# CHAPTER 6

# Stand Damage and Mortality

**St. Louis Moraines, Tamarack Lowlands, Nashwauk Uplands,**
**and Littlefork-Vermilion Uplands Subsections**

*How graphics are labeled:*

Graphics (i.e., Tables, Charts, and Maps) referring to all four subsections combined (St. Louis Moraines, Tamarack Lowlands, Nashwauk Uplands, and Littlefork-Vermilion Uplands) are indicated by a "North-4 Subsections" after the chart designation (e.g., Table 3.2 North-4 Subsections).

Graphics referring to the St. Louis Moraines subsection *only* are indicated by a "slm" after each chart designation (e.g., Chart 3.2 slm).

Graphics referring to the Tamarack Lowlands Subsection *only* are indicated by a "tl" after each chart designation (e.g., Map 3.2 tl).

Graphics referring to the Nashwauk Uplands Subsection *only* are indicated by a "nu" after each chart designation (e.g., Map 3.2 nu).

Graphics referring to the Littlefork-Vermilion Uplands *only* are indicated by a "lvu" after each chart designation (e.g., Map 3.2 lvu).

***Notes relating to this chapter:***
*Color maps may be viewed as PDF files on the St. Louis Moraines, Tamarack Lowlands, Nashwauk Uplands, and Littlefork-Vermilion Uplands Subsection Forest Resource Management Plan (SFRMP) Web site at:*
http://www.dnr.state.mn.us/forestry/subsection/north_4subsections/assessment.html

*Maps in this chapter depict information for an area within a "planning boundary." This boundary is designed to closely approximate the subsection while capturing data summary and planning efficiencies by using survey or jurisdiction lines in some cases.*

Printed documents will be available for review at the Minnesota DNR Grand Rapids Region Headquarters at 1201 E Hwy 2, Grand Rapids, Minnesota, and on compact disk by request to Lynn Sue Mizner at (218) 927-7511 or lynn.mizner@dnr.state.mn.us.

## 6.1 Introduction

This an assessment of forest insects and diseases known to cause tree mortality, growth loss, and quality reduction in forest stands in the Tamarack Lowlands, Nashwauk Uplands, St Louis Moraines, and Littlefork-Vermilion Uplands Subsections. The presence of forest insect and disease agents, as well as animal and abiotic agents, have been documented in reports by the Minnesota Department of Natural Resources (MN DNR), Forest Health Team; University of Minnesota; USDA Forest Service, State and Private Forestry; and North Central Forest Experiment Station.

## 6.2 Role of Insects and Disease

Native forest insects and disease organisms influence forest ecosystem dynamics as pests and agents of stress, but also play a beneficial role in the natural processes. Many native insects and diseases are an essential natural component of healthy forests and may contribute to compositional, structural, and functional diversity. By selectively affecting tree growth and mortality rates, they alter forest composition, structure, and succession. They thin and prune host populations, reducing density and competition. They can slow or stall the process of succession, or they can accelerate it. Through decay and biomass decomposition, they contribute significantly to carbon cycling, nutrient cycling, and energy flow in forest ecosystems. Insect and disease organisms serve as food for many invertebrates and vertebrates. Of vertebrates, birds consume the most tree-feeding insects, but many mammals consume insects to some degree as well. Insects and diseases create structural habitat for shelter and nesting. Many species of woodpeckers are attracted to trees with decay where they excavate cavities for nesting. Many animals use dead wood to roost, nest, or forage.

These same native forest insect and diseases are perceived as problems or pests when occurring at a level or on a site where they interfere with human goals, plans, and desires for trees and forests. Native insects and diseases can reduce timber productivity, lumber grade, site aesthetics, wildlife habitat, and water quality, and can increase the hazard of falling trees and branches and the occurrence of fire hazards, etc. Data from the 1990 Forest Inventory and Analysis for Minnesota indicate that 37 percent of the wood volume produced by all tree species annually is lost due to mortality. Insects and disease organisms account for more than 53 percent of this loss or more than 143 million cubic feet of wood. (Miles, Chen, Leatherberry, 1995). Surveys conducted by the MN DNR, Division of Forestry of oak and birch mortality triggered by drought and attacks by boring insects and root rot organisms, found in excess of 300,000 oaks and 200 million birch dying during the late 1980s and early 1990s (Albers, 1998). More than 40 percent of the birch type in Minnesota was affected.

What is perceived to be beneficial from one perspective may be viewed as detrimental from another. A very low level of decay would be required on a site being managed for high timber productivity, a higher level of decay may be acceptable on a site being managed under extended rotation, while any level may be acceptable on an old-growth site. Some level of decay will occur on every site regardless of the level of management. A forest tent caterpillar outbreak might be viewed as both beneficial and detrimental. The outbreak may benefit some birds that eat them but, be detrimental to others by leaving nests exposed to predators and bright sunlight, which can overheat, dehydrate, and kill young birds in nests. A forest tent caterpillar outbreak may increase the growth of shade-tolerant understory trees due to increased nutrients from insect droppings and dead caterpillars, and due to increased sunlight getting through the defoliated overstory canopy. The same outbreak is detrimental to the overstory aspen due to slower growth and increased mortality caused by the loss of leaves.

While native insect and disease organisms have co-evolved with native trees and forests, exotic insects and disease organisms have not. Exotics do not have a natural "role" in our native ecosystems and have and will continue to alter forest ecosystem diversity, function, and productivity. Exotics historically have caused intensive and severe disturbances over large areas. In extreme cases they have virtually eliminated their host species. The elm resource has been devastated by introduction of the Dutch elm disease fungus and its bark beetle vector. The white pine blister rust fungus, accidentally introduced near the start of the 20$^{th}$ century, has played an important role in reducing the amount of white pine in Minnesota. Gypsy moth, while not yet established in Minnesota, is established in Wisconsin and Michigan and will become established here. While future impacts of gypsy moth in Minnesota are difficult to predict, especially in the northern aspen-birch forest, the insect has the potential to cause widespread mortality and will alter the composition and structure of the forest.

An ecosystem perspective requires that strategies to maintain the health of individual stands consider the beneficial, as well as the detrimental effects of insects and disease organisms. Forests must be considered as an ecosystem and manipulation to one part of that ecosystem affects the other parts. Pests have long influenced forest management, but forest management also affects pest populations. Vigorous trees tend to suffer less damage from these agents. Forest management aims to promote stand vigor and productivity by matching tree species to the planting site; manipulating rotation age, stand density, and species composition; avoiding wounding and root damage during thinning and harvesting; removing diseased and infested trees during harvesting operations, etc. Forest management does not attempt to eliminate native insect and diseases or their processes, but rather to control their activity and impact to a level that allows goals for timber production, water quality, aesthetics, recreation, wildlife, etc. to be realized.

In contrast, a much more aggressive approach is needed with exotic (non-native) organisms. It is important to avoid the introduction of exotics and attempt to contain and eradicate them when first found. Often it is not possible to eradicate or contain exotics once they are established. Attempts to slow their spread and management techniques to minimize their damage are then needed. Dutch elm disease and white pine blister rust are exotics that have become permanent components of the ecosystem. This will also happen with gypsy moth and Emerald ash borer after they become established in Minnesota.

*Table 6.3*

| Insects and Diseases Known to Cause Quality Reductions or Mortality by Cover Type | | |
|---|---|---|
| **Cover Type** | **Agents Known To Cause Mortality** | **Agents Known To Cause Quality Reductions** |
| All cover types | *Armillaria* root rot | Stem decay fungi |
| | | |
| Aspen | *Hypoxylon* canker | White trunk rot |
| | Gypsy moth* | Forest tent caterpillar |
| | | Poplar borer |
| Ash (all species) | Emerald ash borer* | |
| Black ash | Ash decline | |
| Oak | Gypsy moth* | |
| | Two-lined chestnut borer | |
| | Oak wilt | |
| Birch | Birch decline | |
| Tamarack | Eastern Larch beetle | |
| Jack pine | Jack pine budworm | Red rot |
| | *Ips* bark beetles | Stem rusts |
| White pine | White pine blister rust | White pine weevil |
| Red pine | *Ips* bark beetles | *Diplodia* shoot blight and canker |
| | | *Sirococcus* shoot blight |
| Balsam fir | Spruce budworm | |
| White spruce | Spruce budworm | |
| | Spruce beetle | |
| Black spruce | Eastern dwarf mistletoe | |

*Currently not known to be established but eventually will be and need to be considered in this planning period

## 6.4 Insects and Diseases Common to Each Cover Type

The following assessment is organized by cover types. Each cover type includes a description of the Damage Agent(s) followed by a discussion of Management Implications that can both increase and decrease populations of damage agents as well as their impacts. Decisions on which pests and information to include in this assessment are based on literature, surveys, and reports of state and federal agencies and university forest pathologists and entomologists, and on personal experience.

