SFRP, and FRRP, the board should end up being self-funded as much as is practically possible. One of the keys here will be the need for stability, durability, consistency, and independence. Dramatic swings in funding levels or the budgetary process itself would be extremely damaging to the board's ability to have a long-term (strategic) focus.

Figure 4.1 illustrates graphically the Minnesota Board of Forest Resources example presented here, where:

- the board consists of nine members, each appointed for six-year terms, staggered for three appointments every two years;
- the vice chairman is to be appointed for a two-year term and then automatically elevated to the position of board chairman for a four-year term;
- two members of the board will serve on one each of the FRPP, SFRP and FRRP subcommittees with at least a two-year stagger per member, and where the senior member is the subcommittee chairman;
- the ninth board member shall serve as the co-chairman of the citizen's advisory committee with a citizen co-chairman chosen at large for a two-year period by the board chairman;
- the citizen co-chairman of the citizen's advisory committee shall serve as a nonvoting advisor to the board;
- the citizen's advisory committee members will be appointed by the board chairman to represent the broad interests of the state, where the membership shall be 8 to 10, and no member shall serve a term of more than four consecutive years at any one time;
- the board shall employ a managing director of the FRPP who shall be responsible for administering this program and shall sit as a voting member of the FRPP committee and as a nonvoting advisor to the board itself;
- the board chairman shall appoint three additional members to the FRPP committee who shall each serve six-year staggered terms;
- the state forester shall be responsible for administering the SFRP and sit as a voting member on the SFRP committee and as a nonvoting advisor to the board;
- the board chairman shall appoint three additional members to the SFRP committee who shall each serve six-year staggered terms;
- the director of the MAES at the UofM shall be responsible for administering the FRRP and sit as a voting member on the FRRP committee and as a nonvoting advisor to the board;
- the board chairman shall appoint three additional members to the FRRP committee who shall each serve six-year staggered terms;
- the board shall be supported in its day-to-day operations by an assistant executive officer, a program analyst, a management services technician, required clerical support, and a few student interns; and
- the three program committees will also require selected personnel support, which will need to be defined by the board.

More specifics could be offered in *this example*, however, the basics have been outlined in enough detail to illustrate the types of indepth considerations that will be necessary in order to fully establish a comprehensive, working organizational structure. In the final analysis, the state legislature and the governor's office will be responsible for all of the hard decisions that will be needed to set in motion the GEIS recommendations. As was noted in the main report, these decisions will need to be acted on expediently in order to maintain the positive momentum already provided by the GEIS study itself.

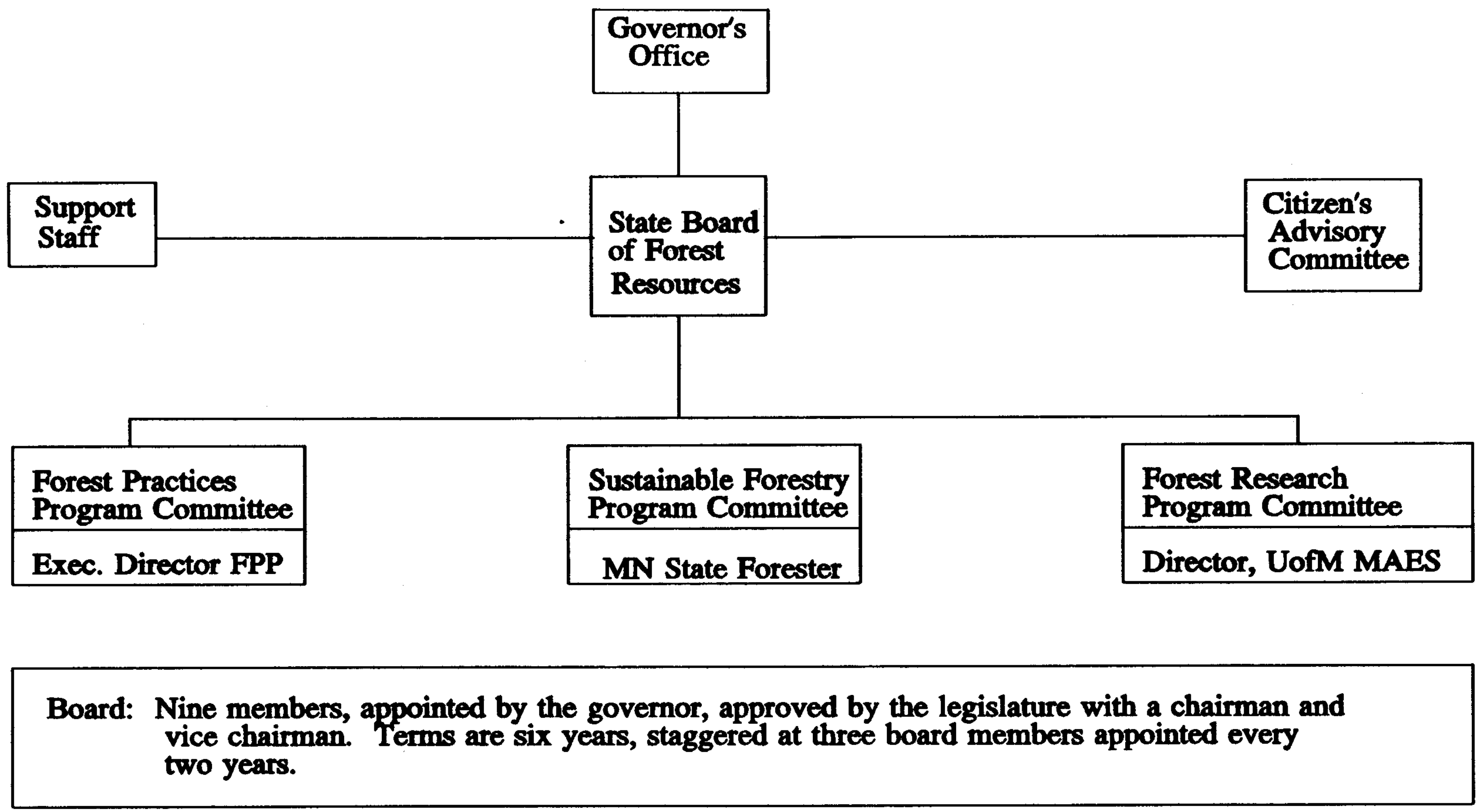

Figure 4.1. Minnesota Board of Forest Resources, illustrative example.

APPENDIX 5
PUBLIC INFORMATION MEETINGS — DRAFT TIMBER HARVESTING GEIS

The following are summaries of the six public information meetings on the draft Timber Harvesting GEIS conducted by the EQB. The purpose of these meetings was to explain the draft GEIS's major findings, conclusions and recommendations; respond to specific questions on the draft; and take public comment on the draft document.

Timber Harvesting Draft GEIS Public Meeting
Tuesday, July 13, 1993
Room 10, State Office Building
St. Paul, MN

Meeting Summary

EQB members present: Bob Dunn

Advisory Committee members present: Wayne Brandt

Staff present: Mike Kilgore, project manager; Drs. James McNutt and Alan Ek, consultants for Jaakko Pöyry; Roger Williams, Office of Mediation Services

There were approximately 110 attendees at the meeting, with 27 making public comments.

Roger Williams introduced members of the panel.

Mike Kilgore presented an overview of the Draft GEIS. He briefly explained the process and described the materials used.

Dr. McNutt summarized areas of concern about the Draft GEIS and cited examples of how determinations and assumptions were reached.

Comments:

Gordon Peterson, Peterson Logging. Stated that the recommendations of the Draft GEIS makes sense, and most of them are already being well implemented. His concerns are that the Draft GEIS doesn't analyze the cost impacts of mitigation strategies, for example, distributing slash as close to the stump as possible. Stump prices are going up, and such a strategy requires expensive, rarely used machinery.

Mel Baughman, MN State Society of American Foresters. (Also submitted written testimony.) Briefly described his organization, complimented findings of the Draft GEIS, warning however that due to its limitations, they recommend care in overdoing oversimplification of the findings. Recommendations include utilizing the findings of the technical papers in long-term planning and policy development; the development of a forest resources board; GEIS for agriculture and urban development.

Bernard Nordlund, logger. (Submitted written comments.) Stated that, coupled with a forestry inventory, the Draft GEIS gives a positive view of traditional, multiple-use forestry management. Expressed the hope that the recommendations of the forest inventory and the GEIS are accepted without further costly bureaucratic involvement.

Floyd Hovarter, Valley Forest Resources, Inc. Commented on the excellence of the Draft GEIS conclusions (although it was hard to read) and stated that if stakeholders use it, and if timber resources are allowed to be managed properly, the stakeholders, resources, and economy of the state will be served in the short- and long-term. His concerns (which will be submitted at a later date) include superficial treatment of silviculture and regeneration and the effects of trying to stretch out the lifetime of aspen.

Tom Evensen, logger. (Submitted written comments.) Commented that, in response to recommendations for visual management, loggers will not clearcut an area next to a resort, that clearcut areas serve tourists by providing locations for blueberry picking and other vacation activities, and that loggers and resort owners generally share amicable relationships. Doesn't want decisions about what the activities of each are to be determined by bureaucrats in St. Paul. Complimented the general content of the Draft GEIS.

Neil DeLack, logger. (Submitted written comments.) Commented that BMPs expansion is not necessary because BMPs guidelines are rigidly followed and already work.

Rod Bergstrom, wood producer. (Submitted written comments.) The conversion of forests to nonforest lands through development is a serious problem. Suggested mandatory reforestation of a like amount of the forest land destroyed by developers.

Warren Johnson. Told stories about the proliferation of wolves in logging areas, suggesting that the activity increase in timber harvest areas contributes to an increase in wildlife population.

Wendell Freeberg. Pleased that Draft GEIS recognizes that large-scale natural disturbance timber harvesting and forest management activities, including fire, are the only tools available to effect large-scale changes to the age-class structure, changes which can only be effected over a long period of time. Cited devastating changes to northern forests due to several fires around the turn of the century. Continuation of current management practices of state forests is the way to prevent such devastation in the future.

Gary Stenglein, Potlatch. If we work together forests can be replenished and last forever. Harvesting mature forest before disease and fire occur is a sound practice. Annual cord-cutting quotas should be flexible due to the proclivities of nature.

William Kleinschmidt, Potlatch, representing United Paperworkers Local 79. Expressed comfort with Draft GEIS findings of sufficient timber and sound forest management practices.

Ken Nickolai, Minnesota Center for Environmental Advocacy. (Comments to be submitted by comment period deadline.) Compliments for accomplishment of the Draft GEIS. However, with the increase in logging permitted by the Draft GEIS findings, significant changes in forest management practices will need to occur. To make logging sustainable, recommended mitigation strategies will have to be implemented, especially if logging is to increase. Procedures which would have to be changed for proper implementation include when to log; whether or not to clearcut; what type of equipment to use; what time of year to harvest; where to put the logging slash; whether to replant with single or many species, etc. Changes required of owners and managers would include extended forest rotation; development and implementation of visual guidelines; reduction in conversion of privately owned lands; reduction of clearcutting; development and implementation of policies to close forest roads, reducing their length and improving their design standards. Also, loggers must use BMPs; retain and redistribute slash; remove bark and cutover area; and restrict operation of equipment. These necessary changes will be difficult to carry out due to 43 percent private land ownership. Cited page 290 of Draft GEIS, "the proposed mitigations will require ... at present there is no agency with authority for such responsibility." Issue of responsibility must be examined in the GEIS. GEIS conclusion that increased logging will prove sustainable is correct only if its recommendations are translated into action.
Other concern: GEIS must clarify numbers on economic impacts. Loss of jobs in tourist and recreation industry are not quantified in Draft GEIS, and value of increased economic input does not acknowledge increased costs to be borne by counties, DNR, private landowners, and loggers, when necessary management changes are made.

Ken Zelinske, Local 164 United Paperworkers International. Agrees with Draft GEIS conclusion that there are no common visions and goals for forest resources. Forest resource base has been well managed in the past. Private sector has done an excellent job of managing resources, however, inconsistent forest management principles of the USDA Forest Service need to be addressed.

Floyd Weske, logger. (Submitted written comments.) Discussed the results of, after a fire near Moose Lake, cutting and peeling genetic strong trees rather than clearcutting, so remaining trees died out. Described practices Potlatch uses for preventing damage to wildlife, like leaving dead trees for nesting, etc. Concluded that the time for rules and regulations is over and now is time to act.

Tom Stemm, Champion International. Commented that numbers in the Draft GEIS, derived from work actually done, are supportable. Would like the GEIS to document the affect of a customer-driven increases in recycled material being brought into the paper industry. Complimented the outcome of the Draft GEIS and urged its acceptance. Minnesota does not need another bureaucracy.

Daral Olson, logger. Concerned about the Draft GEIS chapter recommending delimbing slash on the cutover site rather than the landing, since most loggers operate delimbing equipment at the landing. It's difficult or impossible and expensive to assemble delimbing equipment at the site. The best method would be to delimb trees with chainsaws at the logging site, also a dangerous practice for loggers.

Alan Knaeble, logger. Commended Minnesota logging practices. Approves of research studies being carried out by one, rather than several agencies, and advocates administrative authority of a professional single body, rather than several agencies or individuals. Would like to know who will pay the increased cost of intensive management. Expense of such practices seem to fall on loggers, and costs should be shared with foresters, producers, etc. Also, loggers are assessed for the use of roads which are also used by hunters and vacationers, and costs should be shared. Commended the Draft GEIS.

Gordon Dobbs, logger. Commented that most of the recommendations made in the Draft GEIS are already being done, like identifying and protecting habitat before sale, maintaining patches of cover, and creating corridors for wildlife. Deer hunters seek logging sites; game and nongame species can't be separated; wildlife diversity does exist. Don't manage for wildlife only.

Tom Day, representing Minnesota Restaurant, Hotel and Resort Associations (MHRA). (Submitted written comments.) Is concerned with the potential impact of increased timber harvesting on tourism, the effects of which are poorly handled in the Draft GEIS. Expounded on the extent of the tourist industry in Minnesota. Prevalent concerns are the suggested mitigation measures which may be considered to reduce the impact of timber harvesting, yet would adversely affect recreation and tourism. Takes issue with the suggestion that money from the state's general revenue funds could be used to provide assistance to recreation and resort businesses in compensation for lost business. Minnesota taxpayers may resent using tax dollars to pay one industry for what another industry has done to harm their business. The implications of such changes would also suggest the need to increase advertising to attract more tourists due to the adverse effects of timber harvesting. Tourist promotion has increased significantly in the past decade and future increases are not likely. Tourists are already calling MHRA with concerns about the visual affects of logging in northern

Minnesota. The Draft GEIS suggestion that the tourism industry could focus on a different type of clientele is disturbing since so much time and dedication has gone into creating the current Minnesota image. The position of the MHRA is that the timber and tourism industries are important to the state and that they should work together for the good of both. They have been working with DNR and timber industry to develop BMPs and are disappointed that Draft GEIS study doesn't address the possible adverse affects on tourism in a more responsible manner. Mr. Day volunteered to work with the advisory committee in resolving these issues.

Ken Little, logger. Is concerned about switching to multiple entry harvesting operation addressed in the Draft GEIS. Minnesota loggers probably don't have the means to field test debarking equipment or cut-to-length systems. Cost figures for switching to more automated systems would illustrate how unrealistic recommendations made in the Draft GEIS are. Expressed skepticism that field studies of new equipment would be sponsored by industry or labs. Questioned where subsidies will come from and which innovative loggers will qualify for them.

Roxann Snyder, environmental engineer. Expressed apprehension about making assumptions and predictions with a computer model. Questioned the phrase "current industrial needs" and disparaged the current system of forest harvesting—it is not working. Discussion of cutting trees on an annual basis doesn't address the waste perpetuated by paper producing industry (ex.: proliferation of junk mail). Would like to see the completion of the Minnesota biological survey to identify rare plants species, old-growth forests, and habitat features that need to be protected before decisions are made. This would increase the accuracy of the GEIS.

Bob Graves. Promotion of deer has been overstated—they eat young pine, reducing the growth of older stands of pine. Noted changes of environment in favorite nature spots over the past 30 years, citing areas of expansive, rather than small, clearcuts. Also noted that outdoor experience for tourists has diminished in recent years. The Draft GEIS is superficial in describing job losses in the tourist industry, and doesn't discuss potential gains in paper recycling, and sawtimber products. There's too much focus on the paper industry and not enough on others. Encourages the inclusion of actual impacts in the final GEIS. Also, the issue of how the costs of the recommendations will be covered should be addressed in the GEIS. Suggested that some of the costs could be paid by other forest users—hunters, campers, etc.

K. Cash Luck, Thunder Lake Assoc. The GEIS needs a stronger focus on biodiversity, and more on the effects of various kinds of cutting in the forest on various kinds of wildlife. Is concerned about the impact of timber harvesting on the bird population and water quality. Noted that an increase in the deer population also means an increase in deer tick and lymes disease. Would like to know who is financing chipping mills, paper mills, lumber mills—is it Minnesotans or outside investors, and where our forest products are going. 4.7 million acres for logging is an amazing amount of land—we must be careful, that is a lot of land. Let's maintain and share our beautiful heritage.

Eric Streed, forest user. Don't equate forest health with deer population. In regards to sedimentation and soil erosion, the Draft GEIS relies too heavily on assumed virtue and use of BMPs, based on short period of study. Recommended that caution be taken, and that as harvesting levels increase, the use of BMPs should also be increased in quality and quantity. Additional BMPs could be added, for example, limiting clearcutting on very steep slopes, or promoting selective clearcutting on very steep slopes, especially in hardwood areas of southern Minnesota. Commented on the need to prevent sedimentation problems similar to those found in rivers and streams in the Pacific Northwest. Reminded that BMPs are voluntary and must be adapted and used.

Randolph Rajala, MN Timber Producers Assoc. Described the evolution in status of aspen and how it has changed forest industry. Asks why, since the inception of multiple-use philosophy, would we consider altering an already successful combination of players (man, creature, and forest) in the current forest program. Expressed hope that the Draft GEIS is autonomous enough to discourage detractors from inflicting costly moratoriums and shutdowns to an already marginal business venture.

Thomas Vogen. Commented that biodiversity is important. Expressed concern about the introduction of dangerous non-natives into the forest (ex: buckthorn). Questioned the need to retain logging roads after harvest is completed, noting that they allow too much access for noisy motorized vehicles. People should have access to a quiet, natural environment. Loggers should take more precautions to prevent needless gouging, etc.

Chris Anderson, logger. We need more public awareness about why various things are occurring in nature. Commented that birch bud worm, rather than clear cutting, may be the reason why previous speaker lamented the decline in birch stands. Also, recreation people use logging roads for activities; pine trees planted for logging purposes are often stolen to be used as Christmas trees. The public needs more education about forests.

Timber Harvesting Draft GEIS Public Meeting
Wednesday July 14, 1993
Davies Hall Theater
Itasca Community College
Grand Rapids, MN

Meeting Summary

EQB members present: Bob Dunn, Carolyn Engebretson

Advisory Committee members present: Wayne Brandt, Darrell Lauber

Staff present: Mike Kilgore, project manager; Dr. James McNutt, consultant for Jaakko Pöyry; Roger Williams, Office of Mediation Services

There were approximately 130 attendees at the meeting, with 20 making public comments.

Roger Williams introduced members of the panel.

Mike Kilgore presented an overview of the Draft GEIS. He briefly explained the process and described the materials used.

Dr. McNutt summarized areas of concern about the Draft GEIS and cited examples of how determinations and assumptions were reached. He emphasized that lack of focus on certain impacts in the GEIS does not mean that the impacts don't exist.

Comments:

Frank Smolke, Wood Fiber Council. Commented that although he was originally opposed to the GEIS study, he now supports its findings, noting that Minnesotans have done a good job of managing resources, and will be capable of sustaining resources while accelerating levels of harvest.

John McCoy, Blandin Paper Company. "Echoed" Mr. Smolke's comments, and noted that it was significant that the 4.9 million acres for harvest had been established. Stated the importance of supporting mitigation strategies, like site level responses, low impact harvesting, intensive forestry practices, improved fiber utilization. Also, commented that current forest research data should be utilized.

Ann Amundson, Itasca County Resort and Tourism Association. Noted the lack of data in the Draft GEIS supporting impacts on tourism and the resort industry, based on anecdotal evidence only. Asks how tourism and timber industry can help each other. Quantifying aesthetics is difficult because everyone recognizes the valued "northwoods look." Positive logging practices should continue to be implemented to maintain aesthetics. Is pleased with efforts by the MN Resort Association, DNR, and timber industry to develop visual guidelines. Would like to see forest resources research to develop methods of collecting data to discern impact timber harvesting does have on tourism.

Bill Warren. (Submitted written comments.) Questioned the wisdom of hampering with timber industry to save abundant plant species, like lady slippers.

Robert Wendt, logger. (Submitted written comments.) Read from comments about coordinating forest research.

Lowell Pittack, logger. (Submitted written comments.) Read comments about cut-to-length tree harvesting system.

Scott Pittack, logger. (Submitted written comments.) Read comments about modifying season of equipment operation to minimize compaction of the soil.

George Rossman, retired publisher of *Grand Rapids Herald Review*. Intrigued by proposal for a Forest Resource Board, which could be the answer to finding support for forestry throughout the state of Minnesota. If we have sound developing forests on a balanced rotation, forest areas will be more attractive. Investment will be necessary for better management. Elaborated on a study which details increases in forestry management costs. Investment needs to be made in research, and in coordinating research, perhaps through a board like the EQB. Good forestry practices are needed for better strains, better species of timber, and more scenic and recreational attractions.

Garry Frits, Headwaters Chapter of the Minnesota State Society of American Foresters. (Submitted written comments.) Read a detailed statement expressing his organizations opinions and recommendations on the Draft GEIS.

Ken Nickolai, Minnesota Center for Environmental Advocacy. (Comments to be submitted by comment period deadline.) Stated that, in this region, several impacts are occurring at the base level. There is a projected 7 percent loss of timberland over the study period, a loss which will adversely affect the existence of the Red-shouldered Hawk. The study also shows that there is mining of certain nutrients from the soil which will affect future productivity. The use of mitigations strategies is necessary to help minimize adverse environmental impacts. Described the settlement agreement in a lawsuit which was filed against several state and county agencies by the Crow Wing Environmental Association, an agreement which was entered into between various environmental groups and Aitkin, Cass, and Crow Wing counties. Conditions of the settlement include specific changes ranging from identification and preservation of old growth forests to adoption of aesthetic value management plans, etc. Settlement, which was released in 1990, has only been partially implemented, indicating difficulty in carrying out such plans. Related settlement agreement to GEIS, stating that the 4.9 million acres figure put forth in the Draft GEIS will be sustainable only if mitigation strategies are put in place. Details of that settlement should be noted in the GEIS to provide a handle on county ownerships in the region. Language in the agreement states that "when the recommendations and guidelines from the GEIS are available, the parties shall renegotiate this agreement to incorporate terms in accordance with the GEIS."

Tom Murn, Potlatch Corporation. (Submitted written comments.) Read from comments expressing his and Potlatch's opinions about the GEIS, focusing on further research needs and Potlatch's commitment to various management principles and practices.

Bob Olson, Blandin Paper, Wood Fibers Council. Supports findings of the draft GEIS and recommends the development of mechanisms for ongoing public input, such as the Forest Resources Board.

Al Rime, Minnesota Resort Association. The Draft GEIS study quantifies the impacts of timber harvesting on sustainability of forest, wildlife, water, and soils, but doesn't adequately address expected adverse impacts on tourism, in fact they were mainly ignored. It was suggested that tourism department advertising could be changed to attract a different clientele, one which wouldn't be disturbed by extensive logging activities. The tourism industry cannot accept that position and requests that the GEIS studies the impact of timber harvesting on tourism in a more responsible manner. Would like to see the good, balanced relationship between loggers and resorters maintained.

Mark Johnson. Thanks for a comprehensive GEIS.

Gina Wourinen, Minnesota Women in Timber. (Submitted written comments.) Read written comments expressing her organization's opinions about the GEIS. Although in support of the findings of the Draft GEIS, concern is expressed about insufficient information on the effects on wildlife populations, biodiversity, soils and nutrient relationships, and recreation and tourism.

John Ward. GEIS study should address consequences of less harvesting, or a different type of harvesting.

Wes Libbey. Posed three questions: (1) Will impacts be measured on specific areas of ground, or on the impacts over the whole broad forest; (2) is the recently announced management plan of the USDA Forest Service considered in the Draft GEIS; and (3) has intensive timber development on the most productive land, which would leave less productive lands open for other uses, been considered. Past failure to invest adequately in forest management is the cause of present problems. Foresters have the knowledge and ability to increase per acre production with more funding and manpower. Likes the name of the proposed forest management board.

Brad Knight. Appreciates Draft GEIS admission of limited information. Would like to know how further studies suggested in GEIS will be accomplished expediently. Concerned about impacts of damage done before true impacts are known. Requests that GEIS include information on land management-forestry practices used in building major cities. Concerned about fiber study lack of reference to current market of technical developments, and to fiber alternatives instituted by the federal government. Wonders if industry is declaring our level of harvest management, and whether other feasibility studies should be done on employing more nonpetroleum base harvesting technique. Discussed and recommended consideration of *A forest journey: The role of wood in the development of human civilization,* a historical account of forestry. Noted the Draft GEIS's lack of mention of possible use of various fibers like nettles or hemp.

Dan Flaherty, Maple Syrup Producers. Draft GEIS neglects the Climax forest and the maple syrup industry as a sustainable forest product. Practice of residual cutting of the hardwoods is destroying the cycle of the Climax forest to promote aspen, and also destroys the maple resource forever. Logging practice of, in minimal forests, harvesting aspen and dropping maple to rot is not adequately addressed in draft GEIS. Should be considered for economic impacts, especially as maple trees become more scarce throughout the country. The tourism section of draft GEIS is a failure.

Clair Fetzer, forester. (Will submit written comments at a later date.) Concern about rules, regulations, and policy direction of the GEIS. We should be able to make do with what we have. Cited DNR budget cuts has evidence of lack of commitment to forest management. Programs already exist—use them. Minnesota Forestry Practices Act proposes fines and more regulation for cutting timber on own land--mandatory regulations aren't necessary.

Timber Harvesting Draft GEIS Public Meeting
Thursday July 15, 1993
Duluth Entertainment and Convention Center
350 Harbor Drive
Duluth, MN

Meeting Summary

EQB members present: Bob Dunn, Marlene Marschall, Douglas Magnus, Paul Toren, Bruce Bomier

Advisory Committee members present: Wayne Brandt, Janet Green

Staff present: Mike Kilgore, project manager; Dr. James McNutt, consultant for Jaakko Pöyry; Roger Williams, Office of Mediation Services

There were approximately 140 attendees at the meeting, with 18 making public comments.

Roger Williams introduced members of the panel.

Mike Kilgore presented an overview of the Draft GEIS. He briefly explained the process and described the materials used.

Dr. McNutt summarized areas of concern about the Draft GEIS and cited examples of how determinations and assumptions were reached. He emphasized that lack of focus on certain impacts in the Draft GEIS, does not mean that the impacts don't exist.

Comments:

Jim Alan, Department of Public Service. (Submitted written comments.) Read comments of Department of Public Service Commissioner Kris Sanda about biomass fuel technology, whole-tree burning, which should be exempt from the provisions of the GEIS.

David Johnson, logger. The Draft GEIS doesn't address the significant issue of compaction of wet soils. Noted that loggers generally don't log when it is too wet due to damage which can occur.

Roberta Hanna, ASPEN (Active Supporters of the Potlatch Environmental Network). (Submitted written comments.) Described the history and educational purpose of ASPEN. Read from comments expressing ASPEN's response to the Draft GEIS. Highlighted important points, including the continued need for research, the significant relationship between the timber and tourism industries, and the continued need to promote BMPs.

David J. Schimpf, biology professor. (Submitted written comments.) Commented that those who maximize wood producing control the debate on timber harvesting, and that rather than stating one specific figure for how much wood can be harvested, GEIS should present a range of values. Summarized the main points of his written comments. Requested EQB encouragement of open public debate on possible utilization of open corridors beneath powerlines.

Debbie Ortman, environmentalist. The base scenario of 4 million cords a year is too high, not realistically sustainable, and may be used to justify excessive logging. Definition of sustainable needs to be more clearly explained; the timber industry and environmental community perceive it differently. In reference to Washington state mountain clear cutting, warned against the dangers of clearcutting: erosion, loss of habitat, etc. Supports sustainable forest resources program and urges judicious, cautious use of GEIS by state EQB and DNR.

Janet Green, GEIS advisory committee. Noted that the GEIS is not an inventory study, but an impact study which focuses on impacts and mitigations. Mitigations can be modeled and include practices and planning activities that are either current or proposed (not in current practice). Implementation of mitigation recommendations is the next important step. Also, in reference to Commissioner Sanda's comments on whole tree burning, suggested to EQB that such wood and land utilization include other than CRP land. Such a proposal could be an addendum to the GEIS as a supplemental impact study. Impacts of it must be approached through the environmental review process.

Tom Martinson, Lake County Land Commissioner. (Submitted written comments.) Read from Lake County Board of Commissioner's comments about the positive significance of the Draft GEIS findings.

Dave Ohms, Potlatch. (Submitted written comments.) Read from comments expressing Potlatch Corporation's approval of the Draft GEIS findings, acknowledging the need for further research on wildlife concerns and affects of monocultures, and Potlatch's commitment to the development of BMPs.

Sheldon Aubut. Draft GEIS is a well-balanced document, but individual rights, human lives need to be considered.

Ken Nickolai, Minnesota Center for Environmental Advocacy. (Comments to be submitted by comment period deadline.) The Draft GEIS tells us that significant environmental damage is occurring to our forests. Only if we change forest management practices can current uses be sustainable. Cited page 225 to illustrate nutrient depletion of soil surrounding Duluth area. Cited page 210 to describe shrinkage of available timber land. Over 40 species of birds and mammals will decline as current harvesting levels continue. Changes in management can minimize impacts so that biodiversity, wildlife, soil nutrients, water quality, and recreation can be maintained. Summarized management techniques which will have to be implemented by forest owners and managers. The Draft GEIS calls for a new state board and a voluntary program. Multiple ownership of lands may inhibit voluntary compliance with GEIS expectations. Commitments to changes must be secured, otherwise harvest levels may not be sustainable, and may endanger species like the Red-shouldered Hawk. Mr. Nickolai offered Minnesota Center for Environmental Advocacy assistance in developing strategies for changing forest management.

Eric Uram, Clean Water Action Alliance. Urged consideration of damage caused by whole tree harvesting—nutrient depletion, creation of a monoculture. Interpretation of the GEIS could pose problems. Information may develop into off-site impacts like overconsumption, etc. We need to look into new industrial processes for reducing and recycling raw resources.

Alan Holden, logger. The Draft GEIS doesn't analyze the impact of the 2 million acres of Boundary Waters and Voyageurs land and the effect of those acres on the 14 million other acres of forest. Also, (in reference to comment made by Dr. McNutt) the stability of land based policy management can't be anticipated. Approves of the idea of a state forestry board and the Forest Practices Act.

Kay Desmond, Minnesota Women in Timber. (Submitted written comments.) Read from written comments expressing Minnesota Women in Timber suggestions for the Draft GEIS, including more research on biodiversity, and soil and nutrients, and needed changes in forest management practices.

