Minnesota Department of Natural Resources

Tamarack Assessment Project

April 2013

Division of Forestry
Minnesota Department of natural Resources
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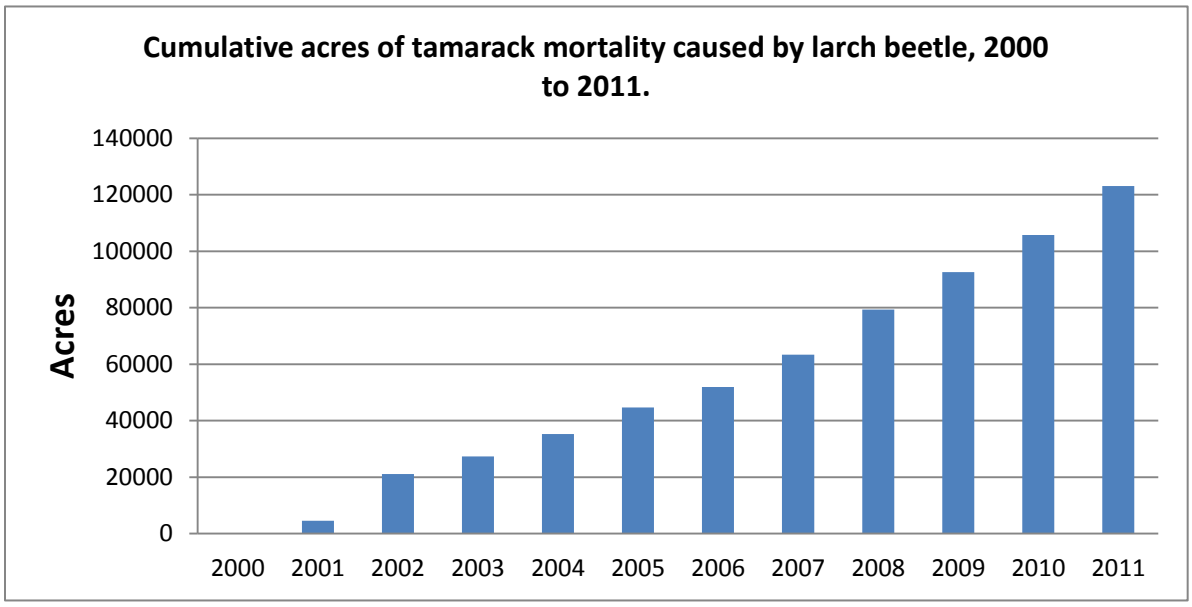
Executive Summary

Tamarack is an important tree species in Minnesota's forests; however, it has been experiencing significant and accelerated insect-caused mortality over the past decade, largely due to the eastern larch beetle.



The major changes to the tamarack resource and the importance of the species itself indicated a need to take a fresh look at the resource and determine if Minnesota's Department of Natural Resources (DNR) and Minnesota's citizens would benefit from any changes to current approaches to tamarack management.

A small team of DNR staff, assisted by external reviewers with a stake in this species, was assembled to perform an assessment of the tamarack resource and markets.

Using the information gathered in the assessment, the team's objectives were to develop recommendations focused on improving as much as practical:

a. Tamarack health, timber and habitat productivity, and ecological diversity;
b. Timber outputs, economic and employment benefits, and DNR revenue; and,
c. DNR, key stakeholders, and public knowledge about the condition and potential of the tamarack resource.

While a silvicultural solution to the current eastern larch beetle outbreak is not apparent, there are some actions that DNR and others with a stake in the tamarack resource can consider that have potential to improve management and benefits from the resource.

Background:
Tamarack has been an important component of Minnesota's forests for the past 3,000 years. At the time of European settlement in Minnesota, tamarack was the most abundant cover type in the state composing 16.9 percent of Minnesota's original Public Land Survey (PLS) bearing trees. In 2011, tamarack represented only 3.8 percent of all trees in the state's Forest Inventory and Analysis (FIA) system. Over half of Minnesota's original 6,000,000 acres of tamarack forests have been lost due to land conversion related to settlement. By 2011, tamarack habitat in Minnesota had declined to just 1,024,000 acres or roughly 17 percent of its former extent in the state. In addition, in recent history tamarack has been subject to boom and bust cycles associated with insect pests, such as the eastern larch beetle and larch sawfly. The stress to the tamarack resource caused by these pests will likely increase if predicted climate change scenarios (warmer and/or drier conditions) take place, since winter die-off of the pests will be diminished; a scenario being witnesses with other insect pests across the country. Lastly, tamarack cover type acreage has been reduced due to competition from other tree species, primarily black spruce.

A team was convened by the DNR to assess the current condition of the tamarack resource and identify any opportunities to improve its health and condition in the future. Recommendations for improving the health, ecological diversity and productivity of the tamarack resource, as well as timber outputs, and the marketing and utilization of this species are described in this document. This assessment will be presented to Minnesota DNR's Forestry Division Management Team as recommended actions to guide the management of tamarack in the future.

Key Findings:

1. Over the past 150 years, tamarack has experienced several boom and bust cycles which can be traced to episodic mortality caused by insect pests (primarily larch sawfly and eastern larch beetle). **The primary pest at this time is the eastern larch beetle which has caused mortality to over 120,000 acres of tamarack in the last decade alone. There is no clear silvicultural solution to this outbreak at this time.**

2. The tamarack cover type has declined more than any tree species due to human development associated with forest conversion, competition with other tree species (primarily black spruce), and pest caused mortality. Tamarack has declined from its original 6,000,000 acres located across Minnesota to just over 1,000,000 acres that exist today (an 83 percent reduction).

3. Predicted climate change scenarios for Minnesota could cause increased stress for the resource. A warmer and/or drier environment would mean better pest survival in winter causing a surge in populations. Warmer and/or drier conditions would also cause stress to tamarack sites that currently exist at the southern range limit for this species.

4. The primary Native Plant Community (NPC) Classes dominated by tamarack are within the Forested Rich Peatland (FP) Ecological System (FPn62, FPn63, FPs63, FPw63, FPn71, FPn72, FPn81, and FPn82). Tamarack is also found in some Acid Peatland (AP) (APn80, and APn81) and Wet Forest (WF) (WFw54, and WFn64) Ecological Systems. FPs63 is the only tamarack NPC Class with a Statewide Conservation Rank of S3 or higher. FPs63 has received a Statewide Conservation Rank of rare or uncommon to imperiled (S2S3) and a NatureServe Global Conservation Rank of vulnerable to imperiled (G2G3). Any management within examples of this NPC Class must follow DNR Policy for managing G1G2 NPCs.

5. Tamarack provides important habitat for several wildlife species: While not an important dietary component of many species, tamarack and lowland conifers provide thermal regulation, escape cover, and nesting and breeding sites, and are associated with several Species in Greatest Conservation Need (SGCN[1]) status.

6. Tamarack utilization for the past several years has averaged approximately 72,000 cords annually. This compares to an estimated average net annual growth of tamarack growing stock of 96,000 cords according to the 2010 FIA Inventory. The most promising options for increasing tamarack's future utilization are probably biomass energy and perhaps chemical extractives. Biomass energy appears to be the only potential large market for dead tamarack.

7. Faced with thousands of acres of dead and dying tamarack, poor markets and limited experience regenerating this species, the development of silvicultural systems to enhance and maintain this resource will remain a challenge for foresters well into the future. Given the lack of research, forest monitoring and field observation will be crucial to the formulation of management strategies moving forward.

Recommendations:
The Tamarack Assessment Work Group suggests the implementation of the following recommendations for improving the tamarack cover type resource in Minnesota:

Recommendations for improving tamarack health, timber and habitat productivity and ecological diversity:

1. The DNR should provide funding for a survey of tamarack mortality sites to determine regeneration success at sites that have been managed (salvaged) post mortality and those where no management has taken place since the mortality event. These efforts should include a range of post-outbreak stand ages to develop a better understanding of the time required for detectable tamarack regeneration to appear on site.

2. The DNR should provide funding for a case-study to determine which native plant communities and geographical locales throughout the state would be best suited for future tamarack management. The case-study would ideally identify the best sites for future tamarack management based on management objective, NPC characteristics (hydrology, soils, nutrients, etc.), and geographic location in the state while taking into consideration likely future climate trends and eastern larch beetle dynamics.

3. The DNR should conduct a case-study focusing on past tamarack stand management to determine if options other than clear-cut with seed-tree reserves for tamarack would improve

[1] Species in Greatest Conservation Need are animal species whose populations are rare, declining, or vulnerable in Minnesota and meet one or more of the following criteria: Species whose population are identified as being rare, declining or vulnerable in Minnesota; Species at risk because they depend upon rare, declining or vulnerable habitats; Species subject to other specific threats that make them vulnerable; Species with certain characteristics that make them vulnerable; and, Species whose Minnesota populations are stable, but are declining in a substantial part of their range outside of Minnesota. For more information on SCGNs and Minnesota's State Wildlife Action Plan, click on the following link: link to dnr website

the cover type's presence throughout Minnesota. The assessment team also suggests that the evolving silviculture guidance for the tamarack cover type should identify sites where tamarack's presence could be increased based on NPC, past management practices, and historic land use.

4. The DNR should increase collection and availability of tamarack seed to facilitate reforestation efforts. There are a number of ways to get this done, but all will require support from Forestry Division management and forestry area staff.

Recommendations for improving timber outputs, economic and employment benefits and DNR revenue:

5. A renewed effort on tamarack marketing will be critical to any efforts to manage tamarack and also to mitigate losses. DNR should task their Utilization and Marketing Program with developing and executing a tamarack marketing plan.

6. DNR should examine tamarack rotation ages for future Subsection Forest Resource Management Plans (SFRMPs). In light of the current insect-caused mortality, predicted climate change scenarios and what appears to be a long history of boom and bust mortality cycles, what are appropriate rotation ages for tamarack?

Recommendations for improving DNR staff's, key stakeholders' and the public's knowledge of the condition and potential of the tamarack resource:

7. DNR should determine methodology for updating its Cooperative Stand Assessment (CSA)[2] inventory in areas of tamarack mortality through use of aerial survey or other efficient methods. These methods may be refined based on the findings from field studies examining the timeframes required to observe tamarack regeneration post-outbreak.

8. It will be important to encourage field staff to try new silvicultural methods and share the results within and outside of the Division.

9. Encourage and support cooperative efforts with other land management agencies and research institutions to develop a comprehensive knowledge of the management approaches for this species and to ensure scientific studies on this species are relevant to the DNR and the current issues facing the resource. These should include, research and /or demonstration efforts, information and educational product development, and inter-agency workshops designed to develop and exchange ideas on approaches to the management of this species.

[2] Cooperative Stand Assessment – The forest stand mapping and information system used by the DNR to inventory the approximately five million acres owned and administered by the state.

Tamarack Assessment Project Team Members

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Keith Jacobson, Managing Sponsor – DNR Silviculture, Lands, ECS and Roads Programs Supervisor

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Mark Johnson – DNR Silvicultural Program Forester; Baudette

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Tamarack Assessment Project Stakeholder Review Team

The Tamarack Assessment Project Team would like to thank the following stakeholders for their assistance in reviewing and providing input to the team prior to finalizing this tamarack resource assessment:

Al Pemberton – Red Lake DNR

Tom Castonguay – Bureau of Indian Affairs

Josh Stevenson – Cass County Land Department

Anthony D'Amato, Ph.D. – University of Minnesota

Kathleen Mctighe – United States Forest Service (USFS)

Art Groot , Ph.D. – Canadian Forest Service (CFS)

Mike Reinikainen – University of Minnesota

Additional assistance provided by the following MNDNR staff:

Kurt Rusterholz – Forest Ecologist

Mimi Barzen – Firewise Program Forester

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Background Information:

Tamarack Species Description:

Tamarack (*Larix laricina*) is a slender, midsize tree with relatively short, horizontal branches and a conical crown. The soft, needle-shaped leaves occur in tufts of 15 to 35. The leaves of tamarack turn yellow and drop each autumn, making it the only deciduous conifer in Minnesota. Tamarack is a common tree throughout most of its range in Minnesota, especially northward. It sometimes occurs in uplands but primarily in acidic, nutrient-poor wetlands, such as peat-filled basins, peaty lakeshores, and boggy stream margins. It often forms pure stands, or in the north it may be mixed with black spruce (*Picea mariana*), northern white cedar (*Thuja occidentalis*), or balsam fir (*Abies balsamea*). In the central and southern counties it is more likely to be found with hardwoods such as paper birch (*Betula papyrifera*), red maple (*Acer rubrum*), or black ash (*Fraxinus nigra*). Because it cannot tolerate shade, it is never found in a forest understory, always in the overstory or scattered in the open.[3]

Tamarack is an important tree species in Minnesota's forests; however, it has been experiencing significant and accelerated insect-caused mortality over the past decade.

These major changes to the tamarack resource indicated a need to take a fresh look at the resource and determine if DNR and Minnesota's citizens would benefit from any changes to tamarack management.

A small team of DNR staff, assisted by external reviewers with a stake in the tamarack resource was assembled to perform an assessment of the tamarack resource and markets.

Using the information gathered in the assessment, the team's objectives were to develop recommendations focused on improving as much as practical:

a. Tamarack health, timber and habitat productivity, and ecological diversity;
b. Timber outputs, economic and employment benefits, and DNR revenue; and,
c. DNR, key stakeholders, and public knowledge of the condition and potential of the tamarack resource.

Rationale for the Project:

Tamarack is an important component of Minnesota's forests, but it has declined more than that of any other tree species in Minnesota in response to exotic and native insects, early-settlement logging practices, agriculture, and settlement and conversion. At the time of European settlement, tamarack was the most abundant tree in the state (16.9 percent of the state's original PLS bearing trees). In 2011, tamarack represented only 3.8 percent of all trees in the state's FIA system. Over half of the state's 6,000,000 acres of forests with tamarack have been lost. By the 1930s, the direct conversion of tamarack habitat to non-forest settled landscape had slowed considerably.

[3] Smith, Welby R.; Trees and Shrubs of Minnesota (2008); Pg. 260.

Beginning in the 1910s, tamarack populations have suffered a series of setbacks due to insect pests, which has resulted in the conversion of tamarack forests to black spruce. The most recent of these pests is the eastern larch beetle (ELB). Over the past 10 years these beetles have killed large areas of tamarack and their impact has been steadily intensifying. A number of stress factors are likely contributing to the current mortality. Droughts and resulting fluctuating water levels in 2002–2003 and 2006–2009 are likely involved. Warmer winter temperatures may also be involved with the increased mortality evidenced for the cover type. For example, ELB overwinters in the above ground parts of the tree. Warmer winter temperatures appear to allow better survival, thus building up larger populations of ELB, resulting in more tree mortality.

Tamarack provides important benefits to wildlife: Snowshoe hares and porcupine browse on tamarack twigs and bark; spruce and sharp-tailed grouse consume tamarack needles and buds; mice, voles, shrews, red squirrels, pine siskins, crossbills and other conifer seed-eating birds consume tamarack cones and their seeds; bear, fisher, marten, bobcat, osprey, eagles, boreal songbirds, great grey owls, black-backed three-toed woodpeckers, and gray jays use tamarack as important habitat for hunting and/or nesting sites.

Tamarack is one of a small number of species well-adapted to thrive in the lowland forest systems that cover much of our landbase. Especially in light of the potential for currently unforeseen forest health issues to attack other of the small group of species adapted to these sites, it is important to pay some attention to the health of the tamarack resource as a risk mitigation strategy for maintaining a forested condition.

Like all wetlands, tamarack swamps provide ecological services essential to all life, including humans. The value of these services is staggering when compared to engineered solutions in urban and otherwise degraded ecosystems. In particular, tamarack swamps are sinks for carbon that help to mitigate the effects of global warming. The *Sphagnum* substrate in tamarack swamps is particularly effective in sequestering pollutants and toxic heavy metals. The alteration of aerobic and anaerobic water chemistry in tamarack swamps is important to the natural cycling of elements necessary for plant nutrition. It is particularly true of nitrogen, the nutrient that limits overall productivity in all of Minnesota's forests. Tamarack swamps are able to store and slowly release stormwater, thus protecting infrastructure from flooding.

Tamarack has had somewhat limited forest product markets that averaged approximately 72,000 cords annually for the last several years, but it does have potential for greater market use. While tamarack demand for forest products is not currently high compared to many other species, it is important to remember that Forestry is a long-term business and market conditions 50 to 100 years from now cannot be predicted with certainty. In consideration of this and the fact that tamarack is one of a small number of species that thrives on much of Minnesota's lowland forest acreage, maintenance of some tamarack is a risk mitigation strategy for future markets and environmental conditions.

Tamarack Assessment Project Intentions:

A team was formed to analyze the tamarack resource and produce recommendations for the best management of this resource in light of a variety of forest health, forest product market and budget

challenges. The team consisted of representatives from the forest health, silviculture, Ecological Classification System (ECS), forest products utilization and marketing, timber sales and resource assessment programs and a wildlife manager and field forester from Areas with a significant tamarack resource. This report is a result of this project and focuses on resource condition, likely outlook and recommended actions for management.

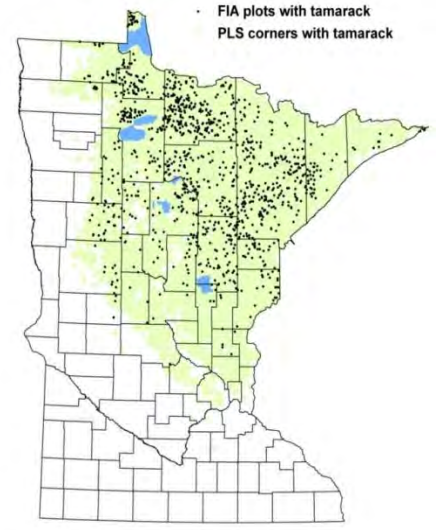
Specifically:

1. The team will be proactive in helping to address emerging resource issues.
2. Through this project and follow-up actions the DNR will demonstrate adaptive management of tamarack resources on DNR administered lands to ensure the most healthy, productive, and diverse forest practical.
3. The team will improve DNR, key stakeholder and public knowledge of the condition and potential of the tamarack resource.
4. The team will prepare a final report with recommendations to improve as much as practical:
    a. Forest health, timber and habitat productivity, and ecological diversity; and,
    b. Timber outputs, economic and employment benefits, and DNR revenue.
5. The final report and recommendations will be sent to the Department's Forestry Division Management Team (DMT) for implementation.

The following report summarizes the historical and current state of the tamarack resource and provides guidance to future management efforts with this species. The first section of this report provides a historical overview of the changes in the abundance of tamarack on the landscape since pre-settlement and is followed by a description of the Native Plant Communities (NPC) in which tamarack commonly occurs and then by a discussion of the past and current forest health issues affecting this species. The second section focuses on the status of the tamarack resource by examining the distribution, productivity, and future yields from DNR administered lands containing tamarack based on DNR forest inventory data and harvest scheduling models. This section concludes with a summary of the wildlife associations and habitat needs of species using this forest type. The final two sections deal with the current and future markets and silvicultural approaches for this forest type and provide recommendations for increasing the utilization of this species and developing silvicultural strategies to maintain and enhance this forest type.