### ALL SPECIES

### Damage Agents

- **Stem decay—**Many species of fungi.
  All tree species are subject to stem decay by an array of fungi. Stem decay in all species increases as tree age increases. Wounds such as dead branch stubs, fire scars, and logging injuries serve as sites where decay can enter the trees. Wounds that occur to residual trees during a partial harvest or other management activities can be critically important. Minimizing wounding during logging, maintaining a level of stocking to promote natural branch shedding, and rotation age management can be keys to controlling the amount of stem decay. The older a tree becomes, the more wounds it accumulates and the greater

potential for volume losses due to decay. Many tree species have the ability to confine decay fungi to the wood present at the time of wounding, but with multiple wounds, decay columns tend to coalesce and the total amount of decay in the stem increases significantly. Also some decay fungi such as *Phellinus pini* and *P tremulae* have the ability to overcome the trees defenses and are able to decay wood formed both before and after wounding. As the stand ages, the proportion of trees in the stand with decay will increase and the volume of decay in each tree will increase. Stem decay does not kill trees outright, but it does lead to more stem breakage from wind and does reduce merchantable volume.

- **Root disease—***Armillaria* spp. and others
  Many species of fungi invade, decay and kill tree roots. Some attack only a few species of trees, while other have a very broad host range. Damage and death from root diseases are likely very common, but impact is not well documented since the damage is hidden below ground. Root diseases reduce the growth of trees and, if severe, can result in death or wind throw. All tree species are susceptible to root disease caused by *Armillaria spp. Armillaria* spp. are present on all forested sites. Hardwood and softwood trees weakened by drought, defoliation, wounding, soil compaction, or old age are predisposed to Armillaria root disease. This is especially a concern when hardwood sites are converted to softwoods. The fungus is able to use stumps as a food base and extend its rhizomorphs through the soil, infecting live roots of the planted softwoods. Partial cutting has also been shown to increase Armillaria root disease.

## Management Implications

As a general rule, as stands of trees are allowed to age, the incidence and impact of stem decay and root rot increase. The presence of stem decay and root rot decreases stand productivity. Stem decay is the primary defect of most species, and as such, has been dealt with in this plan by managing the rotation age of each tree species. Root rot is a concern when hardwood sites are converted to softwoods. Partial cutting has also been shown to increase Armillaria root rot. Trees weakened by drought, defoliation, wounding, soil compaction, and old age can be predisposed to Armillaria root disease.

## ASPEN

## Damage Agents

- **Hypoxylon canker—***Entoleuca mammata (Hypoxylon mammatum)*
  A common disease of aspen, Hypoxylon canker causes mortality and is the most destructive pathogen of young aspen in the Lake States. However, it also plays a beneficial role of thinning young dense stands of aspen. It is estimated that Hypoxylon canker infects 12 percent and kills 1 percent to 2 percent of the aspen in the Lake States each year (Schipper and Anderson, 1976). Hypoxylon canker is primarily a disease of quaking aspen, but bigtooth aspen is also occasionally infected. Aspen of all age classes is susceptible; however, mortality is usually greatest in young trees. The fungus kills the trees by girdling the stem, which leads to stem breakage. Some clones appear to be much more susceptible to Hypoxylon canker than others, and mortality in susceptible clones

may approach 100 percent. Infection levels are not strongly correlated to site characteristics, but do appear to be related to stand density. Insect wounds made by cicadas, poplar-gall saperdas, and tree hoppers serve as infection courts for the fungus causing Hypoxylon canker. These insects prefer open-grown stands and stand edges. Because of this preference, there tends to be a greater amount of insect wounding and Hypoxylon canker incidence in the more open-grown stands and along stand edges (Ostry, et al., 1989).

- **Stem Decay (White trunk rot)—***Phellinus tremulae*
  White trunk rot is the major cause of decay in aspen. It starts to show up in stands at about 20 years of age and increases as the stands age. There does not seem to be a strong correlation between amount of decay and site factors the genetic susceptibility to decay of individual clones seems to override any observable correlations between decay and site factors. The best external indicator of decay is the presence of conks (Jones and Ostry, 1998). However, only about 50 percent of the trees with decay have visible conks, and lack of conks generally leads to an underestimation of decay. For example if 50% of the trees in a stand have conks then close to 100% of the trees contain some decay. Wounds serve as infection sites. Stands with a larger incidence of wounds from such things as equipment scrapes, fire, hail, and storm breakage may have higher levels of decay. Studies have indicated that the pathological rotation age (the age at which the loss of wood volume from decay begins to exceed the annual increment of sound wood) is from 40 to 50 years of age (Schmitz and Jackson, 1927). Others indicate that in many parts of the Lake States, aspen stands begin to deteriorate rapidly when they reach 50 to 60 years of age (Ostry and Walters, 1984). Some stands (or clones) may have relatively little decay even when they exceed 50 years of age, while others may suffer high losses before 50 years. (Christensen et. al., 1951)

- **Forest tent caterpillar—***Malacosoma disstria*
  Forest tent caterpillar (FTC) is a native defoliator that has likely caused outbreaks for hundreds or thousands of years. These outbreaks occur about once a decade and usually last about three to four years, although some have lasted for five to eight years. Outbreaks result in defoliation of most hardwood tree species especially aspen, birch, basswood, and oaks within the outbreak area. Significant growth loss is widespread during the outbreak. The latest outbreak began in 2000, peaked at 7.5 million acres in 2002, and collapsed in 2004. Aspen decline and mortality occurred on 47,000 acres in 2004 across the northern half of the state because defoliation was concurrent with a severe drought. Birch decline (3,200 acres) and oak mortality (15,000 acres) also occurred but were limited geographically. See map of FTC defoliation 2000-2002.

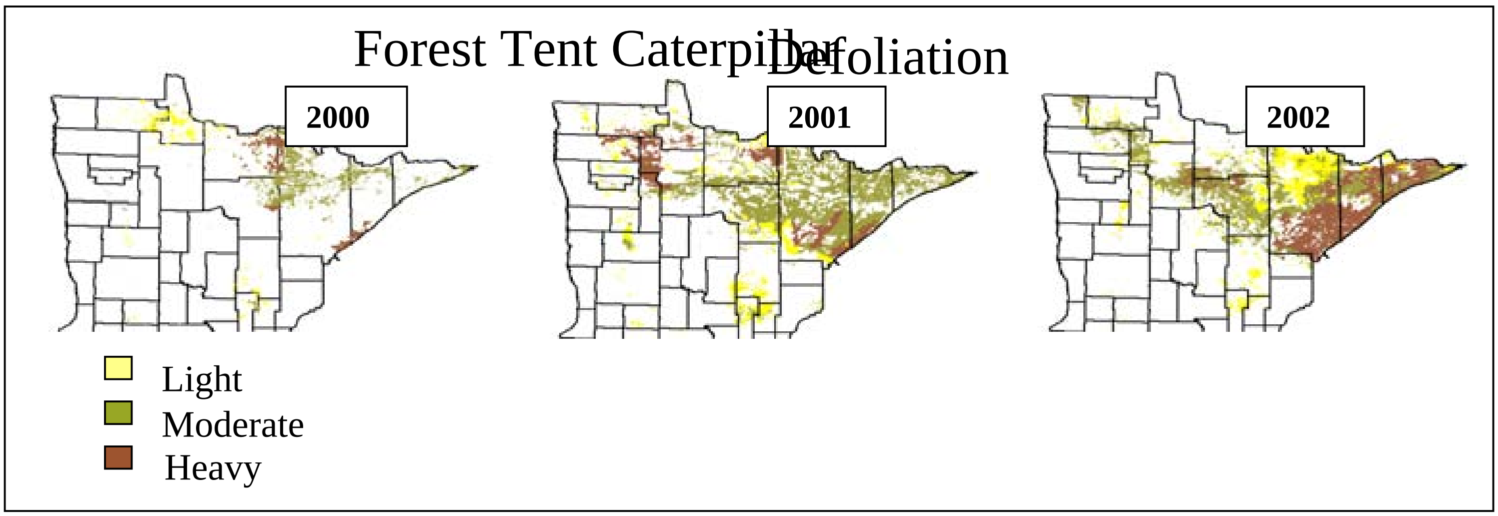
- **Poplar borer—***Saperda calcarata*
  Poplar borer occurs wherever aspen grow but are usually concentrated in a few trees per acre. Larvae bore into sapwood and heartwood, and trees that have been attacked have swollen scars and holes in the trunk and larger branches. Moisture bleeds out of the holes, producing varnished-looking streaks running down the trunk. Extensive tunneling can girdle small trees and makes large trees susceptible to wind breakage. Attack is often concentrated in brood trees that are usually the larger and faster-growing trees in stands. Damage in forest stands can be severe. Infestations tend to increase with a decrease in