John Pegors, Duluth Izaak Walton League. (Will submit comments at a later date.) Disagreed with the Draft GEIS assumption that voluntary BMPs will have an affect on preserving water quality, etc. Industry will weigh costs and benefits to determine how BMPs should be implemented. Loggers need to be educated to employ environmental methods in the forests. We need to conserve our resources and force development of more efficient technology. Incentives or disincentives for change were not truly addressed in GEIS. Draft GEIS fails to adopt an ecological systems approach to the forestry resource in Minnesota. Criticized the selection of Jaakko Poyry as consultant on the project due to its alleged record in handling timber resources. Also, EQB should have provided public with educational "consultative panels" about forestry findings in GEIS before holding open public meetings.

Leonard Anderson. Public policy will now be debated, based on findings of the Draft GEIS. Impacts of forestry on tourism needs to be quantified.

Aspen is less visually interesting than trees formerly grown in north woods regions. BMPs do not adequately protect riparian zones, a detriment to tourism and northwoods life. Forest should be allowed to become diverse, and more mature by increasing rotation time. Also, restrain clearcutting.

Pat Berg. (Submitted written comments.) Read from written comments describing the positive implications of the Draft GEIS.

Gene Glader, Minnesota Resort Association. Tourism and timber industries have a positive relationship. However, since the Draft GEIS doesn't properly address the impacts of timber industry on tourism, the impacts appear to be minimal, which is not necessarily true. Dislikes Draft GEIS suggestion that "money from states general revenue fund...."(Sec. 831), especially in context of the Draft GEIS's lack of information on economic impacts to the tourist industry. Balance of timber and tourism needs to be studied.

Lee Ramsdale, Lake County Board. It's good to have a dialogue between both sides of forestry issue. Education on the document is important. We need to continue to harvest at a sustainable rate. Forestry is a renewable resource, harvesting of which will contribute to the preservation of the rainforests.

Timber Harvesting GEIS Public Meeting
Tuesday, July 20, 1993
Forest Resource Center
Lanesboro, MN

Meeting Summary

EQB Members Present: Elton Redalen, Kris Sanda, Paul Toren, John Hustad (representing Linda Kohl)

Advisory Committee members present: Don Arnosti, Wayne Brandt, Roy Linder, Tom Sawle

There were approximately 40 attendees, with 8 making public comments.

Mike Kilgore presented an overview of Draft GEIS. He briefly explained the process and described the materials used.

Comments:

Pat Schmid, Audubon Society. Appalled by what's taking place up north with clearcutting. Concerned that all cut levels have negative impacts—as found in Executive Summary; thinks the harm that will occur is being seriously underestimated. Prefers tourism forestry interests over industry. Encourages recycling; would like to see recycling of pulp in all paper mills. Saw thinning done in Chippewa National Forest—thinning is done without regard to underbrush, which is destroyed. Don't manage all forests in Minnesota; need to leave some alone. Need BMPs implemented; stop or lessen clearcutting. Thinks GEIS draft is excellent and pleased with opportunity to testify—appreciates the statewide public meetings for Minnesota citizens.

Jon Nelson, Southern Chapter of Minnesota State Foresters. (Submitted written testimony, also.) Burden of implementing mitigation strategies is magnified in southern Minnesota because so much forest land is in private ownership—no incentives are offered to manage those forest lands. Recommends a Forest Resources Board, with explicit mandate concerning its authority, to implement programs and strategies recommended in the GEIS. Prefers to see more cost-effective, less intrusive approaches to implementation over promulgating rules and regulations. Suggested doing a GEIS for agriculture and urban development. In draft GEIS, concerned about lack of addressing regeneration of red oak in southern Minnesota.

Ken Nickolai, Minnesota Center for Environmental Advocacy. (Comments to be submitted by comment period deadline.) Concern about erosion damage in ecoregion 6, southeastern Minnesota, superseding that in other regions. Discussed erosion-related effects on other natural resources; cited p. 242 of report listing 17 environmental impacts. Stressed importance of taking GEIS seriously to encourage/enforce BMPs. Ownership and management of lands in SE Minnesota makes it almost impossible to implement BMPs to mitigate harm with current level of logging. If mitigation cannot be done, may need to revise (lower) level of harvesting to meet realistic sustainability goals. Seconded Jon Nelson's comments on regeneration of red oak in SE Minnesota. Mentioned fiasco with Spotted Owl controversy.

Don Arnosti, National Audubon Society. Rate of current logging impacts negatively on bird life. Clearcutting causes loss of nutrients in soil. Need to do long rotation forestry—grow trees to a longer age. Draft GEIS analysis of ecoregion 6 = lack of analysis, re: red oak regeneration. Economic analysis doesn't break out value-added industry to reflect SE Minnesota's decreasing red oak supply. Draft GEIS doesn't provide understanding for the reader, re: limitations of models and scientific methodology used.

Florence Sandok, Zumbro Valley Greens. Need an understanding of why study is being done. Suggests not going ahead with growth; suggests that the assumption that "growth" is good is not correct here and not appropriate. Need to look at bigger picture; worldwide, not just Minnesota; amphibians are decreasing worldwide. Discussed threatened and endangered species of plants and wildlife. Computer models plan for 50 years in the future; Native Americans suggest planning for 7 generations.

Toni Gilchrist. Concerned about management of microorganisms. Don't clearcut forests of specific trees if they aren't going to regenerate. Need to consider total ecosystem, including all "little things"—moths, bugs, worms, etc. Concerned about loss of forests "up north." Concerns relate to tourism issues. Originally from California and truly appreciates Minnesota's natural resources.

Ken Kailing. Consultant working on project in Wisconsin; client lost confidence in USDA Forest Service. Lives at Hokah, off Highway 16, where roads are washing out—area clearly has been clearcut. Authors of GEIS should look at actual happenings rather than just numbers, facts, and models.

Mike Touhy. User of forest products; from Chatfield. Loggers, other users, and citizens in area are very conscious of value of forest resources, aware of what needs to be done to promote sustainability, and are taking care to do what needs to be done. Area and environmental practices now are so much better than situation in the 1940s. Need studies like GEIS, need education, need to get everyone involved in environment. Studies such as Timber Harvesting GEIS are what is helping to make the difference from 1940s.

Timber Harvesting Draft GEIS Public Meeting
Wednesday, July 21, 1993
Bemidji State University
Beaux Arts Ballroom
Hobson Memorial Union
Bemidji, MN

Meeting Summary

EQB member present: Bob Dunn

Staff present: Mike Kilgore, project manager

Advisory Committee members present: Wayne Brandt, Jim Woehrle

There were approximately 255 attendees at the meeting, with 28 making public comments.

EQB Chair Bob Dunn moderated.

Mike Kilgore presented an overview of the Draft GEIS. He briefly explained the process and described the materials used.

Comments:

Patrick Welle, economist. (Submitted literature.) Outlined four criticisms of the Draft GEIS: (1) Economic research is purely and economic impact analysis—only a narrow slice of what the public has at stake. Comprehensive weighting of public values can be informed by benefit cost analysis. (2) Impacts for job creation in the timber industry is concrete, but information on off-site impacts (tourism quality, recreational activity, etc.) is not. (Dr. Welle will try to submit a deeper analysis of this problem by the end of the comment period.) (3) The Draft GEIS shouldn't use expenditures-only approach in analysis of costs. (4) The Draft GEIS doesn't weigh public values for natural resources, and, for sound policy development, should consider nonuse values—ethics, stewardship, and aesthetics.

Lowell Philp, press operator. The Draft GEIS is a good starting point toward timber management. More work is needed on determining how to balance impacts; wildlife impacts.

Peter Aube. Supports the findings of the Draft GEIS but is concerned about economics and management. Regulation adds to cost; allow for flexibility in public land management. Don't attempt biodiversity everywhere.

Brad Knight, woodworker. GEIS needs to address (1) radioactive fallout in trees; (2) consider how fast forest regulation takes place, and the effects of logging on native prairies; (3) more comments from natural resource professionals; (4) horse-drawn harvesting equipment as an alternative to machinery; (5) population increases; and (6) budworms.

Adam Steele. The Draft GEIS is an excellent overview of timber harvesting. More specific information on which bird species decline with increased harvesting is needed. Also, how will lumber prices be affected by increased timber harvesting?

Robert Shimek. Can't respond to the Draft GEIS because the Native American community has been left out of state planning activities. How do we control the amounts of pollutants put out by forest processing industries, pollutants which affect water quality, effecting fish consumption advisories? Biodiversity needs to be protected—habitat for medicinal plants is disappearing. Biodiversity needs to include cultural diversity.

Stana Bleiler, professional forester, Minnesota Women in Timber. Supports the Draft GEIS but is concerned about: (1) the cost of implementing strategies; (2) additional costs for additional forest resource professionals due to increased harvesting levels; and (3) whether or not programs will be voluntary (supports voluntary.) The Draft GEIS is based on sound principles and is a pro-active document.

Mark Jensen, Potlatch. Potlatch supports Draft GEIS findings and recommendations, which prove that strong forest management has had a beneficial impetus on our forest and environment. Draft Geis puts quantitative issues of forest management to rest; qualitative management is now a concern. Draft GEIS highlights gaps in knowledge about wildlife populations, recreation, and soil nutrient relationships, issues which require more research.

Patricia Black. Appreciates acknowledgement in the technical papers that certain effects are unknown. Current science does know what happens when diversity and gene pools are diminished. Current forest practices don't account for genetic diversity and species diversity. Monocultures don't allow for species diversity. Recommends planning forests based on "less than wonderful" scenario due to imminent environmental changes. The Draft GEIS is flawed because it regards Minnesota as a tree growing factory, not an inherent life force.

Pat Alberg. Minnesota Board of Forestry is a good recommendation. Don't spend a lot of time or money studying reports on tourism. New rules and regulations should be simple to follow.

Daral Olson, logger. Landscaped-based road and trail plan to coordinate between different forest owners is a good idea, but another bureaucracy is not needed. Development of landscaped-based road plans in state forest should be implemented by county road committees.

Judy Johnson. 4 million cords per year is too much. The biodiversity paper doesn't address amphibians adequately. Amphibians seem to be gone already. On page 86 of the biodiversity paper, mitigation addresses species near extinction.

Ted Fulton, forester. The Draft GEIS is timely, scientific document which provides helpful information to industry and local managers, and is a blueprint to companies for long-range planning. Supports the establishment of Board of Forestry resources to create guidelines for resource needs. Also supports the recommendation of the need for additional scientific study, modification of logging equipment and logging silviculture.

Chick Knight, resort owner. Is concerned about the effects of more logging on recreation and aesthetic values. We need to know that these are going to be protected. The Draft GEIS should consider impacts on the tourist industry. The Canadian province of Manitoba has put restrictions on the forest industry to improve the tourist industry. The state Department of Economics has reports which delineate the numbers of jobs created by tourism, agriculture and fishing in the area. Is concerned about expansion of logging—life as we know it in Minnesota is threatened. Supports the Audubon Society comments on the Draft GEIS. BMPs need to be based on actual figures.

Ken Nickolai, Minnesota Center for Environmental Advocacy. Significant environmental damage is occurring at current levels of timber harvesting. On page 242 of the Draft GEIS, 70 environmental impacts are listed. Significant impact reports should be developed for each ecoregion. Concerns in this region would be the effects of mining the soil of nutrients (which would lower future productivity); a decrease in biodiversity; and the decline in population of over 40 species of birds and mammals, including the Red-shouldered Hawk. If GEIS documents what is happening in each ecoregion, appropriate mitigation strategies can be determined. Changes in business practices need to occur if we are to have sustainable uses. GEIS recommendations need to be implemented, although the Draft GEIS does not tell us how to implement them. All owners and loggers need to implement changes. If changes are not made, GEIS estimates of sustainable levels of timber harvesting will have to be revised downward.

Robert Lohman, Preserve Our Land. Briefly described the history of the GEIS petition, which was not originally appreciated by the EQB, DNR, or forest industry. Alleged that a protimber industry consultant was hired to assure an amenable GEIS. The final statement in Draft GEIS on biodiversity is incorrect and is contradicted throughout the Draft GEIS. Consequently, the Draft GEIS is not objective or constructive.

Ron Salisbury. Many Draft GEIS recommendations are already being implemented. The Draft GEIS is unbiased, factually based, and provides sound recommendations for forest management which would assure balance.

Mike Carroll, Society of American Foresters. (Submitted written comments.) Read from written comments expressing the views of the Society of American Foresters, noting three specific points.

Mark DeKeyrel. Local input is needed in implementation of the Draft GEIS recommendations. A good body of science exists in the Draft GEIS. Urban forestry should be addressed in the GEIS.

Frank Bibeau, Leech Lake Reservation. Road side corridors are not true forest, but remnant strips of woods which endanger species living there. Natural habitats should be protected in the woods. Citizens should see the effects of forestry. Ten to twenty-five percent could be cut adjacent to highways to show how much forestry occurs. Animals should be provided with more remote places. No more research is needed; employ selective forestry.

James Woehrle. 5.5 million cords is not sustainable and will be noticed. 2.5 million cords of white pine were harvested at the turn of the century. Today we cut 4 million cords per year. We're just beginning to ask questions about biodiversity. Multiple use forestry is no longer an applicable term; biodiversity issues need to be addressed, as the GEIS is not static. Additional expanses for timber harvesting are not needed. A Board of Forest Resources would only mean more power for timber industries. It's best to retain local control.

Janet Woehrle. GEIS is a fairy tale, and does not adequately reflect the findings of the technical papers.

Mato Awanyankapi, Indigenous Environmental Network. (Submitted written comments.) Read statement expressing the views of the Indigenous Environmental Network, including concern about clearcutting, and how the ecological balance of the area is being altered by the disappearance of white pines and other plant and animal species, and by the proliferation of aspen trees.

Larry Burgoon, Hubbard County. The establishment of more bureaucracy to oversee logging industry is not needed. Hubbard County already has a natural resources management plan similar to the Draft GEIS. The GEIS will be an excellent resource management tool. Forestry activities are essential to many other elements documented in the GEIS.

Steven Hirsch. The forest industry is motivated only by profit. Support of the Draft GEIS by the forest industry should be sufficient to make people who care about forests, forest workers, and communities skeptical about the GEIS.

Star Zavo-al-Mahak. Use recycled products and leave the forests alone.

Jeff Waller, Private Nonindustrial Forest Landowners. Commends the GEIS process. Is concerned about the decrease of the forest land base in Northern Minnesota. Forest land is quickly being turned into agriculture and development land uses. The problem is not adequately addressed in the Executive Summary. With increases in forest harvesting, management, and mill expansions there is also an increase in urban sprawl, road upgrading, etc. These changes may indicate a temporary increase in timber harvesting, but also a loss of forest land. Who will monitor compliance with management activities and, which, if voluntary, should be tied back into property tax issue? The best way of mitigating and maintaining forests and forest management on nonindustrial private lands is long-term incentives to reduce development which breaks up the pieces land.

Timber Harvesting Draft GEIS Public Meeting
Thursday July 22, 1993
Rainy River Community College
1801 West 3rd Street
International Falls, MN

Meeting Summary

EQB member present: Bob Dunn

Staff present: Mike Kilgore, project manager

Advisory Committee members present: Butch Eggen, Wayne Brandt

There were approximately 135 attendees at the meeting, with 18 making public comments.

EQB Chair Bob Dunn moderated.

Mike Kilgore presented an overview of the Draft GEIS. He briefly explained the process and described the materials used.

Comments:

Eldon Voight, Minnesota Women in Timber. (Submitted written comments.) Read from submitted comments. Although in support of the findings and recommendations of the Draft GEIS, would like to see more research on the effects of timber harvesting on the tourism industry, on forest soils and nutrients, and on wildlife habitat.

Larry Hogrefe. Supports the findings of the Draft GEIS.

Dennis Hummitzsch, Koochiching County. (Submitted written comments.) Read the resolution of the Koochiching County Board supporting the findings of the Draft GEIS. Also read additional comments.

J. J. Hasbargen. Logging allows for the revitalization of vegetation and wildlife of forest areas. Noted that perhaps the decrease in wildlife in the Boundary Waters could have to do with its preserved status.

Shawn Mason, International Falls Chamber of Commerce. (Submitted written comments.) Summarized submitted resolution of the International Falls Chamber of Commerce in full support of the findings of the Draft GEIS.

Eric Mayranen, Associated Contract Loggers. (Submitted written comments.) Read from submitted comments stating the position of Associated Loggers, Inc.

Ken Olson, forester. Minnesota has healthy, thriving forests due to past and present responsible forest harvesting practices. Continuation of harvesting, at least a present levels, will ensure the continuation of benefits.

Craig Halla, forester. Emphasized the professionalism of loggers and foresters who can be relied on to manage forests expertly. Urged GEIS readers to base opinions on facts, not perceptions.

Dick Olson, forester. Current beautiful forests are the result of logging which has occurred within this century. Other forestry benefits include: better access to recreation areas; increases in wildlife population; reduced fire hazard (cited danger facing unlogged Boundary Waters area); reduced pest control levels; employment which supports family industries. Management practices continue to improve.

Wayne Brandt, MN Timber Producers. Commendations to EQB for fine job on the Draft GEIS.

Steve Earley, forester. Supports Draft GEIS, which sets direction for future of forestry in Minnesota. New terminology used in Draft GEIS, like biodiversity, ecoregions, sensitive species, nutrient depletion, etc., should be defined in GEIS to enable better understanding of mitigations. Include in GEIS information that all stakeholders, including private landowners, be involved in implementation of mitigations. Forests are the basis for our culture in this area and we will take care of them.

Wayne Larson. Draft GEIS is slanted toward industry. All key findings indicate no need to worry. Disparaged previous EQB activities in northern Minnesota.

Dennis Kreft, logger. Would like to see forestry continue as it is.

John Antanies. The Draft GEIS focuses on facts. It needs to contain more information on effects of forest fires and their relationship to forest revitalization. The Draft GEIS assumes that everyone accepts trees as a renewable resource, but media hype, etc., focus on a negative depiction of timber harvesting.

Jack Murray, Mayor of International Falls. (Submitted written comments.) Read submitted resolution of the International Falls City Council, unanimously in support of the findings of the Draft GEIS.

William Kotarski, Wisconsin Paper Council. Jaakko Pöyry is a credible consultant. Wisconsin's soil conservation commissioner recommends that loggers retain a 100-foot distance from rivers, lakes and roads, to preserve the visual integrity of forests for tourists. The distance spares tourists from seeing clearcuts, which are essential to healthy forests. Good management practices are essential.

Nancy Calder. Would like to see cooperation between state agencies and loggers to protect jobs and the environment. Milford Fish. Would like to see more coordination between forestry people and game and fishery people. There seems to be an emphasis on one or the other in legislature, state.

David Glowski. Would like to see a long-term, ongoing forum implemented into the school system to educate young people as to the facts of forestry, in order to prevent a tragedy like that which occurred in Pacific-Northwest. The Boundary Waters area is a travesty which has become a proverbial biological desert.

APPENDIX 6
PUBLIC COMMENTS ON DRAFT TIMBER HARVESTING GEIS

Over 1,300 comment letters were submitted on the draft GEIS during the EQB's 90-day public comment period ending on September 11, 1993. The breadth of subject matter contained in these comments was substantial. As a means of identifying substantive comments on the draft GEIS from the material submitted, the following eight criteria were used. A comment was considered substantive if it satisfied at least one of the these criteria.

1. The comment disagrees with the study's findings, conclusions or recommendations, and provides an explanation or direct evidence justifying this disagreement.
2. The comment suggests a specific change is needed in the document.
3. The comment asks for clarification/further explanation on the information, analysis, findings, conclusions or recommendations contained in the document.
4. The comment refers to the assumptions, methodology, information or data used to conduct the analysis.
5. The comment relates to the scope of the study.
6. The comment points to a deficiency in the analysis conducted, and identifies additional information that should have been considered or suggests how the analysis should have been conducted.
7. The comment points to an inconsistency in the document's findings or conclusions.
8. The comment identifies a factual error regarding data used or organizations, policies, programs or activities described in the GEIS, and indicates how to correct this error.

Once identified, all substantive comments were labeled and grouped as follows:

E - Suggested changes to the executive summary;
S - Suggested changes to document by section;
G - other suggested changes to the document;
SC - Comments related to the scope of the GEIS;
GC - General comments on the GEIS; and
M - Suggested additional mitigations.

All responses are found immediately following the comment. Where appropriate and/or feasible, the response identifies the general nature and location of any change(s) made to the text.

Suggested Changes to the Executive Summary

E-1

Comment: The discussion of visual management guidelines on page xvi should clarify which lands (e.g., private, federal, state, county) are assumed not to be using VMGs and therefore significantly impacted.

Response: Comment noted and clarification entered on executive summary.

E-2

Comment: The table on page xi of the executive summary should show changes in more than just 14 tree species to include the uncommon species.

Response: Table I.2 in the executive summary refers to the acreage of covertypes which by their definition contained a number of species. Clarification added.

E-3

Comment: The first bullet on the top of page xxvi should suggest other nontimber values in addition to visual quality can be enhanced by timber sale design and layout.

Response: Comment noted and further examples for clarification added.

E-4

Comment: Page xxv of the executive summary should be changed by inserting the following paragraph after the heading "Suggested Strategic Programmatic Responses": The GEIS has found these levels of logging are not sustainable unless the specific recommended mitigation strategies are implemented. Unless implementation occurs across types of land ownerships, the Pollution Control Agency should review and modify as necessary existing permits. No new permits should be issued which would result in increased timber harvest nor should existing permits be renewed, until the recommended mitigation strategies have been implemented.

Response: Comment asks for verification of strategies implementation and specific policy action to assure such. Verification will be added, and the reader will be referenced to actions on how policy might be implemented. The comment suggests permitting as a policy tool. As noted in later sections, a range of policy tools are suggested for consideration. As stated the suggested wording is overly prescriptive and, in fact, would require considerable study as to its own overall implications. The consultant disagrees with this aspect of the suggested change.

E-5

Comment: In the second paragraph of page xvii after the heading "Base Scenario Review," the first sentence should be replaced by the following:

> The results of the study analysis indicate it is likely that the base level of harvesting is below the maximum level of biologically sustainable yield during the next 50 years. As with any modelling effort, this conclusion is valid within a range of error and only to the extent that the assumptions accurately reflect actual conditions.

Response: The request for clarification of assumptions and range of validity is noted. Clarification added.

E-6

Comment: The first sentence of the last paragraph on page xxiv should be replaced by the following:

> The results of the study analysis indicate that a level of harvesting of 5.5 million cords annually is the maximum level of sustained yield during the next 50 years. As with any modelling effort, this conclusion is valid within a range of error and only to the extent that the assumptions accurately reflect actual conditions.

Response: As with comment E-5, an appropriate qualification has been added.

E-7

Comment: After the heading "Economic Impacts Overview" on page xvi, the following should be inserted:

> It was not possible to make conclusions on the overall impact of increased harvesting on the state economy. Analysis of the result of the computer-based IMPLAN model indicated that employment in certain sectors of the economy will increase. For example, the model predicted an increase of 352 direct jobs and 6,752 total jobs at the medium scenario. However, the study was unable to develop data on related economic impacts such as changes in the tourism and recreation industries and the public and private costs of implementing recommended mitigation efforts necessary as harvesting increases. Without this additional data, it was not possible to determine the overall impact on Minnesota's economy of increases in harvesting to either the medium or high scenarios.
>
> In addition, this study did not seek to analyze the potential costs and benefits of increased timber harvesting or alternative management scenarios. Instead, it attempted the more limited task of identifying those economic impacts caused by increased employment and financial flows in the timber industry. The study then quantified one portion of the economic impacts, but those results should be interpreted only as a trend or direction, not a discrete, reliable

number. Since the study was not able to quantify other related impacts, it could not reach a conclusion on the overall impact on employment or income for the state.

Response: Clarification is requested for the portion of economic analyses especially with respect to impacts on the overall state economy. Appropriate clarification added.

E-8
Comment: The first two paragraphs of text and the table should be deleted from pages xvi and xvii.

Response: The request to delete much of the economic impacts overview and summary table is not appropriate as it would seem to call for the removal of virtually all of the document's summary tables. With insertion of the additional clarification noted for comment E-7 regarding verification of direction or detail, the intent of comment would seem to be addressed.

E-9
Comment: The third paragraph of page xxiv related to the level of economic benefits should be deleted.

Response: The paragraph noted has been qualified with respect to comment E-7 and the paragraph has been retained.

E-10
Comment: A discussion regarding the possibility that not all impacts can be effectively mitigated should be included in the executive summary adjacent to the discussion of 5.5 million cords as the sustainable harvest level.

Response: Comment noted and clarification added.

E-11
Comment: On page iii, second paragraph, last sentence, a statement should be included that indicates USDA Forest Service constraints are likely to become more rather than less stringent.

Response: The comment states that USDA Forest Service constraints "will" increase. This is speculative, but limited clarification added.

E-12
Comment: The executive summary should more completely describe the different impacts identified at the three levels of harvesting.

Response: Comment noted and clarification added.

E-13
Comment: The summary list of projected impacts identified on pages xvii-xix should be rewritten to indicate exactly what the impacts will be.

Response: Comment noted. The purpose of the executive summary is to provide a brief overview of the GEIS. See sections 5.6, 6.6, and 7.6 for details of significant impacts for the base, medium, and high scenarios, respectively.

E-14
Comment: The statement on page xxiv "...the level of demand specified under the base and medium scenarios are sustainable in the long-term" and "a level of approximately 5.5 million cords is the maximum that could be sustained" should be deleted.

Response: Comment noted and clarification added concerning range of validity and assumptions associated with these statements (see also E-6 and E-7).

E-15
Comment: All references to sustainable yield should be removed from the executive summary.

Response: Comment noted. Since sustained yield and the conditions and implications are central to this study (see FSD objective 1 on page i) definition is more relevant than deletion. As such, more definition provided.

E-16
Comment: Examples of wildlife species negatively impacted should be listed in the executive summary.

Response: Comment noted and detail about wildlife species negatively impacted added.

E-17
Comment: The executive summary's reference to sustainable yield should reference all underlying assumptions and their uncertainties used in making the calculation.

Response: Comment noted and additional clarification added (see also E-14 and E-15).

E-18
Comment: The executive summary's reference to employment predictions should include statements regarding the lack of critical data needed to provide a complete picture of economic impacts associated with timber harvesting.

Response: Comment noted and clarification added (see also E-7 and E-8).

E-19

Comment: The executive summary should discuss the effect timber harvesting has on the state's water quality.

Response: Comment noted. The GEIS executive summary does discuss the effect timber harvesting has on water quality. However, that presentation is augmented to describe the type of effects.

E-20

Comment: The discussion of recycled fiber on the bottom of page viii should clarify that it is impossible to make projections regarding future use of recycled fiber due to changing technology and government policy.

Response: Comment noted and clarification added.

E-21

Comment: The statement on the bottom of page ix "Simply stated, forests change in species composition and age class structure in response to natural forces with or without timber harvesting" is misleading, and should be revised to suggest some stands (e.g., aspen) that are harvested with the intent to regenerate the same covertype (aspen).

Response: Comment noted and clarification added.

E-22

Comment: Table I.2 on page xi should include the small and uncommon species, not just the large and visible species (same as E-2).

Response: Comment noted and reader directed to portions of document with more detail on uncommon and understory forest species (see also E-2).

E-23

Comment: The discussion of Minnesota's history of forest lands on page vi should recognize timber harvesting as a factor leading to the loss of the state's timberlands, not just a result of expanding agriculture and urbanization.

Response: Comment noted. In the past, especially 1850–1950, changes in land use often followed harvesting. However, timber harvesting by itself does not lead to lost of state timber lands. Timber lands are lost "by definition" when those lands are converted to land uses that are incompatible with forest cover. No changes made.

E-24
Comment: The executive summary should state that extensive timber harvesting that has occurred over the past 150 years has reduced biodiversity, altered the predominant tree types and contributed to the loss of timberland and forest land.

Response: Comment noted. Document revised to indicate extensive timber harvesting followed by changing land use reduced biodiversity and altered the predominant forest types in the state.

E-25
Comment: The impacts for jack pine, paper birch, balsam fir and black spruce should be discussed in the executive summary in addition to the information provided in table I.2.

Response: Comment noted and specific species added (see also E-2 and E-22).

E-26
Comment: The projected decreases in average stand age for balsam poplar and aspen (table I.3) should be more thoroughly discussed in the executive summary.

Response: Comment noted and harvest stand age change issues and implications added.

E-27
Comment: A table that lists the projected numbers of birds and small mammals which are expected to be lost at each level of timber harvesting should be included in the executive summary.

Response: Comment noted. No species are expected to be lost. However, negative changes are expected for a number of species, as summarized in tables I.4 and I.5. No changes made.

E-28
Comment: The executive summary should acknowledge the severe decline in commercial quality red oak that has occurred in Minnesota.

Response: Comment noted and implication of change in the red oak covertype and quality added. A decline in commercial quality is discussed, but limited to available supporting data.

E-29

Comment: The discussion of models and assumptions on pages i to iii should include major assumptions such as forest land areas projections, national forest timber availability, and the degree to which technological changes and natural disturbances are incorporated into the model.

Response: Comment noted and a brief discussion of models and assumptions added. The full set of assumptions and supporting documentation is presented in the various technical and background papers and section 2.3.1 has been augmented.

E-30

Comment: The assumption on page xxiii, second paragraph, and page xxiv, fourth full paragraph and last partial paragraph that the 4, 4.9 and 5.5 million cord level would be sustainable provided the recommended strategies are implemented should be clearly highlighted in a new assumptions section or in the conclusions section.

Response: Comments noted and highlighting incorporated. New assumption section not added due to need to focus executive summary.

E-31

Comment: The executive summary should stress that recommended mitigations for the 4 million cord level must be implemented in the immediate future to address the impacts occurring at this time.

Response: Comment noted and the timing of the mitigations emphasized (see also E-5, E-6, and E-30).

E-32

Comment: On pages ii-iii, the document should emphasize that if the assumed management procedures are not routinely implemented in the way the model assumes, a number of adverse impacts will increase under all three harvest scenarios.

Response: Comment noted and the timing and importance of implementing the mitigations added.

E-33

Comment: The discussion on pages xvi-xvii regarding economic impacts should summarize significant economic impacts on a regional or statewide basis for the medium and high scenarios as described on pages 343-345 and 417-418.

Response: Comment noted. Due to limitations of the economic analysis, as noted (see E-7), the consultant sees no value in bringing additional summary material up into the executive summary.

E-34
Comment: Page xxviii should have a more complete discussion of alternative administrative structures, as is identified on pages 456-466.

Response: Comment noted. Expanding the summary of pages 456-466 beyond that already in the Executive Summary has real potential to mislead the reader. No change made.

E-35
Comment: The executive summary should clearly state the maximum harvest levels that are based on nonmarket values and ecosystem impacts.

Response: Comment noted and clarification of the importance of nonmarket values and ecosystem impacts added.

E-36
Comment: The GEIS (page xi) should include information on expected rotation ages for each covertype in the discussion of average stand age.

Response: Comment noted. Reference to expected rotation ages by covertype added.

E-37
Comment: The comparison of present-day tree volumes with that of the 1930s (pages vi, 67-68) is misleading—present-day tree volumes should be compared to those that existed prior to white settlement and those projected into the future.

Response: Comment noted. The document already attempts comparisons at several points in Minnesota's history. However, it is arguable that any one point is appropriate. Forests have changed dramatically since the last ice age for a variety of natural and anthropogenic reasons. Presettlement condition is an important reference point for the landscape as a whole, and in terms of proportion of the landscape occupied by each covertype and each age class. There are factors which have changed only a few percent each century over the last few thousand years. However, it is also important to use other baselines of comparison, such as the 1930s, so that we can tell if known management practices over the past 60 years are leading to improvement of overall forest conditions. The presettlement baseline represents a near maximum possible acreage of total forest, old growth, and standing volume that we could have in Minnesota, if there were no acreage taken up by cities, roads, housing, resorts, and crops other than trees. No changes made.