History of Tamarack Abundance in Minnesota[4]:

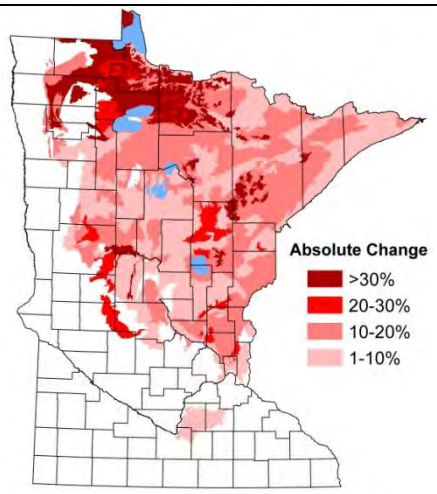
Map 1: Range of Tamarack in Minnesota



In Map 1, the PLS survey corners with tamarack bearing trees (green shaded area) define tamarack's natural range in Minnesota. Forest Inventory Analysis (FIA) plots with tamarack (black dots) document the modern range of the tree. The FIA plots clearly show less continuity and extent than the historic range. The loss of tamarack range is most profound on the southern edge. Once common between Lake Mille Lacs and St. Paul, tamarack is barely detected in this region due to both urban and agricultural development. Tamarack has receded from its historic range in northwestern Minnesota largely because the shallow peatlands and wet-mineral soils of that area have been drained. Along the North Shore and in the Boundary Waters Canoe Area Wilderness (BWCAW) tamarack is now sparsely present. Here, the apparent loss is conversion to other forest types, whether natural or managed. Also, the decline in northeastern Minnesota could have involved upland tamarack that tends to not regenerate well after logging.

Tamarack has declined more than any other species in Minnesota. During the Public Land Survey of Minnesota (ca. 1847–1910), tamarack was used as a bearing tree more than the ubiquitous aspen or oak—and far more than any other single species. Tamarack accounted for 16.9 percent of the state's original bearing trees, but by 1990, tamarack represented just 2.7 percent of all trees greater than 5" diameter at breast height (DBH) in the state's FIA. The trend since then has reversed slightly and by 2011, the relative abundance of tamarack has risen to 3.8 percent. Map 2 illustrates that loss was greatest, more than 30 percent, on flat, paludified (peat-formed) landforms where tamarack and black spruce peatlands are the dominant vegetation. The greatest loss was across the entire Glacial Lake Agassiz basin in northwestern Minnesota and the Glacial Lake Upham basin in southeastern St. Louis County.

Map 2: Percent decline of tamarack's abundance in Minnesota since settlement (1887-1990)



The acreage loss of tamarack habitat is substantial. The DNR estimates that during the PLS survey, forests with tamarack occupied some 5,982,000 acres in Minnesota. By 2011, tamarack habitat had declined to just 1,024,000 acres or roughly 17 percent of its former extent. Most of this loss was due to land conversion. Some 3,305,000 acres of forests that once were populated with tamarack no longer exist. On the remaining forestland, tamarack has steadily lost ground to other species. The DNR estimates that 1,905,000 acres

[4] A Historic Assessment of Tamarack in Minnesota; Almendinger, John C. (September 2012)

of suitable habitat are now occupied by other kinds of trees (i.e. black spruce, lowland white cedar and black ash; in descending order of abundance).

Land Conversion and Habitat Loss:

Much of the direct habitat loss was the result of clearing land for farming. According to the 1990 GAP[5] land classification, some 540,012 acres of former tamarack habitat is now pasture or other agricultural grassland (Table 1). Nearly as much habitat (515,012 acres) was lost to cropland. Thus, agricultural conversion wiped out over a million acres or about a sixth of the tamarack resource in the state. Urban and residential development is the other main source of direct land conversion. The DNR estimates that some 62,000 acres of forests with tamarack were converted to roads, yards, or residences.

Table 1: GAP[2] Land Classes associated with PLS Section Corners

GAP land class (*ca.* 1990) of PLS section corners (*ca*. 1847-1910) where tamarack was used as a witness tree.			
Tamarack	2313	460,287	7.71
Lowland Black Spruce	2999	596,801	10.00
Lowland Northern White-Cedar	1352	269,048	4.51
Black Ash	599	119,201	2.00
Lowland Shrub	6690	1,331,310	22.30
Marsh/Meadow	3195	635,805	10.65
Aspen/White Birch	3930	782,070	13.10
Pine	663	131,937	2.21
Upland Shrub	891	177,309	2.97
Impoundment	419	83,381	1.40
Developed	311	61,889	1.04
Pasture/Grassland	2715	540,285	9.05
Cropland	2588	515,012	8.63
Miscellaneous	1339	266,461	4.46
[1] Corner count includes trees <5", to get equivalent acreage estimates each corner accounts for about 199 acres of 5" trees.			

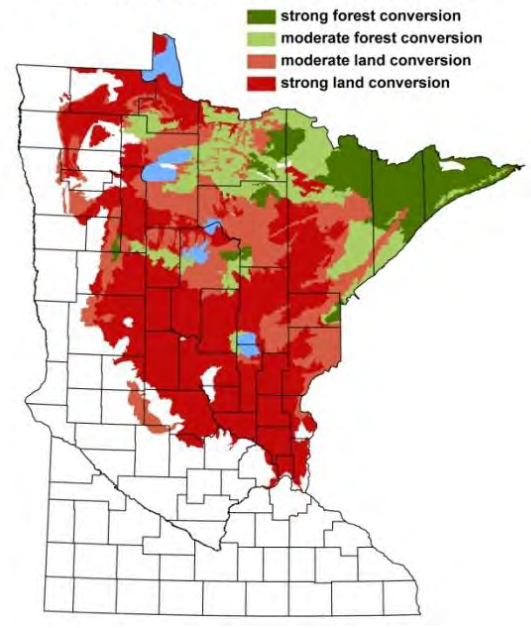
It was a surprise to find that a third of tamarack's historic habitat is now open marsh, meadow, or shrub swamp. About 1,967,000 acres of tamarack has been swamped-out to create these open wetlands (see Table 1). Farmers cleared trees from wet mineral soils that could be re-claimed by draining them. Most likely tamarack, cedar, and ash were cleared and the ditches and field tiles were directed to the adjacent tamarack swamp that was just too wet to re-claim. However, the primary cause of swamping is the system of roadbeds and ditches that have significantly altered the natural hydrology. Tamarack forests on the "upstream" side of roadbeds commonly swamp-out when clear-cut because the site loses its ability to de-water by transpiration. Beavers also cause the conversion of tamarack forests to open wetlands. While their contribution would seem small, it is important to remember that beavers interact with the road and ditch system by plugging culverts and damming ditches. Now that trapping is far less common than in the past, beaver populations have exploded and the acreage of forest lost is becoming significant. Humans also make dams, and it seems that about 83,000 acres of former forest with tamarack is now impounded.

[5] The Gap Analysis Program (GAP) was a project sponsored and coordinated by the Biological Resources Division of the U.S. Geological Survey. The Minnesota DNR participated in this nationwide project. Coordination of GAP activities with neighboring states is done to ensure the development of regionally compatible information. The GAP website defines the project as "… a scientific method for identifying the degree to which native animal species and natural communities are represented in our present-day mix of conservation lands. Those species and communities not adequately represented in the existing network of conservation lands constitute conservation 'gaps.'" The purpose of GAP is to provide broad geographic information on the status of ordinary species (those not threatened with extinction or naturally rare) and their habitats in order to provide land managers, planners, scientists, and policy makers with the information they need to make better-informed decisions. Further information is available at www.gap.uidaho.edu.

Forest Conversion:

The pattern of conversion shows a strong geographic trend from the southwestern edge of tamarack's range to the northeast (Map 3). As expected, direct conversion to non-forest is correlated with agricultural development—reflecting an environment more amenable to agriculture. In the far north and northeast, the climate and soils favor other human endeavors. There, nearly all loss of tamarack is related to forest conversion. A surprisingly small amount of former tamarack habitat still supports the species. According the GAP classification, about 7.7 percent of the historic PLS survey corners with tamarack bearing trees fall in existing tamarack cover type. Today, 312,000 acres of other cover types have a component of tamarack. Tamarack is mostly mixed with black spruce, but it commonly occurs with cedar and sometimes with black ash. Since settlement, all three of these species have been replacing tamarack, but black spruce is by far the most aggressive competitor.

Map 3: Conversion[1] of tamarack in Minnesota



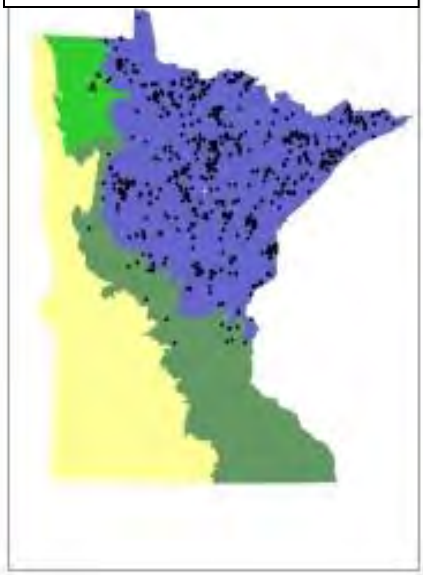
[1] Areas categorized as "land conversion" shifted from forest to non-forest conditions, whereas "forest conversion" areas shifted from the tamarack cover type to other forest cover types (e.g. black spruce).

Description of Native Plant Communities (NPCs) where Tamarack is Common[6]:

(Note: NPC classes that are favorable for establishing tamarack on the site have been **bolded**.)

Acid Peatland Communities (AP): The Acid Peatland (AP) Communities are characterized by conifer- or low shrub-dominated communities that develop in association with peat-forming *Sphagnum*. AP communities are acidic (pH less than 5.5), extremely low in nutrients, and have hydrological inputs dominated by precipitation rather than groundwater. These communities are floristically simple, with the vascular flora composed primarily of a small subset of species characteristic of rich peatlands that are able to survive in the harsh, low-nutrient environments typical in AP communities. The floristic differences between forested AP communities and open, low shrub-dominated AP communities are subtle because of low species diversity in the AP System as a whole and because trees, when present, are usually sparse, making the boundary between forested and open AP communities diffuse.

Map 4: Acid Peatlands in Minnesota by Ecological Provinces

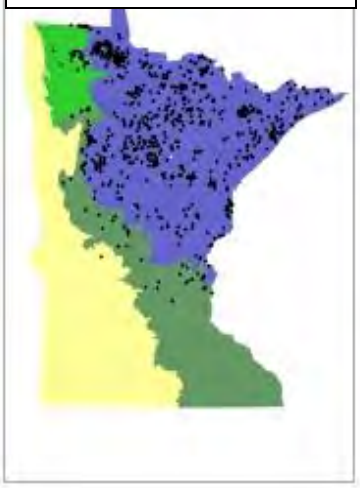


AP communities are widespread in the Laurentian Mixed Forest (LMF) Province (blue area of map), sporadic in the northern half of the Eastern Broadleaf Forest (EBF) Province (dark green area of map), and rare in the Tallgrass Aspen Parklands (TAP) Province (light green area of map); they are absent from the Prairie Parkland (PPA) Province (yellow area of map). Because of marginal climatic conditions for Peatland formation in the TAP Province, with precipitation barely exceeding evapotranspiration, AP communities are limited to a few localities and are not as well developed as in the main part of their range in Minnesota in the LMF Province. (**APn80-Northern Spruce Bog**, **APn81-Northern Poor Conifer Swamp**, APn90-Northern Open Bog, APn91-Northern Poor Fen)

[6] Field Guide to the Native Plant Communities of Minnesota, The Eastern Broadleaf Forest Province; State of Minnesota, Department of Natural Resources (2005); Field Guide to the Native Plant Communities of Minnesota, The Laurentian Mixed Forest Province; State of Minnesota, Department of Natural Resources (2003); Field Guide to the Native Plant Communities of Minnesota, The Prairie Parkland and Tallgrass Aspen Parklands Provinces; State of Minnesota, Department of Natural Resources (2005).

Forested Rich Peatland Communities (FP): Forested Rich Peatland (FP) Communities are conifer- or tall shrub-dominated wetlands on deep (greater than 15" or 40cm), actively forming peat. They are characterized by mossy ground layers, often with abundant shrubs and forbs. FP communities are widespread in the LMF Province and extend across the northern half of the EBF Province. They reach their western limit in the TAP Province, where they are uncommon, and along the border of the northern part of the EBF Province with the PPA Province, where they are extremely rare. In the PPA and the TAP Provinces, high rates of evapotranspiration – caused by warmer climate and relatively low precipitation – combined with historical prevalence of fires limit peat development and restrict FP communities to wetlands fed by upwelling groundwater. (**FPn62-Northern Rich Spruce Swamp [Basin]**, **FPn63-Northern Cedar Swamp**, **FPs63-Southern Rich Conifer Swamp**, **FPw63-Northwestern Rich Conifer Swamp**, **FPn71-Northern Rich Spruce Swamp [Water Track]**, **FPn72-Northern Rich Tamarack Swamp [Eastern Basin]**, FPn73-Northern Rich Alder Swamp, **FPn81-Northern Rich Tamarack Swamp [Water Track]**, **FPn82-Northern Rich Tamarack Swamp [Western Basin]**)

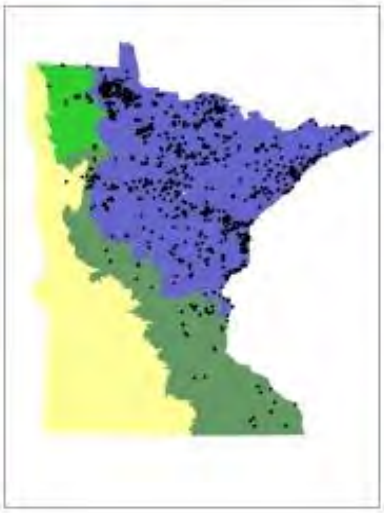
Map 5: Forested Rich Peatlands in Minnesota by Ecological Province



Wet Forest Communities (WF):

Wet Forest (WF) Communities occur commonly in narrow zones along the margins of lakes, rivers, and peatlands; they also occur in shallow depressions or other settings where the groundwater table is almost always within reach of plant roots but does not remain above the mineral soil surface for long periods during the growing season. Because of a cool climate characterized by regular precipitation and slow rates of evaporation, WF communities are common across the LMF Province. They are dominated most often by black ash or white cedar, with understories characterized by patches of shrubs such as speckled alder (*Alnus incana*) or mountain maple (*Acer spicatum*), mosses and upland forest herbs on raised hummocks, and sedges and wetland forbs in wet or mucky hollows. Because the EBF, PPA, and TAP Provinces are characterized by a relatively warm and dry climate, WF communities are uncommon, occurring mainly in areas with high water tables or areas fed by upwelling groundwater from deep aquifers. (WFn53-Northern Wet Cedar Swamp, **WFw54-Northern Wet Aspen Forest**, WFn55-Northern Wet Ash Swamp, WFs55-Southern Wet Aspen Forest, WFs57-Southern Wet Ash Swamp, **WFn64-Northern Very Wet Ash Swamp**)

Map 6: Wet Forest in Minnesota by Ecological Province



In Acid Peatland (AP) communities tamarack was the dominant tree following disturbance, accounting for some 55-80 percent of the initial cohort. Natural succession moves to mature stands enriched in black spruce, but second-cohort tamarack still accounted for 35–70 percent of the trees. Today, young

AP forest might start with 25 percent tamarack, but by maturity black spruce is dominant if not the sole species. Cedar and black ash play no role in AP forests.

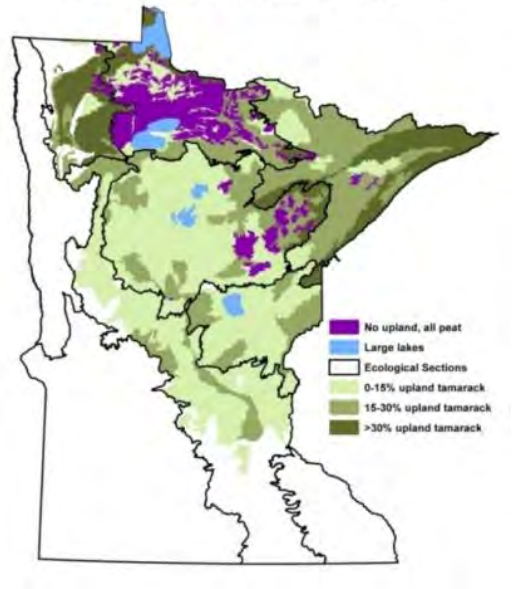
Forested Rich Peatlands (FP) are tamarack's central niche across the state. There are eight Native Plant Community classes in this system and tamarack was a dominant tree in all of them. Presently, black spruce is co-dominant in all eight of these communities, and it is aggressively replacing tamarack. Historically for most of these communities, tamarack strongly dominated young forests at 80–95 percent and maintained dominance into the mature and old-growth stages. Now, black spruce is dominant in the northern and northwestern floristic regions. Only in the FPs63 community has tamarack maintained its dominance since settlement. Although cedar and black ash co-occur with tamarack in several FP communities, they are not replacing tamarack as obviously as black spruce.

In Wet Forest (WF) communities the story of tamarack varies by floristic region. In the northern floristic region, tamarack was an important tree (10-20 percent) only in the old-growth stages. Late-successional status is surprising for a shade-intolerant tree competing with cedar and black ash but in WFn forests, stand re-initiation was so rare that nearly all recruitment was in large gaps or followed species specific mortality events. When WFn forests get old, they develop *Sphagnum* carpets and other characteristics of FPn communities. Apparently, tamarack was successful when that happened. Today, tamarack is barely present except in older WFn64 forests. In the northwestern region, tamarack occurs in the WFw54 community. These forests burned frequently and were dominated by aspen when young, but tamarack was a significant component (10 percent) following disturbance and ultimately a co-dominant with aspen as stands aged. Today, tamarack and aspen are essentially absent from WFw54 forests, having been replaced by black ash and some balsam poplar. Tamarack was not important in WFs57 forests.

Upland Tamarack:

The historic occurrence of tamarack at upland PLS corners (Map 7) is quite interesting, given how infrequently we find tamarack on uplands today. About 1,091,000 acres of historic tamarack habitat is classified as aspen/birch, pine, or upland shrub cover types. The bulk of upland forest conversion (782,000 acres) is to aspen and birch. In the Aspen Parklands and Minnesota and Ontario Peatlands of northwestern Minnesota, tamarack was associated with aspen. In the northeast, tamarack was associated with birch (paper or yellow) across the Northern Superior Uplands. We doubt that tamarack and pine were historically associated because these trees are negatively associated in modern vegetation. Most likely, the 132,000 acres of conversion to pine is the result of survey corners falling on the edge of tamarack swamps in landscapes that are predominantly pine lands. Also, we doubt the conversion of tamarack sites to upland grass. In this case we suspect that the GAP analysis misclassified lowland grass (where tamarack is common) as upland grass.