stand density. The best management practice is to maintain well-stocked stands that are clear-cut at maturity.

**Gypsy moth ----***Lymantria dispar*
Gypsy moth (GM) is an exotic insect pest spreading across the United States and Canada. Gypsy moth is currently not established in the state, but was included in this assessment because of its occurrence in Wisconsin and because it will spread and become established here. A 640-acre site east of Tower in the Nashwauk Uplands was treated in 2005 to eradicate GM. Follow-up trapping indicates the treatment was successful. In 2004, Lake and Cook Counties were added the Federal Slow the Spread Program due to a large increase in moths captured in pheromone traps during the summer. This lead to 138,000 acres in Cook County being treated with pheromone flakes in 2006.

Aspen is a preferred host of GM. Outbreaks may build and decline faster in aspen dominated stands than in oak stands according to observations in Michigan (Program Staff, GM Education Program, 1997). The impact of GM on aspen stands is not yet well known. The combination of back-to-back defoliations by GM and FTC would likely have substantial impacts especially if coupled with drought and over mature aspen. Additional information can be found in the oak section of this assessment.

*Map 6.4a*




**Management Implications**

As aspen stands are set aside to meet extended-rotation and old-growth targets, or as aspen clumps are left behind to meet leave-tree guidelines, white trunk rot is expected to increase as the ages of these aspen stands increase. Harvesting strategies that reduce the number of acres of older aspen will decrease the amount of decay. Partial harvesting or thinning of aspen stands will wound the residual trees. An increase in wounding will increase decay incidence and volume of decay. If wounding is done early in the life of the stand, time will become an enemy in producing sound wood volume. The longer the decay is present in aspen, the less sound volume there will be since white trunk rot has the ability to breach the defenses of the trees and continue to grow at will throughout the infected trees.

The prevalence and severity of Hypoxylon canker and poplar borer are likely to be increased by management practices such as creating irregular stand shapes or aspen thinning. To reduce poplar borer and Hypoxylon canker occurrence and impact, larger clear-cuts, which produce fully stocked stands and minimal edge, are preferred. If clones have greater than 25 percent of the basal area infected with Hypoxylon canker, it has been recommended to convert those clones to other species or other clones more resistant to Hypoxylon canker (Schipper and Anderson, 1976). When selecting aspen stands to convert to other species, choose the aspen stands with the highest amounts of Hypoxylon canker first and maintain the stands with lower amounts of canker as aspen stands.

Defoliator occurrence and impacts are difficult to predict and to influence by management practices. The amount of topkill or mortality during outbreaks depends on the severity and frequency of defoliation and on tree health. Vigorous trees can usually withstand severe defoliation for a few years. Subsequence stress including additional defoliation, drought, or frost injury may kill the tree. Defoliated trees become more susceptible to attack by secondary pests such as Armillaria root rot. If defoliation and drought are simultaneous, expect decline and mortality in aspen, birch, and oaks that occur on light soils and ridge tops where defoliation was prolonged.

## ASH

### Damage Agents

**Emerald ash borer –** *Agrilus planipennis*

Emerald ash borer (EAB) is an exotic insect first found in Michigan in 2002. It is now found in Illinois, Indiana, Ohio, Michigan, Maryland and Ontario. It attacks and kills all species of *Fraxinus*, which includes white, black and green ash. The borer attacks healthy as well as stressed trees and trees of all sizes. Since it is an exotic, it has no native parasites or predators in North America. Control in the forest to date has involved cutting and chipping all infested trees as well as a ½ mile buffer of un-infested trees around the infested trees. Individual trees can be protected by injecting them with insecticides. Quarantines have been enacted to control the possible movement of EAB from infested states to un-infested states. However it is easily moved on firewood. It is assumed EAB will eventually be transported into Minnesota.

**Black Ash decline –** Interacting biotic and abiotic factors

Black ash stands showing signs of branch dieback, declining crowns, epicormic shoots and tree death is a common sight along roads. Periodically the amount of ash showing signs of decline increases. This was apparent in the early 1990's and again in 2004. Aerial survey, in 2004 identified 27,000 acres of declining black ash. While the majority of the acreage was centered in Aitkin, Carlton and southwestern St Louis counties, declining ash can be found throughout its range. Additional but decreasing acreages of decline were identified by aerial survey in 2005 and 2006. An analysis of Forest Inventory and Analysis (FIA) and Forest

Health Monitoring (FHM) data by the Northern Research Station (NRS) in St Paul was recently conducted. Findings included:

-Trees growing on wetter plots had greater decline symptoms than trees growing on drier plots.
-Severity of decline was greater in older trees than in younger trees.
-Black ash regeneration was greater on better-drained plots.
-Trees growing closer to roads had more decline symptoms than those farther from roads.

In field studies conducted by the NRS and the MN DNR Forest Health Unit, no biotic agent was found to be responsible for the decline. Further study is needed and will continue. It appears the decline is caused by a number of interacting factors. Different combinations may be involved on different sites. Some of the factors likely involved include tree age, proximity to roads likely involving changes in hydrology, droughts and above normal precipitation causing fluctuations in water tables, open winters possibly injuring roots, defoliation, soil type, etc.

### Management Implications

At the present time there are no management options to control EAB in forests. It is assumed it will spread to Minnesota but no one knows how soon that might happen. When it does arrive it is expected that a lot of the ash trees will eventually be killed. In the mean time ash will likely be managed much as it has been in the past. However if there are opportunities to encourage other species in order to increase diversity on sites dominated by black ash they should be pursued. This will be difficult to do on the wetter sites but might be possible around the edges of wet stands where the ash is growing onto drier sites.

Black ash decline is a periodic recurring problem especially on the wetter sites in closed drainages. Management on these sites is difficult and it is very easy to degrade the site. Black ash management is more likely to be possible where it is growing onto drier sites and may need some help such as thinning to help it compete with other species growing on the sites. Keeping EAB in mind, any management efforts should try for good species diversity.

## OAK

### Damage Agents

- **Two-lined chestnut borer—***Agrilus bilineatus*

This insect is an opportunistic insect that attacks weakened oak trees. It is a native beetle known to attack all oak species found in Minnesota, red oak being its preferred host. When trees and stands are healthy, two-lined chestnut borer (TLCB) confines its attack to low-vigor trees or broken branches. When drought stress and/or forest tent caterpillar defoliation have reduced tree and stand vigor, oaks are predisposed to TLCB attack. Under severe stress and/or defoliation conditions, widespread outbreaks of TLCB can occur. Oak mortality due to (TLCB) following drought and FTC defoliation was widespread in 2002 and 2003. Mortality was mapped on 12,500 acres in Itasca, Cass, Aitkin and Crow Wing counties in 2003 (Anonymous, 2003). In many stands 80-90% of the red oaks died. Damage was more severe in portions of stands thinned during the FTC outbreak than in unthinned portions. Trees being attacked by TLCB generally were also being attacked by Armillaria as well.