E-38

Comment: The nutrient losses from full-tree removal described on p. 172 should be discussed in the Executive Summary.

Response: Comment noted and the question of nutrient loss of whole tree removal described on page 172 added.

E-39

Comment: The GEIS (page xii) should emphasize more clearly the fact that the significance of nutrient depletion is unknown, yet there is a possibility that site productivity will suffer.

Response: Comments noted and nutrient depletion issue clarified.

E-40

Comment: The GEIS should clarify that the analysis results refer to habitat changes and that population response is an extrapolation (e.g., table I.5 of the executive summary).

Response: Comment noted and clarification added.

E-41

Comment: The last paragraph on page xiii should use "criterion" rather than "criteria."

Response: Comment noted and changes made.

E-42

Comment: The GEIS (page xiii) should discuss the impacts if the MNDNRs pest management guidelines are not followed, as assumed in the study.

Response: Comment noted. The Executive Summary already addresses this point in enough detail to raise the appropriate caution.

Suggested Changes to the Document, by Section

Section 1 Comments and Responses

S-1

Comment: Page 7 in section 1.5.3, "Relationship to Timber Harvesting and Forest Management" should be qualified, as loss of forest land area (which is not a result of timber harvesting) is analyzed in the GEIS.

Response: Comment noted and clarification incorporated. Care has been exercised to follow the FSD.

Section 2 Comments and Responses

S-2

Comment: Table 2.1 on page 35 is incorrect—the issue cultural, historical resources (J1) should be linked to significance criteria #21 (historical and cultural resources - forestwide impacts), not criteria # 20 (regional economics - changes in economic parameters).

Response: Comment noted and correction made.

Section 3 Comments and Responses

S-3

Comment: The discussion on page 78 regarding county management systems should state that although these county-managed tax forfeit lands belong to the state, their management was specifically excluded from the Forest Management Act of 1982, which provides for management of all forest resources.

Response: Comment noted and changes made.

S-4

Comment: The first paragraph of page 79 should indicate how many acres are under cooperative management, in which counties and for what resources.

Response: Comment noted. Approximate acreage under cooperative management is difficult to determine. However, discussion of that limitation added.

S-5

Comment: The USDA Forest Service should be acknowledged as the source of information used to generate the data found in the tables on pages 64 and 76.

Response: Comment noted and changes made.

S-6
Comment: A graph of Minnesota's age class distribution (from page 21, Productivity paper) should be included in 3.1.3.

Response: Comment noted and illustration added.

S-7
Comment: Discrepancies regarding the amount of timber harvested from Minnesota's forests in 1990 and 1991 need to be clarified—page 112 of the Economics technical paper indicates 3.5 million cords in 1990, whereas GEIS's executive summary suggests 4.0 million cords in 1990 and 4 million cords in 1991 (page 82).

Response: Comment noted and clarification added.

Section 4 Comments and Responses

S-8
Comment: On page 130, reference to MNDNR research and inventory efforts should be included.

Response: Comment noted and material added.

S-9
Comment: Page 98 should list the laws, ownerships and affected acreage under the various policies such as multiple use, sustained yield or nondegradation.

Response: Comment noted. However, the various laws and policies that relate to multiple use sustained yield and nondegradation exist in such a wide range from formal to de facto, that a full and unambiguous listing is not possible. Clarifying comment added.

S-10
Comment: A table in section 4.1.2 listing the various forest resources planned for (e.g., timber, wildlife, recreation) and their respective acreage, by ownership, should be included in the GEIS.

Response: Comment noted. A table by owner and objective is difficult to develop because of definition, policy, and procedural differences among ownerships. However, such information is provided by separately for various ownerships in the *Public Forestry Organizations and Policy* background paper. Clarifying note added.

S-11

Comment: In section 4.1.2, the GEIS should indicate that coordination at the forest resource management level is very poor, and is an underlying problem for landscape-level management.

Response: Comment noted and the underlying difficulty of landscape management is emphasized. It is not clear, however, that landscape management, since it is not yet well defined, will necessarily be poorly done in the future.

S-12

Comment: The last sentence on page 103, paragraph 1, should end after "not common."

Response: Comment noted and change made.

S-13

Comment: The description of forestry-wildlife guidelines on page 106 should be clarified as they do not influence how much land is available for harvest and are only used extensively on MNDNR-administered state lands.

Response: Comment noted and changes made.

S-14

Comment: Page 115 should include a table indicating the number of acres in each county under cooperative fish and wildlife management.

Response: Comment noted. However, data of this type in the form requested are unavailable.

S-15

Comment: The term "close ties" should be defined as it is used on page 115.

Response: Comment noted. The revised version of the GEIS no longer uses this terminology. Change made.

S-16

Comment: Page 116, section 4.3.3 should state that county coordination, except through the MACLC, does not exist, and counties do not coordinate with state land managers or national forests on management practices or plans.

Response: Comment noted. The characterization of county coordination in section 4.3.3 is considered an appropriate description of the situation.

S-17

Comment: Page 117, section 4.3.5, should identify the number of counties and their acres in which the public participates in county planning.

Response: Comment noted. Clarification added to indicate the 15 counties with land commissioners as being the most likely to be involved in county-level forest resource planning. Further elaboration is not attempted because of the difficulty of quantifying so many different kinds of participation.

S-18

Comment: Section 4.3.6 should indicate that county management of state lands is conducted without multiple use management, planning, public input or coordination with other public landowners.

Response: Comment noted. Clarification added to indicate the range of county management and public involvement.

S-19

Comment: On page 122, section 4.4.2, a fourth bullet should be added that states: "Tailored to provide equal consideration of all forest resources."

Response: Comment noted. Clarification is not needed because consideration of all forest resources seems inappropriate since resources are still being defined and consideration of all resources ***equally*** is beyond the realm of human capability.

S-20

Comment: On page 139, section 4.8, the second sentence should be "The primary land administrators are..."

Response: Comment noted and change made.

S-21

Comment: The statements on page 133 and 135 regarding the willingness of NIPF landowners to undertake initial and intermediate management activities is incorrect—they consistently demonstrate a willingness to respond to professional management recommendations (e.g., Tree Farm and Forest Stewardship programs).

Response: Comment noted and qualification added to indicate that where the private landowner is reached directly and becomes involved in tree farm and stewardship programs, then the response to professional management recommendation is high.

S-22
Comment: Section 4.3 should recognize that most county-administered lands are actually state-owned lands.

Response: Comment noted and change made.

S-23
Comment: The last bullet on page 106 should delete reference to "old forests" policy, as the MNDNR does not have a formal policy for these forests.

Response: Comment noted and clarification added (with respect to what constitutes policy).

S-24
Comment: The two phrases in the third sentence of the last paragraph on page 107 "as noted in section 4.2" and "which complied with current legislative directives" should be deleted.

Response: Comment noted and changes made.

S-25
Comment: The reference to the MNDNRs ecoregions in the third paragraph on page 112 (first sentence) should be changed to "administrative regions."

Response: Comment noted and change made.

S-26
Comment: The impact of NIPF conservation incentive programs is underestimated on page 137.

Response: Comment noted. Lacking specific information to clarify any underestimate of NIPF conservation incentive program impacts, no change made.

S-27
Comment: The discussion on page 115, second paragraph relating to county policy focus should be revised to downplay the degree to which county land management systems manage for fish and wildlife and coordinate with other fish and wildlife agencies.

Response: Comment noted and wording clarified (see also S-15).

Section 5 Comments and Responses

S-28
Comment: On page 142, it should be pointed out that many of the "never harvested" acres would have recently been harvested before the study period or subsequent to 50 years.

Response: Comment noted and clarification added.

S-29
Comment: The average age of stands indicated on page 157 are meaningless and should be deleted.

Response: Comment noted. Average ages are indicative of overall conditions. Clarification is added to aid interpretation. See response to S-30.

S-30
Comment: On pages 157-158, a summary description of the primary changes in covertype and age-class distribution by ecoregion should be included.

Response: Comment noted. Appendix 2 summarizes covertype changs by age class. That is deemed sufficient for purposes of the GEIS. No change made.

S-31
Comment: On page 186, please clarify why nearly all species projected to increase statewide under all scenarios are early succession species when it is stated there will be more acreage of older age classes for most covertypes.

Response: Comment noted and clarifications added.

S-32
Comment: On page 255, the GEIS should encourage agencies to incorporate linkages in their plans, not discourage their use.

Response: Comment noted. Linkages are discussed under site specific and landscape mitigations. Such linkages are stressed as important in several sections of the document and are encouraged. Clarification added here, however.

S-33

Comment: On pages 162-164, a discussion of the percent of nonaspen forest types converting to aspen after harvest should be included to indicate whether more nonaspen types are being converted to aspen or vice versa.

Response: Comment noted. Clarification added to section 5.2.1 to indicate the conversion of aspen after harvest and vice versa. Reference also made to details provided in the *Maintaining Productivity and the Forest Resource Base* technical paper.

S-34

Comment: The first sentence under "Conclusions" on page 289 should be replaced by the following:

> The results of the study analysis indicate it is likely that the base level of harvesting is below the maximum level of biologically sustainable yield. As with any modelling effort, this conclusion is valid within a range of error and only to the extent that the assumptions accurately reflect actual conditions.

Response: Comment noted. Appropriate qualification to clarify modeling assumptions added.

S-35

Comment: Section 5.1.3 should emphasize the unreliability of information indicating the volume of timber harvested from private lands.

Response: Comment noted. Clarification added on the reliability of information on timber harvested from private land.

S-36

Comment: The heading for table 5.16 (page 190) should be changed from "impacted" to "adversely impacted."

Response: Comment noted and change made.

S-37

Comment: The discussion of potential adverse impacts of increased forest cover in prairie, brushland and other open-land ecosystems should be mentioned at the end of the third full paragraph on page 211.

Response: Comment noted. Implications of increasing forest cover in prairie, brushland, and other open-land ecosystems added.

S-38

Comment: The discussion of page 219 regarding species extirpation should have a broader consideration of the ability to manage species populations.

Response: Comment noted. Statement regarding extirpation was misworded in the draft GEIS. Corrections clarify the point.

S-39

Comment: The mitigation strategy on page 256 that addresses protection of sensitive sites for plant species should clarify what communities are referred to, and whether all communities listed in table 5.23 are to be addressed by this strategy.

Response: Comment noted and clarification added.

S-40

Comment: The statement on page 256, second paragraph, regarding MNDNR and USDA Forest Service efforts to protect sensitive plant species should state that a very small proportion of known occurrences are protected as Registry sites, RNAs or SNAs, while others are protected by informal mechanisms or agreements, and that some sites remain unprotected, especially if those listed in table 5.23 are considered.

Response: Comment noted and clarification added.

S-41

Comment: The recommendation on page 264 regarding retention of key habitat requirements in clearcut areas should be more specific by stating "in clearcuts, leave 7 to 15 snags per acre," etc.; reference MNDNR Forestry-Wildlife guidelines for specific guideline language unless additional measures are deemed necessary; broaden the reference of lowland conifers to mean retention of stand patches the represent the area cut; and clarify whether this mitigation should be applied to all harvest levels, ecoregions and all types of clearcuts.

Response: Comment noted. MNDNR guidelines are referenced to use as a model for habitat features in clearcuts.

S-42

Comment: The discussion on page 266 regarding the strategy to protect sensitive sites should specifically reference Registry Agreements, SNAs, RNA, and Special Botanical Areas and discuss rare natural communities.

Response: Comment noted and more detail provided.

S-43

Comment: The mitigation on page 266 regarding protecting sensitive sites (first sentence, second to last paragraph) is incorrect—the MNDNR does not routinely carry out the measures described two paragraphs earlier with respect to reptiles and amphibians.

Response: Comment noted and clarification added.

S-44

Comment: The last paragraph on page 357 should state that the Louisiana Waterthrush is a listed species that is also negatively impacted.

Response: Comment noted. Reference will be made in section 5.6.8 to the Louisiana Waterthrush, though it is not a forest-dependent species.

S-45

Comment: The discussion of MNDNR old growth candidate stands on page 159 should clarify that a stand may be a candidate if it meets a minimum age or minimum diameter criterion, but does not have to meet both.

Response: Comment noted and change made.

S-46

Comment: The GEIS (page 160) should note that in some cases black spruce lowlands greater than 120 years old will be harvested under the base scenario.

Response: Comment noted and clarification made. The algorithm used in modelling did not project a need to harvest any old growth swamp conifers. By staying with the harvest scenarios as modelled, then no old growth black spruce would be cut.

S-47

Comment: The figures in table 5.10 (page 161) do not match the figures in table 2-2 (p. 2-5) in appendix 2).

Response: Comment noted and changes/clarification made. Tables 5.8 and 5.10 were developed using the GEIS covertype algorithm for 1990 for comparability of present and projected values. Appendix table 2.2 uses FIA test data for 1990 and both the FIA and GEIS covertype algorithms. See appendix 2 introductory section and footnotes at end of appendix table 2.2. Clarification added to appendix table 2.2.

S-48

Comment: The discussion of riparian corridors on page 193 should recognize their highly productive nature for wood fiber production and fine hardwood materials.

Response: Comment noted and clarification provided.

S-49

Comment: The statement on page 280, fourth paragraph, regarding extended rotation forestry policies being implemented on public forests in northern ecoregions is not entirely accurate as ERF are not used on county ownerships or the Superior National Forest.

Response: Comment noted and clarification provided.

S-50

Comment: The fourth paragraph on page 280 regarding corridor effectiveness at maintaining opportunities for animal movement between separated populations should be revised to be consistent with the last paragraph on page 255.

Response: Comment noted and clarification added with regard to limitations of this concept.

S-51

Comment: The discussion on page 261 regarding the recommendation: "Modification to harvesting practices and equipment, and modify season of equipment operation to minimize compaction" should include additional discussion regarding harvest on NIPF lands, and how this strategy should be implemented on these lands.

Response: Comment noted and clarifications added.

S-52

Comment: Constraints on debarking should be identified in the recommendation to retain slash on page 259, as debarked wood becomes too slippery and logs slip off trucks causing safety problems and debarked logs may dry out too fast while in storage inventory.

Response: Comment noted and additional discussion incorporated.

S-53

Comment: The recommendation to increase utilization on page 267 should be clarified as it conflicts with the recommendation to retain slash.

Response: Comment noted. Conflicts among recommendations is clarified.

S-54

Comment: The recommendation on page 269 regarding exotics should be limited to using only sterile plants, as hybridization with native plants could have adverse effects on Minnesota's forest ecosystem.

Response: Comment noted as an oversimplification. Sterile plants and hybridization can also do much to enhance the quality and character of Minnesota's forest ecosystem. No change made.

S-55

Comment: The term "never cut" on page 150, table 5.6 should be changed to "not cut" to be consistent with table I.1 on page x.

Response: Comment noted and change made.

S-56

Comment: In section 5.1.2, the term "never cut" should be changed to "not harvested 1990-2040."

Response: Comment noted and wording modified for clarity.

S-57

Comment: Section 5.2.1, subheading "forest area" should be deleted from the text because it is harvest/management independent.

Response: Comment noted. Forest area description is relevant in describing forest conditions. Further, forestry and related conservation programs and investments do affect forest area. No change made.

S-58

Comment: Section 5.2.2 should include a table of 10-year age class increments for each type, both 1990 and 2040, for all three harvesting scenarios.

Response: Comment noted. Increments can be described in many ways and can be technically difficult to derive. Thus the comment lacks specificity to adequately respond. Further, the suggested table is not needed to present the study findings. However, the section is augmented as it affects or describes forest covertype acreage.

S-59

Comment: The tree species abundance table on page 163 is meaningless and should be removed.

Response: Comment noted. The tree species abundance table is one of many projections that add substance to the study results and presentation. Table retained.

S-60

Comment: There needs to be a definition of the term "inadequate conifer understory" found on page 162.

Response: Comment noted. The term "inadequate conifer understory" described further.

S-61

Comment: The discussion on page 164 regarding covertype conversion after harvest should also present the percentage of other covertypes that come back postharvest as the same type (e.g., nonaspen regenerating into an aspen type).

Response: Comment noted. Presentation in section 5.2.1 augmented to describe more of the covertype dynamics following harvesting.

S-62

Comment: The discussion on pages 141-142 in section 5.1.1 should clarify whether Minnesota is facing a serious demand-supply conflict with oak, noting the information provided in appendix 1, page 1-25.

Response: Comment noted: The supply-demand situation with oak augmented by description of how it was treated.

S-63

Comment: The discussion of covertype acreage on page 155 should clarify how black spruce is expected to decline by 2040 with gains in tamarack and aspen.

Response: Comment noted. The discussion augmented to clarify and reference the dynamics of black spruce versus tamarack and aspen acreage.

S-64

Comment: The discussion of covertype acreage on page 155 should clarify how white cedar is expected to increase in acreage when table 2-2 (page 2-5 of appendix 2) should the current acreage of 644,000 acres being reduced to 361,000 acres under the base scenario by 2040.

Response: Duplicate comment: The correct 1990 acreage, for comparison is shown in appendix 2, table 2.1. See also response to S-47.

S-65

Comment: A table of 10-year age class increments for each covertype at present and for each projected scenario (identical to the one in appendix 2) should be provided in section 5.2.2 on page 157.

Response: Comment noted. Production of further tables is unnecessary for the purpose of the GEIS. No changes made.

S-66
Comment: The term "third order watershed" found on page 230, paragraph 1 should be defined.

Response: Comment noted. Document clarified.

S-67
Comment: The discussion of BMPs on pages 193 and 251 should clarify that current BMPs only require an intact filter strip of ground vegetation, and that overstory, understory and shrub layers could be removed without violating these guidelines.

Response: Comment noted and changes made.

S-68
Comment: The scientific basis of a 100-foot riparian zone in the north and a 200-foot zone in the south should be clearly stated in the last partial paragraph on page 252.

Response: Comment noted and change made.

S-69
Comment: The discussion on the top of page 253 regarding BMPs compliance on private lands should note that the majority of departures from BMPs requirements are minor in nature with few observable impacts.

Response: Comment noted. Comment is accurate based on reported data. However, the surveys to-date are not comprehensive and drawing such firm conclusions now is not appropriate. No change made.

S-70
Comment: The projections on pages 163-164, table 5.11, should incorporate significant forest health problems such as Dutch elm disease and butternut canker.

Response: Comment noted. There is insufficient data available to predict the impact of Dutch Elm Disease or Butternut canker on future tree numbers. A cautionary note is added to the text.

S-71
Comment: A statement should be added on page 221, second full paragraph, that the assumption regarding the assumed use of MNDNR pest management guidelines on NIPF is needed to run the models, but is not true in actual practice.

Response: Comment noted and clarification incorporated.

S-72
Comment: Page 223 should include a discussion of the increase in both susceptibility and vulnerability of jack pine stands to the jack pine budworm, using language similar to that for spruce budworm found under the spruce-fir forest type group.

Response: Comment noted and language added.

S-73
Comment: Pages 257-258 should recognize that the MNDNR and other ownerships are already engaged in the recommended insect and disease strategies.

Response: Comment noted and suggestion incorporated.

S-74
Comment: The following fourth bullet should be added on the bottom of page 257:

- Increase tree species diversity at site and landscape levels.

Response: Comment noted and material added.

S-75
Comment: The fourth sentence, paragraph 1, page 265 should be replaced with:

Snag retention should be directed toward trees that are not infested with insects and diseases other than wood decay. This restriction would not be necessary when stands are regenerated to nonsusceptible forest species.

Response: Comment noted and material added.

S-76
Comment: On page 235, tamarack, basswood, oaks and red pines should be included as food trees for porcupines.

Response: Comment noted and information include

S-77
Comment: The list of existing visual management guidelines on page 239 should include a discussion of the extent to which they are currently applied.

Response: Comment noted and material added.

S-78
Comment: The mitigations recommended in section 5.7.2 should be proposed by ecoregion.

Response: Comment noted. Clarification to be added to indicate these mitigations apply in varying degrees to all ecoregions.

S-79

Comment: Tables 5.15 and 6.13 should be deleted.

Response: Comment noted. Tables 5.15 and 6.13 have been the subject of discussion with the Advisory Committee. Also important is that the scale in these tables (statewide) does provide a different and instructive view of how habitat changes vary according to the spatial resolution used in the analyses. Consequently, they are retained to augment other more detailed information presented.

S-80

Comment: The GEIS should make clear on page 247 that protection of old-growth forests will not occur solely by inventorying old-growth stands, but appropriate policies and strategies need to be implemented.

Response: Comment noted and discussion augmented.

S-81

Comment: The strategy for addressing impact #6 (listed plant species or their habitats, page 274) should be assigned an effectiveness of "low," as the CBS is unlikely to receive large increases in funding and refinement of the survey design is impractical. For this strategy to be judged moderately effective, strategies for protection of sensitive sites for rare plant species and communities (page 256) should be included and elaborated here.

Response: The County Biological Survey (CBS) remains an important vehicle to assess species status and impact. The consultant's judgement is that design changes and modest funding augmentation would allow the CBS to provide sample coverage of the entire state within a decade. The discussion is accordingly elaborated upon.

S-82

Comment: On page 199, paragraph 2, the term "where appropriate" in relation to closing logging roads needs to be defined.

Response: Comment noted. The term "where appropriate" deleted.

S-83

Comment: On page 200, the assumed constraints and mitigations for MNDNR-administered lands should be identified to better understand the magnitude of actual impacts.

Response: Comment noted. Mechanisms that generate the existing constraints and mitigations on public lands addressed.

S-84

Comment: The mitigation strategy included in section 5.7.3 (p. 285) "Increase the proportion of harvests undertaken during winter" should be specifically discussed in section 5.7.2.

Response: Comment noted. Increasing the proportion of harvest undertaken during winter is clarified in section 5.7.2.

S-85

Comment: The discussion of an upgraded cultural resources database on page 248 should address the need for data security, availability and useability.

Response: Comment noted. The discussion of need for an upgraded cultural resources database augmented.

S-86

Comment: An explanation should be provided regarding how a median value of 0 (distance to water) was calculated on the bottom of table 5.17, page 194.

Response: Comment noted. The calculations incorporated in table 5.17 clarified.

S-87

Comment: The discussion of retaining slash on page 258 should have more detail regarding its use and its impact on forest regeneration.

Response: Comment noted. The discussion of retaining slash and its potential impacts on forest regeneration is elaborated upon.

S-88

Comment: The discussion of retaining key habitat requirements in clearcut areas on page 264 should reference existing guideline language in the MNDNR Forestry-Wildlife and USDA Forest Service guidelines instead of the general bullets included at the bottom of the page.

Response: Comment noted. See response to S-41.

S-89

Comment: The GEIS should provide specific standards in its discussion of retaining cavity trees on page 265, combine it with the snag retention/key habitat retention mitigation, and delete any reference to gray squirrels as they do not exclusively require cavity trees.

Response: Comment noted. Discussions of cavity tree importance are provided in the Forest Wildlife technical paper and discussed with respect to several mitigations in sections 5, 6, and 7. Gray squirrel needs and preferences are also discussed in the noted technical paper. No change made.

S-90

Comment: Any recommendations for use of exotics (page 269) should include the statement "use only sterile plants."

Response: Comment noted. The restriction of exotics to sterile plants only is deemed unnecessarily constraining and likely impossible to implement and monitor. No change made.

S-91

Comment: The discussion of guideline development on page 269 should emphasize the use of existing guidelines such as those used by the MNDNR and USDA Forest Service.

Response: Comment noted. Material added.

S-92

Comment: The mitigation on page 248 addressing forest conversion is unrelated to timber management and therefore should be deleted from the text.

Response: Comment noted. Some mitigations beyond those applicable directly to forest management are considered significant to public policy considerations. Maintenance of the forest land base of Minnesota is essential to prevent future declines in wood and fiber supply. No change made.

S-93

Comment: On page 252, paragraph 4, the reference to buffer strips in southern Minnesota should reference the ecoregions affected, and identify standards (e.g., percent crown closure, basal area) for uneven-aged management.

Response: Comment noted. Regions of applicability will be noted, however, it is not within the scope of the GEIS to develop site level standards on this subject.

S-94

Comment: On page 252, paragraph 4, the reference to buffer strips in the rest of the state should reference the ecoregions affected, and identify standards (e.g., percent crown closure, basal area) for uneven-aged management.

Response: Comment noted. Regions affected to be noted. Further detail is beyond the scope of the GEIS.

S-95

Comment: The discussion of extended rotations (page 253) should provide specific targets by covertype or ecoregion.

Response: Comment noted. The specification of assumptions about the extent of ERF were based on discussions with the MNDNR and interpretations of other ownership planning documents. Further specification is appropriately part of a larger effort within and across ownerships and beyond the scope of the GEIS. No change made.

S-96

Comment: The discussion of connected forest corridors on pages 254-255 should have more specific details regarding how to mitigate to protect these values.

Response: Comment noted. The Biodiversity technical paper (Jaakko Pöyry 1992e) gives more detail. Specifics of any given mitigation are beyond the scope of the GEIS. No change made.

S-97

Comment: The discussion of protecting plants and road plans on page 256 should be further developed into mitigation statements or deleted.

Response: Comment noted. Consultant does not understand the request. The road plans and plant protection materials on page 256 are recommended mitigation strategies. For example, in section 5.7.3 the road plans concept is recommended as a mitigation strategy for significant impacts numbers 9, 14, and 16. No change made.

S-98

Comment: The discussion of landscape- and site-level strategies discussed in section 5.7.2 needs to include the additional mitigation strategies discussed in the Historical/Cultural Resources technical paper. Specifically, the development of predictive models should be referenced as a landscape strategy, and location of sites prior to harvest should be included as a site-level strategy.

Response: Comment noted. Section 5.7.2 contains "recommended" strategies from a larger body of "potential" strategies developed in the study's technical papers. The recommended strategies had to pass both a criteria screening process (see section 5.7.1) and approved by the GEIS Advisory Committee. The predictive model strategy was not recommended due to many factors, but lack of practical feasibility statewide, lack of base data, and the like were key. Location of sites prior to harvesting was rated as not possible due to serious database problems and, therefore, not recommended. No change made.

S-99

Comment: The statement on page 282, last paragraph, regarding the commitment of NIPF landowners to multiple use management greatly underestimates this commitment, as the primary purpose identified by landowners for seeking assistance from professional foresters is for wildlife management.

Response: Comment noted. Discussion modified to reflect high interest in wildlife among NIPF owners. More detail is provided in the background paper on public forestry organizations and policies.

S-100

Comment: Tables 5.8 and 5.10 do not match with the figures in appendix 2.

Response: Comment noted (see response to S-47).

S-101

Comment: In the discussion of riparian management on pages 251-253, the GEIS incorrectly states that an objective of BMPs is to maintain the integrity of riparian vegetation.

Response: Comment noted and clarification added.

S-102

Comment: The discussion of the aerial herbicide spraying program on page 258 incorrectly states that the process failed for lack of funding when the main problem was a lack of a sustained effort to implement the agreement by parties to the agreement outside the MNDNR.

Response: Comment noted and interpretation added.

S-103
Comment: Poaching of timber wolves has not been a major problem, as is stated on page 189.

Response: Comment noted and change made.

S-104
Comment: The statement on page 206 indicating that only "individual resort and tourism businesses" may be adversely affected by timber harvesting is incorrect. There is potential for whole communities to be adversely affected.

Response: Comment noted and explanation added.

S-105
Comment: The statement in the last paragraph on page 200 regarding aging under the base scenario is inconsistent with projected future forest conditions described on page 195.

Response: Comment noted. Material on page 200 relates to the average statewide forest age condition, while that on page 195 addresses the increase in acreage of younger stands. Both statements are true. No change made.

S-106
Comment: A clearly stated mitigation recommendation (e.g., retain 2 to 4 cavity trees per acre in all timber sales statewide) should be included on page 265 regarding retention of cavity trees.

Response: Comment noted. The GEIS already has a recommendation of 2.4 cavity trees per acre. No change made.

S-107
Comment: The recommendation on page 269 to increase productivity conflicts with the recommendation to retain slash and cavities.

Response: Comment noted. Various mitigations in general may conflict with each other; thus, site specific practices that minimize conflicts based on existing conditions will be an important part of the management effort and practice. No change made.

S-108
Comment: Instead of recommending guidelines be developed by wood suppliers and consumers (e.g., pp. 268-269), the GEIS should recommend using existing guidelines on all lands, and provide a vehicle for implementing these guidelines on lands without mandates and/or resources (e.g., county-administered and NIPF lands).

Response: Comment noted and discussion augmented accordingly.

S-109

Comment: The recommendation on page 258 to retain slash should describe on what soils this mitigation is required and in which ecoregions.

Response: Comment noted. Brief clarification added. Reader is further referenced to section 5.6.2.

S-110

Comment: The recommendation on page 268 dealing with increasing wood fiber productivity of timberlands should include a discussion of using forest pest management opportunities to decrease losses.

Response: Comment noted and material added.

S-111

Comment: In the discussion of statewide targets on page 250, the GEIS should identify the mechanisms for public input to the planning process.

Response: Comment noted. Reference of need to use public input to the planning process added.

S-112

Comment: The mitigation strategy regarding statewide inventories listed on page 246, second full paragraph, should list the kinds of data which should be collected in stand assessment to make forest inventories more useful for managing all forest resources, and better GIS distribution among cooperating agencies.

Response: Comment noted. The purpose of this section on statewide inventories is to suggest the general kinds of data deficient areas requiring augmentation to meet the needs of GEIS mitigation strategies, however, data elements specification is a technical subject with many complexities and costs that is beyond the scope of the GEIS. No change made.

S-113

Comment: The mitigation strategies listed on page 247 should either be reworded to recognize implementation of both the County Biological Survey and the Old-Growth Inventory (e.g., Complete implementation of the County Biological Survey and the Old-Growth Inventory in Forested Counties), or acknowledge in the text the broad array of activities that legitimately fall under the umbrella of the strategy as stated, including an assessment of forest landscape patterns at the regional level and an improved understanding of species-habitat associations and species-landscape associations.

Response: Comment noted. Section 8.3 of the GEIS has a more detailed description of forest-based research, to which the reader is referenced. No change made.

Ssection 6 Comments and Responses

S-114

Comment: The first sentence under "Conclusions" on page 363 should be replaced by the following:

> The study team constructed a computer model in the effort to approximate the behavior of Minnesota's forest resources. All data and conclusions based on this model are estimates and represent a direction or trend, rather than a firm number. The modelling effort found that significant environmental damage occurs at all three harvest scenarios but that damage can be mitigated with varying degrees of success as harvesting is increased. That model provides useful information but should not be considered by policy makers as a precise tool.
>
> The point estimate of the model is that 5.5 million cords could be harvested annually during each of the next 50 years if all mitigation recommendations were in effect today. That, however, is not the case. This estimate is only a theoretical maximum, as if the model perfectly reflected Minnesota forest resources. Since it does not, policy makers should not rely on this number when determining an annual level of logging which will be sustainable. The level of harvest which is sustainable depends on the uncertainty of the assumptions of the model. Over the study period, that uncertainty could be as high as 50 percent as experienced in the 1993 revisions to the RPA Assessment, depending on the validity of the assumptions.

Response: Comment noted. The section on Conclusions is augmented to clarify the importance of understanding the data assumptions and modelling and analysis that has led to these conclusions. Beyond that it is inappropriate to accept the suggestion that our best and yet still qualified estimates be rejected. That would in effect negate the entire study. The scoping document called for an effort that would provide the best estimates possible at this time. That would also seem appropriate to policy development. Policy makers are free to use this documentation as they see appropriate. The GEIS is a disclosure and recommendations document. It is not binding on the executive or legislative branch of government. Clarification added.