Map 7: Historic range of upland tamarack in Minnesota



Foresters have long noticed that tamarack can grow well on mineral soil sites; Similar silvics have been noticed between aspen and tamarack; and, Descriptions of Minnesota's vegetation in the early- to mid-1900s often mention mixtures of tamarack with aspen and birch. Are we missing the opportunity to

restore or expand tamarack's range by not considering upland sites? In the absence of intensive silviculture practices, probably not. In the modern vegetation of northern Minnesota, tamarack shows no natural ability to compete on uplands. It is important to remember that tamarack's competitive advantage is on sites with a persistent, stable high water table and opportunities to establish seedlings in the open. Peatlands afford this habitat because *Sphagnum* moss can regulate to some extent the water table, and these sites are sufficiently poor that dense canopies rarely form. In the northwest, frequent fire over a flat, water-logged landscape historically provided this habitat, but today these lands are drained and fires suppressed. In the northeast, the historic mechanism for tamarack's success on uplands is not so obvious. Possibly the GAP classification has misinterpreted some incipient peatlands as upland birch because paper and yellow birch can occupy shallow peatlands in the northeast. Alternatively, tamarack may follow the general tendency of boreal conifers to occur more often in uplands as one moves northeast onto the Canadian Shield.

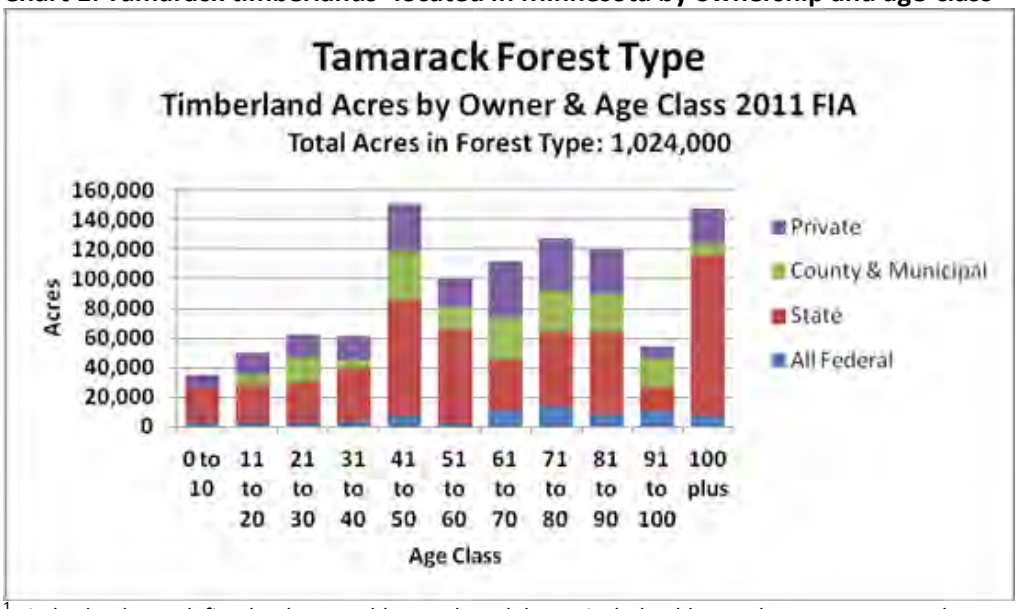
Tamarack and Ash?

Tamarack has also been suggested as an alternative for black ash in anticipation of emerald ash borer arriving in northern Minnesota. Either black ash or tamarack are important tree stand components in 19 NPC classes and their suitability—with one exception—is perfectly complementary with black ash being important in Floodplain and Wet forests and tamarack being important in Acid and Forested Rich Peatlands. The single exception, where we see tamarack and black ash in the same habitat is in Very Wet Black Ash Swamp (WFn64). Even within this community there are physiological and practical reasons why it would be difficult to replace black ash with tamarack. Black ash's forte is to survive ponding, which is an annual spring event on these sites. Tamarack is very sensitive to ponding and is usually killed when spring flooding is prolonged. Tamarack is also very shade intolerant (i.e. tamarack regenerates best in open areas where disturbance has occurred). If enough black ash were removed to suit tamarack's need for sunlight, it is more likely that the site will swamp and convert to lowland grass or alder. Preliminary research examining the survival of planted tamarack in WFn55 and WFn64 communities has confirmed the lack of suitability of these sites, as initial seedling survival is less than 25% in these NPCs.

Forest Inventory Analysis (FIA) – Tamarack Forest Type Acreage Summary:

According to FIA data, 1,024,000 acres of tamarack timberlands currently exist within Minnesota (all ownerships). The chart below shows the amount of acres by ownership and age-class for tamarack timberlands located in Minnesota.

Chart 1: Tamarack timberlands[1] located in Minnesota by ownership and age-class



[1] Timberlands are defined as harvestable stands and do not include old-growth or stagnant stands.

Health Assessment for Tamarack in Minnesota:

Tamarack Pests Information:

Summary: Since the impact of pests began to be recorded in Minnesota, exotic (non-native) insects have caused serious and widespread losses in tamarack. Larch sawfly caused losses of 1 billion board feet of tamarack in the 1910s and 1920s. Then, from the 1940s through 1970s, 40 percent of the surviving tamarack trees were killed. Natural enemies of larch sawfly were imported and released in 1913 and again in 1957 and 1961. For the past 35 years, these introduced insects have effectively controlled sawfly populations in Minnesota. Larch casebearer caused both height and diameter growth losses as well as mortality in the early part of the last century. Natural enemies of larch casebearer were introduced in the 1930s and widespread mortality has not been observed since then.

Eastern Larch Beetle mortality and leading edge of insect attack, Lake of the Woods County, 2011. Photo by Marc Roberts; USFS.

Currently, Minnesota and Canada are experiencing an outbreak of eastern larch beetle (ELB), a native insect that has been previously categorized as a "secondary pest", a pest that is only successful on a weakened or stressed tree. Following outbreaks in the 1970s and 1980s in Canada and elsewhere in the US, eastern larch beetle has been acting as a "primary pest", killing otherwise healthy trees. Mortality from the current Minnesota outbreak started to be mapped in 2000 and has accelerated at a steady pace since then. By 2011, most trees larger than 4 inches DBH have been killed on 123,000 acres of tamarack. Mortality has occurred on lowland sites, upland sites, and in pure and mixed stands of tamarack. Multi-year flooding beginning in the early 1990s and a drying trend since 2005 have been suggested as possible tamarack health stressors that allowed an inroad for eastern larch beetle populations in the northwestern part of the state.

Mortality initiation in tamarack stand. Roseau County. 2010. Photo by Mike Albers, DNR.

At this time, the pace of mortality is still increasing and a silvicultural solution to this insect outbreak is not apparent. Entomologists at the University of Minnesota are investigating the biology and population dynamics of eastern larch beetle in order to offer insights on the causes of the outbreak, why it is perpetuating itself, and possible silvicultural solutions.

Eastern Larch Beetle:

An outbreak of eastern larch beetle, *Dendroctonus simplex,* was first observed in Minnesota in 2000. Since then, tamarack mortality due to eastern larch beetle has been mapped on 123,000 acres of forest land during aerial surveys conducted from 2000 through 2011. Minnesota has just over 1 million acres of tamarack cover type, so this represents a loss of nearly 1/10th.

The eastern larch beetle is a bark beetle, native to North America, which attacks tamarack. Historically, larch beetle was considered a secondary pest attacking defoliated or stressed trees, but following large outbreaks in Canada and the US in the 1970s and 1980s, it is now increasingly viewed as a primary pest

able to attack and kill relatively healthy trees. Additional information about eastern larch beetle can be found in Forest Insect and Disease Leaflet 175, Eastern Larch Beetle by Seybold, Albers, and Katovich at Link to additional information about eastern larch beetle.

Adult eastern larch beetle. Photo by Steven Valley. Courtesy of Bugwood.com

In the past, larch beetles could commonly be found killing small pockets of tamarack generally less than ¼ acre in size and usually associated with beaver flooding, highway construction, or some other stressing factor. However, starting in 2000, we began to see large numbers of tamarack being killed throughout its range in Minnesota, often in stands with no obvious history of defoliation, drought, flooding, or other stress factor.

Biology and Detection Surveys:

Larch beetles become active in early- to mid-May in northern Minnesota. There is one generation per year reported to produce from 1 to 3 broods per year. They overwinter as adults, larvae, and pupae in galleries in the inner bark of tamarack trees.

Winter evidence of eastern larch beetle mortality in tamarack with bark stripped by woodpeckers. Aitkin County. 2002. Photo by Mike Albers, DNR.

The first evidence of attack on a tree is holes in the trunk or branches. Resin flow can be very heavy and conspicuous, coating the surface of the bark during the summer. In late July or early August, foliage begins to yellow. Yellowing often starts on the bottom branches leaving the top of the tree green through the growing season. This makes it difficult to detect currently infested trees from the air because the observers see the green tops of the trees and can't see the discoloration at the bottom of the tree crowns. About 50 percent of trees show no needle discoloration during the year of attack. Their needles stay green through the growing season and drop normally in the fall. However, these trees still die and don't leaf out the next spring.

Abundance of overwintering eastern larch beetle larvae, pupae, and adults under the bark of infested trees. St. Louis County. 2004. Photo by Mike Albers, DNR.

Often people don't notice larch beetle attacks until fall or winter when woodpeckers feed on the larvae, pupae, and adults that overwinter under the bark of tamarack stems and larger branches. Foraging woodpeckers often remove all the bark leaving reddish purple inner bark or white sapwood exposed as well as piles of bark on top of snow at the base of the trees. Black-backed woodpeckers in particular, seem fond of feeding on larch beetles.

Mortality in Minnesota:

Recent analysis of FIA data (Crocker, et al 2012) showed that eastern larch beetle is causing significant mortality. For the last 30 years, tamarack mortality hovered around 5 million cubic feet until 2008 when

the outbreak had doubled the tamarack losses. By 2011, beetle mortality had quadrupled the normal losses (Chart 2)[7]. Although other factors have contributed to these losses, beetle mortality has steadily risen since 2003 and is currently the primary mortality agent (Chart 3).

Chart 2: Volume of tamarack lost due to all mortality agents by inventory year in Minnesota. FIA data analysis by Crocker, et al, 2012.

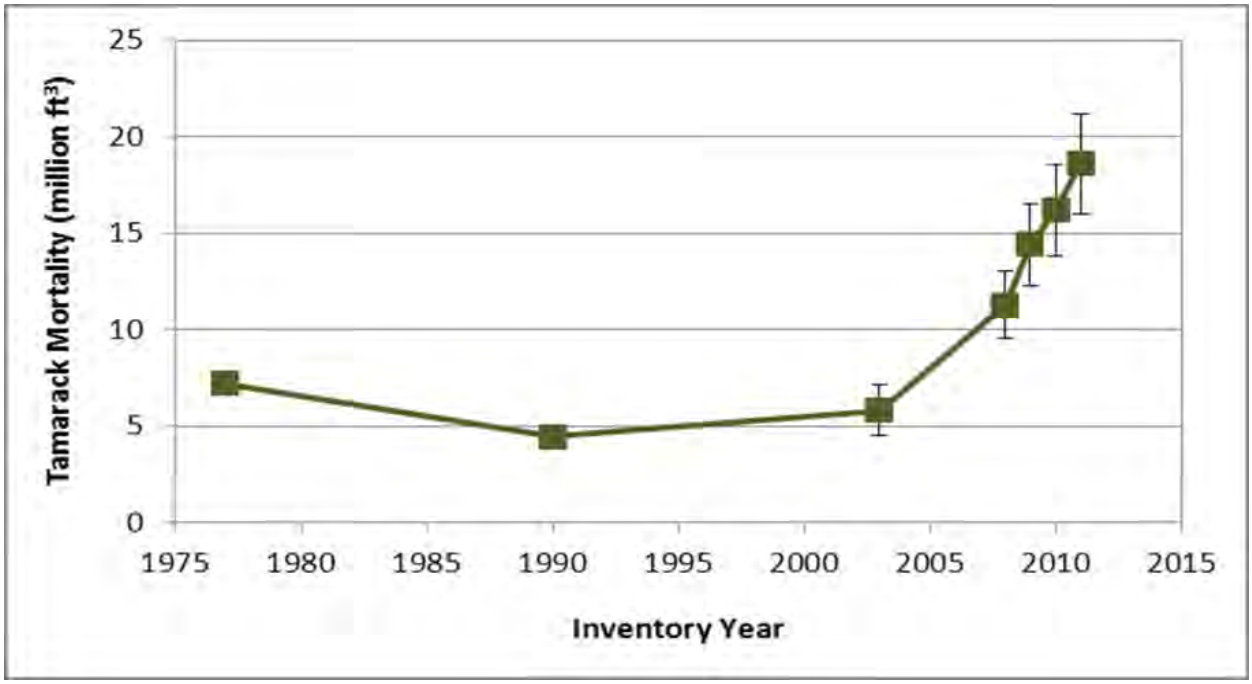
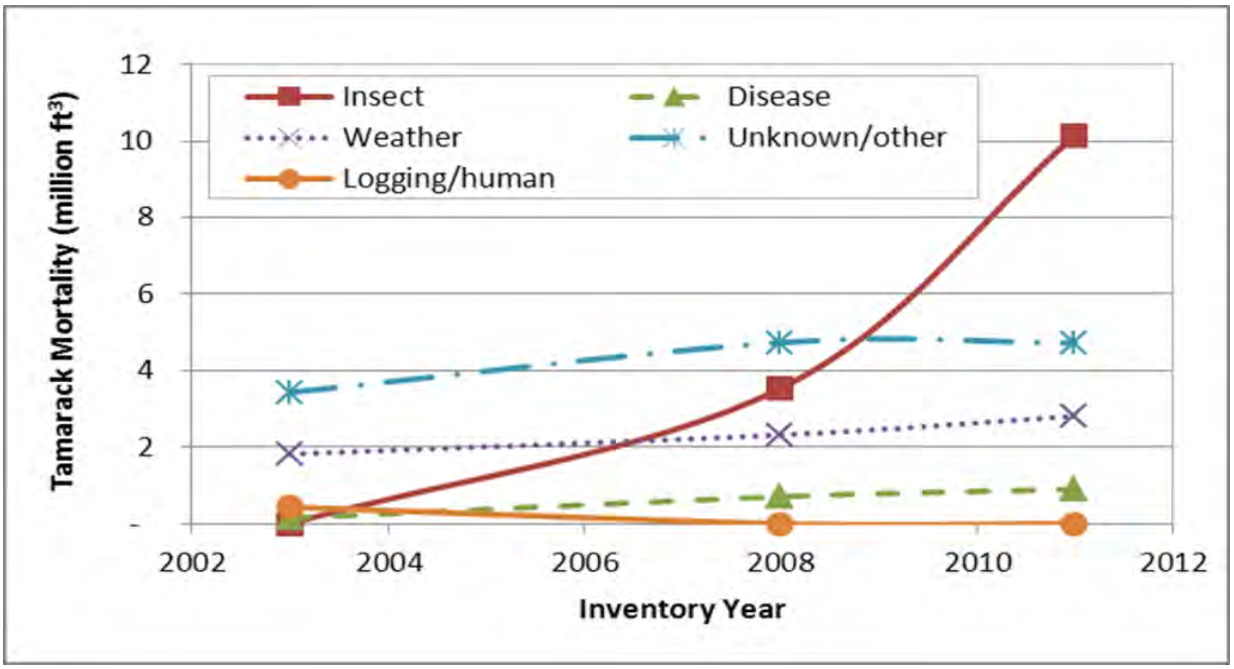


Chart 3: Volume of tamarack lost due to several mortality agents by inventory year in Minnesota. FIA data analysis by Crocker, et al, 2012.



DNR staff started mapping mortality in 2000. Areas of mortality have been mapped annually in the Department's aerial survey (See Map 8 and Chart 4). It is difficult to get a good picture of current year mortality from the aerial surveys; however, the surveys can provide an assessment of cumulative mortality for the tamarack cover type (Chart 5). Since 2000 mortality has occurred on 123,000 acres spread throughout the range of tamarack in Minnesota. Ground surveys have indicated that in some cases the mortality occurs in small scattered patches of trees, but in other cases entire stands have been killed in two to three years. Most trees killed were 4" DBH and larger. Trees that were killed are 40 years of age and older. Mortality has occurred on lowland sites, upland sites, in pure stands of tamarack, and in mixed stands.

Map 8: Larch beetle-killed tamarack, 2000 to 2011

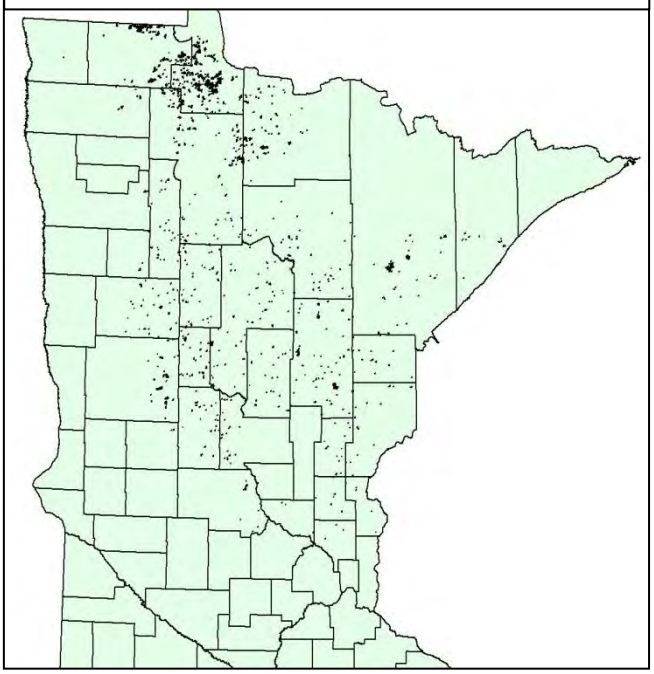


Chart 4: New acres of tamarack mortality (2000-2011)