- **Gypsy moth—***Lymantria dispar*

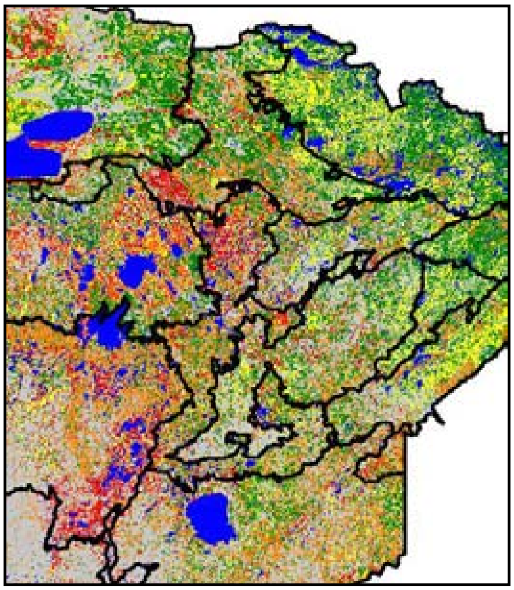
Gypsy moth (GM) is an exotic insect pest spreading across the United States and Canada. While GM is currently not established in the state, it was included in this assessment because of its occurrence in Wisconsin and because it will spread and become established here. GM is invading Minnesota from the east. The invasion pressure will increase as the populations in Wisconsin get closer to Minnesota. GM trapping identified a GM infestation in the Nashwauk Uplands subsection east of Tower in 2004. Two applications Btk were aerially applied to 640 acres to eradicate GM from the site in June 2005. The treatment appears to have been successful according to trapping results in 2006. Lake and Cook County were added to the Federal Slow the Spread Program in 2004 as a result of increased numbers of moths being trapped. The goal in these counties is to reduce the spread of GM rather than eradicating them when populations are found. Pheromone flakes were aerially applied to 138,000 acres in Cook County to slow the spread of GM in 2006.

Natural spread of GM is slow, but the unintentional spread by humans can be very rapid. Egg masses are transported on cars, recreational vehicles, logs, firewood, nursery stock, etc. Gypsy moth caterpillars feed on most hardwood trees and shrubs and in heavy infestations will also feed on conifers. Repeated defoliations lead to tree decline and death. Trees under stress suffer higher levels of mortality. Oaks, aspen, birch, basswood, tamarack, willows, hazelnut, and ironwood- are among the gypsy moth's preferred trees.

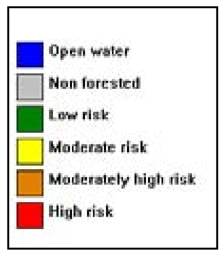
Pheromone traps are the primary method used to detect and monitor GM populations. The DNR is a member of the Gypsy Moth Program Advisory Council and cooperates with the Minnesota Department of Agriculture in its pheromone-trapping program and the federal Slow-the-Spread program.

The extent and severity of impact in this area is unknown at this time; however, GM will cause changes in the forest composition once it is established. According to the latest analysis of GAP data, when GM arrives, hardwood stands will have different vulnerabilities to the effects of multi-year defoliation. A risk potential map (see map) was developed in 2003.

*Map 6.4b North-4 Subsections*



Risk Assessment For Mortality Caused By Gypsy Moth




Risk Potential Map Developed in 2003

**Oak wilt** —*Ceratocystis fagacearum*

Oak wilt is not known to occur at this time in these 4 subsections. It does exist to the south in the Mille Lacs Upland Subsection in Kanabec, Mille Lacs, and Pine Counties. Also in the early 1980's oak wilt was found at a cabin on Big Sandy Lake in the St Louis Moraine subsection. The cabin owner moved infected firewood from his home in the Twin Cities to the site resulting in mortality of red oaks. Oak wilt is no longer believed to be active on this site. Thousands of oaks in woodland and urban settings die from oak wilt every year. Widespread in Minnesota (currently in the central region and southeastern counties) and most of Wisconsin, the disease is caused by a fungus that invades the tree's water conducting system, resulting in wilting and oak tree death. Oaks vary in their susceptibility to the disease; red oaks are very susceptible and white oaks are moderately resistant. Oak trees become infected by (1) beetles carrying the oak wilt fungal spores to fresh wounds or (2) the spread of the fungus in grafted roots of a diseased tree. In the first case, a beetle carrying spores to a fresh wound would usually travel less than 1,500 feet from the infected tree or woodpile. In the second case, tree root systems must be grafted together, usually less than 75 feet between the healthy and infected tree.

Two precautions can decrease the chance of spreading oak wilt. Do not move wood with bark attached (logs or firewood) from infected trees into un-infested parts of the state or un-infested stands. Do not harvest, prune, or otherwise wound oak trees from budbreak to three weeks past full-leaf development (generally from April 1 to July 15) in parts of the state where oak wilt occurs.

**Management Implications**

FTC outbreaks affect trees in these subsections averaging two to three years of defoliation each 8-10 years. The beginnings of FTC outbreaks usually coincide with droughty weather. A goal in oak management should be to promote stand vigor by manipulating stocking in order to prevent and minimize TLCB-caused oak mortality. Once the damage from a population of TLCB becomes evident, management options include postponement of any activity in the stand, salvage, or sanitation. However, thinning during FTC outbreaks and droughts should be avoided because it places additional stress on trees resulting in increased mortality due to TLCB. Trees killed by TLCB usually produce no stump sprouts when harvested. This emphasizes the importance of manipulating stands to develop advanced regeneration prior to outbreaks if oaks are to be maintained on the sites.

Oak wilt may be unwittingly introduced into the subsection by bringing in infested oak firewood. It may be established for a time without detection. Fortunately, its spread is slow and there is proven techniques that can eradicate infestations. The spread of oak wilt through root grafts can be controlled by severing roots around the perimeter of an oak wilt infection center with a vibratory plow. Overland spread can be controlled by cutting and treating all the wilting and recently dead red oaks inside the plow line perimeter to prevent spore production and further spread of the disease.

When it arrives, GM defoliation and mortality will make forest management and planning more difficult, as well as having an adverse impact on tourism and real estate values. Recreational areas in wood lots, parks, and along lakeshores are the most likely sites for GM introduction and establishment. Strategies include:

- Enhance hardwood stand and tree vigor.
- Encourage crop-tree management when thinning stands with oak and basswood in them.
- Clear-cut aspen and birch at rotation age to retain sprouting ability. Alternately, plan to pre-salvage the stands and spray with biopesticides to protect the foliage on the regeneration.
- Spraying to control defoliation will only be fruitful in recreation areas (public or private) along lakeshores or in high-value, high-risk stands.
- Encourage species diversification, especially pines, spruce, maples, and ash which will slowly make the stands less vulnerable to GM. And FTC defoliation.
- Avoid thinning stands in years of defoliation by GM, FTC or other defoliators as this increases stress and can lead t high levels of mortality associated with TLCB.

When GM outbreaks coincide or are closely timed to FTC outbreaks, there is a high risk of oak, basswood, aspen, and birch mortality due to prolonged defoliation. Due to the recurring FTC outbreaks, treating either or both FTC and GM caterpillars with biopesticides would prevent mortality.

## BIRCH

### Damage Agents

- **Birch decline—**

Birch decline is a complex disease caused by a combination of factors including stress from drought, high temperatures, site or stand disturbance, insect defoliation, and the bronze birch borer, *Agrilus anxius.* Birch decline starts as a thinning of the crown with dieback of branches. As the stress continues, the bronze birch borer begins to make successful attacks on the birch and mortality often results. The amount of mortality due to birch decline can increase dramatically as a result of severe and lengthy drought in combination with FTC defoliation. A study of the effects of the drought in the early 1990s estimated that 40 percent of the birch on FIA plots died in Minnesota from 1988 to 1992 as a result of birch decline. Based on the findings on the FIA plots, it was estimated that 228 million birch trees died during this period (Anonymous, 1992).