S-115

Comment: SA caveat should be added on page 357, fourth full paragraph, and page 431, third full paragraph, regarding the feasibility of connected landscapes due to their cost (see last paragraph on page 255 for potential wording).

Response: Comment noted. Material added.

S-116

Comment: The feasibility rating assigned to the biological survey as a mitigation strategy under the medium level of harvest should be revised to "low" as it will be very difficult to accelerate the biological survey. Similarly, the characterization of unmitigated impacts on page 362 as "localized" as unsurveyed acres would be harvested across the state.

Response: Comment noted. The biological survey is considered to have much potential, especially if it were redesigned specifically to sample townships (or counties) in a systematic fashion across the state at say a 1 in 10 township sampling intensity. That would help identify additions, presence, and absence of species in general across the state so as to guide practices. The current design of operating county by county is likely to be too slow to be effective. The consultant believes redesign of the survey to a sample of counties or townships across the state is an important alternative to consider. No change made.

Section 7 Comments and Responses

S-117

Comment: Pages 345 and 418 of the GEIS "Impacts on Forest Management" should be amended by deleting the current sentence and substituting the following language:

> Reliable estimates are not available for the additional funding and personnel that might be required by federal, state and county land management agencies to meet future increase in timber harvests. However, although reliable estimates of the amount are not available, substantial additional resources will need to be committed by state government and the counties to implement these recommendations. Whether those resources came from redeploying resources from other tasks or from increases to the overall agency budget will vary by agency. However, unless the recommended mitigations are implemented, the studied harvest levels are not sustainable.

Response: Comment noted. This topic is addressed further in sections 6.6.7, 7.6.7, and on a statewide basis in section 8.

S-118

Comment: There is a mathematical error on page 372, table 7.6, ecoregion 4, high scenario.

Response: Comment noted. Typographic error for ecoregion 4 corrected.

Section 8 Comments and Responses

S-119

Comment: Page 443 should be modified by inserting the following paragraph after the heading 8.1.3 "Policy Recommendations for Minnesota"
The GEIS has found these levels of logging are not sustainable over the long-term unless the specific recommended mitigation strategies are implemented. Unless implementation occurs across types of land ownerships, the Pollution Control Agency should review and modify as necessary existing permits. No new permits should be issued which would result in increased timber harvest nor should existing permits be renewed until the recommended mitigation strategies have been implemented (same comment as E-4).

Response: Comment noted. Identical comment as E-4 (see response to E-4).

S-120

Comment: On page 453, MNDNRs research programs (particularly those that emphasize multidisciplinary concerns and landscape-levels interactions) should be mentioned.

Response: Comment noted. Material added with response to comment S-8.

S-121

Comment: The suggestion in section 8.3.9 to take money from the general fund and provide assistance to recreation and resort businesses to compensate them for their loss should be deleted.

Response: Comment noted. There is no section 8.3.9 in the study. Furthermore, the issue raised was simply a speculative comment in the *Economics and Management Issues* technical paper and is not referenced anywhere in the GEIS document. No change possible.

S-122

Comment: The GEIS should state that loggers be certified not just for attending a course, but only after they have demonstrated the ability to apply BMPs in the field.

Response: Comment noted and material added.

S-123

Comment: The recommendation on pages 445-446 to establish mandatory compliance rules if compliance falls below a specified threshold is overly bureaucratic as:

- The state does not have the authority to review operations on private land or evaluate compliance;
- The data requirements needed to justify moving from a voluntary to mandatory program would be large, and would require substantial additional resources.

Response: Comment noted. Qualification added.

S-124

Comment: A Forest Resources Practices Program should be mandatory to ensure all ownerships comply with the prescribed standards.

Response: Comment noted. The choice of mandatory vs. a voluntary forest practices program is within the purview of policy makers, and will be a major issue as the state considers implementation options for the program recommendations in the GEIS. No change made.

S-125

Comment: The distinction between government intervention in land use and government's intervention in landowner activities within a given use should be addressed in the structure of any forest practices legislation, and described in the FRPP and SFRP.

Response: Comment noted. The comment raises a valid point, however, it is beyond the scope or need for the GEIS work. No change made.

S-126

Comment: The Forest Resources Practices Program should contain provisions for the development of educational programming to both forest landowners and the general public.

Response: Comment noted. The development of educational programming to both forest landowners and the general public is considered under extension and outreach activities later in section 8. No change made.

S-127

Comment: The Forest Resources Practices Program should include a mechanism to periodically conduct timber harvesting audits, much in the same fashion as is done with BMPs for water quality.

Response: Comment noted. The actual conduct of audits or assessing compliance is beyond the technical specificity of the GEIS. No change made.

S-128

Comment: The GEIS should discuss the data required to justify moving from a voluntary to mandatory program—the information needs would be large and their collection would require substantial additional resources.

Response: Comment noted. The GEIS does consider the cost and data requirements associated with moving from a voluntary to a mandatory program. These are identified in terms of a range of costs observed in a number of other states provided in this section and in appendix material. No change made.

S-129

Comment: The mitigation discussion on page 249 that addresses balancing age class and covertypes should identify targets and objectives that are accepted/developed at least by public landowners in a cooperative planning effort and an estimate of the resources required—this information should be identified by ecoregion.

Response: Comment noted. GEIS suggests that targets or covertype goals are appropriate. The GEIS is an analysis, however, and not a management planning effort involving negotiation among or across landowners. Such targets are suggested as a priority for development by the agencies and ownerships concerned. In fact, it is not at all clear what the long-term implications would be of various chosen targets as those implications would affect a wide variety of the forest and related resources discussed in this document. No change made.

S-130

Comment: The SFRP should mandate joint planning among resource agencies.

Response: Comment noted. The sustainable forest resources practices program cannot mandate by itself. It can only suggest. No change made.

S-131

Comment: Cooperative funding for the Forest Resources Research Program should be provided by private industry, environmental organizations and government.

Response: Comment noted. Clarification added.

S-132

Comment: A broad mix of interests should advise the development and execution of the Forest Resources Research Program.

Response: Comment noted. Material in section 8 explicitly addresses this point. No change made.

S-133

Comment: Section 8.3.4 should be eliminated as there is no need to create another layer of bureaucracy to oversee research.

Response: Comment noted. Section 8.3.4 does not, in fact, suggest the creation of additional layers of bureaucracy to oversee research. In fact, the suggestions involve only existing organizations and administrative structures and ways to consolidate and better manage. No change made.

S-134

Comment: A new section, 8.2.5, Education and Training-based Responses should be added just prior to the Forest Research section (8.3). This section should provide a broad-based discussion of recommendations on education and technical assistance.

Response: Comment noted. The issue is important. However, the GEIS team rejected this way of addressing education and training programs because they need to be interlaced into the three strategic programs that were recommended. The creation of a fourth strategic program that was actually part of the other three did not seem appropriate. No change made.

S-135

Comment: On page 451 under Suggested Strategic Responses, none of the five broad research areas listed are specifically addressed by the four strategies outlined as mitigation strategies in section 5.

Response: Comment noted. The linkage to GEIS recommended research strategies and needs is added to section 8.3.

S-136

Comment: The GEIS should provide more specific guidance regarding how to implement the study's recommendations.

Response: Comment noted. Section 8 and appendix 4 contain substantial implementation guidelines and suggestions. Further expansion here is outside the GEIS scope. No change made.

S-137

Comment: The GEIS should contain more specific data regarding the cost to implement the major mitigation recommendations, as well as who is expected to pay for these costs.

Response: Comment noted. Questions of cost and who might provide funding are included. Further expansion is outside the GEIS scope. No change made.

S-138

Comment: The GEIS should quantitatively indicate how effective the proposed mitigations would be if implemented at all three harvest scenarios.

Response: Comment noted. The precise implication of the proposed mitigation across all ownerships in a 50-year timeframe is beyond the scope of the GEIS. Furthermore, the data for this effort is not now available. No change made.

S-139

Comment: The GEIS should indicate the approximate schedule for implementing the study's recommendations.

Response: Comment noted. The scheduling aspect is addressed in sections 8.5.4 and 9.6. No change made.

S-140

Comment: The forest-based research mitigations should be removed from the mitigation section and put under a new heading "inventory needs."

Response: Comment noted. The GEIS study team does not concur. No change made.

S-141

Comment: The Board of Forest Resources should designate which forest areas (e.g., old-growth forest, riparian areas) should remain uncut.

Response: Comment noted. Detailed specification of forest area appropriate for various types of management is beyond the scope of the GEIS document. No change made.

S-142

Comment: The mission of a board of forest resources should be to balance market forces within and without the state, and create mechanisms to allow loggers to purchase expensive logging equipment that would allow smaller, but profitable cuts.

Response: Comment noted. Creating mechanisms (policy tools) to facilitate the marketplace and environmentally sound harvesting is an important consideration for state policy. The noted comment is, however, too narrowly focused in any regard. Yet further expansion of this topic is beyond the GEIS scope. No change made.

Section 9 Comments and Responses

S-143
Comment: Chapter 9 of the GEIS should be deleted from the document as it is inappropriate for subjective editorial comments to be included in a technical report.

Response: Comment noted. Inclusion of section 9 is quite appropriate in a GEIS document that is a mix of technical, administrative, educational, and policy materials. No change made.

Appendixes Comments and Responses

S-144
Comment: The list of identified research deficiencies in appendix 4 (pp. 4-8 to 4-12) should be the basis for all discussions of research direction identified in the text.

Response: Comment noted. Research needs and research mitigation strategies are not congruent. The needs lists need not be linked with the research mitigation strategies in sections 5 to 7. Furthermore, the research needs listed in appendix 4 are presented as the detail backup to the summarized material presented in section 8. In fact, section 8.3.3 references the reader to the more "comprehensive list of all major research initiatives identified in the GEIS process...." No change made.

S-145
Comment: The tables in appendix 2 should clarify that some of the short-lived species may convert into other types as the stand matures.

Response: Comment noted. Clarification about the future of short-lived species in appendix table will be augmented where those age tables are referred to from the main document and in a footnote to appendix 2, table 2.2.

S-146
Comment: The mitigation strategies are extremely important and those listed in appendix 1 should be relocated immediately after section 7.

Response: Appendix 1 summarizes all of the mitigation strategies from all nine technical papers. These were discussed by the GEIS Advisory Committee, and those that were accepted are in sections 5, 6, and 7. The full listing in appendix 1 is provided so that those readers who are interested can see the full slate of mitigation strategies from which the preferred strategies in the GEIS were selected. No change made.

S-147
Comment: The statement on the top of page 1-6, appendix 1, should explain why matching species to site negatively impacts biodiversity.

Response: Comment noted. Implications for biodiversity will be discussed further.

S-148
Comment: Appendix 1, page 1-27, incorrectly states that BMPs do not address depositing slash from upland areas into wetlands—they do.

Response: Comment noted. The reader is correct that BMPs state that slash should not be deposited into wetlands. However, there is some confusion among the public as to what a wetland is. The BMPs need to be clarified by adding more specific language, and state that ephemeral wet spots and streams in forests are included as wetlands. Absent this, no change can be made.

S-149
Comment: The discussion on page 1-33 of appendix 1, regarding the involvement of the MPCA and MNDNR-Fisheries in assessing impacts in riparian areas, should be revised to focus on educational efforts rather than establishing another review process.

Response: Comment noted. The wording on pages 1-33 to 1-34 more than adequately covers the required role of education. No change made.

S-150
Comment: The discussion of monitoring in appendix 1, page 1-9, should include the following mitigation: Increase tree species diversity at site and landscape levels.

Response: Comment noted. This concern is addressed under IPM strategies in section 5.7.2. No change made.

Other Suggested Changes to the Document
Study Assumptions Comments and Responses

G-1
Comment: The study assumptions, limitations and potential errors associated with the study's major findings and recommendations should be noted in the executive summary, and note how results and predictions would change if the assumptions are incorrect.

Response: Comment noted. This comment has been handled via changes made in response to previous comments.

G-2
Comment: The GEIS's assumptions that all mitigations are or will be implemented needs further discussion and clarification, particularly in light of the uncertainty regarding their use and effectiveness.

Response: Comment noted. The assumption that all mitigations are or will be implemented has already been elaborated upon further in several places in response to previous comments.

G-3
Comment: The GEIS should include a sensitivity analysis for each assumption used in the study, along with a clear interpretation of the results of each analysis.

Response: Comment noted. The comment has validity. However, the complexity and integrated nature of the analyses precludes such an exercise at this juncture. The GEIS team has introduced numerous caveats and cautions on this topic. No change made.

G-4
Comment: The GEIS should clarify the assumptions regarding the expected use of mitigation techniques in discussing the extent to which environmental impacts are projected over the next 50 years.

Response: Comment noted. Material addressing this point has already been added in response to previous comments.

G-5

Comment: The inability of the GEIS to deal with keystone species, biological thresholds and systems interactions at the community, ecosystem and landscape levels should be included in an expanded discussion of the assumptions and limitations of the model in the executive summary and in section 1.5.3, page 7.

Response: Comment noted. These issues are covered in depth in the *Forest Wildlife and Biodiversity* technical papers. Repeating this detail here or in the GEIS document would be inappropriate. However, in order to aid the reader in accessing a more detailed summary, the following has been extracted and summarized from the two technical papers (note no change made to GEIS).

Assumptions and limitation with regard to wildlife and biodiversity.

The major assumption made for analyses of wildlife and biodiversity, is that area of habitat is strongly related to species population, so that projected changes in habitat supplied by the harvest scenarios, can be used to predict future population changes in wildlife. Thus, there is no direct population modelling, keystone species, biological thresholds, or other interactions among species. In addition, the use of habitat area as the predictor of wildlife abundance results in exacerbation of projected impacts on wildlife due to timber harvesting alone in northern Minnesota, where forest area is projected to decline. Similarly, impacts due to harvesting alone in southern Minnesota are partially ameliorated by the projected increase in forest area in that part of the state. It should be noted that the habitat approach was the only feasible method for carrying out statewide analyses of wildlife populations, and the reader is directed to the wildlife and biodiversity technical papers for more discussion on the accuracy of the method, which varies among species and species groups.

Other limitations in the wildlife and biodiversity analyses include those related to the FIA: (1) FIA forest cover typing, which does not necessarily match the division of habitats in the natural world, (2) small-scale spatial factors important to individual animals species, such as abundance of woody debris, or presence of certain herbaceous plants, that are not included in the FIA database, (3) FIA data for reserved forests are much less complete than for timberlands, and (4) lack of spatial data, such as adjacency of two or more vegetation types that are necessary for some animal species. Limitations related to the harvest scenarios include: (1) the postcutting successional sequences in the model do not take into account the full complicated web of successional interactions and mechanisms, (2) covertype change at harvest is modelled with transition probabilities, where probabilities of converting from, for example white pine to aspen, are assumed to be the same with future harvests as in the recent past, (3) lack of detail on the spatial relationship among harvested stands, and the distribution of stands that are harvested by techniques other than clearcutting. Finally, lack of knowledge affected the analyses in the following areas: (1) effects of fragmentation on movement of animals and dispersal of plants, (2) geographic distribution of most plant species and some animal species, (3) amount and distribution of old growth, (4) genetic structure of most plant and animal populations, and (5) all aspects of amphibian and reptile biology.

G-6

Comment: The assumption that the basic tree growth model assumes constant site productivity over time should be stated in the GEIS.

Response: Comment noted. Assumptions about site productivity added.

G-7

Comment: The assumption that an arbitrary amount of old-growth and replacement acreage would be found and reserved on MNDNR and USDA Forest Service lands (i.e., 1 to 2 plots per covertype of 1,300 to 6,600 acres) should be stated in the GEIS.

Response: Comment noted. The description of how old-growth and replacement acreage is handled in the GEIS is augmented in section 2.3.1.

G-8

Comment: The assumption that USDA Forest Service logging will continue indefinitely at the current maximum ASQ under the first two scenarios, and will actually increase from current levels under the third, should be stated in the GEIS.

Response: Comment noted. The assumptions about continuation of USDA Forest Service harvest level is in section 2.3.1 and is added to the executive summary for clarity.

G-9

Comment: The limitations of the model's assumption that harvest decisions are made on the basis of least cost economic considerations across all ownerships should be stated in the GEIS.

Response: Comment noted. Model's assumption about economic considerations as the basis for harvest clarified in section 2.3.1.

G-10

Comment: The discussion of assessment limitations included on pages 75-79 of the Forest Wildlife technical paper should be included in the GEIS.

Response: Comment noted. See response to G-5.

G-11

Comment: The GEIS should summarize the ten limitations related to the harvest scenarios and the FIA database, as well as the five areas lacking in information, as stated in the Wildlife technical paper on pages 75-79.

Response: Comment noted. See response to G-5.

G-12

Comment: The GEIS should state that the study likely underestimated the negative impacts to wildlife because the study wrongly assumed that wildlife corridors exist on public lands and nonpublic lands in southeast Minnesota, and that BMPs prohibit clearcutting next to waterbodies.

Response: Comment noted. The comment suggests that negative impacts to wildlife are underestimated due to assumptions that several constraints on harvesting exist when in fact they do not. However, the GEIS harvesting scenarios assume that the constraints on harvesting listed by the reader will take place in the future, in order to mitigate the impacts of timber harvesting, ie. these constraints are actually mitigations. The GEIS does not assume that all of these constraints are now or have been in place. The impacts on wildlife projected in the GEIS are those that will take place if this list of constraints is put into practice. No change made.

G-13

Comment: The GEIS should point out more clearly the lack of information available to adequately assess the impacts of timber harvesting on biodiversity.

Response: Comment noted. See response to G-5.

G-14

Comment: Because the projected employment figures included in the GEIS seem very unrealistic, the section on economic impacts should be rewritten to include more realistic assumptions about expanded employment resulting from increased harvesting.

Response: Comment noted. Consultant does not agree that the projected employment figures are unrealistic based on available data sources. However, further research here is appropriate, as has been recommended (see appendix 4). No change made.

G-15

Comment: The assumption "a proportion of sites are likely to be protected because they are located in areas harvested when the ground is frozen" should be modified as it is an oversimplification for the data contained in the Unique Historical and Cultural Resources technical paper which states that specific conditions of both frost depth and snow cover must be present before it can be assumed that harvest will be impact-free.

Response: Comment noted. Comment is valid, however, GEIS covers this adequately for its purpose. No change made.

Resource Description Comments and Responses

G-16

Comment: The GEIS should include a discussion of how today's forests differ from that of pre-European settlement with respect to forest composition, size, structure, age and associated wildlife populations, and that the present state of Minnesota's forests was used as a reference point and not necessarily a desirable state.

Response: Comment noted. Biodiversity, in terms of species number and abundance, old growth, and a variety of natural communities was maximal in presettlement times, and has declined steadily since then. One of the purposes of the GEIS, and of improving forest management practices today, is to prevent further loss, or reverse the loss, of biodiversity. This is why 1990 was used as the base year for comparison. Comparisons with other dates, such as presettlement times or 1900, are interesting in their own right. However, for future forests, we can only start with what we have now. No change made.

G-17

Comment: On page vi and 65 of the draft GEIS, it should be stated that Minnesota's forest land *can be* classified into 14 types, and that such an approach has been taken in the GEIS.

Response: Comment noted. Change made.

G-18

Comment: The GEIS should include a section on the historical budgets of the DNR-Forestry Division.

Response: Comment noted. The GEIS is not the appropriate place for this material. No change made.

G-19

Comment: Presettlement forests should be discussed and contrasted with the species mix and existing in 1990.

Response: Comment noted. Information contrasted presettlement and present species mix has been augmented (see response to E-24).

G-20

Comment: The historical discussion of Minnesota's forests should recognize the use of forests by the Anishinabe people.

Response: Comment noted. Historical discussion of Minnesota's forests by Native Americans will be augmented.

G-21

Comment: The discussion on disposition of Anishinabe lands should reference the various treaties signed with the federal government.

Response: Comment noted. Such detailed discussion on this topic is beyond the scope of this document. No change made.

G-22

Comment: The GEIS should contain more discussion regarding the present status of ceded lands that were federally granted to the schools, university and railroads.

Response: Comment noted. Some of this information is provided in the background paper on Minnesota's public forestry organizations. Further discussion of status of ceded lands is beyond the scope of this document. No change made.

G-23

Comment: The GEIS should state that 4.0 million cords is the approximate level of statewide timber harvesting that is likely to occur in 1993, not 1990—3.5 million cords was the level of harvesting that occurred in 1990.

Response: Comment noted. Including firewood, the 1990 removals were approximately 4.0 million cords. No change made.

G-24

Comment: 4.9 million cords is no longer a realistic harvest level projection for 1995—the year 2000 would be more accurate. The text should explain that the 4.9 million cord projection for 1995 was made several years ago and is out of date, but was the best projection available at the time the GEIS was initiated.

Response: Comment noted. The 4.9 million cord level was somewhat arbitrary in the first place. Furthermore, it represents a decade in the model analysis. No effect results from further explanation. No change made.

Resource Sustainability Comments and Responses

G-25

Comment: The GEIS should clarify that reference to 5.5 million cords is an upper bounds limit on sustainable yield for timber only, and not consistent with how sustainable is defined and used in other parts of the document.

Response: Comment noted. Sustainability context of 5.5 million cords is consistent in how it was defined and used in other parts of the document. No change made.

G-26

Comment: The GEIS should state that the current levels of logging are not sustainable and will not be until the mitigations are in place.

Response: Comment noted. Clarification on the sustainability of harvest level and the importance of implementation of the mitigations will be augmented.

G-27

Comment: The definition of "sustainable" should be more clearly explained.

Response: Comment noted. Sustainability has been further clarified for consistency in the document.

G-28

Comment: Reference to 5.5 million cords as a maximum sustainable cut should be rephrased to "more than 4.9 million cords, but less than 7.0 million cords."

Response: Comment noted. Consultant finds specific reference to 4.9, 5.5, and 7.0 million cords as consistent with the approved study plan and the scoping document. No change made.

G-29

Comment: The GEIS should further clarify the uncertainty regarding the study conclusions that harvest levels are sustainable.

Response: Comment noted. Clarification in response to other similar comments already added.

G-30

Comment: The maximum sustainable harvest level of 5.5 million cords should be revised downward, and the expected negative impacts revised upward, since the GEIS incorrectly assumed that all mitigations will be followed on a voluntary basis.

Response: Comment noted. The GEIS did not assume that all mitigations will be followed on a voluntary basis. No revisions are appropriate at this time.

G-31

Comment: The long-term sustained yield calculation should project maximum sustained yield values under different assumptions regarding future timberland availability.

Response: Comment noted. The GEIS scoping document and approved study plan call for analyses of three perspective harvest levels and identification of that level which might be sustainable and a corresponding set of assumptions. Further analyses of portions of the state have been conducted to-date and are described in reports from a conference at the Cloquet Forestry Center, October 6, 1993 (Blinn, C. R.,ed. 1993. *Investing in Minnesota's public forests. Proc. of conference.* St. Paul, MN: University of Minnesota, Department of Forest Resources. 63 p. and associated reports). However, further scenarios as part of the GEIS itself are beyond the scope of work. No change made.

G-32

Comment: The GEIS should calculate sustainable yield using different land-use scenarios.

Response: Comment noted. The GEIS first and second runs differed in their assumptions about land use changes. The first runs assumed no change in forest area. The second runs assumed the study estimated changes in forest area by FIA unit. In this regard the issue has already been addressed. No change made.

G-33

Comment: More extensive discussion about the assumptions used to derive the 5.5 million cord figure as the maximum sustainable harvest level should be included in the document.

Response: Comment noted. More discussion about the assumptions used to drive the 5.5 million cord figure has been included in response to previous comments.

G-34

Comment: The GEIS should not make any statements regarding the maximum sustainable yield level for timber production.

Response: Comment noted. The GEIS provides statements regarding maximum sustainable yield harvest levels as per specifications in the FSD. No change made.

G-35

Comment: The term "sustainable" is misleading because the GEIS uses this adjective in different ways in different places (e.g., p. 152 vs. xxiv).

Response: Comment noted. "Sustainability" is further clarified and qualified in several places in the document.

Mitigation Comments and Responses

G-36

Comment: The GEIS should state that implementing the mitigations will require an increase in public expenditures, and that if Minnesota is to continue logging at current rates or higher, additional public expenditures will be necessary.

Response: Comment noted. Personnel needs of government with respect to harvest levels are noted in the document. Mention of additional public expenditures is appropriate as is discussion of additional revenue which is also referenced in section 8 and appendix 4. No change made.

G-37

Comment: Because research is not a mitigation, any discussion of forest-based research should be included in the Strategic Responses Section rather than piecemeal in the section Mitigation Strategies.

Response: Comment noted: Research can be long-term, short-term, basic, or applied. That which is more appropriate to long-term considerations in emphasized in the strategic responses section. The context in which it is used as a mitigation strategy is appropriate. No change made.

G-38

Comment: The GEIS should clarify the assumption regarding why no old growth forests are projected to be harvested over the study period.

Response: Comment noted. See response to GC-70 and GC-71. No change made.

G-39

Comment: The GEIS should identify a target for age class distribution which is accepted/developed at least by public landowners in a cooperative planning effort; and in the case of noncommercial treatment, an estimate of the resources required.

Response: Comment noted. The GEIS mentions covertype and age class distribution both in general support of balances age class distribution. However, that balance will depend upon rotation and extended rotation ages and natural suggestion of forests. This specification would require more analysis than has been possible in the GEIS. No change made.

G-40

Comment: The GEIS should point out that land-spreading sludge and ash can mitigate nutrient losses.

Response: Comment noted. Spreading sludge and ash can mitigate nutrient losses; however, that is not expected to develop on a large scale. As such, no treatment in the GEIS seems needed. No change made.

G-41

Comment: The suggestion to increase advertising to attract more tourism due to adverse impacts of timber harvesting should be deleted.

Response: Comment noted. The GEIS does not mention this topic. No change possible.

G-42

Comment: The suggestion to change the nature or clientele of the tourism industry should be deleted.

Response: Comment noted. The GEIS does not mention this topic. No change possible.

G-43

Comment: The GEIS should set a 72 percent waste paper recovery goal, then translate that into savings of trees in terms of cords per year.

Response: Comment noted. The GEIS is a disclosure document, setting statewide recovery goals is outside the study scope. No change made.

G-44

Comment: The GEIS should establish guidelines for the development of deinking facilities and regulations permitting future expansions in Minnesota only of paper mills that utilize recycled pulp.

Response: Comment noted. Such guidelines are problematic at best and certainly outside the GEIS scope. No change made.

G-45

Comment: The mitigation regarding modifying the season of harvest should be further developed and provide more specific information regarding its application and how such a mitigation might be implemented.

Response: Comment noted. Discussion of modifying the season of harvest has been clarified in response to other comments.

G-46

Comment: The recommendation to intensively thin stands to increase productivity should include snag retention as a component of this practice.

Response: Comment noted. Thinning and hygiene practices in forests should not be carried to extremes. Discussion modified to indicate the importance of snags and trees with cavities to wildlife.

G-47

Comment: Extended rotation forest recommendations should include specific acreage percentages for each major ownership category.

Response: Comment noted. Questions of extended rotation acreage goals by ownership is in the purview of state officials. It is beyond the GEIS scope. No change made.

G-48

Comment: The forest-based research mitigation linking forest management and tourism should be deleted.

Response: Comment noted. Consultant disagrees. Research linking forest management and tourism is a key component of understanding economic impacts statewide. No change made.

G-49

Comment: The discussion regarding timber sale design and layout addressing nontimber concerns should point out that biodiversity concerns can also be addressed in the design of a timber sale through such things as corridors, stand size and age class structure.

Response: Comment noted. Extra emphasis has already been added to indicate the biodiversity concerns that might be addressed through timber sale design. No further change made.

G-50

Comment: The GEIS should specify whether the 20 percent extended rotation forestry recommendation means: (1) at any point in time, 20 percent of a type will be beyond rotation age; or (2) 20 percent of a type will be managed under an extended rotation forestry prescription.

Response: Comment noted. The reader's point number 2 is correct. Clarification of extended rotation forestry recommendations made.

G-51

Comment: The GEIS should more clearly define the applications of integrated pest management strategies, especially in dealing with situations which may occur with extended rotation forests.

Response: Comment noted. Discussion of integrated pest management in dealing with extended rotation forests is added to section 5.6.1.

G-52

Comment: The recommendations regarding protection of burial sites in Minnesota should include a number of more restrictive regulatory measures and monitoring programs for protecting these sites that could be destroyed by timber harvesting.

Response: Comment noted. The protection of burial sites is covered in the background paper on cultural resources and involves a number of drill checking and informational considerations that make specific recommendations at this time problematic. No change made.

G-53

Comment: The issue of who will pay for the increased costs of intensive management needs to be addressed in the GEIS.

Response: Comment noted. The question of who will pay for forest management investments or lack of investments and who will pay directly or indirectly is important in developing policy. Ultimately society will pay for whatever management is imposed. Those costs of management are discussed in the document under section 8 and in appendix 4. No change made.

G-54

Comment: The GEIS should clearly distinguish between public and private forest lands when presenting and discussing possible programmatic responses.

Response: Comment noted. This distinction already exists in the GEIS. No change made.

G-55

Comment: The recommendation to employ more extensive use of silvicultural methods other than clearcutting should be further clarified.

Response: Comment noted. Reference the *Silvicultural Systems* background paper. No changes needed to the GEIS.

G-56

Comment: The GEIS should indicate the expected effectiveness of the listed mitigations in reducing wildlife impacts.

Response: Comment noted. The GEIS does indicate the expected effectiveness of the listed mitigations in reducing wildlife impacts. However, lacking detailed cause and effect data and the interaction with other mitigations and programmatic responses, it is difficult to be more specific. No change possible.

G-57

Comment: In order to be more meaningful, the recommended mitigation strategies should have specific goals.

Response: Comment noted. The consultant notes that increasingly specific goals will have to be identified post-GEIS by the public agencies and landowners concerned as the study recommendations are being implemented. No change made.

G-58

Comment: The GEIS should clarify in its discussion of riparian mitigations that state shoreland rules do not impose any constraints on timber harvesting or other forest management activities in riparian zones.

Response: Comment noted. The state shoreland rules as applied to timber harvesting and other forest management and riparian zones will be clarified.

G-59

Comment: The forest health mitigation recommendation to "manage changes in susceptibility and vulnerability associated with age class" contradicts the wildlife mitigation of leaving areas of extended rotation forest—these contradictions should be pointed out as being a factor that lessens the conclusion of a 5.5 million cord sustainable harvest level.

Response: Comment noted. A number of mitigations would appear in general to conflict with other mitigations; however, on a site-specific basis it may well be possible to manage the overlapping mitigations. In other cases it is true that management for the highest goals with respect to one characteristic may disadvantage achievement of goals for other forest characteristics. It is a fact that it is impossible to optimize the characteristics simultaneously if they, in fact, compete for or require some of the same resources. Consequently, the concept of constraint and some form of sustainable balance is central to the long-term management. No change made.

G-60

Comment: A mechanism to monitor BMPs compliance on a regular basis should be established.

Response: Comment noted. Mechanisms to monitor practices in compliance on a regular basis are already discussed in the document and an important consideration in application. No change made.

G-61

Comment: Minnesota loggers probably don't have the means to field test debarking equipment or cut-to-length systems—cost figures for switching to more automated systems need to be provided.

Response: Comment noted. No change needed.

G-62

Comment: The GEIS should explain who will be responsible for implementing the proposed mitigations.

Response: Comment noted. The document describes who might implement recommendacions in discussions of their cost and effectiveness and feasibility in sections 5, 6, and 7 and also in appendix 1. Additionally, implementation is described in section 8. No further additions made.