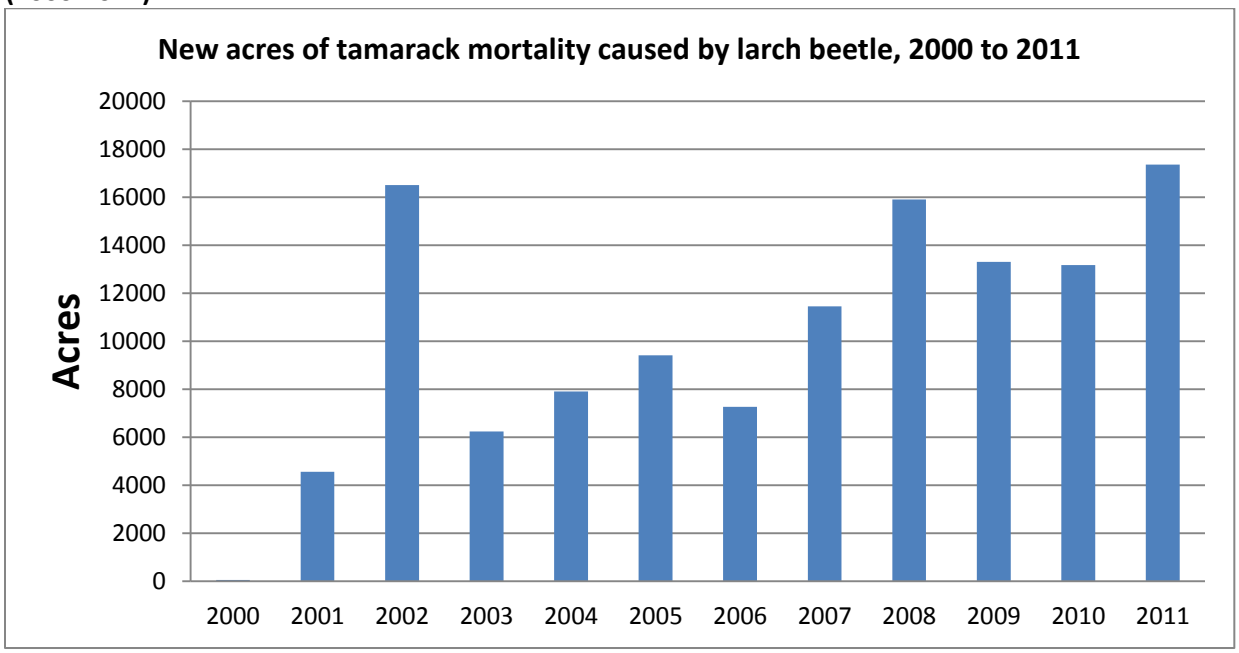
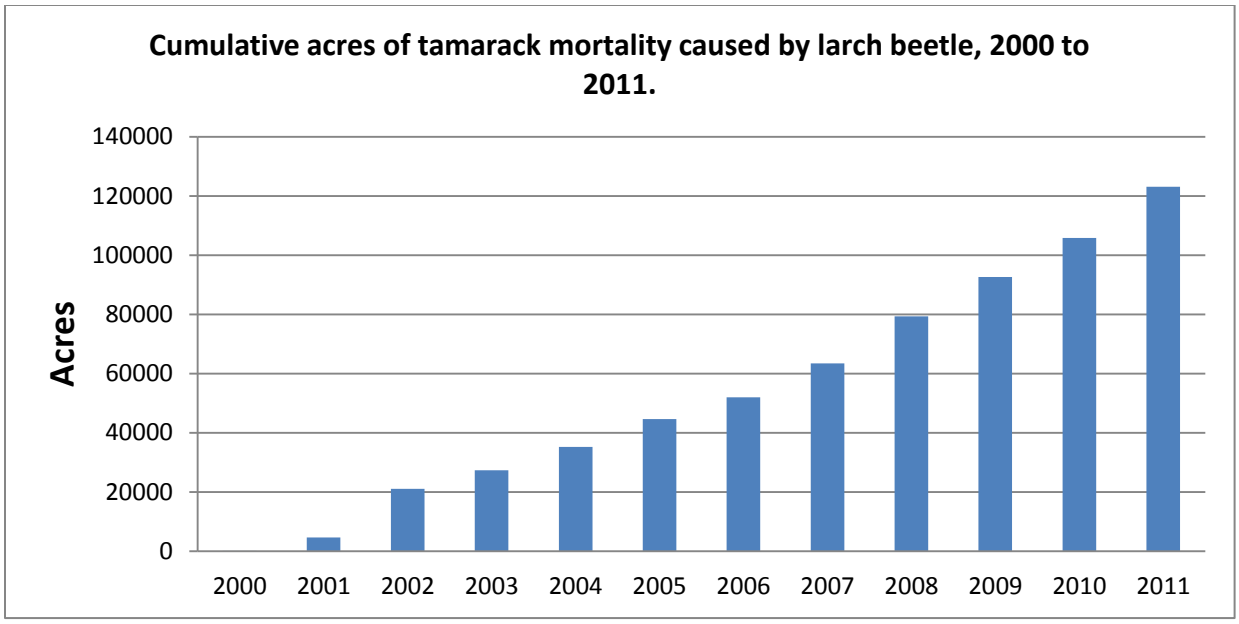


Chart 5: Cumulative acres of tamarack mortality (2000-2011)



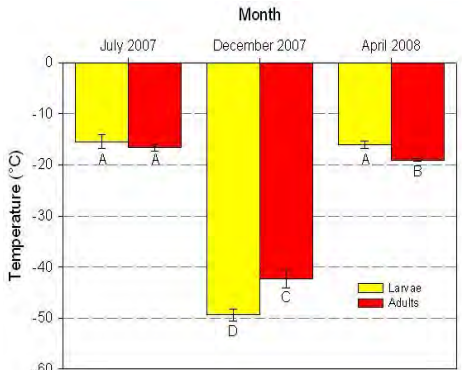
Pheromone Studies:
In 2001, pheromone trapping studies were started in cooperation with Dr. Steve Seybold (USDA FS PSW Research Station, formerly U of MN). Only a couple results are reported here. In a pheromone study in Itasca County, both sexes were most attracted to traps baited with (-)-seudenol. The addition of frontalin interrupts the response of larch beetle to seudenol baited traps. Seasonal flight response to baited traps in 2001 caught the first beetles the week of May 4 and showed three peaks in number of beetles caught: one in early May, a second in mid-June, and the third and largest in late July. The last beetles were trapped the week of August 30.

Overwintering Behavior of Eastern Larch Beetles[8]:
Langor and Raske (1987) reported that in Newfoundland only adult eastern larch beetle overwintered and that freezing temperatures caused complete mortality of immature stages. In much of the past decade, we have experienced winters that were warmer than normal. In Grand Rapids where winter lows would normally reach or exceed (-35F), some recent winters did not even reach a low of (-20F). Since eastern larch beetle overwinter in the above ground portion of tamaracks, we started to wonder if the warm winters might allow larger populations to overwinter and in particular whether larvae were surviving, resulting in larger populations to attack and kill tamarack trees the next year. Could warmer winters be the reason for the larch beetle outbreak? For a number of years we collected larch beetle larvae in late winter (late March or early April) from under the bark of tamarack trees from a height that would have been above the snow line throughout the winter. What we found was that contrary to the report from Newfoundland, **larvae were routinely surviving the winter in Minnesota.**

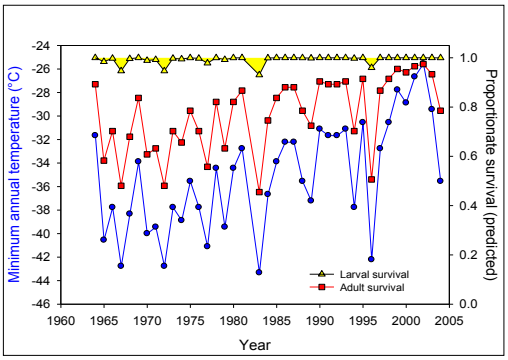
[8] Langor, D.W.; Raske, A.G. 1987. Emergence, host attack, and overwintering behavior of the eastern larch beetle, *Dendroctonus simplex* LeConte (Coleoptera:Scolytidae), in Newfoundland. The Canadian Entomologist. 119:975-983.

Venette, R.C; Walter, A.J. in press. Connecting overwintering success of eastern larch beetle to health of tamarack. Chapter 16 in Potter, K. M.; Conkling, B.L., eds. in press. Forest health monitoring 2008 national technical report. Gen. Tech. Rep. SRS- XX. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station.

This prompted Dr. Rob Venette (United States Department of Agriculture (USDA) Forest Service (FS) Northern Research Station (NRS)) and Abby Walter (UMN graduate student) to investigate the seasonal changes in the supercooling point of eastern larch beetle and to relate these to historical winter temperature records in Minnesota. Eastern larch beetle adults, larvae, and pupae are freeze intolerant, meaning if they freeze they die. To survive winters they supercool, allowing them to survive at temperatures well below the freezing point of water without forming cell-damaging ice crystals. The temperature at which they finally freeze and die is called the supercooling point. Surprisingly the larvae were found to be more winter hardy than the adult beetles. In December larvae supercooled at a lower temperature (-56F) than adults (-43F). Supercooling points change with the seasons. As you would expect, larch beetles, larvae, and pupae are more tolerant of cold in winter than other times of year and by April their supercooling points are about equal to July supercooling points.



Supercooling temperatures of larch beetle larvae and adults. From Venette and Walter (in press).



From: Proceedings Society of American Foresters, 2008, Reno, Nevada; In Press: Forest Health Monitoring 2008, National Report.

Venette and Walter (in press) also looked at winter temperatures and found that over the past 40 years, winters have become less severe. Low temperatures in Isle, Minnesota have increased by approximately 0.25C per year from 1964–2004. Eastern larch beetle larvae are extremely cold-tolerant, so warming winter temperatures have had very little impact on their overwintering success. However, warming has had a substantial impact on adult overwintering success. They predicted that on average, adult survival has increased by 0.7 percent per year from 1964–2004. So in the mid-1960s adult overwinter survival was predicted to be about 60 percent while in the early 2000s adult overwinter survival was predicted to be about 85 percent. Venette and Walter concluded that recent increases in tamarack mortality might be partially explained by warming winter temperatures that allow larger populations of adult eastern larch beetles to survive the winter. This could produce larger populations of offspring the following summer that may be able to overwhelm the defenses of tamarack trees and kill them.

Larch Sawfly:

Larch sawfly, *Pristiophora erichsonii*, was first reported in North America in 1880. The first record of larch sawfly in Minnesota was in 1909. It's reported that between 1910 and 1926 an outbreak killed 1 billion board feet of tamarack in Minnesota. There is another report claiming that between the late 1940s and 1970s, 40 percent of the tamarack trees were killed by the sawfly. The outbreaks in North America during the 20th century occurred across the continent wherever tamarack grew with similar losses reported. For example, an Ontario[9] report on tree decay in the 1950s stated that no studies were

[9] Stem decay in living trees in Ontario's Forests." Info Rpt O-X-408. By JT Basham. 1991.

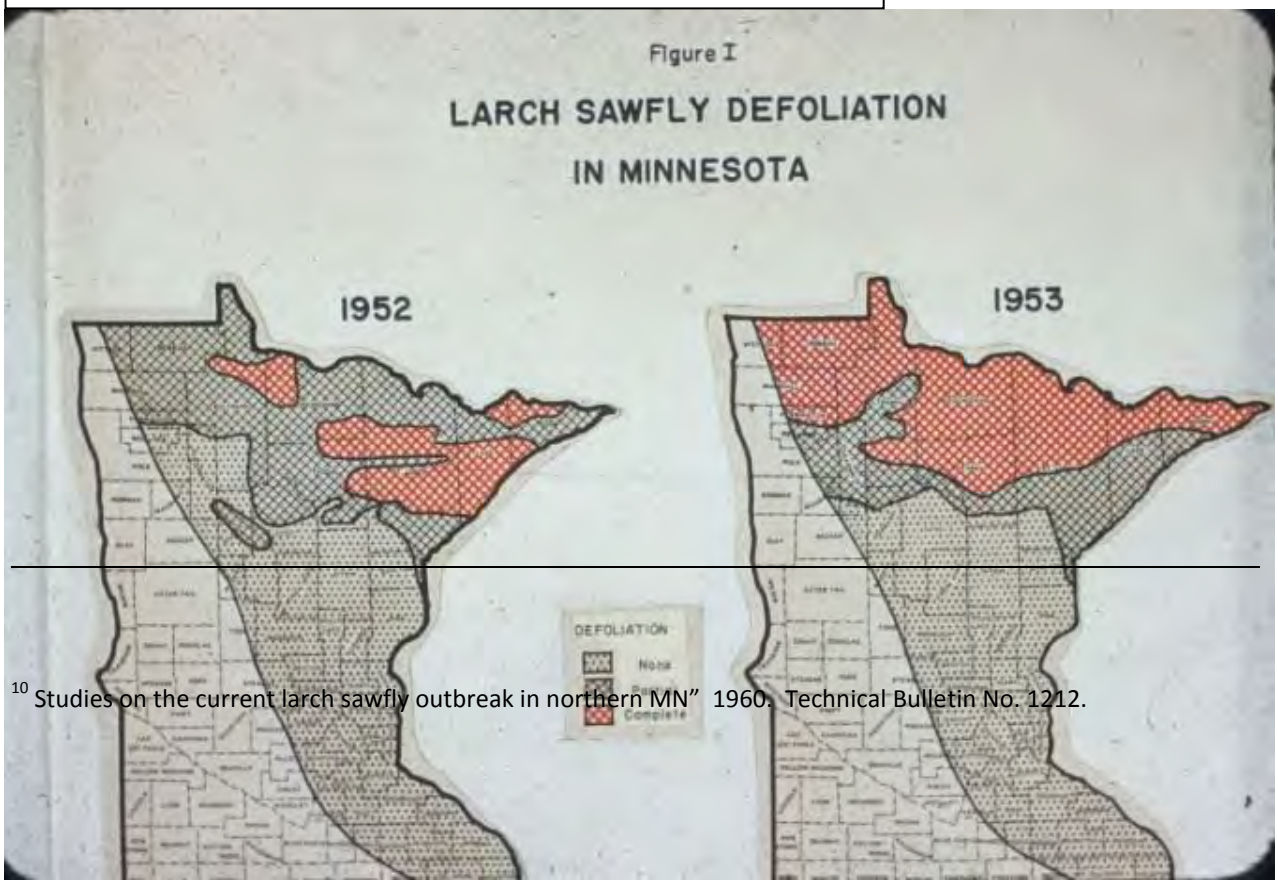
carried out on stem decay in larch because mature trees were so rare due to the severe decimation by the larch sawfly and that some doubt that the species would ever be of commercial importance in the future.

Larch sawflies occur around the world wherever *Larix* species naturally grow. There has long been debate about whether larch sawfly was native to North America or not. Most researchers now agree that there are a number of strains in North America and some of these are native and others were introduced.

Larch sawfly has one generation per year. They overwinter in cocoons in the ground. Adults emerge in the spring and summer. The female lays eggs in slits she cuts into the growing shoots. Larvae emerge and eat the tamarack needles. When full grown in late summer, they drop to the ground and spin silken cocoons in the litter and overwinter. Since tamarack are deciduous and drop all their needles each fall, they are able to withstand defoliation better than other conifers; however, repeated years of defoliation eventually results in mortality.

A lot of research on larch sawfly has been done by many different researchers in North America. Studies in the early 1900s indicated that a paucity of parasites might be why large and damaging outbreaks were occurring. Because of this idea, the ichneumon wasp, *Mesoleius tenthredinis,* was collected in England and released in Canada in 1913. The wasp spread and is thought to have been important in ending the outbreaks in the late 1920s. However, the sawfly populations soon became resistant to this parasite resulting in more outbreaks. It's believed that a resistant strain of the sawfly was accidentally introduced along with the parasite from England. Parasitism declined into the early 1940s resulting in more outbreaks and mortality. Arnold Drooz [10]reported 65 percent parasitism of sawfly in Minnesota in 1935, but low levels by 1952 indicated the parasite could no longer be depended on as an important control factor because the sawfly developed immunity to it.

Map 9: Larch sawfly defoliation in Minnesota (1952 & 1953)



[10] Studies on the current larch sawfly outbreak in northern MN" 1960. Technical Bulletin No. 1212.

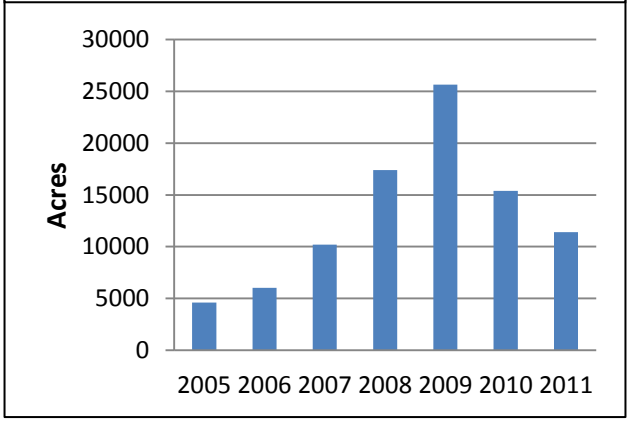
In 1957, Canadian entomologists conducted additional parasite introductions using a Bavarian strain of *M. tenthredini*. The North American sawflies were not resistant to this strain. In 1961 a second parasite from Europe, *Olesicampe benefactor,* was introduced into central and then eastern Canada. In 1970 and 1972, the University of Minnesota collected these two parasites in Manitoba and released them in Lake of the Woods, Beltrami, Koochiching, and Itasca counties. Spread and effectiveness of these parasites were studied into the late 1970s. With the lack of widespread outbreaks of larch sawfly in Canada or Minnesota in the past 35 years, it would appear that the latest parasite releases have been successful; whether this relationship will continue remains to be seen.

Larch Casebearer:

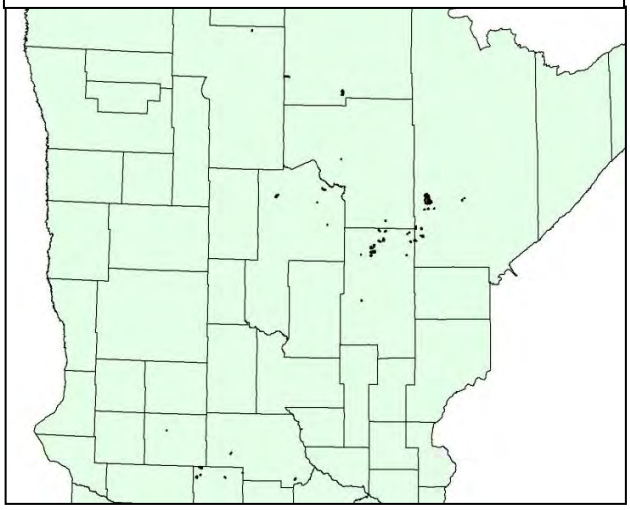
An unfortunate introduction from Europe, the larch casebearer, *Coleophora laricella,* was first found in Massachusetts in 1886 and by the 1920s was found in the Lake States. It is a defoliator of tamarack, primarily saplings and young trees. Needles are mined during the spring causing needle discoloration. When the insect is abundant, heavy defoliation retards both height and diameter growth. Mortality of tamarack due to larch casebearer defoliation has not been observed in Minnesota for decades. A number of parasitic insects have been imported to control the severity of casebearer outbreaks and have been successfully established since the 1930s.

During the time period that eastern larch beetle has been causing mortality (2000-present), we have also experienced an unusual outbreak of larch casebearer, and it has been suggested that the larch casebearer defoliation has been stressing the tamarack leading to attack and mortality from eastern larch beetles. However, this does not appear to be the case in Minnesota. Less than five percent of the acres with larch beetle mortality have also been defoliated by larch casebearer.

Chart 6: Larch casebearer caused mortality of tamarack in Minnesota (2005-2011)



Map 10: Larch casebearer defoliation in Minnesota (2011)



Tamarack Disease Information:

The disease agents listed below are known to exist in tamarack stands located in Minnesota.

Root Diseases and Stem and Root Decays:

The root- and butt-rot fungi reported on tamarack include Armillaria root rot *(Armillaria mellea),* ash root rot *(Scytinostroma galactinum),* red-brown butt rot *(Phaeolus schweinitzii),* and the false velvet top fungus *(Onnia tomentosus)*. They are not aggressive killers on tamarack; however, flood-damaged trees are particularly susceptible to attack by fungi such as Armillaria root rot, and pole-sized trees have been killed by the false velvet top fungus. The principal fungi that cause stem decay are brown trunk rot *(Fomitopsis officinalis)* and red ring rot *(Phellinus pini).*

The presence of decay or root diseases stresses trees because energy that could be used for growth is used for localized responses at disease infection sites in lower boles and roots. The implication for larch beetles is that these diseased trees would be more vulnerable to beetle infestation because the tree that has diverted energy to combating the disease cannot react properly to beetle colonization attempts.

Insects and Diseases of Cones:
Relatively little is known about insects and diseases of cones. External feeding insects such as spruce cone moths, *Dioryctria reniculella*, spruce budworms, *Choristoneura fumiferana*, and internal feeders, such as the larch seed chalcid, *Megastigmus laricis* and the larch cone flies, *Strobilomyia laricis*, are the most commonly found but only occasionally are significant. *Melampsora medusae* causes conifer-poplar leaf rust and occasionally infects tamarack cones rendering them seedless.