### Management Implications

Birch decline depends on stress such as drought, defoliation, and disturbance. This makes it difficult to predict a trend in birch decline over the life of the subsection plan. Older, decadent birch stands will reflect stress conditions and resultant dieback and decline before younger, thriftier stands do so. If stands of birch are set aside or rotations are extended, the vulnerability of these stands to birch decline will increase. Partial harvesting birch stands can create stress to the residual trees from an increase in soil temperatures as the stands are opened up. Partially harvesting birch and using birch to provide leave-tree clumps will likely lead to significant mortality of these stands and residuals.

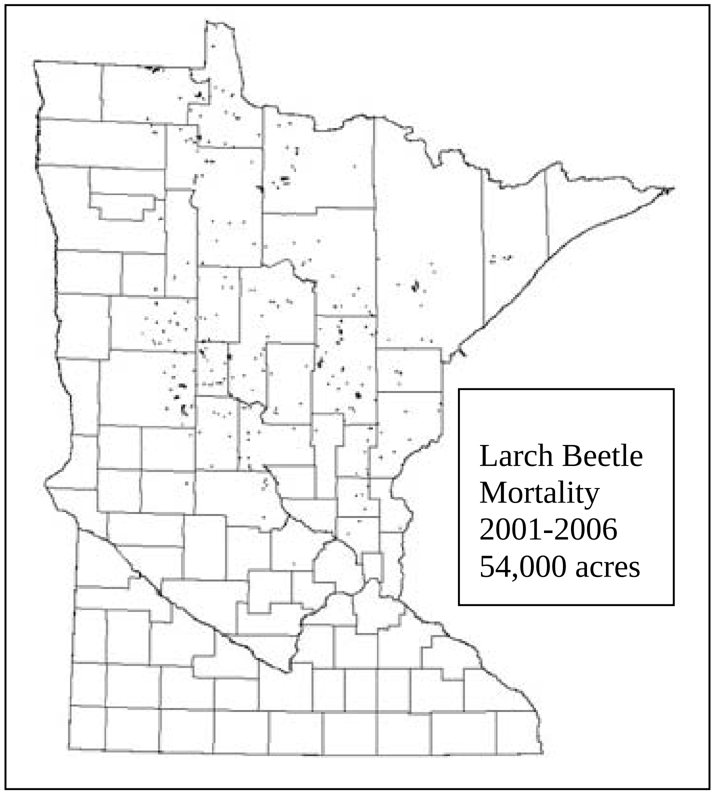
## TAMARACK

### Damage Agents

- **Larch beetle—***Dendroctonus simplex*

  This is a native bark beetle that attacks tamarack and exotic larches. Beetles over-winter in attacked trees. Adults emerge in the spring and seek live trees or fresh slash to attack. Eggs are laid, larvae construct galleries under the bark, and adults are produced. Some of the adults stay in the tree until the following year while others fly to nearby healthy trees to overwinter. Flooding, droughts, defoliation by larch casebearers, and old age have been associated with larch beetle attacks in the past. These have usually been limited to relatively small pockets of mortality. Recently, however larch beetle appears to be able to develop widespread outbreaks and kill healthy trees as well (Seybold, et .al., 2002). This apparent change in behavior may be caused by warm winters that allow larger populations of larvae, pupae and adults to overwinter. The large population of beetles is then able to overwhelm and kill even healthy tamarack. The current outbreak started about 2000. Aerial survey has identified mortality on approximately 54,000 acres since then ( See Map). Aerial survey in eastern Koochiching, northeastern Itasca and northern St Louis, Lake and Cook counties was done by another agency that did not map the tamarack mortality.) Trees of all ages and sizes from 4” DBH and up growing on a range of sites from wet lowlands to drier uplands have been killed. In some stands small scattered pockets of trees have died while in others close to 100% mortality has occurred. The current outbreak is showing no signs of ending, but it eventually reverts to endemic levels.

*Map 6.4c North-4 Subsections*




**Management Implications**

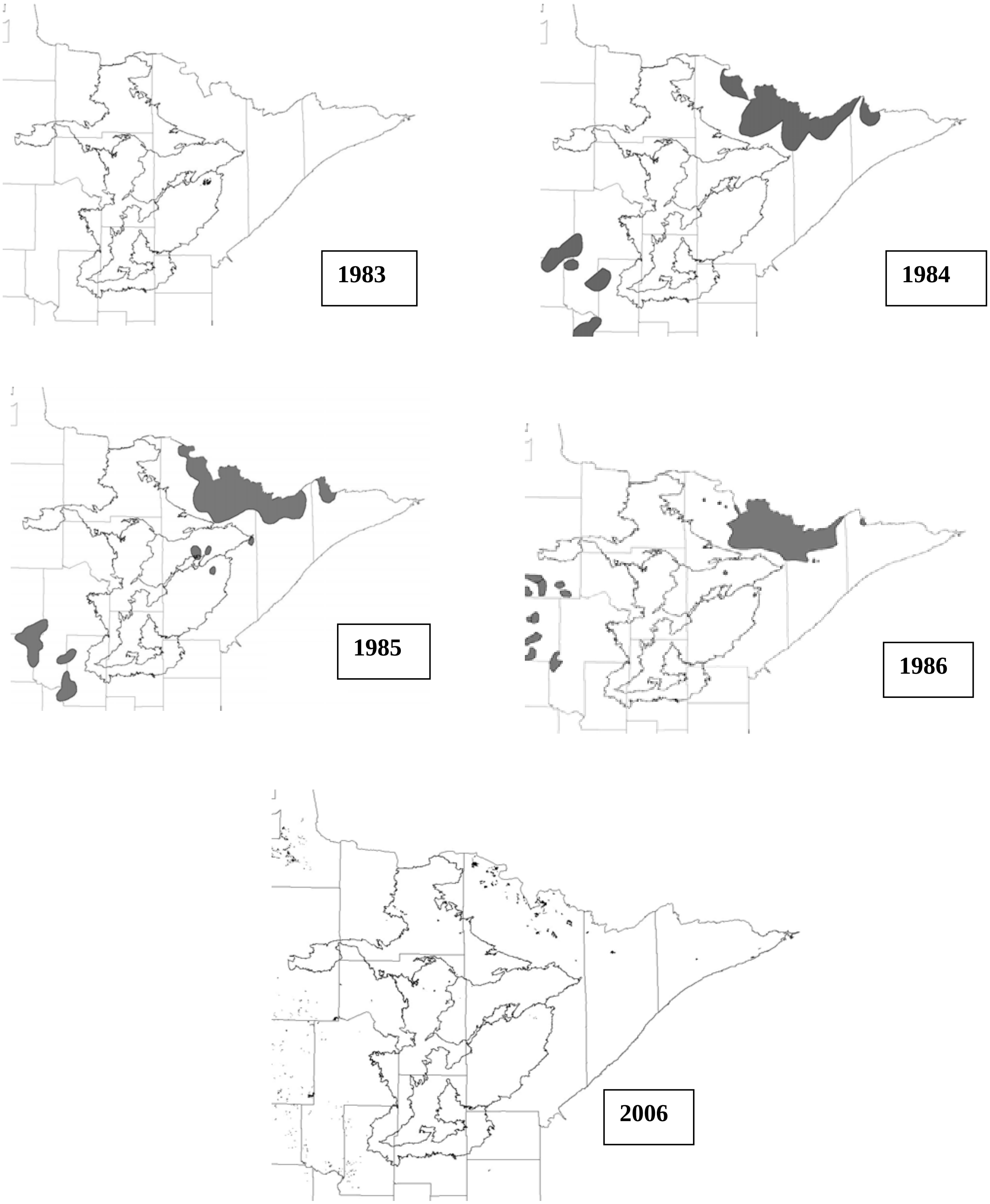
Apparent healthy trees can be successfully attacked when there are high populations of larch beetles. Seed trees left after harvest are often attacked and quickly killed by the larch beetle. Whether these seed trees are able to produce a crop of viable seeds before dying from larch beetle attack is not known. Leaving seed trees is still recommended even though they are likely be attacked and killed by the larch beetle because they are not likely to increase the larch beetle problem Because larch beetles are killing trees throughout the range of tamarack, sanitation cuts to reduce beetle populations and tree mortality are unlikely to be effective. Most harvesting plans are salvage operations due to larch beetle caused mortality.