Discussion or Analysis Comments and Responses

G-63

Comment: A second model run at the 4.9 million cord level without assuming the five environmental protections are in place should be included in the GEIS.

Response: Comment noted. Additional model runs are beyond the scope of the GEIS. Additional runs and analysis are suggested in the research recommendations. No change made.

G-64

Comment: A second model run at the 4.9 million cord level assuming: (1) the five environmental protections are not in place; (2) a 150-year time horizon; and (3) a 10 percent decline in forest land every year should be included in the GEIS.

Response: Additional model runs and sensitivities are beyond the scope of the GEIS. See response to G-3. No change made.

G-65

Comment: The GEIS should state where the forest products produced in the state are shipped.

Response: The GEIS does suggest where forest products produced in the state are marketed. Additional detail is beyond the scope of the document. No change made.

G-66

Comment: The GEIS should address the introduction of dangerous nonnatives into the forest (e.g., buckthorn).

Response: Comment noted. The GEIS does contain general discussions on the implications of exotic species being introduced in Minnesota's forests. See the *Biodiversity* technical paper for more detail. No change made.

G-67

Comment: The GEIS should better clarify the impacts projected to occur at each of the three scenarios, as well as effectiveness of the mitigations at each harvest level as the severity of the impacts increase.

Response: Comment noted. The document has already been augmented to address mitigation needs and their importance with increasing harvest level. No further changes made.

G-68

Comment: References to forest health in the GEIS should emphasize that the impact assessments addressed losses in timber productivity due to insects and disease, not the overall health of the forest ecosystem.

Response: Comment noted. The GEIS does describe the nature of forest health, its possible interpretations and, in particular, the effects of insects and disease on the tree component. The overall health of the forest ecosystem is covered by design in a range of documents considering wildlife, biodiversity, soils, etc. No further comment required.

G-69

Comment: The GEIS should explain which BMPs require thinning or extended rotation forest practices within 100 feet of water (p. iii), and whether this constraint was applied to all lands.

Response: Comment noted. The BMPs assumptions in the model runs are described in the document as pertaining to all lands. Extended rotation forest practices are described in the document as pertaining to state and federal lands. No further clarification needed.

G-70

Comment: More information on the projected gains and losses of forest land in the northern and southern parts of the state (pp. 232-233 of the Productivity technical paper) should be included in the GEIS.

Response: Comment noted. More summary information on forest land area change implications included in section 2.3.1 of the document.

G-71

Comment: The draft GEIS needs to address the significant issue of wet soil compaction.

Response: Comment noted. The GEIS addresses wet soil compaction in section 5.3.1. For more detail, see the *Forest Soils* technical paper. No change made.

G-72

Comment: The GEIS should place greater emphasis on collecting data that determines the net overall economic impact of timber harvesting in Minnesota.

Response: Comment noted. The GEIS does place considerable emphasis on the overall economic impact of timber harvesting in Minnesota. Shortcomings and available data are addressed under research recommendations. No change needed.

G-73

Comment: More information on the conclusion that current aspen demand cannot be sustained under any of the harvest scenarios should be provided in the GEIS.

Response: Comment noted. Background on the assumptions for aspen demand are described in section 5.1.1. Further detail is provided in the *Maintaining Productivity and the Forest Resource Base* technical paper. No material added.

G-74

Comment: The GEIS should identify the magnitude of additional public expenditures necessary to make the medium and high harvest scenarios sustainable.

Response: Comment noted. The comment is valid and is addressed in a general fashion in section 8 and appendix 4. Further clarification is beyond the scope of the GEIS. State policy efforts will need to address this as the GEIS recommendations are being implemented. No additions made.

G-75

Comment: The GEIS should acknowledge that federal and state laws governing county actions regarding endangered and threatened species are not very effective because there are no personnel responsible for review or enforcement.

Response: Comment noted. This is a nationwide concern for many ownerships. Discussion augmented in section 8.1.5 to suggest consideration of personnel needs to treat endangered and threatened species concerns.

G-76

Comment: More specific information should be provided in the GEIS regarding why a species is projected to decrease as a result of timber harvesting.

Response: Comment noted. The GEIS indicates that projections of species decreases are the result of linking population levels to the presence of habitat. As the forest changes, habitat values invariably change. That is the principal reason why species are projected to decrease or increase. Clarification added. More detail provided in the *Forest Wildlife* technical paper.

G-77

Comment: The GEIS should clarify in the recommended mitigation sections that inventories of old-growth forests, by themselves, will not necessarily protect them from harvest. Policies and management guidelines also need to be put in place.

Response: Comment noted. The GEIS emphasized the importance of policy and management guidelines needed for the protection of old growth forests. See also response to GC-70. No change made.

G-78

Comment: The GEIS should reference the Menominee Nation forestry methods for establishing sustainable forestry.

Response: Comment noted. The Menominee Nation is recognized as having long practiced selection forest management over a large area. There is less useful documentation of the overall benefits of that as an example of sustainable forestry and all its ramifications. No additions warranted.

G-79

Comment: The GEIS should provide a more complete analysis of the impacts of forest road development.

Response: Comment noted. The analysis of forest road development, objectives and implications is drawn from several technical and background papers. Impacts are in turn discussed in the GEIS under the area of soils, water quality, recreation, etc. No changes made.

G-80

Comment: The GEIS should include information on the current road milage already in the state's forests, or projections of future road construction.

Response: Comment noted. Specific data is limited. Broad review provided in G-79 response. No change made.

G-81

Comment: The GEIS should clarify why statewide impacts for wildlife are stated in the GEIS, or remove the statewide wildlife impact tables from the document.

Response: Comment noted. The GEIS includes a number of descriptions of impacts at a variety of levels so as to provide helpful interpretation of impacts. It is well known that the number of impacts noted in analysis is the function of the breakdown of the subject area. There is no one best breakdown. Consequently, an interpretation of impacts is included at a fairly fine level of resolution, the ecosystem level, and at the statewide level. No other changes made.

G-82

Comment: The GEIS should not include any economic data until the information on the tourism and recreation industry is determined.

Response: Comment noted. The consultant disagrees. Recent trends in the overall economic picture of the tourism and recreation and the forest products industry are both rising. Information that is lacking is on the linkage between the two. Consequently, it seems counterproductive to delete information on the health of the respective components when only some linkage information is lacking. No changes made.

G-83

Comment: A third model run should be conducted using only those management policies and practices that are currently in place.

Response: Comment noted. See response to G-63. No change made.

G-84

Comment: The GEIS should disclose rotation ages by type and the derived allowable cuts by ownership.

Response: Comment noted. The GEIS rotation age information in the *Maintaining Productivity and the Forest Resource Base* technical paper is added to section 2.3.1. Allowable cuts can be determined in a number of ways through a variety of assumptions. It is beyond the scope of this document to derive them by ownership. Rather, three harvest levels have been projected, and their implications as per the scoping document have been estimated. Allowable cuts and investments can and do vary by ownership. This document assumes a continuation of current investment levels in forest management. Higher or lower investment levels and their implications are discussed in the document.

G-85

Comment: Forest health and deer populations should not be equated in the draft GEIS.

Response: Comment noted. Forest health and deer populations are not equated in the draft GEIS, rather they are both discussed from the standpoint of how they might effect each other and how they are impacted by harvesting levels. No change required.

G-86

Comment: In calculating average age, the GEIS should focus on the projected acreage of each type under the rotation for each forest type.

Response: Comment noted. The calculation of forest age was based on the age of FIA plots weighted by the acreage they represent. Those calculations incorporate consideration of the modelled rotation ages.

G-87

Comment: The tables in appendix 2 should be moved to the main body of the GEIS text.

Response: Comment noted. Concern for the visibility of appendix table 2 is treated by emphasizing the location of that information and the content of those tables. No change made.

G-88

Comment: The GEIS should distinguish commercially valuable red oak from noncommercial stands outside southeast MN in order to avoid masking the extent of current and planned depletion of this resource from this part of the state.

Response: Comment noted. The GEIS treated oak in southern Minnesota separately from that in the northern part of the state with respect to projected harvesting and assumptions. Detail on that analysis is provided in the *Maintaining Productivity and the Forest Resource Base* technical paper. No change made.

G-89

Comment: The GEIS should describe the extent to which the red oak ecosystem has been and is currently being destroyed in southern Minnesota.

Response: Comment noted. The GEIS does not find that the red oak ecosystem in southern Minnesota is being destroyed. Evidence indicates the oak forest acreage is increasing; the quality of that resource is problematic, and the GEIS notes this. No change made.

G-90

Comment: The GEIS should project what level of cutting is sustainable for the red oak resource.

Response: Comment noted. The GEIS does indicate the level of cutting sustainable for the red oak resource. That level of harvesting is described in some detail in the *Maintaining Productivity and the Forest Resource Base* technical paper. No change needed.

G-91

Comment: The tables that project average stand age by covertype and harvest scenario should be modified to exclude national park tree data, as these trees are not available for harvest.

Response: Comment noted. The projected average stand age by covertype and harvest scenario includes all trees including those in reserved areas. As trees in reserved areas age, portions of the forest are reserved as old growth or managed under extended rotations, the forest may well develop a multimodel age class structure within any particular covertype. These implications are discussed in the section on projected forest age. Changes are not warranted.

G-92

Comment: The GEIS should determine the cumulative mileage of stream impact areas within each ecoregion.

Response: Comment noted. The mileage of stream impact areas within each ecoregion aside from general statements is beyond the scope of the GEIS. No change made.

G-93

Comment: The GEIS should assess the impact on fish breeding and hatching after 2 to 5 years of increased sedimentation, nutrient loading, light, and temperature.

Response: Comment noted. Impacts on fisheries were considered in detail in the technical paper on water quality and fisheries. No more detail required.

G-94

Comment: The GEIS should discuss the impacts of controlling pests due to a decreased harvest.

Response: Comment noted. The GEIS does discuss the impacts of controlling pests due to potentially decreased harvesting. No more detail required.

G-95

Comment: The GEIS should have more specific information on which bird species decline with increased harvesting.

Response: Comment noted. The GEIS does incorporate a complete list of all negatively impacted species for the base, medium, and high scenarios in sections 5.6.4, 6.6.4, and 7.7.4, respectively. No additions needed.

G-96

Comment: The GEIS should identify which species and biological communities are sensitive to harvest.

Response: Comment noted. These are listed in tables in section 5.6.1. Also see response to G-95.

G-97

Comment: The GEIS should discuss which species are presently limited more by other factors such as hunting than by habitat availability.

Response: Comment noted. Factors other than harvesting and forest management are beyond the scope of the GEIS. The reader is directed to the *Forest Wildlife* technical paper. No change made.

G-98

Comment: A Missouri study by Thompson et al. (1992) examining the issue of landscape fragmentation not dominated by agriculture or urbanization should be referenced in the discussion of acceptable bird habitat requirements.

Response: Comment noted. It is not possible for the GEIS to incorporate at every step all the new literature which may have since arisen. In fact, the consultant has incorporated much of the published literature, and to some extent, the as yet unpublished information in the technical background papers. No additions made.

G-99

Comment: The GEIS should provide a better explanation regarding the differences between statewide and ecoregion wildlife impacts—how they were calculated and how to interpret the results.

Response: Comment noted. Elaboration of the statewide versus ecoregion wildlife impacts and how to interpret them provided in section 5.6.4. See also response to G-81.

G-100

Comment: The GEIS needs a stronger focus on biodiversity and the effects of various kinds of cutting on different various wildlife habitat.

Response: Comment noted. The GEIS is directed to consider biological, social, and economic impacts of harvesting and does so in detail to the extent that information is available. No one area should be the focus. No change introduced.

G-101

Comment: The relationship between clearcutting and the aesthetic values of the forest should be discussed in the GEIS.

Response: The relationship between clearcutting and aesthetics values is discussed in the GEIS. See the *Recreation and Aesthetics* technical paper for more detail. No additions made.

G-102

Comment: The draft GEIS should clarify numbers on economic impacts—loss of jobs in the tourism and recreation industry are not quantified in the draft GEIS, and the value of increased economic output does not acknowledge increased costs borne by counties, MNDNR, private landowners and loggers when necessary management changes are made.

Response: Comment noted. The GEIS does point out the trend in jobs in the tourism and recreation industry. Additionally, it does discuss the increased costs that might be borne by various parties as management changes are made. However, it is difficult to be specific about either one of these given available information. Additional detail is not is possible.

G-103

Comment: The GEIS should make it clear exactly what was considered in the GEIS related to the economic analysis conducted.

Response: Comment noted. The GEIS does describe the key elements of economic analysis considered. Additionally, the *Economics and Management* technical paper contains great detail. Please refer to that document. No change made.

G-104

Comment: The export of pulp substitutes and high grade deinking from Minnesota mills should be further explained and clarified in the GEIS.

Response: Comment noted. The subject of pulp substitutes and deinking is explained in the GEIS to the extent that the consultants have knowledge of it. No additions made.

G-105

Comment: The GEIS should examine how much OWP can be reliably collected in Minnesota and imported from the Midwest region to expand deinking capacity.

Response: Comment noted. The GEIS does examine implications of expanded deinking capacity in the Midwest and Minnesota. Please refer to the *Recycled Fiber Opportunities* background paper. No additions provided.

G-106

Comment: The GEIS should discuss technological developments that enable greater flexibility in using different wastepaper sources.

Response: Comment noted. This material has been discussed thoroughly within the GEIS. See also G-105 response. No change made.

G-107

Comment: The GEIS should provide a detailed economic analysis of the cost structure of virgin vs. deinked pulp.

Response: Comment noted. This request is clearly outside the GEIS FSD. No material added.

G-108

Comment: The GEIS should address the issue of energy consumption in virgin vs. recycled paper production.

Response: Comment noted. See response to G-107.

G-109

Comment: The economic analysis of additional jobs resulting from increased timber harvesting should include additional employment resulting from development of the Synertec deinking mill.

Response: Comment noted. The Superior Recycled Fiber Incorporated (SRFI) mill employment should not be added to timber-related employment levels. No change made.

G-110

Comment: The inconsistent forest management principles of the USDA-Forest Service need to be addressed in the GEIS.

Response: The management principles of the USDA Forest Service and certain documentable deficiencies have been addressed as much as is possible in section 4. No changes made.

G-111

Comment: The GEIS should specifically note whole tree burning for energy, and specifically exempt it from study in the GEIS.

Response: The GEIS study was scoped to include harvest levels for whatever purpose. It is inappropriate to exclude whole tree burning for energy. No changes made.

G-112
Comment: Details of an out-of-court settlement between various environmental groups and Aitkin, Cass and Crow Wing counties should be noted in the GEIS.

Response: Comment noted. The details of the settlement are beyond the scope of the GEIS. No changes added.

G-113
Comment: The GEIS should include a discussion about the impacts of timber harvesting on bacteria.

Response: Comment noted. Discussion of the impacts of timber harvesting on bacteria is beyond the scope of the study. No changes made.

G-114
Comment: The GEIS should note in the section on Impacts on Unique Cultural and Historic Resources that the intact forest is the cultural and historic resource.

Response: Comment noted. Consultant found a range of definitions of resource characteristics of values important to assessing cultural and historic resources. Interpretation in the comment is one of those. No changes made.

G-115
Comment: The economic analysis should break out value-added industry to reflect southeast Minnesota's red oak supply.

Response: Comment noted. The value added by the processing of the red oak resource supply in southeastern Minnesota is important, however, its breakout is beyond the scope of the GEIS. No change made.

G-116
Comment: The assumed increases in secondary employment associated with the conclusion that 6,800 jobs will be added by increasing harvesting to 4.9 million cords annually appears high and should be reevaluated.

Response: Comment noted. The secondary employment associated with the 4.9 million harvest scenario is the consultant's best estimate. It appears high to some, low to others. It has already been the subject of considerable evaluation and reevaluation. No change made.

G-117
Comment: More information on silviculture and regeneration systems should be included in the GEIS.

Response: Comment noted. More information can be found by reviewing the *Silvicultural Systems* background paper. No additions made.

G-118

Comment: The GEIS should examine the effects of stretching out of the lifetime of aspen.

Response: Comment noted. The GEIS has described in several places the implications of stretching out aspen rotations. No new material added.

G-119

Comment: The practice of harvesting aspen and dropping maple to rot should be more thoroughly addressed in GEIS.

Response: Comment noted. The implications of various harvesting and silvicultural practices is described in the background papers on silviculture and forest harvesting. Since site specific practices vary widely and change over time, it is difficult to address them in great detail within the GEIS. Rather, those concerns are appropriate to research and evaluation efforts focused on in section 8 and associated appendixes. No changes made.

G-120

Comment: The analysis of recycled fiber opportunities should reference technical developments and fiber alternatives instituted by the federal government.

Response: Comment noted. The federal government has instituted no technical developments or fiber alternatives anywhere in the U.S. No change is appropriate.

G-121

Comment: The GEIS should provide a more thorough explanation as to how the significance criteria for wildlife populations were selected.

Response: Comment noted. Description of the development of significance criteria are provided in detail in the *Forest Wildlife* technical paper. No material added.

Study Conclusions Comments and Responses

G-122

Comment: The conclusion of a "sustainable" harvest level should be revised downward to recognize that the management changes necessary to mitigate identified environmental harm will not occur to the extent assumed by the GEIS on privately owned, county managed, state and federal forest lands.

Response: Comment noted. The GEIS makes assumptions in its projections about the management changes likely to be implemented. The consultant feels there is good evidence to support the assumptions made about mitigation implementation. No changes made.

G-123

Comment: The GEIS should have a definite statement opposing all clearcutting.

Response: Comment noted. The consultant disagrees. No change made.

G-124

Comment: The EQB should recommend lower timber harvesting below the current 4.0 million cord level.

Response: Comment noted. The GEIS does not advocate any particular harvest level. The levels used were established by the FSD to help document potential impacts as levels changed. Neither the GEIS nor the EQB recommend any best harvest level. No change needed.

G-125

Comment: The GEIS's conclusions regarding quantities of northern white cedar are flawed and need to be modified because they fail to take into account the fact that deer browse 100 percent of natural cedar reproduction in most areas of Minnesota as well as seed tree removal by clearcutting.

Response: Comment noted. Acreage of white cedar forest is projected to increase from 322,400 to about 360,000 acres by 2040 (using the GEIS covertype algorithm). Two factors are mainly responsible for this increase. First, very little white cedar forest is harvested, so that conversions to other types after harvest are rare. Second, mature white cedar in existing mixed stands will outlive aspen, balsam fir, and other species, and attain a plurality of stocking in many stands as other species drop out. Eventually, old white cedar will die and stands will convert to other covertypes if cedar regeneration continues to be prevented by deer browsing. Successional pathways that may occur are not clear. Experience with older heavily browsed white cedar stands in Wisconsin indicates that some are reinvaded by species that deer do not prefer, such as balsam fir and spruce. In other stands, regeneration of all tree species is inadequate, and the stands become shrubland with scattered emergent trees. No changes made.

G-126

Comment: The statement that 5 percent of northern Minnesota timberlands will be lost during the 50-year study period should be supported by information provided at the county level.

Response: Comment noted. The data upon which the changes in timber lands were estimated does not support precise predictions at the county level. No change made.

G-127

Comment: The feasibility of strategy #6 should be revised downward to "low" or "low to moderate" as the likelihood of expedited funding is uncertain.

Response: Comment noted. The issue of funding certainty has been addressed for all GEIS recommendations in several places. No material added.

G-128

Comment: The words "likely mitigate" should be replaced by "partly mitigate" in the statement on the top of page 286 and the first sentence in section 6.7.4 "the mitigation strategies described in the previous section will likely mitigate many, but not all, of the significant impacts...."

Response: Comment noted. Initially mitigation may vary in its effectiveness on a site specific basis. The likelihood of success is adequately qualified throughout 5.7.4 (and elsewhere). No further clarification is called for.

G-129

Comment: The statement that recreational use of an area increases after logging a site should be revised and further qualified that a few activities (e.g., hunting) may increase, but most recreational activity will decrease.

Response: Comment noted. The consultant notes that both the breadth and amount of recreational activity is likely to increase with harvesting due to access and a variety of factors which involve the entire area around the "accessed" harvested site, not just the site itself. No changes made.

G-130

Comment: The statement on page 39 of the Historical and Cultural Resources technical paper "...it is not possible to quantitatively assess the degree to which heritage sites would or would not be damaged as a result of harvesting during the winter months" should be included in the GEIS.

Response: Comment noted. Section 5.7.3 (impact 17) covers this aspect in the GEIS. This section has been augmented.

G-131

Comment: The information presented in section 3.2.2 does not support the statement in section 5.5.5 that public ownerships are committed to long-term sustained yield of timber.

Response: Comment noted. The discussion in section 5.5.5 is augmented to reflect the varying policy and constraints of public ownerships in their consideration of long-term sustained yield of timber.

G-132

Comment: Wherever economic impacts are quantified, the GEIS should clearly state "it was not possible to develop complete information on the cumulative economic impacts of various levels of logging."

Response: Comment noted. The document now has adequate caveats on this aspect. No material added.

G-133

Comment: The executive summary and conclusions of each section of the GEIS addressing the economic analysis should include the following statement from page 69 of the Economics technical paper:

> The results of the IMPLAN analyses described here should be viewed only as approximations of the kinds and magnitudes of changes that are likely to occur as the result of expansions in the forest products industries being considered.

Response: Comment noted. The document has been modified in response to other comments to deal with this issue. No additional changes made.

G-134

Comment: The GEIS should clarify that it was not possible for the economic analysis to estimate the economic impact of logging on the recreation and tourism industries.

Response: Comment noted. The document has been changed in response to other comments to deal with this issue. No additional changes made.

G-135

Comment: The GEIS should state that it was not able to identify the economic impacts of related changes on the Minnesota economy, and did not attempt to identify the range of benefits (use and nonuse) and their related costs.

Response: Comment noted. See responses to G-132, G-133 and G-134. No other changes made.

G-136

Comment: The following three paragraphs should be inserted beneath the heading on pages 341 and 415:

> It was not possible to make conclusions on the overall impact of increased harvesting on the state economy. Analysis of the result of the computer-based IMPLAN model indicated that employment in certain sectors of the economy will increase. For example, the model predicted an increase of 352 direct jobs and 6,752 total jobs at the medium scenario. However, the study was unable to develop data on related economic impacts such as changes in the tourism and recreation industries and the public and private costs of implementing recommended mitigation efforts necessary as harvesting increases. Without this additional data, it was not possible to determine the overall impact on Minnesota's economy of increases in harvesting to either the medium or high scenarios.
>
> In addition, this study did not seek to analyze the potential costs and benefits of increased timber harvesting or alternative management scenarios. Instead, it attempted the more limited task of identifying

direct economic impacts of increased harvests. The study was able to quantify impacts of one of the impacts, but those results should be interpreted only as a trend or direction, not a discrete, reliable number. Since the study was not able to quantify other related impacts, it could not reach a conclusion on the overall impact on employment or income for the state.

The following pages describe the results of the Input-Output analysis as it was used to identify the economic impacts of the medium and high scenarios. The results of the IMPLAN analyses described here should be viewed only as approximations of the kinds and magnitudes of changes that are likely to occur as the result of expansions in the forest products industries being considered. Because of data limitations, these results do not reflect the overall impact on employment or income from the state. They represent a look at only one aspect of the economic picture.

Response: Comment noted. See response to G-135. No new material added.

G-137
Comment: The GEIS should indicate that increased use of mechanization has generally had a strongly negative impact on forest industry jobs.

Response: Comment noted. Most primary raw material processing, including wood products, has been impacted by mechanization. No change made.

G-138
Comment: The GEIS should identify fossil fuel burning as a cause of ozone depletion.

Response: Comment noted. The discussion of fossil fuel burning and ozone depletion is described in the background paper on global atmospheric change. No change made.

Format and Presentation of Information Comments and Responses

G-139

Comment: The 17 identified impact categories should be consolidated for each ecoregion.

Response: Comment noted. The 17 impact categories are impacts that occur in each ecoregion. Consequently it is unnecessary to replicate their discussion seven times. No change needed.

G-140

Comment: The GEIS should provide numerical data on the impacts after the proposed mitigations are in place.

Response: Comment noted. The GEIS provides a wide range of data on numerical data or projection on impacts after the proposed mitigations are in place. No change made.

G-141

Comment: The GEIS should summarize the past, present and future projected timber harvesting activity impacts on the annual growth and harvest of each individual tree type in Minnesota.

Response: Comment noted. The impacts of past and projected timber harvesting activity on the extent of individual forest types is described in the *Maintaining Productivity and the Forest Resource Base* technical paper and summarized in the GEIS. No new material added.

G-142

Comment: The GEIS should indicate the amount of postconsumer fiber used in the paper the GEIS is printed on.

Response: Comment noted. Amount of postconsumer waste used is indicated on the case sheet of the document.

G-143

Comment: New terminology used in GEIS, like biodiversity, ecoregions, sensitive species, nutrient depletion, etc., should be defined in GEIS to enable better understanding of mitigations.

Response: Comment noted. The consultants recognize that there is considerable technical language in the documents. Efforts have been made to simplify and clarify the terminology used in the GEIS as compared to the technical and background papers. No new material added.

G-144

Comment: The term "landowners" should be used consistently throughout the GEIS rather than mixing use of "landowners" and "land managers" (page 8 of the executive summary).

Response: Comment noted. *Landowners* and *land managers* are not always equivalent, hence the choice of terms. Clarification of the appropriate use of landowners versus land managers attempted.

G-145

Comment: The term "harvesting" should not be used in the draft GEIS, but rather "logging" or "cutting."

Response: Comment noted. The use of the terms harvesting, logging, and cutting were carefully considered by the consultant and the EQB in choosing a language for the document. No changes made.

G-146

Comment: The term "forest health" should not be used in the draft GEIS, as the study refers to health as the health of trees and not entire forests.

Response: Comment noted. Forest health can be defined in a variety of ways. Note that the GEIS considered the breadth of definitions by its inclusion of analyses on trees, other vegetation, soils, wildlife, biodiversity, etc. Consequently, it is less important that a particular definition was used rather that the breadth of concerns is considered. No change made.

G-147

Comment: The term "ecotype" (boxes on pp. 215, 322 and 396) is a scientific concept that has been largely abandoned.

Response: Comment noted. The term ecotype is still widely used in textbooks and scientific journals. No change made.

G-148

Comment: The GEIS should define "balanced" as it applies to age-class distribution.

Response: Comment noted. A "balanced" age class distribution is described in section 3.1.3. More details are found in the *Maintaining Productivity and the Forest Resource Base* technical paper. No change made.

G-149

Comment: The use of the terms "north" and "south" is inconsistent with the terms used in the technical papers.

Response: Comment noted. The terms *north* and *south* described in the *Maintaining Productivity and the Forest Resource Base* technical paper refer to partitioning of model runs to treat the different market location patterns between those two regions. The *Economics and Management* technical paper dealt with four economic regions. Likewise, other technical papers, depending on the questions addressed and available data, used various other breakdowns. Such differences are inevitable in a study of this breadth. The GEIS has been drafted to simplify the reader's need for understanding these differences in detail. Those seeking such detail are directed to the various technical and background papers. No changes made.

G-150

Comment: All references in the GEIS to cubic feet should be converted to cords for consistency.

Response: Comment noted. Commonality of usage addressed. Some differences remain due to the source and intent of work cited. No changes made.

G-151

Comment: The terms "base, medium and high" should not have been used to describe the different harvest levels, as they assume that harvesting will occur at least at the base level and nothing lower.

Response: Comment noted. The harvest levels associated with base, medium, and high scenarios were identified in the scoping for the GEIS. The reader need not assume that the base level reference is the lowest harvesting level that might be projected. No change made.

G-152

Comment: In discussing age class and covertype structure balance, the wording should be to "develop landscape objectives for age class and covertype structure with appropriate stakeholder involvement."

Response: Comment noted. The incorporation of stakeholder involvement is an important consideration of a land management agency involved with respect to the process for developing those objectives. The GEIS can suggest such involvement and an approach to developing objectives. Section 8 of the document makes such suggestions for stakeholder involvement. No further change made.

G-153
Comment: The MNDNRs definition of old forests should be used in the study.

Response: Comment noted. The MNDNRs definition of old growth forest was used in the study. However, the MNDNR does not yet have a finalized definition of old forest.

G-154
Comment: A more explicit definition of the term "forest health" should be included in the GEIS to clarify the focus of the impact assessment.

Response: Comment noted. The *Forest Health* technical paper clearly defines the terminology used. The GEIS extends that usage. No change made.

G-155
Comment: The phrase "increased tree damage due to specific organisms such as insects worms or fungi" should be used instead of "pests," "infestations," and "outbreaks."

Response: Comment noted. This represents a significant change from the *Forest Health* technical paper. To avoid confusion, no changes made.

G-156
Comment: The term "age diversity" should be used instead of "age imbalance."

Response: Comment noted. The term *imbalance* follows from definition of a balanced age class distribution (see section 3.1.3) where each age class is represented by an equal number of acres. Imbalance, among other things, identifies the condition where an age class might not be followed by sufficient acreage in a younger age class to provide for replacement of the older class. It is an important term with much history in forest ecology and management. *Diversity* is a newer term that presumably implies the presence of various age classes. Terminology with respect to age examined for consistency. No changes made.

G-157
Comment: More of the information contained in the Historical and Cultural Resources technical paper needs to be reflected in the GEIS.

Response: Comment noted. The consultant believes that substantial data from the referenced paper is included in the GEIS. No changes made.

G-158

Comment: Sections 5 to 7 should be combined so that an issue is discussed in one location, with a clear distinction made between impacts at the three modeled scenarios.

Response: Comment noted. The separation of the three levels of harvesting in the final document was specified through consultation with the EQB on the format of the document. No change made.

G-159

Comment: The first four sections of the GEIS should be deleted and handled in an appendix.

Response: Comment noted. The consultant disagrees. No change made.

G-160

Comment: Tables in the GEIS referencing statewide population changes (e.g., table I.5) should be deleted.

Response: Comment noted. See response to G-81 and G-99. No other changes made.

G-161

Comment: The statewide assessment of wildlife impacts occurring over the 50-year study period should be deleted from the GEIS.

Response: Comment noted. See response to G-81 and G-99. No other change made.

G-162

Comment: Tables 2.34 and 2.35 of the Economics technical paper should be included in full in sections 6.5.4 and 7.5.4 of the GEIS.

Response: Comment noted. The economics tables addressed will be included.

G-163

Comment: The first paragraph on page 341 should be deleted.

Response: Comment noted. The consultant disagrees. No change made.

G-164

Comment: Because recycling has little to do with timber harvesting, any discussion of recycling should be removed from the main text of the study and included only as a supporting appendix.

Response: Comment noted. The GEIS FSD specifically identified examining recycled fiber opportunities in Minnesota. As such, the discussions of recycling and recycled fiber have been retained.

G-165

Comment: The GEIS should acknowledge the Office of Waste Management's study conducted by RISI, and indicate the variability between these and the GEIS's figures on wastepaper recovery and generation figures.

Response: Comment noted. This is clearly beyond the GEIS scope. The interested readers of both documents can develop their own conclusions. No changes made.

G-166

Comment: Tables on current wood use and pulp production (by facility), and 1995 projected wood use and pulp production (by facility) should be included in the GEIS.

Response: Comment noted. Various details are provided in the *Economics and Management* and *Maintaining Productivity and the Forest Resource Base* technical papers. No change planned.

Comments Related to the Scope of the GEIS

The following comments relate to the scope of the Timber Harvesting GEIS.

SC-1
Comment: The GEIS should discuss the effect air pollution has on the health of the forest.

SC-2
Comment: The GEIS should look at the global implications of timber harvesting.

SC-3
Comment: Individual rights and human lives should be considered in the GEIS.