Climate Change Implications:

A growing body of evidence overwhelmingly supports the conclusion that climate change is real[11] and will have serious implications for people and the natural world upon which we depend. In Minnesota, the average annual temperature essentially did not change between 1891 and the early 1980s. "Since then, the temperature has risen slightly over 1°F in the south to a little over 2.1°F in much of the north." Since 1950, average "ice out" dates have tended to get earlier by 2 days per decade. Since 1996, the trend is 7.5 days per decade. Lake Superior water temperatures, measured since the early 1980s, have risen more than 4°F in the last 25 years[12]. Tamarack is a cold-climate conifer species. Minnesota is at the southern reaches of tamarack's range due to surface temperature limitations. If anticipated climate changes produce warmer and/or drier conditions in Minnesota in the future, tamarack will become stressed, and thus, harder to grow and maintain on individual sites due to a warmer and/or drier climate.

Larch Beetles in Northwest and North-central Minnesota and Long-term Climate Trends:
As delineated by Southern Climate Impacts Planning Program (SCIPP)[13], the long term climatic trends in both northwest and north-central (Minnesota) climatic regions indicated annual temperatures varied slightly around the mean until 1980 when a warming trend began and has continued through the present (see Charts A and B in the appendix to this report). Looking at the seasonal data available on the IPCC website (see footnote), trends of increased temperatures in the spring were noted in 1976 in both regions indicating earlier spring warmth. Since 1995, autumns have also been warmer than average in both regions. Taken together, warmer springs and warmer autumns have made the growing season longer in both of these regions. Winters have also been warmer. Implications of these warming trends on larch beetles are:

1. Longer growing seasons for brood development; and,
2. Increased survival of the overwintering populations due to warmer winters.

Annual rainfall amounts have trended higher in both regions since 1993, although the trend has weakened in the north-central region (see Charts C and D in the appendix to this report). Since 2005,

[11] "There is a robust scientific consensus that human-induced climate change is occurring. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the most comprehensive and up-to-date scientific assessment of this issue, states with "very high confidence" that human activities, such as fossil fuel burning and deforestation, have altered the global climate. The IPCC projects that the global average temperature will rise another 1.1 to 5.4°C by 2100, depending on how much the atmospheric concentrations of greenhouse gases increase during this time. ...It is very likely that the Earth will experience a faster rate of climate change in the 21st century than seen in the last 10,000 years."
[12] Minnesota climate information from Jim Zandlo, State Climatologist.
[13] The Southern Climate Impacts Planning Program (SCIPP) is a climate research initiative whose goal is to help communities better plan for weather and climate-related disasters in the southern United States, particularly in the face of changing climate. Long-term weather trends are available for each state. Minnesota has nine climatic regions. The Northwest region is 01 and the North-central region is 02.
link to Southern climate impacts planning program

summer rainfall amounts have declined in both regions, most severely in the north-central region. Implications of these rainfall trends are that trees were experiencing excessive rainfall until about 2005 when a drying trend occurred in the northwest and a drought started in the north-central region. Taken together, it is likely that trees in both regions became more vulnerable to attack by larch beetles due to initial flooding then an abrupt drying trend that has occurred recently.

Resource Assessment for Tamarack in Minnesota:

Relationship between NPCs and DNR Forest Inventory Module (FIM) covertypes:

The table below shows the relationship between native plant community classes (NPCs) found in Minnesota where tamarack is common and the corresponding DNR Forestry Inventory Module (FIM) cover types where tamarack is a major component of the stand. Each NPC lists a suitability index for establishing tamarack on the site. Suitability indexes range from poor sites to establish tamarack as a component of the stand (i.e., suitability index of 1-2) to excellent sites to establish tamarack as a component of the stand (i.e., suitability index of 4-5).

Table 2: Native Plant Communities Classes (NPCs) and corresponding cover type frequencies by growth stages

Native Plant Community Class	Suitability Index[1]	Young Growth-stage		Mature Growth-stage	
		Cover type[2]	Frequency[3]	Cover type[2]	Frequency[3]
APn80	1.7	T	24%	T	12%
		BSL	71%	BSL	83%
APn81	4.5	T	29%	T	24%
		BSL	59%	BSL	66%
FPn62	4.5	T	9%	T	8%
		BSL	78%	BSL	81%
		BF	8%	BF	8%
FPn63	3.5	T	7%	T	9%
		BSL	59%	BSL	31%
		BF	17%	BF	39%
		C	12%	C	17%
FPn71	3.9	T	41%	T	19%
		BSL	47%	BSL	66%
		BF	6%	BF	4%
		C	4%	C	10%
FPn72	5.0	T	24%	T	44%
		BSL	71%	BSL	47%
FPn81	4.7	T	39%	T	33%
		BSL	58%	BSL	60%
		C	1%	C	5%
FPn82	5.0	T	39%	T	57%
		BSL	56%	BSL	38%
FPs63	5.0	T	79%	T	77%
		BSL	15%	BSL	18%
FPw63	5.0	T	29%	T	55%
		BSL	68%	BSL	43%
WFn64[4]	4.0	T	0%	T	0%
		BF	16%	BF	16%
		C	1%	C	31%
		Ash	55%	Ash	36%
		Bg	8%	Bg	1%

WFw54[4]	**2.8**	**T**	**0%**	**T**	**0%**
		Ash	**60%**	**Ash**	**49%**
		Bg	**18%**	**Bg**	**25%**
		A	**6%**	**A**	**8%**

[1] Tree suitability index values: 4-5=excellent, 3-4=good, 2-3=fair, 1-2=poor
[2] T=tamarack, BSL=lowland black spruce, BF=balsam fir, C=northern white cedar, Ash=ash, Bg=balm-of-Gilead, A=quaking aspen
[3] Frequency, e.g. Using FIA data, we estimate that 24% of the young APn80 forests would be typed as T, and that 71% of them would be typed as BSL.
[4] Tamarack was important historically and in modern releves, but was not sampled in FIA plots assigned to the NPC.

The table below shows the DNR's FIM cover types which contain tamarack as a significant component of the stand (as based on merchantable volume (cords) percentage). The percent tamarack of total cords column in the table shows the average percent of merchantable volume within stands that contain tamarack.

Table 3: Average percent of merchantable tamarack volume (cords) present within stands for DNR FIM cover types

DNR FIM Cover type (cover type code)	MN Cover Type Code (MN CTYPE)	Number of stands	Percent tamarack of total cords[1]
Stagnant tamarack (TX)	76	133	79.5%
Tamarack (T) – low SI[2] (SI<40)	72	2,946	79.0%
Tamarack (T) – high SI (SI>or=40)	72	3,657	77.6%
Black spruce, lowland (BSL) – medium SI (SI=30-39)	71	5,341	10.3%
Black spruce, lowland (BSL) – high SI (SI>or=40)	71	2,645	10.0%
Stagnant spruce (SX)(SI<23)	75	381	9.6%
Black spruce, lowland (BSL) – low SI (SI=23-29)	71	2,603	9.0%
Stagnant cedar (CX)	77	2,945	6.3%
Northern white cedar (C)	73	6,627	2.8%

[1] (cords=2 *MBF, MBF=1000 board feet)
[2] SI is Site index The DNR uses site index as a measure of productivity in forest cover types located in the state. Site index is a measurement of a tree's height in feet when it reaches 50 years of age. Thus, higher site indices correspond to stands that are estimated to be more productive over time.

Statewide Heritage Conservation Ranks:
Minnesota's NPC types and subtypes have all been evaluated and assigned a state conservation rank (S-Rank) by the Division of Ecological Resources[14]. The resulting S-Rank is a value assigned to a NPC type (or subtype) that best characterizes the relative rarity or endangerment of the NPC statewide. Through NatureServe[15], some of these plant communities have been evaluated across their entire range in the world and have a global rank (G-Rank). This global ranking is an assessment of the condition of the ecological community across its entire range.

FPs63 is the only tamarack NPC with a State Conservation Rank of S2S3 or higher (i.e. S1, S2 or S2S3[16]). FPs63 has received a State Conservation Rank of imperiled (S2S3) and a Global Conservation Rank of imperiled (G2G3). There are less than 17,000 acres[17] of tamarack on FPs63 communities in the state. All other NPCs containing tamarack located in Minnesota are widespread or abundant throughout the state. FPs63 sites are found primarily in or near the Eastern Broadleaf Forest Province located in central Minnesota (see Map 11 below).

Map 11: Location of FPs63 NPCs in Minnesota

[14] link to dnr network of natural heritage programs and conservation data centers
[15] NatureServe - In cooperation with the Network of Natural Heritage Programs and Conservation Data Centers. 2002. Element Occurrence Data Standard. Arlington, VA.
[16] It is standard NatureServe practice to round down range ranks such as S2S3 to S2
[17] It should be noted that DNR staff believe that this acreage figure is likely higher than the final figure will be due to misclassification of type and likely degradation to these communities caused by non-native invasive species and other non-natural disturbances.

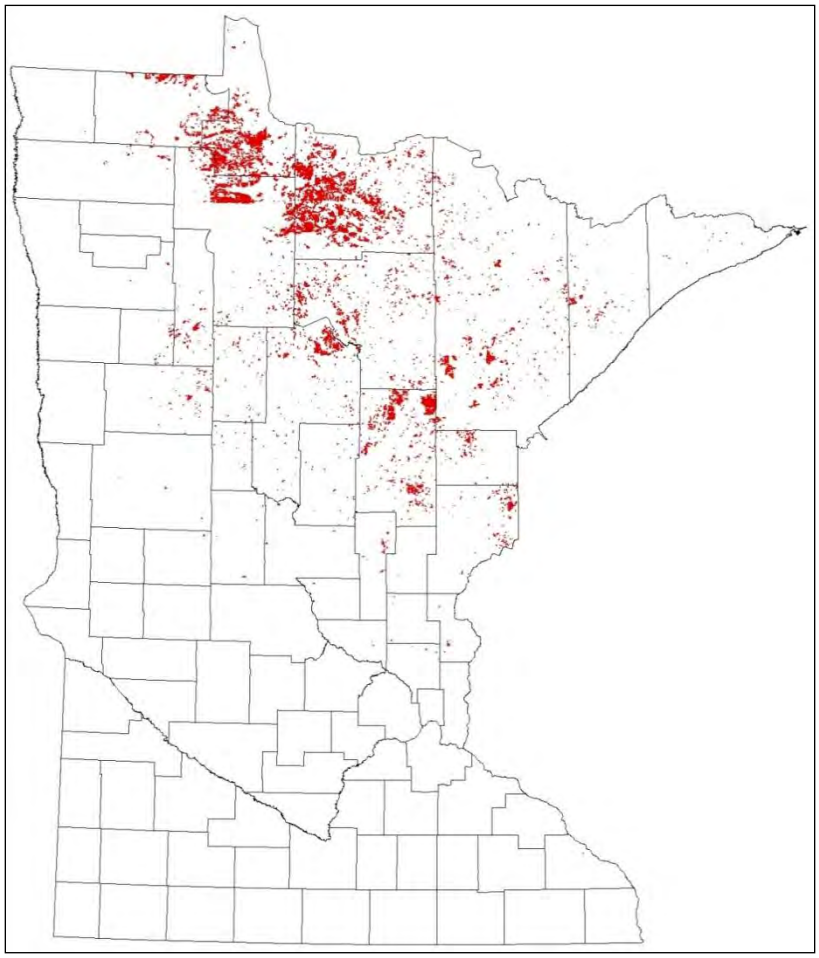
Management Implications:
Management plans on DNR lands for G1 and G2 NPCs by DNR policy must identify maintaining or enhancing the ecological integrity of the NPCs as the primary goal (2005-2009 Sustainable Forestry Initiative Standard® 4.1.3), this coincides with High Conservation Value Forest (HCVF) management guidance of maintaining or enhancing the identified High Conservation Values (HCVs), in this case the imperiled NPC. For more information on G1 and G2 native plant communities see fact sheet in the appendix to this report.

For more information on Minnesota's High Conservation Value Forest (HCVF) policy use this link:
link to dnr website of high conservation value forest

FIM Inventory Information on Current Condition of the Tamarack Cover type in Minnesota: (includes both stagnant and non-stagnant tamarack stands)

According to the DNR's FIM data system there are 12,466 tamarack stands (504,491 acres) located on state administered lands in Minnesota (see Map 12 below).

Map 12: Location of tamarack stands[1] in Minnesota

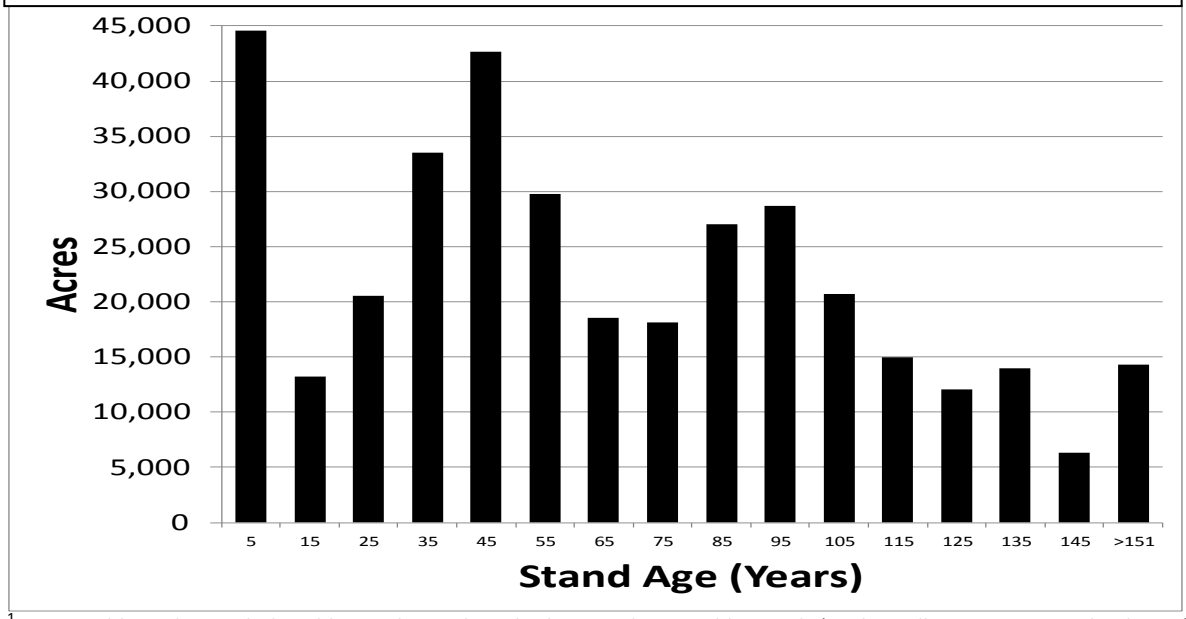


[1] Includes non-stagnant (MN CTYPE = 72) and stagnant stands (MN CTYPE = 76)

Tamarack Age-classes:

The age-class distribution for harvestable tamarack cover type (MN CTYPE=72) located on state administered lands in Minnesota shows a majority of tamarack stands in the younger (0-50) age-classes and a much smaller acreage of tamarack stands in the older (110 and above) age-classes (see Chart 7 below). There are 10,957 stands and 359,010 acres of harvestable tamarack on state administered lands.

Chart 7: Harvestable[1] tamarack cover type (MN CTYPE=72, SI=23 or higher) age-classes on state administered lands in Minnesota



[1] Harvestable timber excludes old growth stands and other non-harvestable stands (Ecologically Important Lowland Conifers (EILC), Representative Sample Areas (RSAs), etc.)

[2] Stand age for the chart represents the mid-point of the age-class. For instance, an age-class of 35 corresponds to stands aged 31 to 40 years. All stands classified as "under-development" were placed in the 1-10 year age-class.

Tamarack Productivity by Site Index:

The DNR uses site index as a measure of productivity in forest cover types located in the state. Site index is a measurement of a tree's height in feet when it reaches 50 years of age. Thus, higher site indices correspond to stands that are estimated to be more productive over time. FIM indicates that a majority of tamarack stands located on state administered lands in Minnesota fall into the medium to high (greater than 35) site indices. These higher site index stands comprise a total of 222,128 acres of the tamarack cover type contained on state administered lands in Minnesota (see Table 4 below).

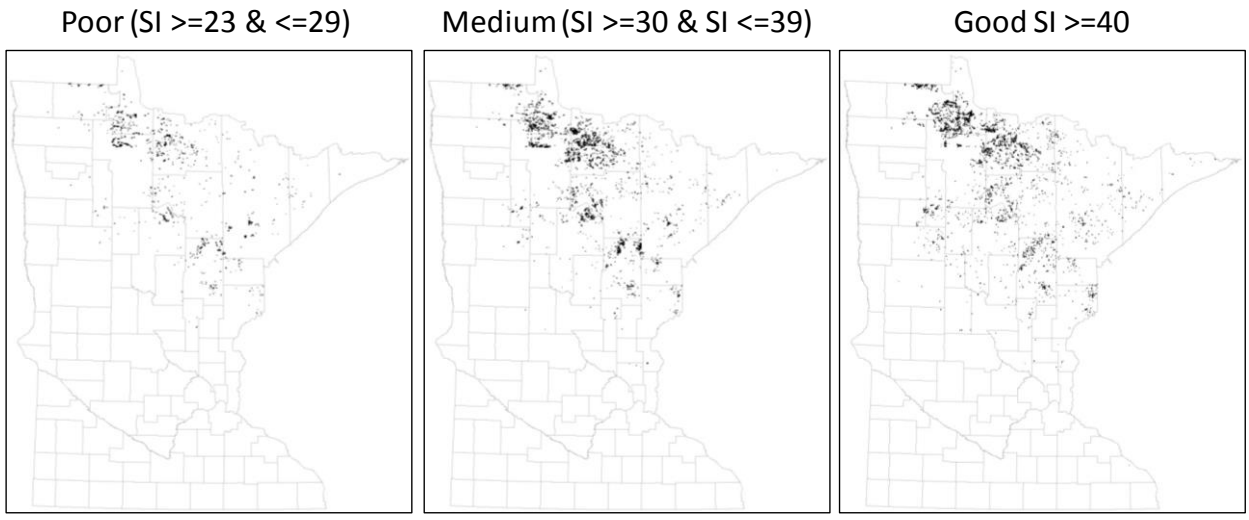
Table 4: Number of stands and acreage by site index class for all[1] stands classified as tamarack[2] on state administered lands in Minnesota

Site Index (class)	Site Index (range)	Number of stands	Acres
Stagnant	< or =22	1,486	145,052
Very low	23-25	272	11,715
Low	25-29	1,120	46,719
Low-medium	30-34	1,903	78,877
Medium	35-39	2,271	81,058
Medium-high	40-44	2,141	58,939
High	>45	3,273	82,131

[1] Includes harvestable and non-harvestable stands.
[2] Includes MN CTYPE=72 and 76 all site indices.

There are a total of 10,980 stands (359,439 acres) classified as the tamarack cover type (MN CTYPE=72) with a site index of 23 or higher on state administered lands in Minnesota. Of these stands 1,392 or 58,435 acres have site indices of 29 or below (Poor), 4,174 of these stands or 159,934 acres have site indices between 30 and 39 (Medium), and the remaining 5,414 stands or 141,070 acres have site indices of 40 or higher (Good). Maps detailing the location of tamarack stands by site indices are shown below.