## JACK PINE

### Damage Agents

- **Jack pine budworm—***Choristoneura pinus pinus*
  Jack pine budworm (JPBW) larvae eat the needles of jack pine causing defoliation, which can lead to top kill and mortality. In west central Minnesota, JPBW outbreaks tend to occur at roughly six- to 12-year intervals and persist for two to four years and then decline (Albers, et. al., 1995). In Canada to the north of Minnesota they have experienced 5 to 6 outbreaks of JPBW in the past 50 years. In NE Minnesota however, including these 4 subsections, jack pine budworm outbreaks appear to be occurring on about 20 year intervals. However, there are no known factors to prevent NE Minnesota from having more frequent outbreaks even though we have not been experiencing them in the recent past. JPBW populations will build up in poorly stocked stands, overstocked stands, over-mature stands, and stands with low-vigor trees. These stand are also the most vulnerable stands for tree mortality to occur as a result of a JPBW outbreak. The most recent outbreak in west central Minnesota occurred from 2002 through 2006. An outbreak started in northeastern Minnesota in 2006 and is expected to continue for one or two more years.

*Map 6.4d North-4 Subsections Jack Pine Budworm Defoliation in NE Minnesota*



- **Bark beetle** (pine engraver beetle) - *Ips pini* and other species

  Many species of bark beetles exist in Minnesota. The pine engraver beetle is very common and sometimes very abundant. Bark beetles feed and reproduce in the moist cambium of freshly cut, recently killed, or blown down red pine, jack pine, and occasionally white pine. In Minnesota up to three generations of *Ips pini* can develop during a growing season. After developing in the dead material, the new adults may attack standing live trees nearby. Successful attacks are made on trees under stress, but massive attacks often are able to overwhelm and kill healthy trees. Dead trees generally occur in patches or pockets because emerging beetles tend not to fly far but attack trees adjacent to where they emerged. Attacks often begin in tree tops and progress downward. Stress from JPBW defoliation, drought, overcrowding, equipment and fire scarring, and weather events such as hail, snow, and ice breakage can reduce tree vigor and predispose the trees to bark beetle attack. Stressed trees cannot defend themselves against bark beetle attacks and they become easy prey for beetles. In the forest, significant bark beetles problems generally only develop when there is both drought and a supply of fresh brood material for the bark beetles to build up on. Fresh brood material can be created by such things as fires, storms, or thinning and logging operations.

- **Stem decay (red rot)** - *Phellinus pini*

  This organism attacks most softwoods and causes significant decay. It is a "canker rot" organism. This type of decay organism cannot be walled off and confined to the portion of the stem present at the time infection takes place. This organism will grow and cause decay throughout the stem as the stem increases in size. In this way, it is similar to the decay fungus that causes white trunk rot of aspen. It is difficult to predict occurrence and extent of red rot in jack pine stands. External indicators of red rot are difficult to detect. Fruiting bodies that would predict red rot are not prominent and are easily missed during inventory and cruising and they often do not develop until after the tree has died. Often red rot is not discovered until harvesting takes place. Red rot increases with increasing age of the trees. Research has not correlated, with any degree of confidence, decay with site characteristics. Foresters have observed that jack pine stands grown on relatively droughty soils will have a higher incidence and more extensive decay loss due to red rot. Red rot is usually considered a problem of older trees but it is also a problem in young trees where *P pini* has infected sweetfern cankers. For more details see the discussion of stem decay for aspen.

**Stem and gall rusts of jack pine –** *Cronartium quercuum, Endocronartium harknessii, Cronatium comptoniae, Cronartium comandrae, Cronatium coleosponoides*

Stems and branches of jack pine can be infected by five different rust fungi. Gall rust infections on seedlings and saplings often lead to wind breakage and mortality. Stem and branch infections by stem rust fungi on older trees commonly lead to losses in growth (sweetfern rust volume losses average 20%), formation of cankers (cankers can make basal log unmerchantable), and create entryways for decay fungi and insects. When rust cankers and decay fungi are present, volume losses increase dramatically. Trees infected with rust commonly are stunted in height growth and die earlier than their cohorts due to suppression. In the eastern side of the George Washington State Forest, scattered plantations have been observed with up to 40% of the stems deformed by sweetfern blister rust cankers.

Based on work by Dietrich (1985) and Mital (1982), the distribution of rust fungi in these subsections can be found in the table below.

*Table 6.4 North-4 Subsections*

| Occurrence of Rust Fungi on Jack Pine in the North-4 Subsections | | | | |
|---|---|---|---|---|
| | Littlefork Vermilion Uplands | St. Louis Moraines | Nashwauk Uplands | Tamarack Lowlands |
| Pine-pine gall rust<br>Endocronartium harknessii | + | + | + | + |
| Pine-oak gall rust<br>Cronartium quercuum | – | + | + | – |
| Sweetfern blister rust<br>Cronartium comptoniae | + | – | + | – |
| Commandra rust<br>Cronartium comandrae | + | + | – | – |
| Stalactiform rust<br>Cronartium coleosponoides | + | + | + | – |

**Management Implications**

In subsections to the west, the occurrence and impact of JPBW outbreaks forces managers to decrease jack pine rotation age to 40-45 years. Because outbreaks in the subsections covered by this plan, have been less frequent, it may not be necessary to be as restrictive with rotation ages based solely on the risk of JPBW. However there are no guarantees outbreaks won't occur more frequently in the future than they have in the past especially with the pressure of moth influxes from outbreaks to the north and west. Managers should use local knowledge about the incidence of stem decay and stand breakup in determining appropriate rotation ages. It remains important to maintain age class diversity at the landscape level to avoid loosing all your older jack pine at one time during outbreaks, whatever their frequency.

In jack pines approximately 90% of the stem decay is due to *P. pini* (red rot). This is generally not a significant problem when jack pine is managed under a normal rotation age. As tree age increases the amount of stem decay increases and the amount of decay in stands should be considered when selecting stands for extended rotation.

Stem rusts are usually not a significant problem in jack pine stands. Occasionally gall rust reach high enough levels to affect stocking levels in regenerating stands. There are occasional sites in eastern George Washington State Forest where high levels of sweetfern rust develop. At the current time there are no site characteristics, other than lots of sweetfern, to identify these sites. Where local knowledge identifies these sites regeneration to another tree species is advisable. In thinning, trees with stem rust cankers and galls should be removed because these trees grow slower, are prone to wind breakage and higher amounts of decay.

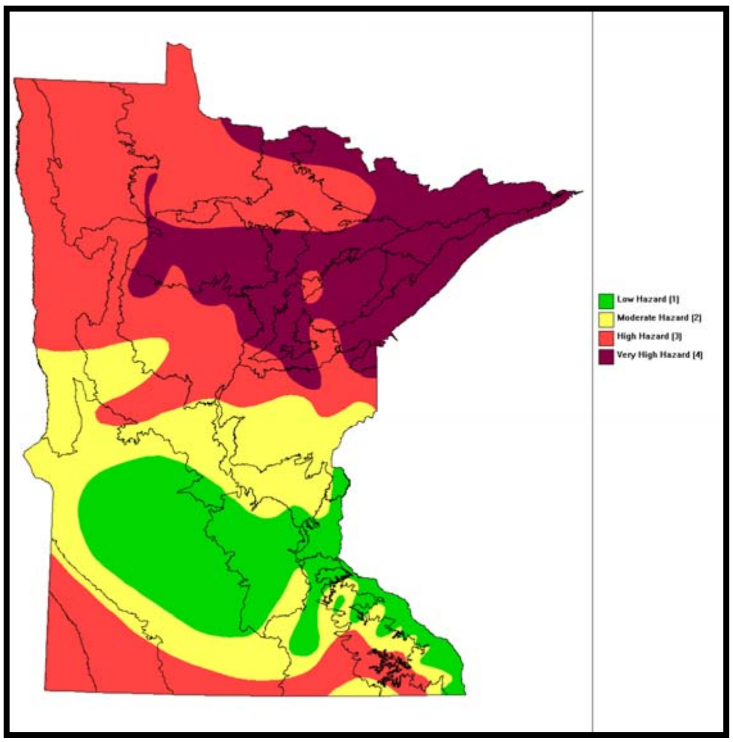
## WHITE PINE

### Damage Agents

- **White pine blister rust -** *Cronartium ribicola*

  White pine blister rust is an exotic fungus, first found in Minnesota in 1916. Blister rust is found throughout Minnesota wherever white pine is grown. This disease has changed where and how white pine is grown in northern Minnesota. The fungus requires both white pine and the alternate host species of *Ribes* to complete its life cycle. Disease-caused injury to infected trees includes dead branches, stem cankers, and mortality. Levels of infection of 80 percent or more of the trees in a stand or plantation have been reported in northern Minnesota. The Littlefork-Vermilion Uplands subsection is mostly in hazard zone 3 (High Hazard) while the St Louis Moraines, Nashwauk Uplands and Tamarack Lowlands subsections are mostly in hazard zone 4 (Very High Hazard). Within these zones the levels of infection can vary greatly from site to site due to micro-site climate differences, age of trees, presence and abundance of *Ribes*, topography, and, forest-stand structure. No major gene for resistance has been found in eastern white pine, but breeding efforts continue to try to produce a more resistant tree..