SC-4
Comment: The GEIS should include information on land management-forestry practices used in building major cities.

SC-5
Comment: The GEIS should address radioactive fallout in trees.

SC-6
Comment: The GEIS should assess the effects of timber harvesting on native prairies.

SC-7
Comment: The GEIS should examine the maple syrup industry as being a sustainable forest product.

SC-8
Comment: The GEIS should state who is financing chipping mills, paper mills and lumber mills—is it Minnesotans or outside investors?

SC-9
Comment: GEIS should document the effect of a customer-driven increase in recycling materials being brought into the paper industry.

SC-10
Comment: The GEIS should address the amount of waste wood that is going into landfills or garbage incinerators.

SC-11
Comment: The effect of expanded timber harvesting on lumber prices should be addressed in the GEIS.

SC-12
Comment: Horse-drawn harvesting equipment as an alternative to machinery should be analyzed.

SC-13
Comment: The GEIS should address the impact of cutting trees on the waste perpetuated by the paper producing industry (e.g., proliferation of junk mail).

SC-14
Comment: The GEIS should discuss the number of Fish Consumption Advisories for Minnesota's lakes and rivers.

SC-15
Comment: The issue of below-cost timber sales should be included in the GEIS.

SC-16
Comment: The impact of timber harvesting on Lyme Disease incidence should be included in the GEIS.

SC-17
Comment: The GEIS should examine the jobs impact of managing additional forest land for sawtimber rather than pulp.

SC-18
Comment: The GEIS should examine the ability of state parks to sustain the biological diversity needed to sustain healthy ecosystems.

SC-19
Comment: The GEIS should discuss the impact of timber harvesting on resources that affect surrounding states and provinces (e.g., flooding, spread of disease, reduced bird populations).

SC-20
Comment: The GEIS should examine employment impacts resulting from managing forest land for sawtimber rather than pulp.

Response: SC-1 to SC-20 comments noted. The subject matter addressed in the GEIS is based entirely on the direction provided by the Final Scoping Decision for this study. Specifically, the scoping document identifies the study's main objectives, major study assumptions, the types of issues to be examined, and alternative levels of timber harvesting from which these issues would be assessed. The Final Scoping Decision document was developed over a nine-month process in which the EQB solicited public input on a draft scoping document and sponsored three public meetings to obtain input on that document.

Comments SC-1 through SC-20 relate to specific forestry and/or timber harvesting issues which were not identified in the Final Scoping Decision and consequently not addressed in the Timber Harvesting GEIS. Their exclusion from attention in this study does not diminish their validity or importance.

However, unless the Final Scoping Decision is amended, these issues fall outside the scope of the study. No changes made.

SC-21
Comment: The GEIS should examine the environmental benefits of selective cutting vs. clearcutting.

Response: Comment noted. The GEIS in the silvicultural and background paper and in the GEIS itself does examine the benefits of selected cutting versus clearcutting. No change made.

SC-22
Comment: The GEIS should examine the impacts of converting mixed hardwood stands and conifer forests into aspen groves by the paper industry.

Response: Comment noted. The GEIS does examine the impacts of increasing aspen acreage. No change made.

SC-23
Comment: The effect of timber harvesting on the maple syrup industry should be examined in the GEIS.

Response: Comment noted. The impacts of timber harvesting on the maple syrup industry are expected to be minor. No change made.

SC-24
Comment: A discussion of toxic hazards (e.g., mercury) in Minnesota's lakes and rivers that affect fish should be included in the GEIS.

Response: Comment noted. The impacts of mercury from forest harvesting are indirect in the form of pulpmill pollution control capabilities or inadequacies. Discussion is beyond the GEIS scope. No changes made.

General Comments on the GEIS

The following are comments that address: (1) an inconsistency in the draft GEIS; (2) pose questions or ask for clarification regarding study assumptions, data and methodology, analysis and conclusions; or (3) disagree with the information, analysis or conclusions contained in the draft GEIS and provide a reason(s) supporting that disagreement. The comments in this section are organized according to major topical areas addressed in the GEIS.

Model Generation and the Forest Resource Base

GC-1

Comment: The second run model assumptions listed on pages ii and iii are not correct because:

- The MNDNR and USDA Forest Service timberland is not currently managed as extended rotation forests.
- The Superior National Forest does not have an extended rotation program.
- There is no clear trend towards more uneven-aged management.
- Thinning or extended rotation forestry within 100 feet of water is not universally practiced.
- Wildlife buffers are not routinely provided in the southeast.
- Old growth and old growth replacement acreage have not been designated or reserved on state or federal lands.

Response: Comment noted. While developing the second model run assumptions, contacts were made with state, federal, and county land management agencies to determine the degree to which these practices are or will likely be in place in the near future. While there is considerable variation in the current application of these practices, based on feedback secured from the noted agencies, the consultant has no reason to support the concept that the assumptions used are not in the process of implementation. The question is not so much whether all are in place completely at the moment, but whether they are expected to be in place within the next few years. Various agencies have a range of de facto to explicit policy development that cause the term "policy" to have varying meanings by agencies. No changes made.

GC-2

Comment: Why didn't the GEIS use detailed non-FIA forest inventories of public forest and NIPF lands to provide a basis for spatial analysis and modelling?

Response: Comment noted. The GEIS used the FIA forest inventory because of its recent date, quality of coverage and detail across the entire state, and because of the detail and consistency it provided. More detailed forest inventory by owner or agency is spotty, of varying dates, consistency, and precision. In particular, GIS coverage by ownership and the usage of that spotty information would have presented large gaps in spacial coverage and enormous problems in developing a unified and precise modelling approach. The consultant's experience with combining diverse data sets of varying detail and precision and the development of such data in Minnesota suggest such approaches that would achieve a high level of precision are unlikely in the next decade. No change required.

GC-3

Comment: Why didn't the first model run reflect present management practices and the second run include mitigations not presently in place?

Response: Comment noted. The first model run reflected many present-day management practices. The second run included a number of mitigations that are in the process of being implemented or likely to be implemented for reasons noted in response to GC-1. Further model runs would have been more definitive, but not particularly necessary to address the scope and intent of the GEIS. No change required.

GC-4

Comment: Why were some mitigations (e.g., ERF, uneven-aged management and BMPs) incorporated in the model runs, yet others were excluded (e.g., retention of key habitats, conifer inclusions)?

Response: Comment noted. Mitigations that were likely to be common and easily modelled were incorporated in the second model runs. Retention of site-specific detail, such as conifer inclusions was possible only through constraints on harvesting of certain forest types. Additionally, mitigations, such as conifer inclusions, and their impact, may be postulated by considering acreage of the parent type simply spread further to allow for the retention of local inclusions below the level of resolution. No change required.

GC-5

Comment: How can the aspen supply be projected to fall short of demand over the next 50 years, yet 442,000 acres of aspen are projected to advance to ages that are extended rotation age by 2040?

Response: Comment noted. The projected advanced age of some aspen acreage is due to a combination of factors, such as having some of those forests located in reserved or unproductive areas or located so as to be inaccessible (high transportation and other costs). Additionally, land management policy may protect some stands considered unproductive (e.g., extended rotation). No change required.

GC-6

Comment: On pages 147 and 148 under the base scenario for table 5.5, it is unclear whether the national forest's allowable sale quantity or present harvest levels were used.

Response: Comment noted. The national forest harvest for the base and medium scenarios was based on their allowable sale quantity or approximately thereof. Those levels are also fairly close to present harvest levels. The high scenario abandoned those allowable sale quantities. The document will be further clarified to indicate this.

GC-7

Comment: It appears very unlikely that private owners and counties will increase their level of cutting as is suggested in the medium and high scenarios, given recent surveys on these owner's attitudes.

Response: Comment noted. The consultant finds the consistent rates of harvesting on private ownerships over the last 50 years as indicative of continued timber availability. Further, the tightening timber supply due to land reservation in the western states and increasing constraints, such as BMPs, wildlife and aesthetics management, will likely increase the value of private timber and, as western experience shows, increase the rate of harvesting on private lands. Additionally, the analysis is not prescriptive, but suggestive of where the timber might come from under different levels of removal. No change required.

GC-8

Comment: On page 152, the discussion of data on long-term sustained yield analysis is confusing—if only half of MN's timberland is needed for 4 million cords (7.4 million acres), wouldn't this imply that the entire acreage (14.7 million acres) could sustain twice that or 8 million cords?

Response: Comment noted. The 7.4 million acres providing long-term sustained yield at the 4.0 million cord level is generally the most productive and accessible forest land. It does not necessarily follow that the remaining acreage is as productive or would allow a doubling of harvest. No change required.

GC-9

Comment: On page 152, because jack pine is projected to decline as a result of succession to other covertypes—does this mean succession after harvest or natural conversion of stands by succession without harvest?

Response: Comment noted. The existing jack pine acreage is likely a result of fire history. The lost of some of that acreage with the various harvesting scenarios is a reflection of the failure to regenerate to jack pine after harvest and the natural conversion of stands via succession without harvest. Both of these processes are factors in the decline of jack pine acreage. No change required.

GC-10

Comment: The information in table 5.8 (p. 156) is inconsistent with the equivalent figures in table 5.3 (p. 144) and appendix 2.2 (p. 2-3 to 2-10), even though total acreage in all covertypes do agree.

Response: Comment noted. The apparent inconsistency in the tables noted is largely due to a necessary change in the definitions used. The 1990 values are those based on the FIA test data while projections are based on the test data treated with the GEIS specific cover type algorithm developed for the study. Additionally, table 5.8 and appendix table 2.2 were developed from slightly different data bases and algorithms. Given the complexity of the FIA data base, minor differences in results from various types of sorting and processing can lead to minor differences in tabular values. No change required.

GC-11

Comment: On page 160, why are none of the present natural stands of black spruce or tamarack older than 145 years, yet in 50 years both types will include thousands of 145- to 195-year-old trees? If 195-year-old stands are possible, why aren't there any now?

Response: Comment noted. The 1990 age class distribution shown in appendix 2.2 shows the oldest category as 145 years plus. In fact, there were stands older than that in the FIA data set. However, the FIA tables typically end at 145 years. Likewise, the tables for 2040 were extended to terminate at 195, though some stands presumably might survive to older ages. No change required.

GC-12

Comment: The average yield of 28 cords per acres for the base scenario appears too high, given the application of mitigation strategies such as conifer patch retention that will reduce expected yields.

Response: Comment noted. The average yield noted per acre over the 50-year horizon suggests a continuation of past history of gradually increasing per acre stocking plus emphasis on harvesting on the better sites at close to optimal rotation ages. Conifer patch retention will not affect those yields as they will simply change the acreage subject to harvesting and not the volumes per acre. No change required.

GC-13

Comment: Was the assumed "greater use" of uneven-aged management (p. iii) presumed to occur on nonriparian lands?

Response: Comment noted. The second model runs allowed for the opportunity of uneven-aged management on nonriparian lands though little was implemented in terms of thinning or other selection cuts, except on areas designated extended rotation forest. Further use of uneven-aged management in the modelling would have to prescribe it on the basis of noneconomic arguments. No change required.

GC-14

Comment: Losses of forest land in northern Minnesota are overstated as the Aspen-Birch and Northern Pine units lost 0.1 percent and 0.18 percent of forest, respectively, over the last 15 years.

Response: Comment noted. The reader is directed to table 2.4 and table 6.19 of the technical paper on maintaining productivity in the resource base. Calculations based on data presented for 1990 and 1977 suggest the projections used do, in fact, lead to substantial forest area changes over the 50-year period. The comment seems to have erred in calculation of the annual percent of change. No change made.

GC-15

Comment: Linear programming models should not have been used in the GEIS as they suffer from the following two problems: (1) many relationships between variables are not linear; and (2) there are no meaningful analyses of complex systems for which deterministic models are veridical.

Response: Comment noted. Linear programming is not restricted to relationships that are strictly linear and the methodology used here does not rely on linear programming formulations. The methodology represents a substantial extension of the LP techniques that allowed for very complex system analysis and forms of sensitivity analysis that describe the import of the various analyses and findings. No change required.

GC-16

Comment: How does the GEIS address the impact of timber harvesting on the regeneration of red oak in southern Minnesota?

Response: Comment noted. The GEIS notes an increase in the oak cover type acreage in southern Minnesota. It further notes that oak regeneration on a site-specific basis is problematic and that the speed of oak regeneration and its success is highly dependent upon harvesting and regeneration investments and activities. Additionally, it is often obvious when harvesting has occurred—it is a very significant visual impact. Less evident is the enormous sum total of the annual growth increment put on existing trees and the positive impact of the millions of small oak trees in the region. No change required.

GC-17

Comment: On page 144, the acreage cut over the next 50 years is underestimated because surveys indicate that more land is under selective harvest management than was included in the model.

Response: Comment noted. The second model runs do appear to underestimate the area subject to selective harvest and therefore over estimate the acreage subject to clearcutting. However, the estimates and model run output do allow interpretation as to the likely impact if selection harvesting was reduced and clearcutting was diminished. No change made.

GC-18

Comment: On page 144, the acreage needed to meet various harvest levels is underestimated because projected harvest was based on an assumption of improved stocking in the future.

Response: Comment noted. The assumption of improved stocking continues a trend noted since the second inventory update in Minnesota in the 1950s. The assumption about increasing stocking is judged appropriate. No change made.

GC-19

Comment: In appendix 2, p. 2-2, stand ages in 1990 and 2040 are not exactly comparable because 1990 ages were determined empirically while 2040 ages were predicted by adding 50 years to uncut stands and the appropriate number to harvested stands.

Response: Comment noted. The discussion of age determination will be expanded in the revised GEIS.

GC-20

Comment: In appendix 2, p. 2-2, predicted stand age in 2040 for some types are unrealistically high because there is not allowance for natural lifespan in those types.

Response: Comment noted. The second model runs allow succession to other forest types yet some stands still remain in the original condition. Likely, many of those stands would include a combination of older and younger stems, or they might possibly resemble some type we have yet to deal with in the relatively recent history of forest management. In natural stands, adding 50 years might not add 50 years to the life of these, rather the older ones would die and be replaced by stems at least slightly younger in the dominant canopy. At the same time, estimating how much younger those remaining trees would be is beyond the scope of this project. As the reader notes, determining the age of a forest is not always a straight-forward question. No change made.

GC-21

Comment: How can sustainability of harvest scenarios be determined when the modelling time period of 50 years is shorter than normal rotation age for many tree species?

Response: Comment noted. The sustainability of harvest scenarios can be determined in several ways: one way is in the modelling, by valuing the remaining unharvested forest at the end of the 50-year period and, in fact, at each time harvest decisions are considered; second, by running the model longer than 50 years (in fact we ran to 60 years); and a third by simulations of allowable cut and resulting patterns of growing stock development and age class imbalance and sustainability up to 200- to 300-year periods or even for an infinite time period. This is described in more detail in the *Maintaining Productivity and the Forest Resource Base* technical paper where use of the infinite time period for the GEIS work is explained. Additionally the limitations of modelling for short periods are well understood in modelling circles and can be treated in a variety of ways. No change required.

GC-22

Comment: Because the GROW model assumes static environmental conditions over time, the GEIS overprojects tree growth through the 50-year study period, and consequently underestimates the acreage needed to supply the wood fiber required to satisfy each of the three modelled timber harvesting scenarios.

Response: Comment noted. The GROW projection model assumed static environmental conditions only in the sense of a stable site index by species. In reality, site index might increase or decline slightly over a 50-year or even longer study period. Overall this is unlikely to be a notable source of inaccuracy unless climatic conditions changed dramatically. The possibility and implications of that were discussed in the background paper on global atmospheric change. Furthermore, the consultant does not agree that anyone can accurately predict that such growing conditions will worsen or improve over the next 50 years. No change made.

GC-23

Comment: The probabilities for calculating covertype change matrices were incorrectly done as was pointed out in the peer review of the technical paper: Maintaining Productivity and the Forest Resource Base.

Response: Comment noted. This comment was dealt with earlier through an extensive description of the covertype change model components. Briefly, the probabilities in covertype change (at harvesting) matrices were developed as event rather than time-based probabilities. They stand as correct calculations and procedure. Details on this subject are provided in section 4.10.1 of the *Maintaining Productivity and the Forest Resource Base* technical paper. No change made.

GC-24

Comment: The forest growth modelling is devoid of important biological processes that control stand production and composition over the study's time period.

Response: Comment noted. The argument about the adequacy of biological processes incorporated into forest growth and change models is an ongoing consideration. Clearly, there is no biology in a computer model based on numbers and equations. However, the form of those models and the processes they approximate are considered by the consultant as adequate for the modelling purposes. Indeed, the complexity of the detail in modelling considered in the GEIS, such as inclusion of natural succession modeling, suggest it is a landmark study in the depth and breadth of such considerations. No change required.

GC-25

Comment: The calculation of 5.5 million acres overestimates the maximum sustained yield value for timber production because it assumed no biological impacts, loss of acreage or changes in productivity during stand development.

Response: Comment noted. The calculation of 5.5 million cords as a maximum sustained yield, is presented as based on a number of assumptions and qualifications. It assumes mitigation of impacts, and also assumes changes in acreages and the varying productivity of stands across time and acreage. It does not include everything, but it is a good scientifically based approach that meets the GEIS needs more than adequately. No change made.

GC-26

Comment: Is it likely that ASQ on the national forests will be increased to meet higher harvest levels, as is suggested on page xxv?

Response: Comment noted. Note, first of all, the GEIS analyses are only suggestive, not prescriptive, of where timber will come from. Yet at the same time, the consultant agrees that allowable sale quantities on national forests will not likely be increased to meet higher harvest levels, at least not substantially so. This follows a long-term trend in the reduction of harvest levels on national forests for a variety of factors, and is one of the reasons the long-term statewide sustained yield level is lower than the high harvest level. No change required.

GC-27

Comment: Where is the additional funding and personnel going to come from if timber harvesting will increase on Native American lands as is projected in the GEIS?

Response: Comment noted. The increased funding and personnel from an increase in timber harvesting on Native American lands will likely come from the judgement that those lands provide returns that justify and cover those investments. No change required.

GC-28

Comment: What are the reasons why forest land in northeast Minnesota is projected to decline over the 50-year study period?

Response: Comment noted. The reason for forest land loss in northeastern Minnesota over the project 50-year study period is due to a combination of factors. The most important is a projected increase in Minnesota's population and the continued development of primarily upland forest areas for roads for recreational development and industrial developments and infrastructure. These are discussed in more detail in the *Maintaining Productivity and the Forest Resource Base* technical paper. No change required.

GC-29

Comment: Is the 50-year planning horizon used in the long-term sustained yield analysis adequate to document the long-term impacts (e.g., wood supply and environmental) resulting from age class distributions projected to occur in the year 2040?

Response: Comment noted. See also the response to GC-21. In general, the planning period is adequate, providing analyses follow appropriate methodology. In this study, the 50 year study period was also augmented by much longer period analyses outside the data reported in the GEIS documents. As noted, methodologies are available to deal with relatively short-term planning horizons in longer-term processes. No change required.

GC-30

Comment: The characterization of forest cover patterns is not adequate to cover the range of possible covertypes and treatments, as only 30 sites were used.

Response: Comment noted. The information on the 30 sample sites is presented as an illustration only. More such data were not available at this time under the constraints of the study scope. Spatial and temporal analyses of forest cover type development and land use change on more such sites is encouraged in the GEIS research recommendations. No change made.

GC-31

Comment: The conclusion that white cedar is projected to increase in acreage contradicts the information contained in appendix 2, which indicates the acreage will be reduced from 644,000 to 361,000 acres under the base scenario.

Response: Comment noted. The reader should note the footnote indicating the 1990 acreage is based on the FIA cover type algorithm while the 2040 base, medium, and high scenarios were based on the GEIS covertype algorithms, and as such, would better be compared to the values in parentheses in appendix 2, table 2.1, which, based on the GEIS algorithms, shows 322,400 acres of northern white cedar. Clarification added to various tables. No change made.

GC-32

Comment: How can the GEIS project large increases in white pine covertypes through succession when the document states the modelling process was unable to model successional changes?

Response: Comment noted. The modelling used was designed to model successional changes. Detail on methods used to provide this capability are described in the *Maintaining Productivity and the Forest Resource Base* technical paper. No changes made.

GC-33

Comment: The calculations regarding forest aging need to be reexamined as they project future covertype ages beyond the life span of the type's tree species and therefore present misleading information regarding average covertype age.

Response: Comment noted. See responses to GC-11, GC-19, and GC-20. Document augmented.

GC-34

Comment: How can the counties increase their harvest volumes by two-thirds, as is projected in the GEIS—wouldn't that exceed their allowable cut?

Response: Comment noted. Increasing the allowable cut of some counties by as much as two-thirds would still not exceed their allowable cut. The reader needs to recognize that many forest types are presently harvested at very low levels. No change required.

GC-35

Comment: Because seed trees are removed in a white pine stand clearcut, the GEIS's forecast of increasing white and red pine acreage are unlikely.

Response: Comment noted. The harvest and regeneration matrices developed from 1977-1990 FIA plot records suggest that red and white pine will be retained in future harvest. This follows from current actual practices of leaving many such trees for regenerating the areas through natural regeneration or planting. No change made.

GC-36

Comment: The GEIS incorrectly asserts that the annual timber harvest peaked around 1900 at a volume in excess of 7 million cords, when other sources state Minnesota's peak annual timber harvest was only 2.4 million cords—Minnesota Lands (Cunningham 1960) indicates that 2,342,000,000 board feet of lumber was cut in 1899; the Seventh Biennial Report of the Bureau of Labor of the State of Minnesota, 1899-1900 states that 1,125,000,000 board feet of logs were cut in the winter of 1899-1900.

Response: Comment noted. The harvest in 1899 (Cunningham 1960) indicates that about 5 million cords were cut. However, that figure needs to be augmented by estimates of firewood, land clearing and simple burning of materials and the fact that merchantability standards at that time left large volumes of material now usable on the ground. No change made.

GC-37

Comment: The computer models used in the GEIS are flawed because they are based on national rather than Minnesota-specific figures.

Response: Comment noted. The computer models used in the GEIS are based largely on Minnesota-specific figures. No change required.

GC-38

Comment: Tables 5.9 and 6.10 are misleading as they fail to account for the large acreage shift during the 50-year period from "older" covertypes into the younger aspen covertype—these tables should show average age changes on a per acres basis.

Response: Comment noted. The table of average stand age by cover type was developed by weighting FIA plots by the acreage each such plot represented. As such, the procedure does account for the older and younger cover types in an unbiased manner. No change made.

Forest Water Quality/Fisheries

GC-39

Comment: Why did the GEIS rely so heavily on the assumed use and virtue of BMPs, when compliance monitoring has only been in place for short periods of time?

Response: Comment noted. The GEIS notes considerable development and rapid implementation of BMPs nationally over the last two decades. The experience in Minnesota parallels that of many other locales. There has also been much study of the positive effectiveness of BMPs. No change required.

GC-40

Comment: Timber harvesting impacts on aquatic ecosystems should have been projected based on current levels of BMPs compliance, not the assumption of mandatory compliance.

Response: Comment noted. The assumptions used in the GEIS concerning BMPs were not based on mandatory compliance. Rather they were based on recent experience and estimates of likely compliance as that develops over the next few years. See the *Water Quality and Fisheries* technical paper for a thorough explanation of the assumptions used. Also, note that the GEIS did not assume mandatory compliances. The base assumption and recommendation was for a voluntary system with periodic checks and stimulants. No change required.

GC-41

Comment: Did the GEIS examine the potential impacts of using fertilizers and pesticides on forest lands?

Response: Comment noted. The GEIS *Forest Soils* and *Water Quality and Fisheries* technical papers did consider the impacts of fertilizers and pesticides on forest lands. However the present and likely near future use of those items is very small, and impacts are likely to be small. No change required.

GC-42

Comment: Did the GEIS determine the impacts from potential high acidity in water that could be caused by depletion of calcium soil nutrients?

Response: Comment noted. The GEIS considered the impacts of acidity and water from a variety of sources, and impacts due to depletion of soil calcium were judged to be minimal. No change required.

GC-43

Comment: The GEIS should clarify the uncertainty regarding the impacts of timber harvesting on fish populations—section 5.4.2 estimates a 1 to 3 percent decline in fish populations if BMPs are not followed, yet table 5.14 suggests a high level of uncertainty regarding the impacts to aquatic ecosystems.

Response: Comment noted. The GEIS analysis defines the impacts of timber harvesting on fish populations as likely to be small. The reason for the uncertainty is in part due to inability to consider small and very local bodies of water. Such site specific aspects were either outside the GEIS scope, or simply data deficient. No change required.

GC-44

Comment: The models used to assess water quality impacts should have used Minnesota-specific models that incorporate state glacial terrain and lake formations, rather than national models.

Response: Comment noted. The GEIS used some locally developed models. However, some national models used have wide applicability and problems of poor model fit are small at the level of scoping for the GEIS. No change required.

GC-45

Comment: The discussion of BMPs and other riparian corridor protection efforts on page 251 is misleading because the MNDNR's 200-foot buffers apply to insignificant acreage, the USDA Forest Service buffers do not apply to all streams, and the shoreland rules do not regulate forest management practices anywhere in the state.

Response: Comment noted. The discussion on page 251 is augmented. These protection efforts expressed as mitigations are expected to apply to all ownerships in the future.

Forest Health

GC-46

Comment: The statement on page 195, that under the base scenario, projected harvesting levels will increase the acreage of younger stands for most covertypes is inconsistent with previous statements regarding average projected future stand age.

Response: Comment noted. See response to S-105. No change made.

GC-47

Comment: The climatic hazard zones for white pine blister rust infection potential are based on old data and are most applicable to white pine plantations.

Response: Comment noted. It is not clear that there is improved data. No change required.

GC-48

Comment: Why did the GEIS value insects simply as pests and not for their role in the ecosystem?

Response: Comment noted. Insects are considered for their role in ecosystems in the ***Biodiversity*** technical paper. No change required.

GC-49

Comment: Why is striped maple included in table 5.11 as it is not native to Minnesota?

Response: Comment noted. Striped maple is included in table 5.11 as it was noted in the FIA data and the consultant was advised by plant ecology experts that populations, native or not, may well exist in isolated spots in Minnesota. No change required.

Forest Wildlife Populations

GC-50

Comment: The assertion on page 235 that protecting lowland conifers is not important where it occurs in vast expanses is incorrect as some species (e.g., spruce grouse) adapt to this condition as easily as to isolated patches of lowland conifer.

Response: Comment noted. No change made.

GC-51

Comment: The GEIS assumed that there was no clearcutting within 100 feet of water when, in fact, MNDNR's BMPs guidelines allow clearcutting up to the water unless the waterbody is a designated trout stream. Therefore, the GEIS underestimates the potential damage to waterbodies as well as destruction to wildlife.

Response: Comment noted. The BMPs guidelines consider a variety of factors at each site and by each water body. Additionally, sample sites in the GEIS analyses and recent BMPs audits indicated very little recent clearcutting near waterbodies. The *Water Quality and Fisheries* technical paper addresses this issue properly. The GEIS does not err as the comment indicates. No change made.

GC-52

Comment: Will a decrease in the amount of timber harvested also create decreased habitat of certain species?

Response: Comment noted. Habitat changes will occur with or without timber harvesting. Similarly, changes in timber harvest levels will both increase and decrease habitat for different species. Population changes are, therefore, inevitable under any circumstances. No change required.

GC-53

Comment: Is the model that assessed wildlife impacts consistent with known changes in wildlife that have occurred over the last 50 years?

Response: Comment noted. It is the consultant's judgement, based on extensive literature review, that the wildlife impacts are consistent with changes that have occurred over the last 50 years. No change required.

GC-54

Comment: How does the discussion of timber harvesting impacts on vertebrates address the issues of population size or distribution?

Response: Comment noted. The discussion of timber harvesting impacts on vertebrates addresses population size and distribution by the amount and distribution of suitable habitat within each ecoregion. Habitat quality for each species is a function of forest covertype and stand size class. No change required.

GC-55

Comment: The assumption that mature hardwood forests can support birds requiring early-successional habitat because of small habitat inclusions within mature stands (e.g., tree fall gaps and woodland ponds) is not correct if only the first year of stand development is considered as bird species diversity rapidly increases by the second or third year.

Response: Comment noted. The reader notes correctly that vegetation dynamics and available habitat can change rapidly as stands and associated vegetation develop. To the best of its ability, the GEIS team was thorough in incorporating those same concerns. No change required.

GC-56

Comment: The consultant's statement that small islands of early-successional habitat within a large expanse of mature forest are suitable for species that require young habitats suggests that area sensitivity is a phenomenon peculiar to those species that breed in mature forests—in fact, some species require large, contiguous areas of early successional habitat.

Response: Comment noted.

GC-57

Comment: Table 5 in appendix 5 suggests the consultants incorrectly assumed a greater breadth of suitable habitat than is appropriate for some bird species that breed in early successional habitats, and the potential use of pole-sized stands has been discounted for some species that breed in mature forests—these assumptions may have inflated predicted declines of mature species under the high scenario and minimized expected declines for early-successional species under the low [base] harvest scenario.

Response: Comment noted. The reader is directed to the *Forest Wildlife* technical paper and the matrices of abundance developed by habitat and the discussions supporting those developments.. No change required.

GC-58
Comment: Neither the hognose snake nor the pickerel frog are forest-dependent species.

Response: Comment noted. No change required.

GC-59
Comment: Because the hare population will increase in response to aspen regeneration, the projection that the lynx population will be adversely affected from timber harvesting is incorrect.

Response: Comment noted. The consultant recognizes that there are a number of dependences and mitigating factors in predator-prey relationships. Actually many of those are difficult to predict precisely. However, in this case, the *Forest Wildlife* technical paper indicates that hares have a low abundance in aspen stands as compared to other habitats, such as lowland conifers. There is no significant increase predicted in snowshoe hare populations for any of the three harvest scenarios. No change made.

GC-60
Comment: Because the availability of young aspen will increase by over 1 million acres, the projection that beaver habitat will be adversely affected by timber harvesting is incorrect.

Response: Comment noted. Beaver are predicted to be significantly negatively impacted by the base and medium scenarios in a few ecoregions only, not statewide. Even with a statewide increase in aspen, there will not necessarily be an increase in each ecoregion. No change made.

GC-61
Comment: Bobcats are not mature-forest obligates and therefore would not be expected to be impacted by the base level of harvesting activities.

Response: Comment noted. A number of factors went into the assessment of habitat for bobcats which are projected to be significantly impacted only in ecoregion 3 under the base scenario. The reader is directed to the *Forest Wildlife* technical paper.

GC-62
Comment: Raptors, such as Goshawks, should respond to improved aspen habitat for its prey, and therefore should not experience declines as a result of timber harvesting.

Response: Comment noted. Various raptors were judged to depend on a variety of habitats. Some raptors prey on bird or rodent species that live in conifer forests. Thus, there is no simple relationship between aspen coverage and raptor prey abundance. No change made.

GC-63

Comment: The GEIS overstates the role of lowland conifers for many species such as deer, moose, hare, cats and muskelids.

Response: Comment noted. The consultant disagrees. No change made.

GC-64

Comment: There is no vital linkage to white spruce for red squirrels, as is stated on page 235.

Response: Comment noted. White spruce provides the highest quality habitat for red squirrels. However, they can live in any type of conifer forest. No change made.

GC-65

Comment: American Robins are more dependent upon invertebrates than berries as is suggested on page 235.

Response: Comment noted. The significance criterion regarding tree species that serve as food for wildlife is the context for the comment. The mention in the GEIS document of robins as consumers of berries does not imply that they do not also consume invertebrates. No change required.