Map 13: Location of all low (Poor), medium and high (Good) site index tamarack cover type (MN CTYPE=72, SI=23 or higher) stands on state administered lands in Minnesota



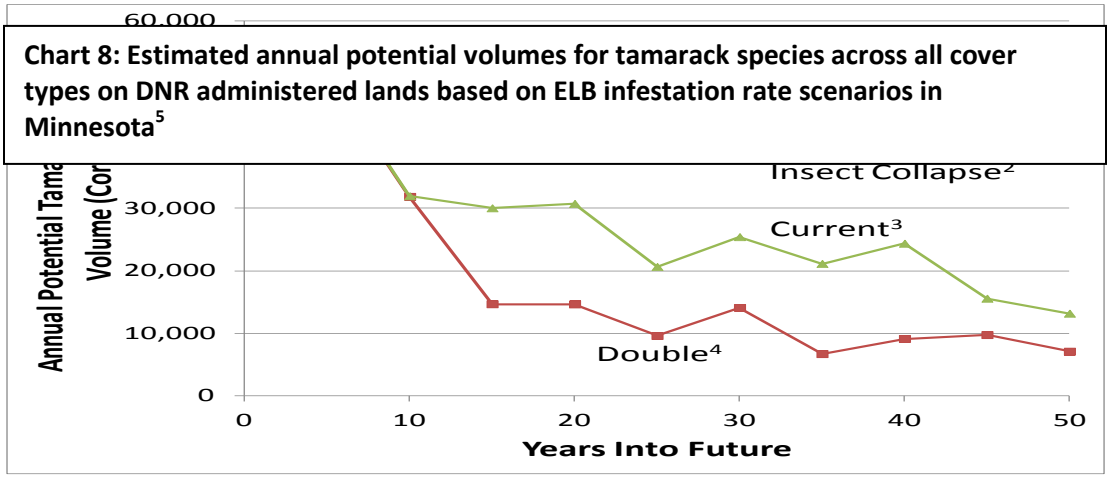
Forest Modeling of the Tamarack Resource[18] on MNDNR Administered Lands:

[18] To view the full version of the Remsoft Woodstock tamarack mortality forest harvest scheduling model use the following link: link to version of the Remsoft Woodstock tamarack mortality forest harvest scheduling model

The Remsoft Woodstock forest harvest scheduling model was used to estimate the likelihood of potentially available or "potential" volumes of tamarack in Minnesota. Woodstock is a software package that allows users to examine how various land uses, management alternatives, and social policies will impact timber supply, given the existing forest types and stand inventories. Woodstock attempts to establish an even-flow scenario for each modeled cover type. Even-flows by cover type provide a target relative range of potential volume over the next 50 years and represent the stability of potential volumes. Factors such as rotation ages and yield tables that predict merchantable volumes all play an important part in estimating even-flows and their variation about the annual average potential volume. Quantifying the average annual amount of potential volume and the likely variation about that average over the next 50 years provides industry some idea of the amount of fiber available for the production of primary wood products (e.g., pulpwood for oriented strand board and paper/pulp production, and sawlogs for lumber, pallet, and veneer production) and even the production of secondary wood products. Only acreage of cover types commonly managed for timber production were included, thus the stagnant tamarack cover type (MN CTYPE=76) acreage was not included in the analysis.

The objective of this current study is to determine how different assumptions about the rate of tamarack mortality caused by the ELB and their interaction with varying Desired Future Conditions (DFC) impact long-term potential volumes on state administered lands. Within Woodstock, the objective function is to maximize total potential cordwood volume across all species and cover types relative to a set of management constraints or goals. Scenarios were modeled assuming that first, the current annual rate of ELB infestation in the state will remain constant (Current); second, the current annual rate of ELB infestation in the state will double (Double); third, the current annual rate of ELB infestation in the state will collapse within five years (Insect Collapse); and fourth, an estimate of volumes associated with no future ELB infestation in the state (No Future Infestation). The estimated potential tamarack species volumes anticipated for each modeled scenario is contained in the chart below.

Chart 8: Estimated annual potential volumes for tamarack species across all cover types on DNR administered lands based on ELB infestation rate scenarios in Minnesota[5]



[1] No Future Infestation Scenario – Assumes that the Eastern Larch Beetle infestation in Minnesota stops immediately;
[2] Insect Collapse Scenario – Assumes that the Eastern Larch Beetle infestation in Minnesota stops five years into the future;
[3] Current Scenario – Assumes no change in the current annual rate of Eastern Larch Beetle infestation in Minnesota; and,
[4] Double Scenario – Assumes that the current annual rate of Eastern Larch Beetle infestation in Minnesota will double on an annual basis.
[5] [5] Estimated harvest volumes based on the assumption that management practices remain static in the future; No accelerated harvest of tamarack cover type or species volumes is assumed, regardless of cover type; And, If harvested, 5% of the tamarack was assumed to be regenerated. (i.e. On acres randomly selected to become infested during the projection, and if harvested, 5% of the tamarack was assumed to be regenerated.) The DNR has calculated a sustainable harvest level for tamarack (all ownerships) of 115,000 cords/yr. (see page 39 of MNDNR's report on Minnesota's Forest Resources at the following link: DNR's report on Minnesota's Forest Resources - pdf)

Summary and Results of Remsoft Modeling Effort

As expected, if future infestation ceases after the next five years, the impacts on potential tamarack species volumes harvested on DNR administered lands will be relatively minimal. However, if infestation continues at its current rate, future annual potential tamarack species volume on DNR administered lands could decrease by 35,000 cords. If infestation rates double, they could decrease by 40,000 cords. It appears that mortality rates beyond the current rate will still produce additional decreases in potential volume (e.g., Double), but at a lessening rate.

There are many potential ways to model the impacts of ELB on future tamarack volumes and cover type acreage, how changes in markets could impact future tamarack supply and demand, and how ELB infestation would drive changes in markets. This modeling effort assumed that harvest and management practices remain stable in the future, hence we did not try to incorporate any accelerated or altered management of the tamarack resource. For stands currently infested by ELB, and for stands randomly assigned ELB infestation during the projection, regardless of cover type, 5% of the existing tamarack resource was assumed to survive and hence some merchantable tamarack volume will remain in these stands. Following harvesting, regardless of cover type, 5% of the tamarack resource was assumed to be regenerated.

Our most recent estimate (using a combination of data from 2008, 2009, and 2010) of annual harvest amounts showed that 72,000 cords of tamarack was harvested across all ownerships in Minnesota (see Table 5). Chart 8 only estimates potential harvested volume on DNR lands and these volume estimates are based on the assumption of no change in management or accelerated harvesting. Thus, purposeful management to increase the harvest amount of tamarack on DNR lands will result in greater harvest amounts than depicted in Chart 8. And although Chart 1 clearly shows that the DNR owns the majority of tamarack forest/cover type acres, and hence the resource, harvest amounts from other ownerships will also result in greater harvest amounts than depicted in Chart 8. A recent sustainable harvest analysis conducted by the DNR using 2005 FIA inventory data estimated that around 115,000 cords of tamarack could be harvested sustainably on an annual basis (see page 39 of MNDNR's report on Minnesota's Forest Resources at the following link: Minnesota's Forest Resources report). This estimate did not directly account for ELB and other mortality causing factors of tamarack, and thus might be slightly optimistic, but it does show that additional tamarack volume is available.

Wildlife Associations and Habitat Needs Associated with the Tamarack Cover type in Minnesota:

Beyond providing important ecosystem services, such as water filtration and timber resources, tamarack systems support at least a portion of the life cycle for the following wildlife species.

Birds:

Compared to many other forest systems, bird species diversity in Peatland Forest (Rich Peatlands-Acid Peatlands) is high, perhaps because of the wide ecological gradient this forest system spans (see diversity of bird species in peatland forests). Although a large number of bird species is associated with lowland conifer forest landscapes, few are entirely restricted to these landscapes. Within lowland conifer landscapes, not all species are associated with forested stands. Some could favor the juxtaposition of a lowland conifer forest stand with a ditch or opening or bog. For example, the American bittern, sedge wren, and swamp sparrow.

The Minnesota Biological Survey (MBS) has conducted a total of 144 point counts in lowland conifer stands with tamarack cover of at least 25 percent. Based on this point count data, nongame birds common in tamarack stands (tamarack cover greater than or equal to 25 percent) with relatively closed canopy include yellow-bellied flycatcher, hermit thrush, nashville warbler, yellow-rumped warbler, and white-throated sparrow. Less common, but still important, breeding species are black-backed woodpecker, blue-headed vireo, winter wren, golden-crowned kinglet, and connecticut warbler. The veery is very common in tamarack stands in more southerly areas and near the prairie-forest border (e.g., Eastern Broadleaf Forest Province, and the Mille Lacs Uplands ECS Subsection in the Laurentian Mixed Forest Province). However, elsewhere in the Laurentian Mixed Forest, the veery is much less common in tamarack.

Open tamarack stands (tree canopy cover less than 50 percent) provide important breeding habitat for alder flycatcher, palm warbler, and Lincoln's sparrow. Common Yellowthroats can be quite common in wet, shrubby openings within and adjacent to tamarack stands, but they are not dependent on tamaracks. Golden-winged warblers frequent tamarack-shrub edges and openings within portions of this species' breeding range in central Minnesota. However, golden-winged warblers do not occur in extensive tamarack stands.

Black-backed and American three-toed woodpeckers rely on dying and recently dead trees, particularly tamarack and black spruce, for foraging throughout the year. These conifer-dependent woodpecker species specialize in flaking bark off of recently dead trees and often make heavy use of burned areas or other concentrations of recently dead trees.

Northern hawk owls and great gray owls, species highly sought after by birders, make frequent use of tamarack for hunting perches. Foraging northern shrikes are also commonly observed perched at the top of tamaracks. Spruce and sharp-tailed grouse consume tamarack needles and buds.

Mammals:

Bear, deer, and moose use tamarack and other lowland conifers to escape summer heat, and some bear den in tamarack stands during winter. Predator species, such as bobcat, fisher, and marten frequent

tamarack in search of hares, squirrels, and small mammals, such as bog lemmings and red-backed voles. Snowshoe hares feed on tamarack twigs and bark, and porcupines feed on the inner bark. Red squirrels cut and cache tamarack cones.

Reptiles and Amphibians:

Blue-spotted and four-toed salamanders may use lowland conifers near hardwoods, especially lagg[19] areas (Figure BHB-3, p. 23 Brushland Biomass Harvesting, Voluntary Site Level Guidelines). American toad, gray tree frog, spring peeper, western chorus frog, leopard frog, mink frog, wood frog, redbelly snake, and common garter snake may also be found in tamarack stands.

Species of Greatest Conservation Need:

DNR's State Wildlife Action Plan (DNR's state wildlife action plan) lists Species of Greatest Conservation Need (SGCN) associated with tamarack and lowland conifers. For example, Connecticut warblers nest in tamarack and spruce bogs with varying amounts of shrubby understory; Boreal chickadees prefer young and mature wet spruce forests, where they require cavities for nesting; Rusty blackbirds use lowland conifer forests as breeding habitat, often nesting at the edge of beaver ponds; Olivesided flycatchers breed in lowland conifers, generally requiring a fairly open canopy with tall prominent trees and snags; Two butterflies, the disa alpine and the bog copper, require lowland conifers with cranberries (*Vaccinium macrocarpon* or *V. oxycoccos*) and lowland black spruce forests, respectively; Northern bog lemmings are limited to lowland conifer forests and open peatlands in extreme northern Minnesota; they have been shown to disappear from peatlands altered by human activities.

Management Implications:

Each management action, including doing nothing on a site, will at once favor some wildlife species and disfavor other species. For example, the conversion of tamarack stands to more open landscapes may benefit open bog species such as sharp-tailed grouse. Managers will have to use department landscape goals and management direction (as established in the DNR Subsection Forest Resource Management Planning process), site conditions, available markets and budgets to decide if maintaining tamarack is desirable on an individual site.

Because tamarack is slow growing, the wildlife habitat benefits of older stands would not be replaced for some time following harvest and/or mortality. However, other lowland conifer types can also supply the habitat benefits of older stands. It will be important to try to maintain a full range of age-classes of lowland conifer stands (including old and young stands).

Site level guidelines for snag and coarse woody debris retention should be followed during harvest to preserve these elements for birds, small mammals and amphibians. Lagg areas should be avoided as much as possible during harvest where tamarack stands are adjacent to upland deciduous forests to protect potential four-toed salamander habitat.

[19] Lagg: A wet, moat-like depression that occurs where a peatland comes in contact with an upland.

Wildlife Browsing:

Tamarack is not an important dietary component of very many wildlife species. Tamarack is browsed by some animals but generally to a limited extent. Snowshoe hares feed on tamarack twigs and bark, and porcupines feed on the inner bark. Thus, the Tamarack Assessment Team believes that browsing is not a significant factor in tamarack establishment.

Tamarack Markets and Utilization in Minnesota

Summary and Recommendation:

There is potential for tamarack market expansion, but also a number of challenges to achieving any expansion.

Given both tamarack's advantages and challenges, the greatest opportunity for increasing development of high volume markets appears to be in expanded pursuit of energy markets for both dead and dying tamarack. In fact, dead tamarack seems to have little other utilization opportunity.

Ongoing insect-caused mortality means an absence of a large, relatively assured and stable supply of tamarack fiber. This will have major impacts to marketing efforts. Specifically, forest product companies will be unlikely to make large capital investments in products that utilize only tamarack. Important considerations in any expansion efforts will be a focus on existing businesses and products that can utilize tamarack as only one component of their species mix. This would enable species flexibility over time as tamarack availability is reduced.

A renewed effort on tamarack marketing will be critical to any efforts to manage and mitigate losses. DNR should task their Utilization and Marketing Program with developing and executing a tamarack marketing plan.

It may seem counterintuitive to suggest that better markets are needed for a species experiencing serious mortality losses. However, improved markets would provide the only realistic alternative for both utilizing a portion of trees likely to be lost to mortality, and also trying a variety of management techniques with potential to result in desirable future site conditions. It should be recognized however that even with improved markets, it is highly likely that thousands of acres of stands will succumb to mortality.

Tamarack Products, Wood Properties, and Marketing Challenges:

Wood Products from Tamarack:

The heavy, durable wood is used principally for pulpwood, but also for engineered wood products, posts, poles, mine timbers, rough lumber, railroad ties, boxes, crates, pails, and fuelwood. It is occasionally used for trailer beds, paneling, and flooring. Chemicals in the bark and wood can be used to produce pharmaceutical products.

Wood Properties:

The sapwood of tamarack is white and narrow (less than 1 inch wide), while the heartwood is yellow to russet brown. The wood is medium to fine texture, has a silvery cast and an oily feel, and has no distinctive odor or taste. It is intermediate in strength, stiffness, and hardness. It is moderately high in shock resistance. Wood density is relatively high among softwoods.

Tamarack has moderately large shrinkage, but is moderately low in warping and checking. Tamarack is rated as moderately resistant to heartwood decay. It is difficult to penetrate with preservatives.

Tamarack Timber Marketing Challenges:

1. Seasonality of harvest (almost all tamarack is accessible by frozen ground harvest only);
2. Forest health concerns (Eastern Larch Beetle and flooding has caused rather large scale mortality);
3. Many stands have low volume per acre;
4. A relatively small diameter for much of the resource; and,
5. A boom-bust cycle of availability that appears to be occurring every 30-40 years has become more evident over time. The absence of a large, relatively assured and stable supply of fiber will have major impacts to marketing efforts. Specifically, forest product companies will be unlikely to make large capital investments in products that utilize only tamarack.

The economics of producing tamarack fiber may be one of the greatest constraints to increased utilization. Winter is the prime harvesting season. Access and site requirements pit low volume per acre tamarack against other more abundant, valuable and profitable forest resources that are also required to be harvested during the winter season. Low demand for tamarack and higher economic returns from other forest resources makes it difficult to entice loggers into purchasing and harvesting tamarack.

Minnesota Wood Market Overview:

The forest products industry in Minnesota provides important economic development benefits, as well as timber markets that are an important tool for managing forests to maintain health and productivity. In order to achieve an understanding of the current and potential impacts of the forest products industry on management of the tamarack resource, it is important to have a basic understanding of the industry and to identify the product sectors most relevant to tamarack markets in Minnesota. Minnesota has a large and diverse forest industry, which is commonly separated into two general categories, “primary” and “secondary”.

Primary Forest Products:

“Primary” industry refers to initial processors of trees. These primary products are often inputs into “secondary” or “value-added” products.

Primary producers are commonly broken into five major product categories, including producers of:

1. Solid wood products such as lumber and veneer;
2. Engineered wood products such as Oriented Strand Board (OSB);
3. Pulp and paper;
4. Specialty products; and,
5. Wood energy.

Secondary Forest Products:

The secondary forest products category includes producers that use inputs from primary industry such as lumber to further process or manufacture “value-added” products in the form of cabinets, pallets, and many others.

Current Tamarack Market Conditions by Primary Industry Sector:

Table 5: Tamarack utilization by industry type for Minnesota[1]

Industry Type	Cords
Minnesota pulpwood	41,400
Exported pulpwood	5,100
Saw logs & Other	7,100
Fuelwood (bioenergy)	18,100
Total	**71,700**

[1] Source NRS & DNR Surveys

1. **Solid Wood Products (Sawmills):** According to the DNR sawmill database, there are 20 sawmills that use various amounts of tamarack in Minnesota. Annual use per mill varies from 1,000 to 300,000 board feet. A total of about 880 MBF (equivalent to about 1,800 cords) is used annually by sawmills in Minnesota (10 percent of harvested volume).

2. **Pulp and Paper Mills:** One large Kraft pulp and paper mill in Minnesota uses some tamarack for papermaking. In addition, there are two paper mills in Wisconsin that buy tamarack from Minnesota. They have utilized between 3,000 and 5,000 cords of tamarack harvested from Minnesota for the last several years. Total tamarack used for Kraft pulpwood is approximately 27,500 cords (38 percent of harvested volume).

3. **Engineered Wood Product Mills:** One large OSB mill uses tamarack in their wafer mix. They procure roughly 7,000 cords per year (10 percent of harvested volume) within a 60-mile radius of the mill and expect to maintain that targeted volume.

4. **Specialty Mills:** One manufacturing company is currently extracting a chemical component of tamarack wood and producing a health aid supplement. This company uses about 12,000 cords annually (17 percent of harvested volume).[20]

5. **Woody Biomass Energy Facilities:** According to the Woody Biomass Energy Facility database maintained by DNR, there are approximately 10 biomass facilities that list tamarack as one of their feedstocks. These facilities use any species that become available. The use of tamarack is tied to what stumpage volume a producer has available and the circumstances of a geographic production schedule. The price of stumpage is also a major determining factor for biomass facilities. Because of these variables, a consistent volume of tamarack used for fuel feedstock is a very hard target to measure or predict. The latest use survey, completed for 2010, showed approximately 18,000 cords of tamarack used for fuelwood in Minnesota (25 percent of harvested volume).