*Map 6.4e White Pine Blister Rust-Hazard Zone*




**White pine weevil**---*Pissodes strobe*

White pine weevil is considered the most important insect pest of eastern white pine. Weevil larvae feed under the bark of the previous years terminal. This feeding girdles the stem, killing everything above the injury. With the death of the terminal leader, lateral shoots compete to become the new terminal leader resulting in multiple stems and deformed stems. Weevils prefer open-growing, vigorous trees less than 30 feet tall. In addition to white pine, the white pine weevil will attack all species of spruce and pine in Minnesota although attacks on red pine and black spruce are rare.

**Management Implications**

Choosing planting sites based on microclimatic factors is critical to success (Jones, 1989). Plant white pine on slopes, hilltops or shoulders of hills. Avoid potholes, bases of slopes, v-shaped valleys or small openings in dense forest that favor the collection of cool moist air. Such conditions favor infection by blister rust. Establishing white pine as an understory tree will mitigate the impacts from both blister rust and white pine weevil. Pruning to remove the lower branches, which are the most likely to become infected, is beneficial in reducing mortality. It is best to start when the trees are small, 2 to 3 feet, and continue until all branches on at least the lower 9 feet of the tree are removed. Pruning should be done during the dormant season, fall or winter. Avoid the spring and early summer when bark is easily damaged. Don’t remove too many branches at one time in order to maintain good height growth. Try to leave at least 2/3rds of the tree’s height with branches (Anonymous, White pine planting and care guide. 2003)

**RED PINE**

**Damage Agents**

- **Diplodia tip blight and canker –** *Diplodia pinea*
  Diplodia damage is greatest on red pine seedlings and saplings growing under or within 1 to 2 chains of mature red pines or jack pines. It can infect and kill seedlings up to at least 4 chains away from overstory trees. Air borne and rain splashed spores from fruiting bodies on pine cones are the main source of infection. Diplodia causes a tip blight as well as a canker that can girdle branches and stems and kill trees. It can infect through wounds and result in high levels of infection after hail storms, but this fungus does not require a wound for infection. It spreads most during wet weather and so infections are much more common in some years then in others. *Diplodia* causes both symptomatic and latent infections (Stanosz and Cummings Carlson 1996). In a latent infection, the tree may show no symptoms or signs of infection for years but it remains infected with the fungus. These latent infections can become activated when the host tree become stressed from such things as drought, overcrowding, or “j” rooting.

- **Sirococcus shoot blight -** *Sirococcus conigens*
  Damage from this fungus can be locally high on sites where large infected red pine are left on or next to sites being regenerated to red pine or in uneven-aged stands. This fungus kills only current year shoots, but multiple years of infection will lead to mortality of young trees.

- **Bark beetle** (pine engraver beetle) - *Ips pini*
  See bark beetle discussion under the jack pine cover type.

**Stem decay**
See stem decay in the jack pine section

**Root disease**
See root disease in the all species section

### Management Implications

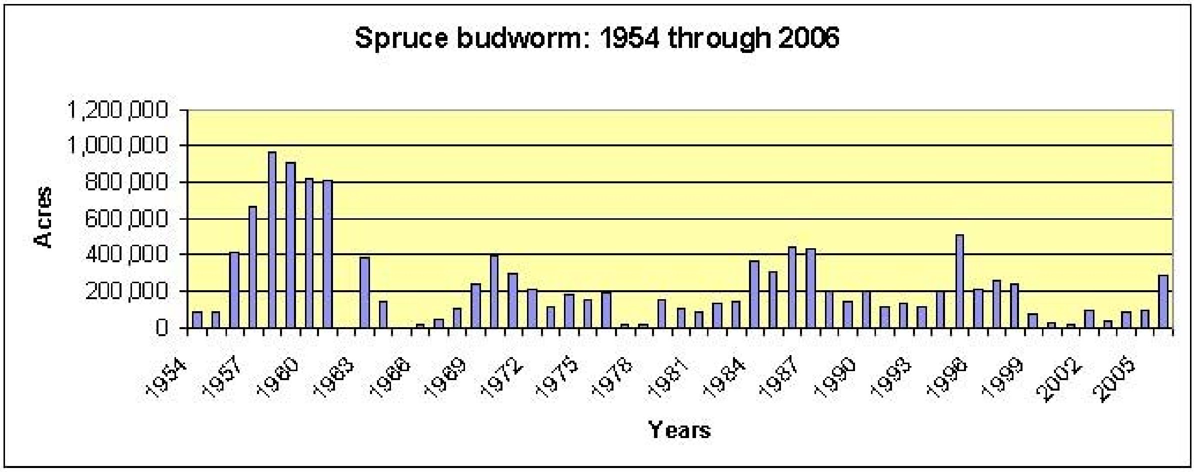
This is a long-lived tree species that is relatively free of potential catastrophic pests problems. Concerns are more directed at young stands regenerating under or next to existing stands of pine (Ostry, et.al., 2002) As management strategies lead to more partial harvesting and attempts to development two-storied or multi-aged stands, understory pines will be susceptible to both shoot blights. In many locations, the presence of one or both of these diseases will preclude natural red pine regeneration under the overstory red pine trees. Mortality will be greatest on seedlings directly under or within 1-2 chains of red pines old enough to produce pine cones. Leaving live residual red pine trees on sites being regenerated back to red pine is not recommended. Note that BMP guidelines allow variance from recommendations where they would lead to increases in insect or disease problems. If some residual trees will be left, choose locations near the edges of the site and group /clump the leave trees. Bark beetle problems will arise in plantations when they're under drought stress and/or slash-creating activities have occurred in the spring or summer especially during droughts. Thinning of plantations is not recommended during the growing season from March 15 to Sept 1st.