GC-66

Comment: Red fox are more dependent upon small mammals than berries, as is suggested on page 235.

Response: Comment noted. As with robins in response GC-65, the GEIS does not claim that foxes are dependent on berries, only that they are part of its diet. No change required.

GC-67

Comment: Why wasn't the impact of timber harvesting on amphibians examined in the GEIS?

Response: Comment noted. The impact of timber harvesting on amphibians was examined in the GEIS. See the *Forest Wildlife* technical paper. No change required.

Forest Biodiversity

GC-68

Comment: What model was used to assess the impacts of timber harvesting on biodiversity, and what is the model's basis, credibility, and shortcomings?

Response: Comment noted. The background paper on biodiversity and related papers on maintaining productivity in the forest resource base used a variety of quantitative and subjective models to assess biodiversity. The shortcomings of these models are that biodiversity is evident at the organism population and landscape level and relatively little is known about some of these components for a number of species, particularly dynamics over space and time. No change required.

GC-69

Comment: Would the biodiversity conclusions be different if the base assessment year was the early 1900s?

Response: Comment noted. See response to G-16. No change required.

GC-70

Comment: The projections regarding loss of old-growth are incorrect, because the consultants assumed agency policies would protect existing or replacement stands, and such consideration is not mentioned in the significance criteria and therefore should not be used to evaluate whether a significant impact will occur.

Response: Comment noted. The projections regarding the loss of old growth given specified assumptions appear appropriate. The reservation of old growth, both by formal policy and de facto policy, is a part of forest management activities, and is, therefore, appropriate for consideration in impact analyses. The assumptions regarding reservation from harvest for old growth are in effect, mitigations. The GEIS recommends that these reservation practices for old growth be made formal policy in cases where they are not now, and then applied on all public forest lands. No change made.

GC-71

Comment: The GEIS contention that no swamp conifers greater than 120 years old will be harvested is incorrect as black spruce lowlands are now being harvested and there are no federal, state or county prohibitions on harvesting this covertype.

Response: Comment noted. The GEIS assumes that true old growth in excess of 120 years will not be harvested. The model runs used for the GEIS harvest scenarios make the assumption that old growth will not be harvested, and the projected harvest is appropriately constrained. For this constraint to happen in the real world forest situation, it is necessary to do an inventory to locate remaining old growth tracts, and then reserve them from harvest, which is what the GEIS recommends. One additional factor to note, with regard to black spruce, is that the harvest scenarios predicted that much of the old growth black spruce would be uneconomical to harvest, due to slow growth rates, low timber volumes, and remote locations. No change made.

GC-72

Comment: The conclusion regarding the mitigation effectiveness directed at genetic variability of plant or animal species (base and medium scenario) is incorrect because the strategies suggested in sections 5.7.3 and 6.7.3 will have little bearing on the projected impacts discussed on pages 219, 220 and 322.

Response: Comment noted. The consultant disagrees. No change required.

GC-73

Comment: The discussion of impact #5 under the medium scenario (pages 350-351) is incorrect as it assigns identical effectiveness and feasibility ratings as under the base level of harvesting, yet two of the three mitigations affect the same number of acres under both scenarios when the number of acres harvested increases by 20 percent—these facts should be discussed in section 6.7.4 "unmitigated impacts."

Response: Comment noted. Discussion clarified.

GC-74

Comment: Will the identified mitigations fully mitigate timber harvesting impacts on biodiversity at the medium scenario?

Response: Comment noted. The consultant believes the identified mitigations, if fully implemented, would largely mitigate timber harvesting impacts on biodiversity at the medium scenario level. No change required.

Recreation/Aesthetic Resources

GC-75

Comment: Why wasn't the relationship between timber harvest/access and hunting recreation addressed in the GEIS?

Response: Comment noted. The relationship between timber harvest access and hunting recreation was addressed in the GEIS under the general subject of access. See also the *Recreation and Aesthetics Resources* technical paper. No change required.

GC-76

Comment: Why weren't visual sensitivity ranks calculated based on an aggregation of FIA plots—aren't individual FIA plots too small to determine different ranks of visual sensitivity?

Response: Comment noted. Visual sensitivity ranks were based on FIA plots and the information available about their site specific and broader locational characteristics. Aggregation of plots would have deteriorated the data detail and made average interpretation potentially misleading. No change made.

Unique Historical and Cultural Resources

GC-77

Comment: The assumption that winter harvest will likely reduce the number of cultural sites impacted is incorrect as much of the terrain harvested in the winter is unlikely to contain cultural resources and therefore the impact of winter harvest is minimal.

Response: Comment noted. See response to G-130. No change made.

Economics and Management Issues

GC-78

Comment: Why didn't the GEIS provide numbers on the projected impact of timber harvesting on the state's tourism industry?

Response: Comment noted. The GEIS provides information on the timber harvesting and related economy and on the state's tourism and recreation industry. Available data do not provide for any more than suppositional conclusions about the relationships between these two industries. No change required.

GC-79

Comment: Why wasn't a benefit-cost analysis used to establish an economic value of Minnesota's forests?

Response: Comment noted. A cost-benefit analysis in the situation like the GEIS is very difficult because of the many nonmarket valued interests that society may have in forests. Consequently the scoping document asked that the consultant consider a range of concerns. In fact, the total of these provides much of the input appropriate to such analyses. A definitive cost-benefit analysis covering the entire subject, however is simply unfeasible in large part because of many nonmarket values, differing value systems, and data availability problems. More appropriate is tradeoff analysis, which is the real basis of the GEIS work effort. No change required.

GC-80

Comment: How does the information projecting additional employment from timber harvesting relate to population increase, and to increases or decreases in other industries within the region?

Response: Comment noted. The economic impact analysis considering employment did not factor in population increases expected over the 50-year period. Increases or decreases in other industries were likewise not included unless components were in fact impacted by timber harvesting. Unless population or industry changes will directly affect timber harvesting, there would be no need. The consultant found no compelling reason to believe that such external changes would affect the timber harvesting area in Minnesota over the next 50 years. No change required.

GC-81

Comment: The GEIS overestimated additional employment in the forest products industry because it did not take into account the fact that improved technology will continue to reduce the need for a timber-related labor force.

Response: Comment noted. The GEIS did consider that improved technology will likely reduce the need for direct timber-related workforce. Reductions in direct raw material work forces are evident in many sectors of the economy. However, the GEIS considered, but likely underestimates, the workforce that would evolve as products processing evolves to provide wider array of products than simply pulpwood and paper. Yet, on the whole, the GEIS did use future employment multipliers that are driven by the impacts of technology improvements. No change required.

Harvesting Systems

GC-82

Comment: What was the source of information used to estimate that about one-third of harvested sites have delimbing and topping carried out at the landing—this value seems too low?

Response: Comment noted. The source of information used to estimate the extent of delimbing and topping and other harvesting practices was based on a survey of a large number of harvesting operators in the state conducted for the GEIS. See the *Harvesting Systems* background paper. No change made.

Recycling

GC-83

Comment: The conclusion that recycled pulp mills are unlikely to replace existing virgin pulp mills is inadequate because it fails to anticipate future growth and improvements in technology and the industry.

Response: Comment noted. The GEIS does consider the likelihood that existing virgin pulpmills will be affected by growth and improvements in technology and the industry, notably in the area of recycling. This subject is addressed in great detail in the *Recycled Fiber Opportunities* background paper. It is more than adequately treated. No change required.

Global Climate Change

GC-84

Comment: The discussion on p. 97 regarding displacement of southern Minnesota woodlands by grassland following significant warming is not consistent with the ideas found on pp. 6-7 of the Global Climate Change background paper.

Response: Comment noted. The information from p. 6-7 of the *Global Atmospheric Change* background paper is summarized in the GEIS in the third paragraph after the statement regarding displacement of forests by grasslands. No change required.

Base, Medium, or High Harvest Level Scenarios

GC-85

Comment: The GEIS assumes the size of wooded stands and logged tracts would show the same frequency distribution in the future as they do now—this may not be accurate. Qualitative impacts and their possible mitigations should have been outlined for the various scenarios.

Response: Comment noted. The GEIS does assume that the size of stands and logged tracts would have a distribution in the future similar to the present frequency distribution. That seems to be adequate from the standpoint that more harvesting would impact more stands and larger areas, and those stands might then be in closer proximity than at present. Alternatively, selection harvesting may lead to less concentration of harvesting (vs. clearcutting) while harvesting technology advances may allow smaller harvest areas. Additionally, various constraints may serve to separate and change the size of harvested tracts. However, in the last several decades, the size of logged tracts has tended to follow stand size. No change required.

GC-86

Comment: Does the data support the conclusion that annual timber harvests for 4.9 or 5.5 million cords are sustainable relative to wildlife and other forest resources?

Response: Comment noted. The GEIS provides several paragraphs of specification and discussion of the assumptions associated with the 4.9 and 5.5 million cord harvest. These have been further augmented in the revised GEIS document. Based on the assumptions used and the analyses done, the GEIS does support the comments assertion. No change required.

GC-87

Comment: Is the 7 million cord scenario a realistic harvest level for Minnesota's forest managers?

Response: Comment noted. The 7 million cord scenario is described in considerable detail in the GEIS. It is described as a scenario that is not very realistic given present levels of investment in Minnesota's forest management and its forest industry and the impacts such harvesting levels might have, and further the likelihood of full mitigation of those impacts. No change required.

GC-88

Comment: Why didn't the scenarios examined in the GEIS include:

- at least one lower level of harvesting.
- a zero harvest scenario.
- no harvest scenario greater than the amount of timber currently harvested.

Response: Comment noted. The concern precipitating GEIS preparation was on increased timber harvesting activity. Consequently, the scoping document specified the three levels of harvest, the current level and two increased levels, by which impacts would be assessed. Lower or zero harvest levels, while of interest in research, clearly seem to be of very low likelihood.

Significance Criteria

GC-89
Comment: Why was a third criterion, 25 percent change in habitat statewide over a 50-year period, added after the significance criteria were developed?

Response: Comment noted. The presentation of results in terms of a 25% change of habitat statewide over a 50-year period was not a criteria. It was one of many descriptions of results to aid interpretation. See also response to G-81 and G-99. No change required.

GC-90
Comment: Why wasn't the Federal CRM definition used to define significant impacts to cultural resources?

Response: Comment noted. The federal CRM definition was not used because to define significant impacts, except indirectly, because it requires more information than was available for the majority of the area considered in the GEIS. Feasibility of application would have been low to not at all in many areas. No change made.

GC-91
Comment: Why did the GEIS consider a species significantly impacted only if a 25 percent habitat loss occurs over a 50-year period as opposed to a 10-year period?

Response: Comment noted. The GEIS considered a species significantly impacted if a 25 percent decline was projected in any 10-year period in any ecoregion. Thus the study was not limited to consideration of declines only over a 50-year period. No change required.

GEIS Mitigations – General

GC-92

Comment: The draft GEIS contradicts itself—on one page it says key habitat requirements in clearcut areas should be retained, yet a couple of pages later it states that loggers need to increase utilization of tree species—these two seem mutually exclusive.

Response: Comment noted. The technical papers and the draft GEIS do suggest difficulties in identifying a single path that satisfies all interests. While this may suggest contradictions, it also serves to identify problem areas. As an example, increasing utilization of tree species and retaining certain habitat requirements in clearcut areas are not always mutually exclusive. A function of the GEIS is to disclose these difficulties and recommend approaches to their resolution or management. No change required.

GC-93

Comment: Why are assumed practices (e.g., ERF, BMPs) identified as mitigation strategies if they are already in use?

Response: Comment noted. A mitigation strategy is defined as an action directly related to harvesting or land management practice that is effective, or potentially so, in mitigating the impacts of such practices. In some cases, these mitigation strategies were found to be in partial use, but full implementation on all ownerships and on all sites and conditions is yet to be sought or achieved. If an action will mitigate impacts of a practice, it makes no difference if that action is taking place today or is a new concept. No change required.

GC-94

Comment: How long is an extended rotation?

Response: Comment noted. Extended rotations are defined in the GEIS as those that are approximately 50 percent longer than the typical economic rotation for a species. A species with a 50-year rotation might be considered for a 75-year rotation under ERF. No change required.

GC-95

Comment: Why does the GEIS modelling assume average productivity of 28 to 33 cords per acre for the three scenarios, yet the 1992 MNDNR data suggests only 20 cords per acre?

Response: Comment noted. The GEIS assumes average productivity of harvested stands to be in excess of average inventory conditions by virtue of harvesting being focused on the most productive stands. Further, over the 50-year study period, the stocking, as in the last 50 years, is expected to gradually increase or improve. No change required.

GC-96

Comment: Is clearcutting within the 200-foot buffer along both streams and lakes in ecoregions 4 to 7 assumed to be prohibited, and is this a recommended mitigation?

Response: Comment noted. In the second model runs, clearcutting was prohibited within 200-foot buffer along streams and lakes in ecoregions 4, 5, 6, and 7. The prohibition was adopted as an extension of BMPs for the two national forests and ecoregion 6, the southeastern part of the state. Aside from the two national forests, and ecoregion 6, BMPs prohibiting clearcutting within 100 feet of water were assumed to be implemented statewide. Such mitigations were assumed in assessing impacts of second model runs. No change required.

GC-97

Comment: On page 220, was consideration given to the mitigating action of winter harvest in minimizing the impact of trampling on federal- or state-listed species?

Response: Yes, winter harvesting was considered a factor that in many cases mitigates such impacts. See section 5.7.2. No change required.

GC-98

Comment: The GEIS mitigations to protect biodiversity do not address the full extent of unmitigated impacts because:

- it incorrectly assumes known locations of rare communities are automatically protected by the MNDNR and USDA Forest Service (e.g., red and white pine forests).
- the suggestion to redesign or prioritize the county biological survey or interpolate or extrapolate information in nonsurveyed areas will not result in more or better biodiversity information, let alone serve as a means of protecting rare species or communities.
- recommendations for extended rotation forestry will not result in practices different than what is occurring now.
- extended rotation forestry corridors were relied on heavily in the Biodiversity technical paper as a mitigating technique, but are referenced in the GEIS as an area for further research. Therefore,

reliance on corridors as a mitigation technique is not consistent with what the GEIS is recommending in this area, and any references to corridors as a research priority should be removed from the text.

- a 100-foot riparian corridor buffer for northern Minnesota is not sufficient to mitigate impacts on riparian areas.

Response: Comment noted. The GEIS did not assume that rare communities are automatically protected. The suggestions to redesign or prioritize the County Biological Survey would very likely lead to improved information about biodiversity and risks in harvesting in certain areas. Extended rotation forests are shown to impact the age class distribution of projected forests. The GEIS attempts to balance the many suggestions of background and technical papers and is the final reference and statement of findings of the consultant in the study. The independence of technical and background paper development was an asset in arriving at conclusions about the likelihood of various mitigations being effective. The sufficiency of 100-foot riparian corridor buffers for northern Minnesota would presumably vary by site. Judgement of the consultant was that buffers are a very important mitigation. No changes made.

GC-99
Comment: Why didn't the draft GEIS analyze the cost impacts of the mitigation strategies?

Response: Comment noted. The GEIS suggests the importance of the cost and feasibility of the various mitigation strategies, however, detailed cost accounting information for the various practices in many cases singly and combined is simply not available at this time. Expected cost ranges were, however, taken into consideration in helping rate a mitigation strategy's feasibility and hence effectiveness. No change required.

GC-100
Comment: Why weren't the costs of operating a timber sale with new requirements to retain key habitat calculated in the GEIS?

Response: Comment noted. The GEIS did review the literature on the cost of timber sales with new requirements. That literature is not yet well developed, but and the likelihood of various costs was included in considerations for feasibility and effectiveness. No change required.

GC-101

Comment: Are the mitigations modeled to include practices and planning activities that are either current or proposed (not in current practice)?

Response: Comment noted. The mitigations modeled include practices and planning activities that are in some cases implemented and in other cases proposed, and likely to be implemented. Actual implementation and status as a formal policy or practice varies widely among ownerships. Further, the definition of practices and planning activities vary among ownerships. Consequently, it is difficult to be precise about what activities are actually in place and broadly understood to be so, but yes, the GEIS dealt with both current and proposed practices. No change required.

GC-102

Comment: The recommendation on page 263 that refers to alternative silvicultural systems will create difficulties in regenerating oak, particularly on those sites where oak competes with sugar maple as a result of using nonclearcutting techniques.

Response: Comment noted. Alternative silvicultural systems will have advantages and disadvantages for regenerating oak and other species. That is where site specific knowledge and professional expertise are expected to be important to overall success in regeneration efforts. The GEIS analysis was very sensitive to the unique and site-specific requirements for red oak regeneration. No change required.

Site-level Mitigation Strategies

GC-103

Comment: The recommendation in the draft GEIS regarding slash be delimbed at the site rather than the landing is not practical—it's expensive and difficult to assemble delimbing equipment at the site. Chainsaws are the best means of delimbing at the logging site, and this is a dangerous practice.

Response: Comment noted. The GEIS recognizes that desired practices, their expense and difficulty and safety hazard at the present time present operational dilemmas. The GEIS recommends strongly that harvesting technologies be studied, tried and improved so that slash/disposal can be accomplished close to the stump in a cost effective and safe manner that aids subsequent silviculture practice and management. These conflicts are well noted in the GEIS. No change required.

GC-104

Comment: Does the Forest Resources Practices Program suggest the use of permanent, mandatory and costly restrictions on private woodland owners?

Response: Comment noted. The Forest Resources Practices Program suggests a number of mitigations and activities that would affect private landowners. The GEIS does not specifically recommend that they ultimately be voluntary, mandatory or whether they might be implemented with incentives, rather a range of policy tools to accomplish various objectives are recommended for consideration. The initial philosophy presented is a voluntary approach, with incentives to comply. The cost of mandatory programs is significant and must be avoided if possible. No change required.

GC-105

Comment: In developing visual management guidelines, who will determine what is aesthetically pleasing and visually adverse?

Response: Comment noted. Development of visual management guidelines (VMGs) is an interactive search and development process involving a variety of individuals and points of view. It should be expected that these guidelines will change as the field practice and forest-user interest becomes understood more clearly. The starting point would be the existing VMGs and their supporting literature from the MNDNR and USDA Forest Service. No change required.

Forest-based Research Mitigation Strategies

GC-106

Comment: In section 5.7.2, why were four research responses identified and no others? Unless a comprehensive discussion of research needs and future research directions is included in this section, the entire discussion of research should be included elsewhere.

Response: Comment noted. The section 5.7.2 illustrates four broad research responses for issues directly related to implementation of mitigation strategies. The reader is also referenced to section 8.3 for a more comprehensive array of research needs, as well as to appendix 4 (part 4.5), which further outlines GEIS-identified research deficiencies. No change made.

GC-107

Comment: Why isn't there information regarding what the future research needs identified in the GEIS will cost? (e.g., funding a research program to investigate the effects of timber harvesting and forest management activities on the tourism and travel industry, biodiversity studies, historical and traditional use sites, etc.)?

Response: Comment noted. The identification of future research needs costs is far beyond the GEIS scope. Section 8.3.5 addresses financial requirements for research needs from a developmental perspective. One of the major needs for implementation of the GEIS recommendation, including research, is the identification of budget requirements. No material added.

Minnesota Board of Forest Resources

GC-108

Comment: What is the relationship between the Minnesota Board of Forest Resources and the existing Minnesota Forestry Coordinating Committee?

Response: Comment noted. The Minnesota Board of Forest Resources is a proposed organization. The Minnesota Forestry Coordinating Committee is an existing coordination group with a limited charter and responsibilities. Section 8.4.1 outlines the characteristics required for the future needs associated with meeting the recommendation of the GEIS. Section 8.4.2 compares and contrasts such alternative organizational structures, including a forestry board and a coordinating committee. Furthermore, this topic is also addressed in appendix 4. The reader is directed to these materials. No change required.

GC-109

Comment: What will a board of forest resources contribute that is not currently provided by the federal, state and county land managers?

Response: Comment noted. See response to GC-108. In general, a Board of Forest Resources can contribute in a number of ways beyond what is currently provided by federal, state, and county land managers. No change required.

Implementing the GEIS Recommendations

GC-110

Comment: Will harvesting 4 million cords be able to occur on 7.4 million acres, as stated on page xvii, when considering implementation of mitigation measures, including the spatial requirements on national forests?

Response: Comment noted. The second model runs indicated the 4 million cord harvest level is feasible and sustainable, as stated in the GEIS. Those statements include assumption of mitigation measures, some of which were included in the model runs. However, further mitigations or reductions in harvest levels on the national forests would lead to additional or other nonfederal acreage harvesting to achieve the 4 million cord level. No change required.

GC-111

Comment: Who will be responsible for monitoring compliance with voluntary management activities?

Response: Comment noted. The GEIS suggests in section 8 various ways for monitoring compliance with voluntary management activities. Appendix 4 provides additional material on this topic. In the final analysis, the state will need to establish the necessary monitoring programs as part of the GEIS implementation activities. No change required.

Other

GC-112

Comment: The statement "few aspects of either issue are in peril at this time in Minnesota" is not consistent with the study's projected problems that have been identified (e.g., old-growth acreage).

Response: Comment noted. The statement referenced, from the Executive Summary conclusions, refers to "biodiversity and social and economic health of our society." The comment is taken out of context. The same paragraph goes on to point out that without timely and effective responses to the GEIS findings and recommendations, necessary momentum in dealing with issues that exist and will evolve will be lost. The reader's opinion is apparently that the issues noted are in peril and that the GEIS sidesteps the matter. The consultant disagrees on both parts. No change required.

GC-113

Comment: Was the impact of the 2 million acres of Boundary Waters and Voyagers land and the effect of those acres on the 14 million other acres of forest analyzed in GEIS?

Response: Comment noted. The Boundary Waters, Voyagers and other similarly classified acreage was assumed as part of the overall forest age class distribution. It's acreage was a factor in overall forest health considerations and in habitat availability. In particular that acreage accounted for much of the oldest forest acreage anticipated in the future. It did impact the overall study direction and results. No change required.

GC-114

Comment: Did the GEIS adopt an ecological systems approach to the forestry resource in Minnesota?

Response: Comment noted. The GEIS study approach considered ecoregions and management of the forest and its harvesting so as to facilitate sustainability in defense of the needs of ecological systems. In the broadest and purest sense the study did consider "ecosystem" management. No change required.

GC-115

Comment: Are impacts identified in the GEIS measured on specific areas of ground, or on impacts over the whole, broad forest?

Response: Comment noted. The impacts identified in the GEIS were those expected to occur on a site or landscape or whole forest watershed or statewide basis depending upon which variables were being examined and which level of resolution was being applied. The approach used was based on examining results at various levels of resolution. No change required.

GC-116

Comment: Has the GEIS considered using intensive timber development on the most productive land, which would leave less productive lands open for other uses?

Response: Comment noted. The GEIS considered the option of investments in timber management, although those were not considered in great detail. The document does indicate that active and high levels of investment on productive lands can leave less productive lands more available for other uses, and/or help mitigate impacts of harvesting and management on such lands. No change required.

GC-117
Comment: Does the GEIS use field evidence, or just numbers, facts and models?

Response: Comment noted. The GEIS numbers, facts and models are derived from yield observation and evidence including reports of a variety of kinds across decades and all landscapes. Rarely, if ever, has a study of this magnitude been done and/or based so completely on field type observations. No change required.

GC-118
Comment: Did the GEIS consider what will happen if state-administered forest lands have to support the bulk of the proposed increased cutting levels?

Response: Comment noted. The GEIS did consider the affect on various ownerships of supporting different proportions of the potential increased harvest levels. That documentation is included in the *Economics and Management* and the *Maintaining Productivity and the Forest Resource Base* technical papers. Some of that is also included in the GEIS document itself. The question is a good one and deserves investigation of the material referenced. No change required.

GC-119
Comment: Why did the GEIS focus only on the paper industry, and not on other wood-based industry segments?

Response: Comment noted. The GEIS focused on virtually all components of the wood-based industry from pulpwood to panels to lumber to sawlogs to fuelwood to specialty products. All products must be included, as the comment alludes to. No change required.

GC-120
Comment: The GEIS understates impacts because: (1) projected mitigation strategies are likely to be unrealistic in the assumed level of implementation and unsubstantiated in effectiveness; (2) the model's assumptions and biases are neglected in discussing results and conclusions; and (3) impacts are focused primarily at the statewide level, particularly in the executive summary.

Response: Comment noted. The projected mitigation strategies and their associated implementation levels are considered to be appropriate assumptions. The consensus from the literature and study are that mitigation strategies would be effective as noted. Additionally the model's assumptions and limitations are discussed in a variety of places in the document. Finally, impacts are described at the ecoregion, watershed, site, landscape, and statewide levels in a variety of ways and places in the document. Further, 14 technical and background papers cover over 4,000 pages of technical documentation on the topic at hand. Lack of inclusion in the Executive

Summary is not a foundation for noting failure to meet the needs. No change required.

GC-121

Comment: The GEIS assumes that many of the recommended mitigations are already in effect, therefore the study underestimates environmental harm. For example, the assumed use of extended rotation forestry in the model is three times greater than current practice; uneven-aged management is only 10 percent of what the model assumes to be occurring; and model's assumed best management practices for water quality are more stringent than the MNDNR's existing guidelines.

Response: Comment noted. The GEIS assumed that mitigations were in place or would be in place within relatively few years. Assumptions are necessary in any case. These appeared, from study and actions of the agencies in recent times, to be appropriate. Regarding uneven-aged management, the model, in fact, underestimated the amount of uneven-aged management in the second model runs and is thus conservative from that standpoint. The consultant does not agree that the study underestimates environmental harm. No change made.

GC-122

Comment: Is the recently announced management plan of the USDA Forest Service considered in GEIS?

Response: Comment noted. The recently announced plans of the USDA Forest Service are evolutionary and in the sense of the study assumptions and model runs they are included in the GEIS. No change required.

GC-123

Comment: The final statement in the Executive Summary that addresses biodiversity is incorrect and is contradicted throughout the GEIS.

Response: Comment noted. See also response to GC-112. Apparently the reader disagrees with the consultant that few aspects of biodiversity are in peril in Minnesota at the present time. The study clearly identified significant current and future impacts at all three levels of harvesting analyzed. The study found, however, that "science" does not support the theories of "imminent peril," but do support the theories of evolving significant problems if major actions do not occur almost immediately. No change required.

Suggested Additional Mitigations

There were 127 public submissions which included suggestions for additional and/or modified mitigations to address the impacts arising from timber harvesting and forest management activities. As an aid to responding to these suggestions, they have been grouped into one or more categories. Five categories were developed:

Site-based mitigations
These mitigations are directed at modifying the practices employed at a specific site such as increasing retention of certain tree species, changing the type of harvesting systems used and widening riparian protection zones.

Landscape-scale mitigations
These mitigations are directed at modifying the practices employed in the management of forests at a wider geographic scale such as developing linkages of unharvested forest between patches of old growth and protecting unique or threatened plant species.

Research mitigations
These mitigations are directed at using research to provide the information needed to improve forest management and to set policy and programs. Research areas include topics such as inventories and development of pulping processes to expand the use of nonvirgin pulps.

Programmatic mitigations
These mitigations are directed at how agencies manage forest lands, and which agencies manage forest lands.. Programmatic mitigations include investing in the forests to increase the amount of pine in the state's forests, and changes in the responsibilities of the various forest management agencies.

Objectives/policies
These mitigations are directed at changing the objectives/policies adopted by the forest management agencies, the state government and private landowners. This category of mitigations includes limitations on the amount of clearcutting used across the state, establishing goals for the restoration of old-growth, and prohibition of logging in primitive areas.

Many of the suggested mitigations are modifications of mitigations already considered in the GEIS. These mitigations have been identified. The process used to identify and develop the mitigations recommended in the GEIS were set out in section 2.3.2. In the absence of a clear scientific, technical or economic basis for changing these mitigations they have not been altered. Where the suggested mitigations were not previously considered they are identified and/or briefly discussed.

The following lists the suggested mitigations by category and identifies those which have been addressed (and hence are not discussed further), and those which have not been discussed with the relevant discussions following.

Site-based Mitigations

M-1
Comment: Retain 8 to 12 trees per acre of white and red pine, where present, in clearcut areas to ensure sufficient residual habitat.

Response: Comment noted. Retention of conifers is addressed in existing mitigations. The retention rate and species were selected based on expert advice, therefore, these mitigations have not be amended.

M-2
Comment: Require a 200- to 300-foot forested zone adjacent to waterbodies.

Response: Comment noted. The management of riparian zones is discussed in the context of maintaining water quality, wildife, recreation and aesthetics, and cultural resources. These factors are incorporated into the mitigations proposed for management of riparian forests. The management proposed varies depending on circumstances and was based on advice from relevant experts.

M-3
Comment: Incorporate the following mitigation strategy to protect biodiversity:

- Expand the definition of extended rotation forests to provide rotation periods more reflective of the natural expected lifespan of each tree species, rather than as currently referenced to the culmination of mean annual increment.

Response: Comment noted. The average lifespan of trees within natural unmanaged stands in Minnesota ranges from 60 to 100 years for jack pine, aspen, and paper birch to 150 to 180 years for sugar maple, oaks, and white pine. In fact, these ages are close to the recommended extended rotation periods.

M-5

Comment: Incorporate the following mitigation strategies directed at the sawlog industry:

- Rely on selective cutting, rather than clearcutting.
- Encourage selective cutting of mature aspen in uneven-aged, mixed covertypes.

Response: Comment noted. The relative benefits and uses of both clearcutting and selective harvesting were discussed at length in the Silvicultural Systems background paper. The most appropriate systems under a range of circumstances are identified in the GEIS document.

M-6

Comment: Incorporate the following mitigation strategies directed at the soil resources:

- Prohibit clearcutting on 12 percent or greater slopes as well as soil types that are conducive to erosion.

Response: Comment noted. The BMPs have been developed based on field experience. The influence of slope and soil erodibility has been factored into the BMPs. Where harvesting proceeds in more difficult areas the prescriptions change to reduce the risk of erosion.

M-7

Comment: Expand BMPs to require buffer zones along all streams, lakes and wetlands.

Response: Comment noted. The existing BMPs provide adequate protection for all categories of waterbodies. See also response to M-2.

M-8

Comment: Incorporate the following mitigation strategies directed at forest roads:

- Erosion control practices on existing roads should be maintained.

Response: Comment noted. The need to maintain existing roads is recognized in the GEIS. Road closure is also recommended where no further use of the road was envisioned.

M-9

Comment: Incorporate the following mitigation strategies directed at forest wildlife:

- A 300-plus acre sanctuary of forest surrounding known nesting sites of Red-shouldered Hawks (within which all logging and other disturbance is prohibited) should be established.
- Riparian corridors should be at least 300 feet, and selected cutting should be considered only if it can be established that no adverse impact would occur.
- A lakeside buffer (no harvesting or other disturbance) of one-fourth mile should be established where eagles are known to or likely to reside or feed.

Response: Comment noted. The measures put forward broadly reflect those developed in the GEIS.

M-11

Comment: Incorporate the following mitigation strategies directed at forest recreation:

- Clearcutting should be reduced for aesthetic reasons.

Response: Comment noted. Modifications to the use of clearcutting in visually sensitive areas is put forward in the GEIS as were other techniques to mitigate visual impacts.

M-13

Comment: Incorporate the following mitigation strategies directed at forest roads:

- All forest roads no longer in use should be closed.
- Guidelines to reduce compaction and erosion of forest roads should be implemented.

Response: Comment noted. The GEIS recommends closure of roads which have no useful purpose. It is not possible to avoid compacting roads as this is a necessary part of constructing a useful road. The GEIS recommends ways to limit erosion.