[20] According to USFS pulpwood survey figures, a total of about 47,000 cords of tamarack from Minnesota was used by all pulpwood mills in 2009. A pulpwood mill reduces small logs into a fiber slurry or chips. From there they manufacture end-products such as sheets of paper, paper towels, bath tissue, and oriented strand board. Pulpwood manufacturers includes manufacturers from the Pulp and Paper Mill Industry, Engineered Wood Product Mills Industry and Specialty Mills Industry.

Tamarack Market Outlook by Primary Industry Sector:

Solid Wood Products (Sawmills): Larger mills have tested tamarack and found handling and product performance deficiencies for their target markets, and they report they do not expect to use any tamarack on a consistent basis. Smaller volume mills will continue to use tamarack as their spot market allows. A couple of Minnesota sawmills would be willing to use more tamarack as indicated on their responses to a survey done in 2012. Specifications limit the amount of tamarack they are likely to be interested in.

Pulp and Paper Mills: One Minnesota pulp and paper mill has consistently used a few thousand cords of tamarack and will probably continue this utilization of tamarack, but are only interested in live tamarack.

Two Wisconsin pulp and paper mills are consistently able to use Minnesota tamarack, but their decision to buy is based on economics. Their transportation and handling costs determine the level of stumpage they can afford to pay. Since the transport and handling costs vary by year, the decision to buy Minnesota tamarack is a yearly one. Thus "go-no go" decisions, including amounts, are contingent on the current stumpage price of tamarack.

Another large pulp and paper mill in Minnesota that had previously used some tamarack is no longer using it and will soon be phasing out all softwoods as they convert to a new product called chemical cellulose.

Engineered Wood Product Mills: One large Oriented Strand Board (OSB) mill expects to continue using only "live" tamarack in the wafer mix. They expect to use roughly 7,000 cords per year procured within a 60-mile radius of their facility.

Specialty Mills: A recent DNR analysis of larger tamarack trees that might be suitable for the pole market indicated that most of the tamarack resource is below size standards for making poles, making it uneconomical to pursue acquisition of tamarack.

One manufacturing company is using Minnesota tamarack for chemical extraction. They currently use about 12,000 cords of tamarack a year. They are optimistic that as demand for their product increases, so will their use of tamarack.

Woody Biomass Energy Facilities: Energy markets are being considered with more frequency across the entire tamarack range in Minnesota. There is currently no plan in place to specifically utilize tamarack as an energy feedstock, but discussions are occurring. Talks have run the gamut from direct firing of solid wood to converting to torrified forms of biofuel that co-fire with coal burning units. Tamarack has been anecdotally recognized as having a "high heat value" when compared to other wood species. This will presumably make tamarack a good candidate as a fuel and feedstock source.

Current Silvicultural Practices for Tamarack in Minnesota

Tamarack is found in both pure and mixed stands. Black spruce is usually tamarack's main associate in mixed stands. Tamarack is most commonly found in three Ecological Systems: Wet Forests (WF), Rich Forested Peatland (FP), and Acid Peatland (AP).

Preferred Site Conditions:

Tamarack can tolerate a wide range of soil conditions but grows best on moist, well-drained loamy soils along streams, lakes and swamps, in seep areas, and on mineral soils with a shallow surface layer of organic matter. It grows well on poorly to moderately well-drained sandy loam to clay soils. Productivity is best on moist fine textured soils. Avoid very wet or very dry sites.

Table 6: Preferred landscape, hydrology, soil structure, and moisture regimes for tamarack in Minnesota

	Wet Forest	Rich Forested Peatland	Acid Peatland
Landscape/Hydrologic Regime	Drains, edges of wet depressions	pH > 5.5, poorly drained basins and glacial lake plains over peat	pH < 5.5, poorly drained basins, glacial lake plains over peat
Soils and Moisture Regime	Mucky soil surface, over mineral soil or shallow peat (<16"), soil saturated in spring, dry by mid-summer	Actively forming hemic peat, water table typically below peat surface, drops during summer	Actively forming peat, water table below peat drops during summer, water inputs mostly from precipitation

Best growth on organic soils occurs on moderately- to well-decomposed material (dark brown to blackish) that contains many fragments of partially decomposed wood fibers and has mineral soil in the rooting zone or a water system that is carrying nutrients from a mineral soil to the rooting zone.

Poorest growth occurs on poorly decomposed (yellowish brown) deep peats of *Sphagnum* origin that depend on precipitation for incoming nutrients.

Seed Production:

Tamarack is monoecious. Late April to early May, male and female flowers appear, usually before leaves appear. Cones begin to appear in June and ripen in early to mid-August. Good crops appear every three to six years. Best crops are found on vigorous, open grown trees, 50 to 150 years old. Cones are ripe when they turn from green to reddish purple or yellow to tan. The most effective way to collect cones is to fell good trees and have pickers strip the cones off limbs. Cones need to be checked to make sure they have seed inside and that the seeds are full. Check for sound seeds by cutting the cone in half with a sharp knife.

Tamarack cones

Rotation

On many sites, Tamarack stands will rotation age up to or beyond 90 years to produce merchantable products. High site index stands, typical of the more upland soils, will produce quality products and high yields on a rotation as low as 40 years.

Ages:

after 40 years.

Regeneration Methods:

Regenerating tamarack is complicated for many reasons: poor markets, eastern larch beetle (ELB), poor access, difficulty timing harvests during good seed years, low seed availability for aerial seeding, wet sites, potential for swamping out following tree removal, and low stumpage values. All of these reasons make tamarack regeneration challenging.

During the last decade, ELB has further complicated regeneration success and restricted silvicultural methods due to the need for much larger salvage clear-cuts necessary to economically capture the dead and dying tamarack. Because these harvests have been focused on removing merchantable timber versus regenerating a new cohort of tamarack, the scale and intensity of these removals may be inconsistent with the conditions needed to secure successful tamarack natural regeneration.

Planting harvested tamarack sites remains impractical for some of the same reasons noted above. However, planting can be successful if properly prescribed. Consider planting containerized seedlings grown from superior seed sources. Control grass and brush competition until fast juvenile growth of the seedlings allows them to dominate the site. Use of mechanical, chemical, or prescribed burning as site preparation individually or in combination must be tailored to address site specific competition and water table impacts on the new seedlings; however, the wet conditions in these areas will limit mechanical site preparation to frozen soil conditions. Dozers used to shear sites for site preparation has resulted in mixed results from successful plantations to failed/flooded sites of lowland brush. Over the years, regeneration surveys have also shown that hummocks and other micro sites provide ideal tamarack regeneration even on difficult sites.

Seeding has been successful on some sites. Aerial seeding has been used when seed is available. Using natural seeding through strip clear-cuts, reserve islands, and adjacent surrounding lowland conifer trees is the preferred method. Conifer tree retention also provides non-timber values for wildlife habitat, aesthetics, and diversity. On sites infested with ELB, it is somewhat speculative but likely that infected tamarack trees are producing larger quantities of seed as a result of stress from ELB. This increase in seeding may be aiding stand regeneration in harvested areas. Conversely, it is expected that some of the

reserve trees infected with ELB will not persist for an extended period and therefore are not a good source for seed production.

Recognition of seedbed requirements, proper orientation and size of rim cuts (i.e., perpendicular to prevailing winds and less than 5 chains wide), timing of block cuttings to occur during heavy seed years, and selection of superior quality seed trees are necessary for successful natural regeneration.

The best seedbed is warm, moist mineral or organic soil with no brush but a light cover of grass or other herbaceous vegetation. Hummocks of slow-growing *Sphagnum* moss often make a good seedbed, but some *Sphagnum* mosses may offer too much competition. In Minnesota, germination beneath tamarack stands was best on fine-textured mosses, primarily *Mnium, Drepanocladus,* and *Helodium.* Findings from clear-cut peatlands in Minnesota show that slash-burned seedbeds favor tamarack reproduction, whereas slash hinders it. On uplands, tamarack apparently reproduces well on rock-raked areas after natural seeding; however, these findings may not translate to the lowland sites where much of the current resource exists.

There are a number of silvicultural systems which have been used in Minnesota to regenerate lowland conifers. Some common methods are described below. Whichever method is used, it is highly recommended that reserve trees be retained as seed trees in order for natural seeding to have some opportunity to occur.

Seed Tree Method of Regeneration:
Seed trees are left on site for the primary purpose of producing seed and are not harvested. ELB has made it difficult for proper live tree selection. This method has been used with limited regeneration success. Seed tree regeneration can include uniform tree distribution, group tree distribution, or a combination of the two.

Uniform Tree Distribution
Within the harvest area, sale regulations specify that a small number of selected trees be reserved as seed trees. Logger select is often the recommended way to retain seed trees by having the feller operator uniformly reserve 7 to 9 (or other specified spacing) tamarack per acre.

Group Tree Distribution
Within the harvest area, sale regulations specify that seed trees be left in small reserve blocks or patches to provide natural seed regeneration.

Strip Clear-cut Method of Regeneration:
Strip clear-cuts are used to harvest a stand by removing several strips rather than harvesting the entire stand all at once. The removals may take a period of 3 to 7 years to complete. This system has been very successful where live, healthy tamarack occurs. Using strip clear-cuts in healthy stands of tamarack can help take advantage of economical natural seeding. It is also very advantageous during times of low seed stock availability from the state nursery program.

The strips are often oriented at right angles to the prevailing winds to maximize seed dispersal into harvested strips and minimize windthrow. Strip widths are suggested to be up to 4 to 5 chains wide in order to best utilize natural seeding. Wind damage due to the resulting larger edge can be a concern. Strip clear-cuts can be designed in an alternate or progressive fashion. Using alternate systems, the

harvest units are cut in two stages. The initial harvest produces long narrow clear-cuts with leave strips in between. The final harvest may require supplemental aerial seeding.

Progressive systems would involve three or more stages of harvest. As soon as the harvested strips have successfully regenerated, subsequent harvests can be completed. Progressive harvests may allow better right angle wind orientation reducing the exposed edge to potential windthrow.

Small Clear-cut with Reserves Method of Regeneration:
Using the clear-cut with reserves system, the overstory is generally removed in one harvest. New even-aged stands are regenerated from reserve islands, group reserve trees, and the surrounding lowland conifers. This method works well on smaller stands up to 40 acres in size. This method has been successful.

Large Clear-cut with Reserves Method of Regeneration:
As mentioned above, using large clear-cuts has become necessary in order to capture significant quantities of ELB killed and dying tamarack. When seed has been available these harvested areas have been aerial seeded the following spring. During years when seed is not available, foresters have had to rely on natural seeding resulting in poor stocking and regeneration. Some of these large clear-cuts, with or without reserve islands, have resulted in less than ideal tamarack regeneration.

Management Considerations and Concerns:

Tamarack grows best on the same type of soils as cedar, but tamarack will grow better on more acidic soils where cedar is best on slightly alkaline soils. The management decision on those sites is to choose between tamarack, with faster growth rate and poor regeneration possibilities, and black spruce, with usually slower growth and more favorable regeneration.

Where trees have been affected by a damaging agent such as drought, sawfly attack, or are over-mature, they may be attacked by the eastern larch beetle when populations build up. Because ELB may quickly remove the options for natural regeneration if the infestation becomes stand-wide, it may make sense to begin regeneration harvests as soon as ELB is detected in an area to take advantage of living trees as seed sources in either strip clearcuts or seed-tree harvests.

Because of the weak organic substrate and poor drainage found where tamarack grows, the use of heavy equipment on Rich Forested Peatland (FP) and Acid Peatland (AP) is restricted entirely to solidly frozen site conditions.

Sources:
Roe, Eugene I., 1957. Silvicultural Characteristics of Tamarack, USDA Forest Service, Lk. States Exp. Sta., Sta. Paper #52.

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Johnston, William F., 1990. Tamarack, Silvics of North America: 1. Conifers; Ag. Handb. 654.
U.S. Department of Agriculture, Forest Service, Washington, DC.
US Department of Agriculture, Forest Service

Key Findings

1. Over the past 150 years, tamarack has experienced several boom and bust cycles which can be traced to episodic mortality caused by pests (primarily larch sawfly and eastern larch beetle). **The primary pest at this time is the eastern larch beetle which has caused mortality to over 120,000 acres of tamarack in the last decade alone. There is no clear silvicultural solution to this outbreak at this time.**

2. The tamarack cover type has declined more than any tree species due to human development associated with forest conversion, competition with other tree species (primarily black spruce), and pest caused mortality. Tamarack has declined from its original 6,000,000 acres located across Minnesota to just over 1,000,000 acres that exist today (an 83 percent reduction).

3. Predicted climate change scenarios for Minnesota could cause increased stress for the resource. A warmer and/or drier environment would mean better pest survival in winter causing a surge in populations. Warmer and/or drier conditions would also cause stress to tamarack sites that currently exist at its southern range.

8. The primary Native Plant Community (NPC) Class dominated by tamarack are within the Forested Rich Peatland (FP) Ecological System (FPn62, FPn63, FPs63, FPw63, FPn71, FPn72, FPn81, and FPn82). Tamarack is also found in some Acid Peatland (AP) (APn80, and APn81) and Wet Forest (WF) Ecological Systems (WFw54, and WFn64) NPCs. The FPs63 is the only tamarack NPC Class with a Statewide Conservation Rank of S3 or higher. FPs63 has received a Statewide Conservation Rank of rare or uncommon to imperiled (S2S3) and a NatureServe Global Conservation Rank of vulnerable to imperiled (G2G3). Any management within examples of this NPC Class must follow DNR Policy for managing G1G2 NPCs.

4. Tamarack provides important habitat for several wildlife species: While not an important dietary component of many species, tamarack and lowland conifers provides thermal regulation, nesting and breeding sites, and escape cover, and are associated with several Species in Greatest Conservation Need (SGCN) status.

5. Tamarack utilization for the past several years has averaged approximately 72,000 cords annually. This compares to an estimated average net annual growth of tamarack growing stock of 96,000 cords according to the 2010 FIA Inventory. The most promising options for increasing tamarack's future utilization are probably biomass energy and perhaps chemical extractives. Nevertheless, the increasing rates of mortality for this species may dramatically reduce future harvest levels and opportunities, as biomass energy appears to be the only potential large market for dead tamarack.

6. Faced with thousands of acres of dead and dying tamarack, poor markets and the fact that we have limited regeneration experience, actively conserving and maintaining this forest type will remain a challenge for foresters well into the future.

Management and Utilization Recommendations for Tamarack on DNR Administered Lands

The Tamarack Assessment Work Group suggests the implementation of the following recommendations for improving the tamarack cover type resource:

Recommendations for improving tamarack health, timber and habitat productivity and ecological diversity:

1. The DNR should provide funding for a survey of tamarack mortality sites to determine regeneration success at sites that have been managed (salvaged) post mortality and those where no management has taken place since the mortality event. These efforts should include a range of post-outbreak stand ages to develop a better understanding of the time required for detectable tamarack regeneration to appear on site.

2. The DNR should provide funding for a case-study to determine which native plant communities and geographical locales throughout the state would be best suited for future tamarack management. The case-study would ideally identify the best sites for future tamarack management based on management objective, NPC characteristics (hydrology, soils, nutrients, etc.), and geographic location in the state while taking into consideration likely future climate trends and eastern larch beetle dynamics.

3. The DNR should conduct a case-study focusing on past tamarack stand management to determine if options other than clear-cut with seed-tree reserves for tamarack would improve the cover type's presence throughout Minnesota. The assessment team also suggests that the evolving silviculture guidance for the tamarack cover type should identify sites where tamarack's presence could be increased based on NPC, past management practices, and historic land use.

4. The DNR should increase collection and availability of tamarack seed to facilitate reforestation efforts. There are a number of ways to get this done, but all will require support from Forestry Division management and forestry area staff.

Recommendations for improving timber outputs, economic and employment benefits and DNR revenue:

5. A renewed effort on tamarack marketing will be critical to any efforts to manage tamarack and also to mitigate losses. DNR should task their Utilization and Marketing Program with developing and executing a tamarack marketing plan.

6. DNR should examine tamarack rotation ages for future Subsection Forest Resource Management Plans (SFRMPs). In light of the current insect-caused mortality and what appears to be a long history of boom and bust mortality cycles, what rotation ages should tamarack be managed at?

Recommendations for improving DNR staff's, key stakeholders' and the public's knowledge of the condition and potential of the tamarack resource:

7. DNR should determine methodology for updating its Cooperative Stand Assessment (CSA) inventory in areas of tamarack mortality through use of aerial survey or other efficient methods. These methods may be refined based on the findings from field studies examining the timeframes required to observe tamarack regeneration post-outbreak.

8. It will be important to encourage field staff to try new silvicultural methods and share the results within and outside of the Division.

9. Encourage and support cooperative efforts with other land management agencies and research institutions to develop a comprehensive knowledge of the management approaches for this species and to ensure scientific studies on this species are relevant to the DNR and the current issues facing the resource. These may include, research and /or demonstration efforts, information and educational product development, and inter-agency workshops designed to develop and exchange ideas on approaches to the management of this species.