## BALSAM FIR

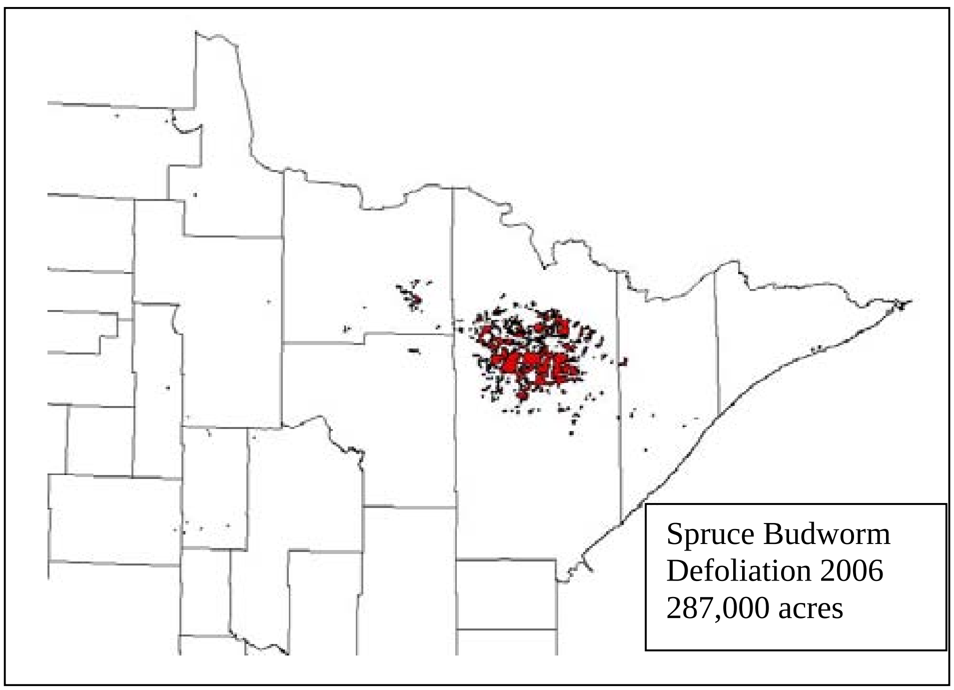
### Damage Agents

- **Spruce budworm -** *Choristoneura fumiferana*
  Spruce budworm (SBW) is a native insect defoliator. Outbreaks of this defoliator have occurred periodically for hundreds of years. The larvae prefer the needles of balsam fir and white spruce, causing defoliation, top kill, and mortality. On balsam fir, top kill can begin after two to three years of heavy defoliation and tree mortality after three to five years of feeding. Outbreaks tend to occur when there are extensive and continuous areas of mature and over-mature balsam fir. Losses of balsam fir are highest in stands with the highest abundance of fir and where surrounding stands also contain fir. Mortality in mature and over-mature fir stands may approach 100 percent. Damage tends to be higher in older-age fir, but in outbreaks, fir of all ages can be killed. Stands with multiple ages of fir often experience greater levels of damage to the young fir trees than would normally occur in single-age stands. Spruce budworm has defoliated an average of 250,000 acres per year in northern Minnesota for the past 53 years (personal communications with Mike Albers). Balsam fir is the preferred host, but since 1990 budworm has been causing defoliation, top kill, and mortality in plantations of white spruce that are 25 years and older. Budworm populations are on the rise defoliating 90,000 acres in 2005 and increasing to 287,000 acres in 2006. Based on the pattern of defoliation since 1954, it is likely this increase will continue for the next few years.

*Chart 6.4*




*Map 6.4f*




**Management Implications**

Spruce budworm is a perennial invader of balsam fir and white spruce in these subsections. Balsam fir is a prolific seed producer and has the ability to persist and even increase in the aftermath of an outbreak. Management strategies that increase the component of balsam fir will only lead to more frequent and more severe SBW outbreaks. Since the older stands tend to serve as the niches in which the budworm builds up, strategies to develop extended rotation balsam fir will only add to the potential for stand-destroying budworm populations to develop. When regenerating spruce fir stands, emphasis should be given to regenerating the white spruce and not the balsam fir. The increased occurrence of spruce budworm in white spruce plantations may be related to the plantations being overcrowded and not managed. Commitments must be made to do periodic thinning in the white spruce plantations.

## WHITE SPRUCE

### Damage Agents

- **Spruce budworm -** *Choristoneura fumiferana*
  See spruce budworm discussion under the balsam fir cover type.

- **Spruce beetle –** *Dendroctonus rufipennis*

Spruce beetle is a native bark beetle that attacks and kills white spruce. Spruce beetle likes large trees usually 12 inches in diameter and larger. Most trees seem to take 2 or more years to die from attack. Attacked trees often have some other problem such as root rot making them more susceptible to attack and mortality. Outbreaks in the western US usually result when spruce beetles buildup on windthrown trees (Holsten et. al., 1999). In Minnesota most of the problems with spruce beetle have occurred in State Parks within the North Shore Highlands subsection. However, three stands of large old white spruce were attacked by spruce beetle in Pine Island State Forest near the junction of Littlefork-Vermilion and the Agassiz Lowlands subsections. The beetles in these stands appeared to have built up in trees that had fallen over either in a windstorm or possibly a winter storm. Spruce beetles have been captured in bark beetle traps in eastern Itasca County in the St Louis Moraines subsection. So it is likely that they occur through the range of white spruce in MN and have the potential to kill trees where there are concentrations of large diameter trees.

### Management Implications

Since there are probably few stands of large diameter white spruce, spruce beetle is not currently a significant problem in these subsections. The best way to avoid problems would be to examine stands following windstorms or in the spring to determine if tops or trees came down over winter. These downed trees should be removed before May 1st if possible. In Minnesota spruce beetle has caused considerable mortality within stands with a concentration of large diameter white spruce trees, however, we have not seen it move into adjacent stands and kill trees. More information on managing spruce beetle can be found on the DNR website.

The increased occurrence of spruce budworm in white spruce plantations may be related to the prevalence of pure stands white spruce with few species of non-host trees. This tends to conserve spruce budworm larvae allowing larger population of budworm to develop and thrive. If white spruce plantations had more non-host tree species, budworm larvae landing on the non-host trees would die reducing the population.

Also it appears that more timely thinning of white spruce plantations is necessary to maintain a good growth rate and prevent mortality. Although research on this subject is lacking it appears that when the live crown ration drops below about 40%, the white spruce trees respond very slowly if at all after thinning. In some plantations this would require thinning at around age 30 or in some cases even younger. In some plantations over 30 years of age, tree mortality has continued to occur after thinning.

## BLACK SPRUCE

### Damage Agents

- **Eastern dwarf mistletoe -** *Arceuthobium pusillum*
  Dwarf mistletoe is a disease caused by a parasitic seed plant and is the major mortality agent of black spruce. It primarily affects black spruce, but occasionally is found on white spruce and tamarack. It causes witches brooms on infected trees, and trees of all sizes become infected and killed. Natural fires were the major factor in keeping this disease in check in the past and without fires the amount of eastern dwarf mistletoe infection is believed to be increasing. Dwarf mistletoe can only live on living trees. Once a stand is infected, it remains infected until all of the mistletoe-infected trees are killed by fire, harvesting, shearing or hand cutting. Residual infected trees left behind after harvesting introduce the disease to the regenerating stand. Mistletoe spreads locally by seeds that are explosively discharged and can travel up to 55 feet. Long-distance spread is by birds carrying the sticky seeds on their feet and feathers. When an even-aged stand becomes infected, the large trees are killed, creating openings in the stand. Young trees seed into these openings and become infected. The stand then gradually changes to an all-aged stand with heavy infections of all ages and very little to no merchantable volume (Baker et. al., 2006)

### Management Implications

Incidence of this disease is increasing due to the absence of fire and because there is no practical means of killing all infected trees at the time of harvest. Shearing after the harvest has also met with a variety of successes and rarely eradicates mistletoe from the stand. Even young trees that are infected will live long enough to continue the cycle of dwarf mistletoe in the regenerating stand. These young, infected trees are nearly impossible to kill in the absence of fire. A survey of sites, one year or so after harvest, to determine if follow-up treatment is necessary should be done to ensure that all black spruce on the site have been killed. Leaving infected trees standing on or next to harvested sites will ensure that the regenerating stand is infected by mistletoe. If dwarf mistletoe is not aggressively eradicated from black spruce stands when harvesting and regenerating the stands, the total merchantable acreage of this cover type will decline. Refer to the MN DNR Division of Forestry Forest Development manual for more details and suggestions.

## 6.5 Additional Information Sources

Additional information on these and other insects and diseases of forest trees in Minnesota can be obtained by referring to the Minnesota Forest Health Reports prepared by the MN DNR, Division of Forestry, Forest Health Unit. They can be found in the DNR Library in St. Paul and in various other libraries in the state. They have been printed on an annual basis since at least 1974. The title has varied over the years from the Forest Pest Report, to the

Forest Insect and Disease Report, to the current title of Minnesota Forest Health Annual Report. They contain data on the insect and diseases included in this assessment as well as others. Observations and annual survey results are included. Current information can be found in the Minnesota DNR Forest Insect and Disease Newsletter, which is published four or five times during the growing season and can be accessed online through the DNR Web site at http://www.dnr.state.mn.us/fid/index.html.

Other sources of information include reports from the USDA Forest Service, University of Minnesota, and Minnesota Department of Agriculture.

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