M-16

Comment: The GEIS should incorporate the following mitigation strategies directed at clearcutting:

- Clearcutting should be prohibited in riparian zones.

Response: Comment noted. The GEIS identifies the circumstances where clearcutting practices should be modified in proximity to riparian areas.

M-32

Comment: All harvesting plans should include provisions to protect the integrity of forest soils.

Response: Comment noted. Section 8.1.3 of the GEIS recommends a state Forest Resources Practices Program which included consideration of soils in the development and application of harvesting plans.

M-37

Comment: There should be greater use of uneven-aged management in place of clearcutting.

Response: Comment noted. The GEIS recommends application of selective harvesting systems in place of clearcutting where such a change would achieve desired management objectives.

M-42

Comment: Selective cutting practices should be required.

Response: Comment noted. See response to comment M-37.

M-43

Comment: Allow trees to reach older ages before harvesting, and protect old growth stands.

Response: Comment noted. The ERF, conncected landscapes and riparian zone management strategies will collectively increase the age of selected stands prior to harvesting. The GEIS recommends that all old growth stands be protected. See response to M-3.

M-63

Comment: Prohibit clearcutting in riparian zones.

Response: Comment noted. See response to comment M-16.

M-64

Comment: Prohibit clearcutting in mixed species forests where the natural species diversity can not be regenerated by use of clearcutting.

Response: Comment noted. The site-level mitigations recommended by the GEIS includes a recognition that projected changes to tree species mixes could be mitigated by using a variety of silvicultural techniques and other measures. This mitigation is assessed as being moderately feasible on public lands.

M-66

Comment: Close forest roads that are no longer in use.

Response: Comment noted. See response to M-13.

M-67
Comment: Implement guidelines for reducing compacting and erosion from roads.

Response: Comment noted. See response to comment M-13.

M-75
Comment: Prohibit clearcutting of young white and red pine stands, allowing only selection logging in these areas.

Resposne: Comment noted. The GEIS recommends use of both selection and clearfelling silvicultural systems. Both systems have legitimate uses in forest management, therefore, a prohibition of one system in certain age classes of certain covertypes is not supported.

M-78
Comment: Do not allow clearcutting to occur in maple-basswood forests.

Response: Comment noted. See response to comment M-75.

M-81
Comment: Localized impacts of timber harvesting on sedimentation, mercury loading, and pesticide and herbicide runoff should be examined as part of environmental review of individual logging projects.

Response: Comment noted. The GEIS concludes that the Minnesota BMPs were effective in mitigating impacts on water quality. The GEIS recommends the FRPP which incorporates various prescriptions and postharvesting reforestation practices.

Landscape-scale Mitigations

M-3
Comment: Incorporate the following mitigation strategies to protect biodiversity:

- Maintain large blocks of forests that are connected with corridors to allow species to move between these blocks.
- Protect unique or threatened plant communities.
- Implement forest practices that discourage further increases in deer populations.

Response: Comment noted. These mitigations are discussed in the GEIS recommendations.

M-7
Comment: Expand BMPs to require buffer zones along all streams, lakes and wetlands.

Response: Comment noted. See response to comment M-7 under site-scale mitigations.

M-10
Comment: Incorporate the following mitigation strategies directed at forest insects:

- Protect and promote a diversity of habitat and tree species in the forest to encourage potentially endangered insects.

Response: Comment noted. While not considered explicitly because of a fundamental lack of data, insect populations are likely to benefit from the recommended strategies to maintain a diversity of covertypes and age classes in Minnesota.

M-16
Comment: The GEIS should incorporate the following mitigation strategies directed at clearcutting:

- Clearcutting should be reduced dramatically across the entire state for all covertypes.
- Clearcutting should not be used in mixed species forests where natural species diversity cannot be regenerated with this logging technique.

Response: Comment noted. See response to comment M-37 under site-scale mitigations.

M-20
Comment: Specific strategies should be developed to address the changing forest landscape.

Response: Comment noted. The GEIS Study Team is unsure of the intent of this suggestion.

M-22

Comment: Extended rotation forestry practices should be applied to at least half of the forest area rather than only seven percent as recommended in the GEIS.

Response: Comment noted. The strategy recommended in the GEIS is based on the timberland ownership and species mix in Minnesota.

M-23

Comment: Riparian protection zones should be established along waterbodies statewide.

Response: Comment noted. See response to comment M-2 under site-scale mitigations.

M-30

Comment: Do not allow timber harvesting in areas where there are known threatened and/or endangered plants or animals.

Response: Comment noted. The GEIS recognizes the need to limit the risk of adverse impacts on populations of these species. The strategies recommended includes completion of the MNDNR county biological survey and similar measures as a way to identify the locations of these species. Provision of buffers around known locations of these species and retention of key habitat features is also recommended.

M-31

Comment: Eliminate forest practices that contribute to forest fragmentation.

Response: Comment noted. Many activities including roading, development of infrastructure, housing, and timber harvesting contribute to fragmentation of the forest. The GEIS recognizes the effect fragmentation can have on many plants and some categories of animals. The strategy proposed is to ensure that key habitat requirements of these species are retained at a landscape level by either altering the silvicultural system used or by retaining areas of comparatively unfragmented forest. This latter part of the strategy would be especially important in southern Minnesota.

M-35

Comment: Inventory and reserve old-growth forests on all public lands immediately, and establish incentives for old-growth protection on private lands.

Response: Comment noted. The MNDNR and USDA Forest Service have programs to identify and manage old growth on their lands. Few significant old growth forest areas exist on private lands. A program specifically for private lands would require substantial incentives.

M-38
Comment: Riparian management zones must be expanded to cover ecosystem functions beyond water quality protection.

Response: Comment noted. The GEIS recognizes that riparian zones had important functions in addition to maintaining water quality. This is addressed under the landscape-level responses.

M-45
Comment: Provide a greater variety of all mature tree species.

Response: Comment noted. The GEIS indicates that under the base and medium harvest levels thre will be more old forest in the future for all forest covertypes. Therefore, no specific mitigations are required to achieve this objective. The GEIS recommends that the age class distributions of the various covertypes be monitored and that statewide objectives be set.

M-46
Comment: Maintain or reestablish large blocks of uninterrupted forest, and avoid isolated fragments.

Response: Comment noted. The areas where benefits could accrue from reestablishing forests correspond to the developed southern and central parts of the state. Most land in this part of the state is in private ownership and the likelihood of large contiguous areas being made available for this purpose is limited. As discussed in the response to M-31, the need for areas of unfragmented forest is recognized in the GEIS and strategies are put forward to address this need.

M-47
Comment: Maintain forest cover in and along river corridors.

Response: Comment noted. Strategies covering riparian corridors covered this point.

M-48
Comment: Complete the state survey of locations of endangered and threatened plants and animals so that they can be protected from logging.

Response: Comment noted. See response to comment M-30.

M-49
Comment: Reduce clearcutting dramatically across the entire state.

Response: Comment noted. See response to comment M-75 under site-scale mitigations.

M-52

Comment: Blocks of undisturbed forest should be preserved to protect interior forest species and their habitat by maintaining a 300-foot buffer strip around the entire stand.

Response: Comment noted. The use of buffers around blocks of undisturbed forest is recommended under the connected landscape strategy.

M-53

Comment: Maintain trees of different species (including conifers) to maintain plant and animal species diversity.

Response: Comment noted. The GEIS recommends several strategies intended to maintain and, in some cases, increase tree diversity to maintain habitat.

M-54

Comment: Exclude timber cutting from areas that contain rare plants.

Response: Comment noted. See response to comment M-30.

M-55

Comment: Identify and protect rare communities of trees and plants, such as white pines in southern Minnesota.

Response: Comment noted. See response to comment M-30.

M-57

Comment: Protect species by keeping ecosystems functioning naturally.

Response: Comment noted. Maintenance of natural ecosystem processes is an integral part of the GEIS recommended strategies.

M-59

Comment: Maintain a diversity of species in the forest, in addition to old and young trees.

Response: Comment noted. Maintenance of species diversity is an important component of the landscape-level strategies to balance age class and covertype structure. In addition, the biodiversity inventory is recommended as a way to identify populations of species with limited distributions and hence to provide the opportunity to manage these areas to maintain diversity.

M-84

Comment: Establish a 200-foot buffer in riparian areas statewide, and not just in southern Minnesota.

Response: Comment noted. See reponse to comment M-2 under the site-level mitigations.

M-85

Comment: Extended rotation forestry blocks of at least 300 acres should be recommended as a means of protecting interior species in both northern and southern Minnesota.

Response: Comment noted. ERF blocks and corridors are recommended for southern and northern parts of the state. The problem of coordinating between multiple ownerships is highlighted as a constraint to achieving this objective in the southern part of the state.

M-88

Comment: Prescribed burning should be recommended as a means of maintaining biodiversity.

Response: Comment noted. The role of fire as a tool for effective large-scale change to age class structures in the forest is recognized as part of the strategy to balance age clas and covertype structures.

M-89

Comment: Diversity maintenance areas (10,000 acres) where no harvesting is allowed should be established to maintain biodiversity.

Response: Comment noted. The GEIS recognizes that diversity in the ways the forest is managed is an integral part of maintaining species diversity. With respect to maintenance of large unharvested blocks, the public land management agencies have policies to maintain significant areas where harvesting is either precluded or highly modified. The BWCAW is an example of a very large area managed without harvesting.

M-90

Comment: Natural regeneration should be used to perpetuate some rare natural communities and genetically distinct populations of forest herbs.

Response: Comment noted. The GEIS recommends that care be exercised in the management of areas known to support populations of rare natural communities and genetically distinct populations of any species. The main problem identified in the GEIS is that the current state of knowledge about these matters is limited for much of the state. Also, our understanding of the ecology of many of these species is even more limited. Consequently, the GEIS recommendations to exclude harvesting from known locations of these species is likely the most prudent approach until more is known.

M-94
Comment: Recommendations for allowing stands of trees to mature longer should also include recommendations for greater diversity of mature species.

Response: Comment noted. See response to comment M-59, in this section and M-3 under site-based mitigations.

M-95
Comment: Large blocks of forest should remain undisturbed by logging.

Response: Comment noted. See response to comment M-89.

M-96
Comment: Exclude from timber cutting areas that contain rare or endangered plants such as areas in southern Minnesota that contain white pines.

Response: Comment noted. The GEIS recommends that no known locations of rare or endangered plants should be harvested.

M-97
Comment: Reduce the use of clearcutting which removes all trees at once. Clearcutting should not be used in mixed species forests where the natural species diversity cannot be regenerated with this logging technique.

Response: Comment noted. See response to comment M-5 under site-based mitigations.

M-100
Comment: Candidate old growth sites should be designated throughout the state, and the program should withdraw at least another 5 percent forest acreage of such ecosystems.

Response: Comment noted. Candidate old growth sites are identified under existing state programs. The state and federal lands will include significant areas (approximately 20 percent) managed as ERF.

M-104
Comment: Protect larger blocks of forest landscape to maintain biodiversity.

Response: Comment noted. See response to M-89.

M-106
Comment: Greater use of prescribed burning.

Response: Comment noted. Prescribed burning is identified in the GEIS as a viable management practice where feasible.

M-124

Comment: Suggest setting aside large contiguous tracts within each forest type to manage and protect biodiversity.

Response: Comment noted. Biodiversity will be protected by managing the state's forests to provide a diverse range of age classes. There are already large contiguous tracts of forest in the state which have been set aside. These tracts will be augmented by ERF under the recommended GEIS mitigations. For some covertypes there are few large tracts, nor is it likely that such areas could be developed given the ownership patterns in the southern and central parts of the state. In these circumstances the riparian lands will be the most likely areas to be managed primarily to maintain biodiversity.

Research Mitigations

M-10

Comment: Incorporate the following mitigation strategies directed at forest insects:

- Insects considered endangered, threatened or special concern should be identified, and their habitats/ecosystems preserved.

Response: Comment noted. With the exception of some insect pest species, the level of information concerning even basic taxonomy or ecology of forest insects is lacking, as are analyses of species' conservation status. This will impede any assessments related to these species.

M-12

Comment: Incorporate the following mitigation strategies directed at recycling:

- An economic and jobs creation analysis should be provided to compare virgin pulp paper production to recycled paper production.

Response: Comment noted. The GEIS identifies the likely scenario for use of recycled fiber in Minnesota. The feasibility of such uses and the comparative employment and economic consequences are properly assessed on the basis of specific proposals.

M-14

Comment: Incorporate the following mitigation strategies directed at recycling:

- Research examining nonvirgin wood paper production methods should be examined.

Response: Comment noted. The suggested strategy is unclear. See response to M-12.

M-15
Comment: Manage forests for diversity to minimize impacts of global warming, and conduct research on potential impacts of global warming and possible mitigation strategies.

Response: Comment noted. The ERF and connected landscape strategies developed in the GEIS are intended to cover this aspect. Research recommendations in the GEIS also address these interests.

M-29
Comment: The loss of recreation and tourism jobs should be fully researched before allowing expanded timber harvesting in Minnesota.

Response: Comment noted. The GEIS identifies that there has been no relationship established between changes in the levels of harvest and changes in employment in the tourism industry. The research needed to establish the relationship, if present, is recommended by the GEIS.

M-56
Comment: Expedite completion of biological surveys to identify rare trees and plants and undisturbed forest communities.

Response: Comment noted. Completion of the biodiversity (biological) survey is an integral part of the proposed mitigations.

M-58
Comment: Identify endangered, threatened and species of special concern and preserve their habitat.

Response: Comment noted. See response to M-56.

M-60
Comment: Include insect inventories in a statewide biological survey.

Response: Comment noted. See response to M-10.

M-71
Comment: Expand research examining nonvirgin wood paper production methods.

Response: Comment noted. Presumably the comment refers to nonvirgin fiber. The GEIS research recommendations address this need.

M-73
Comment: Emphasize research on potential impacts of global warming and possible mitigation strategies.

Response: Comment noted. This is currently a major focus of research by federal agencies and the universities. Research recommendations to address this need are included in the GEIS.

M-80
Comment: Research the possibility of reducing deer numbers in blocks of forest for a period of years sufficient to allow successful regeneration of northern white cedar.

Response: Comment noted. The benefits of effecting deer control to promote white cedar are understood. The decision to implement such a program and to obtain funding for it are less certain.

M-92
Comment: An inventory of potential community sites outlined by Robert Giles in his review of the Biodiversity technical paper should be used to mitigate impacts on biological diversity.

Response: Comment noted. The review was actually by Stephen Chaplin. An inventory of rare natural communities is one of the mitigations in the GEIS.

M-107
Comment: Monitor plant and wildlife populations in forest ecosystems.

Response: Comment noted. The GEIS has recommendations that address this suggestion.

M-108
Comment: Develop a comprehensive research program to assess the effects of forest management on plant and wildlife species.

Response: Comment noted. The research program recommended by the GEIS addresses this objective.

M-117
Comment: An inventory of potential community sites for biological diversity (as suggested by Dr. Robert Giles) should be included as a mitigation strategy.

Response: Comment noted. See response to M-92.

M-121
Comment: Recommend a program to monitor harvesting impacts on a continuing basis before making any increases in harvest levels.

Response: Comment noted. Ongoing monitoring of the effects of harvesting is an important strategy to cope with uncertainty and is included in the GEIS.

M-123
Comment: As a means of mitigating the loss of forests converted to other land uses, a strategy to grow trees beneath utility lines should be considered.

Response: Comment noted. Trees grown beneath utility lines pose significant access, maintenance, and safety problems and involve consideration of easement rights.

M-125
Comment: The recommendation to complete an inventory of the state's biodiversity features should also include an inventory of insects.

Response: Comment noted. See response to M-10.

Programmatic Mitigations

M-3
Comment: Incorporate the following mitigation strategies to protect biodiversity:

- Require a site-specific biological survey before allowing a cut on public lands until the site has been included in the county-by-county survey
- Mandate use of current and additional BMPs, and develop a rigorous inspection program.

Response: Comment noted. The scale of the survey program suggested is infeasible. It would not be possible to require federal agencies to undertake modifications to existing programs. From a practical perspective there would be seasonal staffing, logistical, and funding issues that would have to be confronted. The issues surrounding mandating BMPs are fully discussed in the GEIS.

M-5

Comment: Incorporate the following mitigation strategies directed at the sawlog industry:

- Place a moratorium on red oak and white pine harvesting on public lands.

Response: Comment noted. Eliminating these sources of red oak and white pine sawlogs from public lands would be a significant adverse impact on the sawmilling industry and would place significant additional pressures on the NIPF resource.

M-6

Comment: Incorporate the following mitigation strategies directed at the soil resources:

- Do not allow increased harvesting until more data is available for determining the viability of the proposed GEIS mitigations for maintaining soil integrity.

Response: Comment noted. The time taken to collect definitive data on the full range of soil types and operations preclude a prohibition of harvesting. Research recommendations in the GEIS address knowledge gaps.

M-17

Comment: A program should be established to enforce all mitigations adopted for use.

Response: Comment noted. The issues surrounding mandating BMPs and other mitigations are fully discussed in the GEIS.

M-25

Comment: Investments should be made in forest management to encourage more pine in our forests.

Response: Comment noted. This mitigation is supported in the GEIS.

M-26

Comment: The overharvest of red pine should be acknowledged and measures taken to curb this practice.

Response: Comment noted. This conclusion is not supported by the data under present and projected levels of harvest.

M-35

Comment: Inventory and reserve old-growth forests on all public lands immediately, and establish incentives for old-growth protection on private lands.

Response: Comment noted. See response to M-35 under landscape-scale mitigations.

M-39

Comment: The EQB should provide program direction and funding to state and county agencies to carry out the GEIS recommendations.

Response: Comment noted. The EQB recognizes the importance of ensuring recommendations identified in the GEIS are considered for implementation. To that end, the EQB has developed a process to review the GEIS's findings and recommendations once the study is complete. Using broad stakeholder input, this process will identify appropriate responses to the GEIS recommendations with respect to changes in forest resource policies, programs, and operational procdures. It will be through this process that program direction and funding requirements are identified not only for state and county land manaegment agencies, but other landowner or manager groups as well.

M-40

Comment: Constitutional arrangements to govern forest policy in Minnesota must be created.

Response: Comment noted. See response to M-39.

M-41

Comment: State statues and agency policies relating to private forest management should be reviewed to identify potential partnerships that would increase service to private landowners at a reasonable cost.

Response: Comment noted. The GEIS acknowledges the need for cooperation in delivery of services and makes numerous recommendations that address this area.

M-50

Comment: Require loggers to use best management practices to reduce negative impacts.

Response: Comment noted. The issues surrounding mandating BMPs were fully discussed in the GEIS.

M-61

Comment: Extensive use of pesticides (forest) should not be contemplated without thorough environmental review prior to such use.

Response: Comment noted. The problems associated with the use of pesticides are identified in the GEIS as well as the need to consider the implications of all aspects of IPM strategies in advance of their use.

M-69
Comment: Elevate the importance of recreation in forest planning.

Response: Comment noted. The importance of recreation in forest planing depends on the owner's objectives and a variety of site and location factors.

M-74
Comment: Invest in forest management that promotes more pines in Minnesota's forests.

Response: Comment noted. See response to M-25.

M-77
Comment: Land managers should increase regeneration of red oak stands, and educate private landowners in sustainable oak management.

Response: Comment noted. Improved management of NIPF timberlands, including red oak stands, is recognized in the GEIS as an important function of technical assistance extension programs.

M-82
Comment: Enact formal, long-term old-growth protection policies on federal and county lands, along with the state.

Response: Comment noted. The management of federal lands is a matter for federal authorities and cannot be mandated by the state. Previous land uses for most county lands means there are few occurrences of old growth on land under this ownership.

M-83
Comment: Protect old-growth on private ownership, via acquisition for Scientific and Natural Area designation, or purchase of a conservation easement.

Response: Comment noted. The MNDNR Natural Heritage Program searches for sites throughout the state that may qualify for scientific and natural area (SNA) status. Sites that meet SNA standards for quality are purchased if the landowners are willing to sell.

M-87
Comment: Formally dedicated natural areas should be established to maintain biodiversity.

Response: Comment noted. Such areas exist in the form of scientific and natural areas as well as in other conservation reserves such as the state parks and the BWCAW. Additions to these reserves will continue as biological surveys continue. See response to M-83.

M-91
Comment: Amend the Forest Management Act of 1982 to require county tax-forfeited lands to be managed under the provisions of this act.

Response: Comment noted. The GEIS discusses a range of vehicles for assisting county tax-forfeited land management. See also response to M-39.

M-93
Comment: Recognize that regional and local agencies (e.g., Mississippi Headwaters Board and regional development commissions) may be able to initiate mitigation actions far quicker than the MNDNR.

Response: Comment noted. The GEIS recognizes that initiating the changes recommended would require cooperation from all levels of government.

M-101
Comment: The amount of saw log red oak and white pine harvested should be limited.

Response: Comment noted. See response to M-5.

M-102
Comment: Recommend that policies be enacted on all public lands for formal, long-term protection of old growth.

Response: Comment noted. See response to M-82.

M-103
Comment: Support the development of BMPs for winter operations in wetlands.

Response: Comment noted. BMPs do apply to wetlands.

M-105
Comment: Establish and maintain an interagency natural area network.

Response: Comment noted. Promoting cooperation between natural resources management agencies is discussed in the GEIS.

M-109
Comment: Establish incentives for private landowners to protect endangered ecosystems and species on their land.

Response: Comment noted. The GEIS recognized that NIPF landowners would likely require assistance to protect sensitive sites.

M-110
Comment: Place county-administered land under the Forest Management Act.

Response: Comment noted. See response to M-91.

M-111
Comment: Plan for all forest resources across all ownerships by geographical area.

Response: Comment noted. The benefits of cross ownership planning are recognized, especially in areas such as integrated pest management, ERF, riparian areas, and road development.

M-112
Comment: Adequately fund geographic information systems development and share data between agencies.

Response: Comment noted. The ability for agencies to share GIS and other data, preferably in a digital format, will assist in the development of cross ownership cooperation.

M-113
Comment: As a strategic programmatic response in section 8 (page 440), forestry education should be included as a fourth general category of mitigation.

Response: Comment noted. Forestry education, extension, and continuing education are part of GEIS recommendations for forest resources research in section 8.3.

M-115
Comment: Recommend methods and strategies by which private forest landowners could be encouraged to learn more about sound forest management.

Response: Comment noted. The GEIS considers the delivery of forest extension services. See response to M-113.

M-116
Comment: A major program focused on forest resource management education should be recommended in the GEIS.

Response: Comment noted. See response to M-113.

M-119

Comment: Additional mitigation strategies that should be included in the GEIS are as follows:

- Include state tax-forfeited lands in the Forest Management Act.
- Plan for all forest resources by geographical area.
- Adequately fund Geographic Information Systems, including an interagency composite vegetation database and the equipment and personnel.

Response: Comment noted. See responses to M-91, M-111, and M-112.

M-120

Comment: Develop recommendations on how to stop overharvesting of timber on private lands.

Response: Comment noted. Such recommendations would have to deal with the *taking* issue. See also response to M-39.

M-122

Comment: Include a strategy that deals specifically with regenerating and managing oak for high quality sawlogs.

Response: Comment noted. The need for NIPF landowners to have access to research and technical assistance is recognized.

M-127

Comment: To enhance coordination and sharing data, the GEIS should recommend funds be made available for digital data capture, GIS hardware, software training, and a composite vegetation database.

Response: Comment noted. See response to M-112 and research recommendations in the GEIS.

Objectives/Policies

M-3

Comment: Incorporate the following mitigation strategies to protect biodiversity:

- Prohibit clearcutting on public lands that have not been clearcut since 1950, and reduce clearcutting in other areas to preserve the seed source of nonaspen components.
- Place a moratorium on harvesting mature or regenerating white pines and mixed-hardwood forests containing white pines on public lands, regardless of age.
- Prohibit the introduction of exotic and hybrid plant stock into Minnesota forests.
- Prohibit harvest of certain species unlikely to regenerate at a given site to approximate preharvest proportions.
- Favor tree species near the edge of their range.
- Develop clear and effective guidelines prohibiting high-grading through selective cutting.

Response: Comment noted. The suggested mitigations all involve a component of prohibition or compulsion. The issue of voluntary versus mandatory compliance is discussed in the GEIS.

M-4

Comment: Incorporate the following mitigation strategies to protect old growth forests:

- Develop an old growth inventory that identifies significant unique sites that have sustained old growth in the past, and manage a representative sample of these sites.
- Develop forest management plans and principles that will restore the relative abundance of species and communities, age-class distribution and successional composition to approximate presettlement conditions.
- Prohibit clearcutting on any public lands that have not been clearcut in the past 30 years.

Response: Comment noted. Mitigations to protect old growth forests and develop additional areas of older age class forests are developed in the GEIS. The goal of attaining presettlement conditions is not realistic. Restoring presettlement conditions would require enormous investments to alter millions of acres to establish species and conditions other than those currently present. Realistic goal setting must address the present and projected human population and its impact on the various uses of forests, and the full range of resources and values they represent. Additionally, blanket constraints on harvesting methods reduce management flexibility in achieving the species and other goals suggested here and elsewhere. The issues of old growth, covertype goals, and harvesting practices are all discussed in the GEIS.

M-6

Comment: Incorporate the following mitigation strategies directed at the soil resources:

- Reduce the amount of rarest lands being clearcut, especially in southeastern Minnesota.

Response: Comment noted. The GEIS addresses this concern in a variety of recommendations.

M-8

Comment: Incorporate the following mitigation strategies directed at forest roads:

- There should be no more development of new roads in forest lands.

Response: Comment noted.

M-11

Comment: Incorporate the following mitigation strategies directed at forest recreation:

- No logging or road building should be allowed in "primitive" timberland areas, and reduced in semiprimitive nonmotorized timberland areas.

Response: Comment noted. The GEIS discusses roading in ROS *primitive* and *semiprimitive nonmotorized* timberlands.

M-12

Comment: Incorporate the following mitigation strategies directed at recycling:

- Aggressive goals should be established for increased recovery of each type of paper to reduce the need for tree harvesting, and a model for that level of recovery should be established.
- No future expansions of pulp/paper mills should be considered unless a much higher amount of only local recycled pulp is used.

Response: Comment noted. The GEIS discusses the potential role of recycled paper in the future of Minnesota's pulp and paper industries. Clearly, there is a role. However, that role is likely to be defined more by market demands than by compelling industries to use certain proportions of recycled paper.

M-13

Comment: Incorporate the following mitigation strategies directed at forest roads:

- reduce new forest road construction so that it is balanced by permanent forest road closures (resulting in a no net gain of forest roads).

Response: Comment noted. The concept of developing landscape-based roading plans are developed in the GEIS. These plans are aimed at minimizing the length of road constructed and to develop consistent road closure policies. This is considered a more realistic mitigation than setting an arbitrary balance that would be virtually impossible to measure or police.

M-14

Comment: Incorporate the following mitigation strategies directed at recycling:

- The development of deinking facilities that produce recycled pulp should be encouraged.
- No future expansions of Minnesota pulp and paper mills should be permitted unless they use recycled pulp.

Response: Comment noted. See response to M-12.

M-18

Comment: Clearcutting should be prohibited on public lands that have not been clearcut in the past 50 years.

Response: Comment noted. See response to M-4.

M-19

Comment: Forest practices should be developed to reduce the size of the deer herd in Minnesota.

Response: Comment noted. The management of forests to increase or decrease the deer herd is discussed in the GEIS.

M-21

Comment: Timber harvesting of all old-growth forests should be halted.

Response: Comment noted. The GEIS recommends that old growth forests be located by inventory on public lands and reserved from harvest.

M-24
Comment: Long rotation forestry (minimum of 1.5 times the rotation age) should be implemented on the majority of forest lands available for harvesting.

Response: Comment noted. The GEIS recommends that 20 percent of state and federal lands be managed under extended rotation guidelines. Under current law, the state cannot compel private landowners to use any given rotation length.

M-27
Comment: No future expansions of MN pulp and paper mills should be permitted unless they utilize recycled paper.

Response: Comment noted. See response to M-12.

M-28
Comment: No logging should occur in primitive and semiprimitive areas.

Response: Comment noted. This issue is discussed in the GEIS.

M-33
Comment: Any increases in timber harvesting should be phased-in stages to accurately assess the impacts of increased harvesting on the environment.

Response: Comment noted. Increases, if they occur are likely to be staged to correspond with increases in the capacity of processing facilities.

M-34
Comment: Do not provide public funds to conduct research on improving the efficiency of wood utilization.

Response: Comment noted.

M-36
Comment: Extended rotation forests should comprise 20 to 40 percent of public lands.

Response: Comment noted. The GEIS recommendations for ERF are 20 percent of state and federal forest lands.

M-44
Comment: No increases in harvest levels should be recommended until it can be documented that all forest resources can be sustained.

Response: Comment noted. The monitoring and research programs recommended in the GEIS are intended to provide the data needed to make assessments of sustainability.

M-51
Comment: Encourage the use of recycled fiber so that fewer trees need to be cut.

Response: Comment noted. See response to M-12.

M-62
Comment: Establish goals for restoring some percentage of each old-growth type ecosystem to an old-growth like condition at some determined future date.

Response: Comment noted. Setting statewide goals for covertype age class distributions is recommended by the GEIS.

M-65
Comment: Reduce new forest road construction so that it is balanced by permanent forest road closures (i.e., no net gain of forest roads).

Response: Comment noted. Issues surrounding road construction and decommissioning are discussed in the GEIS.

M-68
Comment: Eliminate logging from primitive areas and reduce logging in semiprimitive nonmotorized areas, and establish specific forest acreage goals for these two recreation classes.

Response: Comment noted. The GEIS discusses management of primitive and semiprimitive nonmotorized areas.

M-70
Comment: Encourage the development of deinking facilities to produce recycled pulp.

Response: Comment noted. See response to M-12.

M-72
Comment: Prohibit any further pulp and paper expansions unless they utilize recycled pulp.

Response: Comment noted. See response to M-12.

M-76
Comment: Reduce red oak logging to balance harvest with regrowth. If efforts to reduce overcutting on private lands are not successful, red oak should not be cut on publicly-owned lands in southeastern Minnesota.

Response: Comment noted. The need for various mitigations to achieve sustainable harvesting of red oak is recognized in the GEIS.

M-79
Comment: Prioritize restoring the southern maple-basswood forest type in Minnesota (Big Woods).

Response: Comment noted. Priorities for treating particular covertypes will be set by forest management agencies and individual landownerships. Setting such priorities is discussed in the GEIS.

M-86
Comment: Extended rotation forests should be applied to 50 percent of all state and federal forest lands.

Response: Comment noted. See response to M-24 and M-36.

M-98
Comment: Clearcutting should be limited to less than 20 percent of the harvested acres statewide.

Response: Comment noted. Use of various silvicultural systems and their legitimate place in the management of forests is discussed in the GEIS.

M-99
Comment: Best management practices should be mandatory.

Response: Comment noted. This issue was discussed extensively during the GEIS process and recognition of that is included in the GEIS.

M-100
Comment: Candidate old growth sites should be designated throughout the state, and the program should withdraw at least another 5 percent forest acreage of such ecosystems.

Response: Comment noted. The need to identify and manage old growth forest is identified in the GEIS.

M-114
Comment: Conversion of forests to nonforest lands through development is a serious problem—the GEIS should consider a recommendation to require mandatory reforestation of a like amount of the forest land destroyed by developers.

Response: Comment noted. Policy and mechanisms to retain forest land is discussed in the GEIS.

M-118
Comment: Include recommendations for less clearcutting and more selective harvesting practices.

Response: Comment noted. See response to M-98.

M-126
Comment: Establish goals for restoration of old-growth.

Response: Comment noted. See response to M-100.