Appendix: Climate Trends for Minnesota

Chart A: Northwest Minnesota Annual Temperature

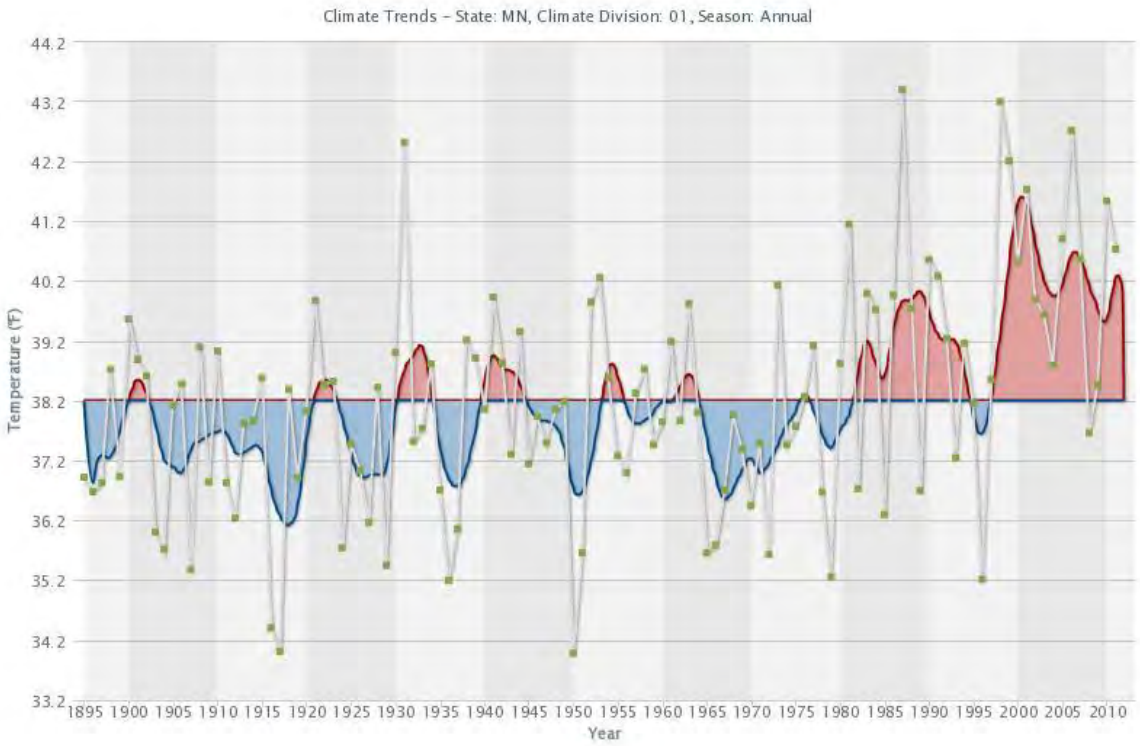


Chart B: North-central Minnesota Annual Temperature

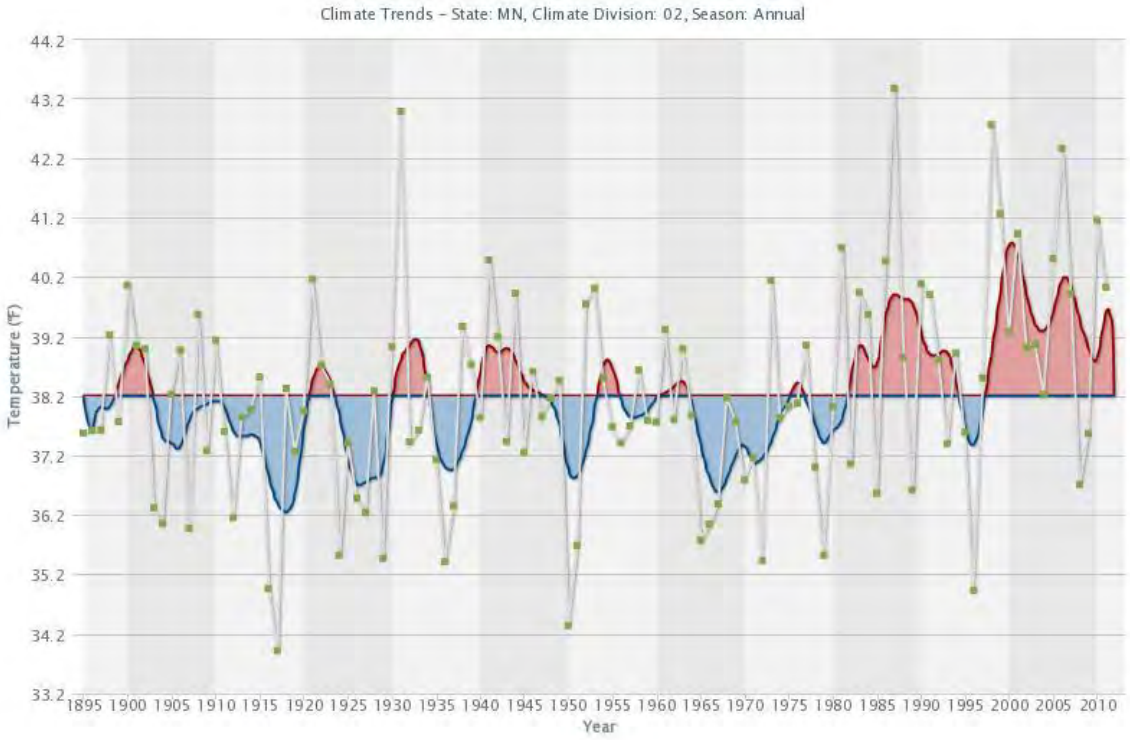


Chart C: Northwest Minnesota Annual Precipitation

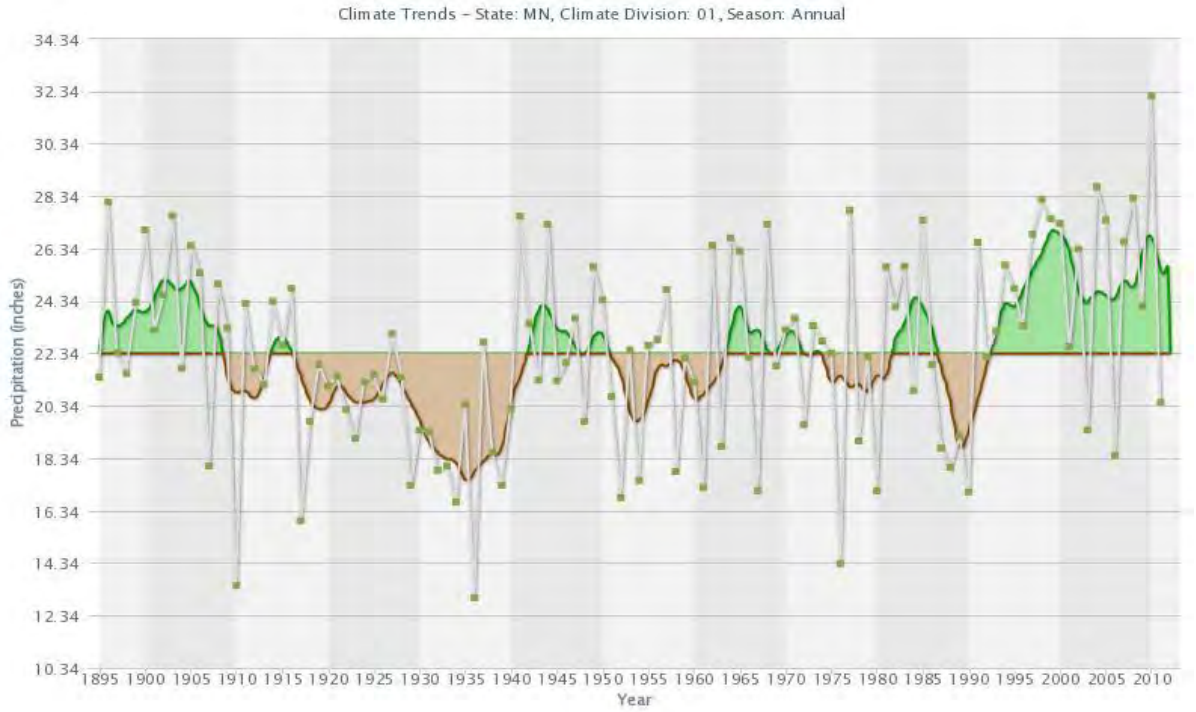
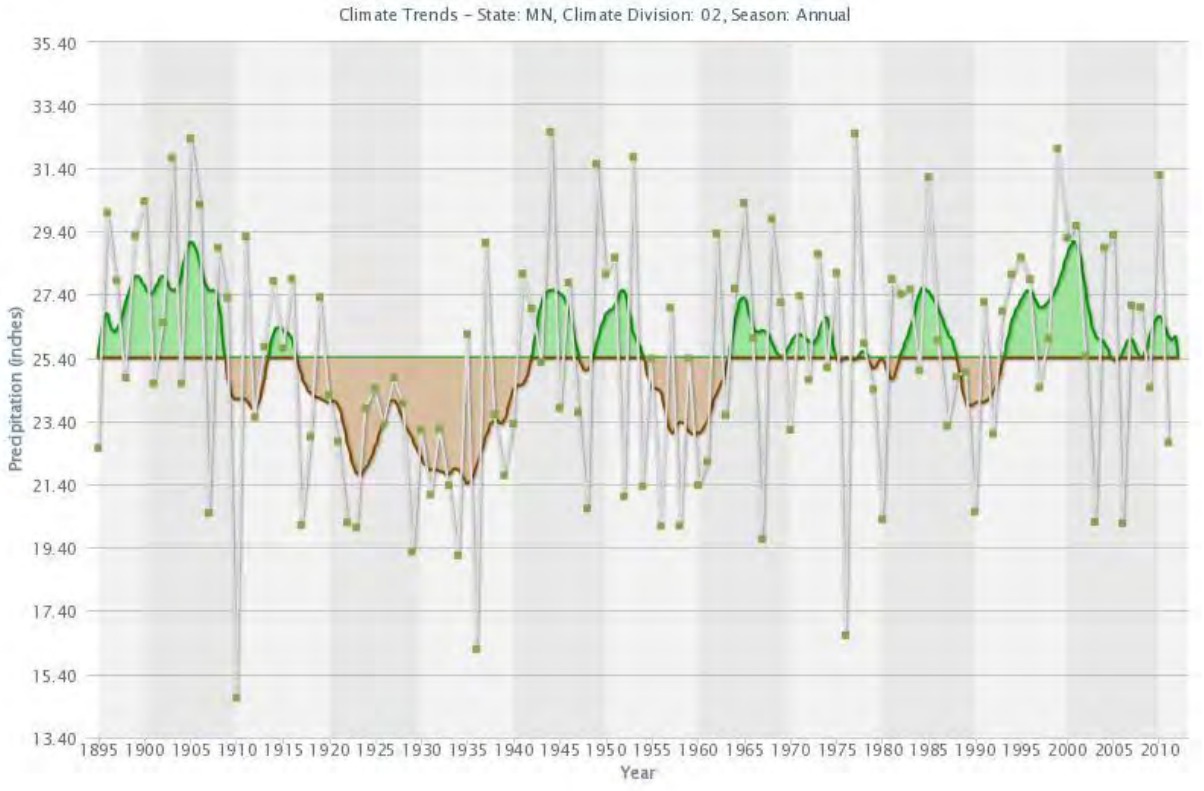


Chart D: North-central Minnesota Annual Precipitation



G1-G2 Native Plant Communities — FACT SHEET

What Are G1-G2 NPCs?

NatureServe and its natural heritage member programs (e.g., ecologists in DNR Ecological Resources) have developed a consistent method for evaluating the relative imperilment of native plant communities (NPCs). These assessments lead to the designation of a conservation status rank, which is determined independent of a NPCs viability. For ecological communities they provide an estimate of the risk of elimination of that community. These status assessments are based on the best available information and consider a variety of factors such as abundance, distribution, trends, and threats.

The conservation status is assessed and documented at three distinct geographic scales: global (G), national (N), and state/province (S). Global ranks (G-ranks) are assigned by NatureServe for plant community associations in the National Vegetation Classification (NVC), whereas state ranks (S-ranks) are assigned by natural heritage programs in each state. In Minnesota, S-ranks have been developed for NPC types and subtypes.

The conservation rank of a community association plant or NPC is based on a one to five scale:

- **1 = critically imperiled**
- **2 = imperiled**
- **3 = vulnerable to extirpation or extinction**
- **4 = apparently secure**
- **5 = demonstrably widespread, abundant, and secure**

For example, a G1 rank indicates that a NPC is critically imperiled across its entire range (i.e., globally). In this sense, the community as a whole is regarded as being at very high risk of elimination. On the other hand, a rank of S3 indicates that the NPC is vulnerable and at moderate risk within a particular state, even though it may be more secure elsewhere.

SFI G1-G2 Requirements

The Sustainable Forestry Initiative (SFI) certificate holders are required to have *"plans to locate and protect known sites associated with viable occurrences of critically imperiled and imperiled species and communities. Plans for protection may be developed independently or collaboratively and may include Program Participant management, cooperation with other stakeholders, or use of easements, conservation land sales, exchanges, or other conservation strategies." (2005-2009 Sustainable Forestry Initiative Standard ® 4.1.3)*

SFI does not require certificate holders who have information regarding NPCs existing on their lands to conduct new surveys or inventories. It is important to note that certificate holders are only required to protect *viable* G1-G2 NPCs.

MN DNR's History / Background

MN DNR has not focused much attention previously on G1 and G2 NPCs because:

1) Most G1 and G2 NPCs are prairie and savanna communities and site disturbing activities on these sites are generally designed to maintain or enhance the ecological integrity of these sites,
2) The most frequently encountered G1 or G2 forest community, White Cedar – Yellow Birch Forest, is often a subject of interdisciplinary joint site visits,
3) The most widespread treed G1 or G2 community, Tamarack Swamp (Southern) [S2S3], is relatively common in the state.

Following the 2009 annual surveillance audits, MN DNR's SFI accredited auditor found that G1 (critically imperiled) and G2 (imperiled) NPCs *"while generally designated for special management, are not automatically designated for such management. Plans for appropriate protection were not available for all such sites." (MN DNR 2009 SFI Annual Audit Report)* As a result, MN DNR was assigned a minor corrective action request (CAR) requiring MN DNR to develop a plan to locate and appropriately manage or protect known sites of imperiled plant communities.

What has been done to locate G1-G2 NPCs?

Using information obtained by the Minnesota County Biological Survey (MCBS), MN DNR has taken the following steps to locate known G1-G2 sites and make this information available to resource managers:

1) Ecological Resources GIS staff, created a preliminary GIS cover including all the known and *potential* G1 and G2 NPC polygons.
2) This preliminary GIS cover was revised by:
   a. Removing polygons that were determined to not be G1 or G2 plant communities, and
   b. Removing very small polygons (<1.0 acre) that are either not viable or were the result of mapping errors by overlaying DNR Forestry and Wildlife ownership on existing NPC polygons.
3) This statewide GIS cover and list of known and *potential* G1 and G2 NPC polygons, along with written descriptions of NVC associations for these polygons, has been uploaded to the ftp site. (*ftp site for polygons*)

G1-G2 Native Plant Communities — FACT SHEET

Scope of Issue:

An analysis of MN DNR's extensive MCBS database *(current as of 12/30/09)* of over 50,000 NPC polygons[1], collected primarily by MCBS ecologists, showed that 349 NPC polygons totaling 7,796 acres on MN DNR's SFI-certified land base[2] potentially crosswalk to G1 or G2 plant communities in the NVC (Table 1).

The actual number of G1 and G2 polygons and acres, is less than the numbers indicate because several NPC types (for example Tamarack Swamp (Southern)) in the Minnesota classification crosswalk to more than one NVC association. Those NPC types that crosswalk to more than one NVC association, where at least one NVC association is ranked G1 or G2 and at least one other association is ranked G3, G4, or G5, are referred to here as *potential G1-G2 NPC polygons.*

Additionally, the SFI standard only requires MN DNR to protect known viable G1-G2 NPCs. The viability of several NPC types, such as White Cedar –Yellow Birch Forest and Jack Pine-(Yarrow) Woodland, need to be determined. Elements used to determine viability include condition ranks (occurrence frequency), size, and landscape context.

Management Implications

Management plans for G1 and G2 NPCs must identify maintaining or enhancing the ecological integrity of the NPC as the primary goal. *(2005-2009 Sustainable Forestry Initiative Standard ® 4.1.3).* This coincides with HCVF management guidance of *maintaining or enhancing* the identified High Conservation Values (HCVs), in this case the imperiled NPC. Similar to Representative Sample Areas (RSAs), plans or prescriptions may range from no active management, prescribed fire, active management, or a combination where consistent with the primary goal for the site.

Many of the polygons are non-forested (prairies or savannas). Therefore, it is unlikely there will be significant impacts on current management operations at these sites.

[1] NPC polygons are classified according to the Minnesota Native Plant Community Classification, Version 2.0 (2003). NPC polygons created by MCBS plant ecologists, typically classified to the NPC type or subtype level.

[2] MN DNR's SFI-certified land base includes 4.9 million acres of Division of Forestry and Section of Wildlife lands, as well as Section of Fisheries lands in Lake County.

Management Process

To ensure that G1 and G2 NPC polygons are protected through appropriate management, MN DNR has committed to taking the following steps:

1) **Prior to development of a site prescription, resource managers should review sites or stands that are scheduled for management in their management area and determine whether they overlap with known or *potential* G1 or G2 NPC polygons.**
   a. **This determination should be made by comparing the location of the site or stand to locations of known and potential G1 and G2 NPCs found on DNR's ftp site @ *Minnesota DNR's ftp site*.**
2) **Consult with Ecological Resources Regional Ecologists or MBCS staff when a site or stand overlaps with a *potential* G1-G2 NPC polygon or if there are questions regarding the viability or status of the *potential* G1-G2 NPC polygon.**
   a. **All *potential G1-G2 polygons* are included in MN DNR's corrective action efforts until such time as sites can be evaluated on the ground to confirm their NVC association (if necessary) or to determine their condition rank/viability.**
3) **All known and *potential* G1-G2 NPCs will be addressed per MN DNR's interim HCVF approach, rather than adding a duplicative separate process.**
   a. **This is the most efficient approach because over 70% of the known and *potential G1 and G2 NPCs* on Forestry and Wildlife lands are included in MCBS Sites of Outstanding or High Biodiversity Significance, most of which are being assessed using MN DNR's HCVF approach (Table 2).**
   b. **As with RSAs and MCBS sites that are being managed as HCVFs, management plans or prescriptions for stands within known or *potential* G1 or G2 NPC polygons should be developed through use of information on the ftp site, application of information in the ECS Silvicultural Interpretations, and interdisciplinary discussions. Management decisions and actions must be documented.**

Applicability: The direction and management guidance outlined above is effective as of June 30, 2010. Stands or sites where management has already been contracted (i.e., timber sale has been sold) are exempt from this process. Efforts should be made to accommodate any new information obtained prior to awarding a contract or sale.

G1-G2 Native Plant Communities

FACT SHEET

Next Steps

In order to ensure that G1 and G2 NPCs are protected, MN DNR will take the following actions:

1) **Ecological Resources staff will complete Condition Rank Guidelines for all G1 and G2 NPCs.**
2) **Ecological Resources staff will annually update the GIS cover of G1 and G2 NPCs located on MN DNR's SFI-certified land base. This updated information will be posted on MN DNR's ftp site by December 31 of each year and will include:**
   a. **Removal of *potential G1 and G2 NPC polygons* determined not to be G1or G2;**
   b. **Removal of G1 and G2 NPC polygons determined to be non-viable; and**
   c. **Newly recorded G1 and G2 NPC polygons and their associated condition ranks, as provided by MCBS plant ecologists.**
3) **Ecological Resources staff will alert Regional and Area Managers of status changes (see above) to existing polygons or new discoveries of G1-G2 NPC polygons within their work areas as soon as possible upon discovery.**
   a. **Efforts should be made to accommodate new information where feasible.**
   b. **Because the MCBS field work season and process does not align exactly with the Timber Sale process and ASEL review period, the situation may arise where new information is obtained after a stand has been set up as a sale.**
   c. **Disputes should be handled per the Forest Management Interdisciplinary Coordination Framework.**
4) **MN DNR will explore options to more efficiently and clearly identify locations of known and *potential* G1 or G2 NPC polygons, as well as other areas to be managed as HCVFs.**
5) **MN DNR will review options and opportunities to use ECS mapping data collected by Forestry and Wildlife staff to help identify additional examples of G1-G2 NPCs.**
6) **MN DNR will continue to include known viable G1 and G2 communities within its overall HCVF efforts. MN DNR plans to make improvements in its HCVF approach to facilitate improved understanding and consistency at the field level.**

Additional Resources

- MN DNR's ftp site @ *Minnesota DNR's ftp site*.
- MN DNR's CAR Responses (4.1.3) @
  - I:\FOR\Forest Certification\DNR's CAR Responses & Memos\2008 CAR Responses
  - DNR Intranet @ Minnesota DNR's Intranet website
- Additional Documents:
  - Directors' Memo *(Signed June 30, 2010)*
  - Table 1: Summary of G1 and G2 NPC Polygons on SFI/FSC Certified Lands *(sorted by Forestry and Wildlife Management Areas)*
  - Table 2: Summary of G1 and G2 NPC Polygons on DNR Certified Lands *(Relative to MCBS High & Outstanding Sites)*
  - NatureServe Conservation Status Rank: Interpreting G-ranks and S-ranks for Native Plant Communities *(version 3.1 – September 14, 2009)*
  - HCVF Memo & Fact Sheet
- SFI Standard

Contacts

For questions regarding interpretation of this information or the attached materials, please contact Kurt Rusterholz (651-259-5135) or Rebecca Barnard (651-259-5256).