Northern Superior Uplands

Section Forest Resources Management Plan

Preliminary Issues and Assessment Chapter 7: Forest Health

MNDNR

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Contents

Forest Insects and Diseases

Introduction

This is an assessment of forest insects and diseases known to cause tree mortality, growth loss, and quality reduction in forest stands in the Northern Superior Uplands (NSU) Section. 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 (DNR), Forest Health Team; University of Minnesota; USDA Forest Service, State and Private Forestry; and North Central Forest Experiment Station.

Role of Insects and Pathogens in the Forest

Native Insect and Disease Organisms

Native forest insects and disease organisms influence forest ecosystem dynamics as pests and agents of stress, but also play a beneficial role in 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 woodpecker 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, and Leatherberry, 1995). Surveys conducted by DNR Division of Forestry looking at oak and birch mortality triggered by drought, 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 for older forest attributes, 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.

Non-native (Exotic) Insect and Disease Organisms

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 20th century, has played an important role in reducing the amount of white pine in Minnesota. Gypsy moth is becoming established in northeastern Minnesota and will eventually spread through the state. 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.

Forest Management Implications

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 utilized to limit damage and buy time for development of possible effective control measures. 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 as they continue to spread through Minnesota.

Table 7.1. Insects, pathogens and declines known to cause volume reductions or mortality losses

The first column lists tree species grouped ("All Species") and as individual forest cover types. The remaining two columns list agents that cause mortality for the listed covertypes, and agents that cause volume reductions, respectively.

Covertype	*Agents that cause mortality*	*Agents that cause volume reductions*
All species	*Armillaria* root disease http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043192.pdf Storm damage http://files.dnr.state.mn.us/assistance/backyard/treecare/stormDamagetoForests.pdf	Stem decay and root rot fungi http://na.fs.fed.us/pubs/misc/decay/first_look_decay.pdf Stem decay and root rot fungi (2) http://www.na.fs.fed.us/spfo/pubs/fidls/decay/decay.htm
Aspen	Aspen decline http://www.forestpathology.org/pdfs/worrall2013aspendeclineNA.pdf Hypoxylon canker http://www.na.fs.fed.us/spfo/pubs/fidls/hypoxylon/hypoxylon.htm Bronze poplar borer http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5349702.pdf	White trunk rot http://www.na.fs.fed.us/spfo/pubs/howtos/ht_aspen/ht_aspen.htm Forest tent caterpillar http://www.dnr.state.mn.us/treecare/forest_health/ftc/index.html Gypsy moth * http://www.dnr.state.mn.us/invasives/terrestrialanimals/gypsymoth/index.html (see GM silvicultural considerations for Minnesota)
Ash	Ash decline http://www.nrs.fs.fed.us/pubs/gtr/gtr_wo079/gtr_wo079_115.pdf Emerald ash borer * http://files.dnr.state.mn.us/forestry/ecssilviculture/policies/guidelinesManagingAshMinnesotaForestryLands-100723.pdf	
Birch	Bronze birch borer http://www.na.fs.fed.us/spfo/pubs/fidls/bbb/bbb.htm	Gypsy moth * http://www.dnr.state.mn.us/invasives/terrestrialanimals/gypsymoth/index.html
Oak	Two-lined chestnut borer	Gypsy moth *

	http://www.dnr.state.mn.us/treecare/forest_health/tlcb/index.html	http://www.dnr.state.mn.us/invasives/terrestrialanimals/gypsymoth/index.html (see GM silvicultural considerations for Minnesota)
Tamarack	Eastern larch beetle http://files.dnr.state.mn.us/forestry/ecssilviculture/policies/tamarackAssessmentProject2013.pdf	Larch casebearer http://www.na.fs.fed.us/spfo/pubs/fidls/larch/larch.htm
Jack pine	Jack pine budworm (fed) http://www.na.fs.fed.us/spfo/pubs/howtos/ht_jack/ht_jack.htm Jack pine budworm (state) http://www.dnr.state.mn.us/treecare/forest_health/annualreports.html for 2012	Red rot http://en.wikipedia.org/wiki/Phellinus_pini
Red pine	*Ips* bark beetles http://files.dnr.state.mn.us/assistance/backyard/treecare/forest_health/barkbeetles/barkbeetlebroch.pdf	Red rot http://en.wikipedia.org/wiki/Phellinus_pini
White pine	White pine blister rust * http://www.na.fs.fed.us/spfo/pubs/howtos/ht_white/white.htm	Red rot http://en.wikipedia.org/wiki/Phellinus_pini
Black spruce	Eastern dwarf mistletoe http://www.na.fs.fed.us/pubs/fidls/ed_mistletoe/ed_mistletoe.pdf	
White spruce	Spruce budworm http://www.na.fs.fed.us/spfo/pubs/fidls/sbw/budworm.htm	Red rot http://en.wikipedia.org/wiki/Phellinus_pini
White cedar		Red rot http://en.wikipedia.org/wiki/Phellinus_pini
Balsam fir	Spruce budworm http://www.na.fs.fed.us/spfo/pubs/fidls/sbw/budworm.htm	
* = Exotic insect or disease		

Assessment of selected agents in Northern Superior Uplands

Emerald ash borer

Emerald ash borer (EAB) first detected in North America in 2002 has killed untold millions of ash trees in forest, riparian, and urban settings. It appears likely that EAB could functionally extirpate one of our most widely distributed tree genera (Fraxinus) with devastating economic and ecological impacts. EAB was first confirmed in Minnesota in 2009. Currently the counties of Olmstead, Dakota, Ramsey, Hennepin, Houston and Winona are quarantined for EAB. The 2012 find of the beetle in the City of Superior Wisconsin puts in within a mile of the Northern Superior Uplands. Cold winters in northern Minnesota may slow its spread but will likely not prevent it from spreading throughout the state.

Ash management guidelines which consider the impact of EAB have been developed by the divisions of Forestry, and Fish and Wildlife. Both sets of guidelines share many of the same goals and provide similar direction. Differences in management objectives and guidelines for all stands with ash are noted below.

Guidelines for Ash Management on Forestry-Administered Lands

Management Objectives:

- Landscape perspective: Manage ash populations in the landscape to protect sensitive wetland ecotypes, reduce outbreak losses and costs without eliminating ash within forest ecosystems.
- Stand perspective: Create conditions that will reduce impacts and increase the resiliency of forested stands by keeping forested sites forested, increasing tree species diversity, and maintaining an ash component but reducing the amount of ash in the stand.
- Management objectives should focus on ecosystem health and management, not on the emerald ash borer. The intent is to increase stand resilience.

Guidelines for Ash Management on Fish and Wildlife Administered Lands

Management Objectives:

- Landscape perspective: Manage ash populations in the landscape to protect sensitive wetland habitats and reduce outbreak costs without eliminating ash within forest ecosystems.
- Stand perspective: Create conditions that will reduce potential impacts and increase the resiliency of forest stands by:
    - keeping forested sites forested,
    - maintaining an ash component while increasing the presence of other tree species, and

- increasing tree species diversity.

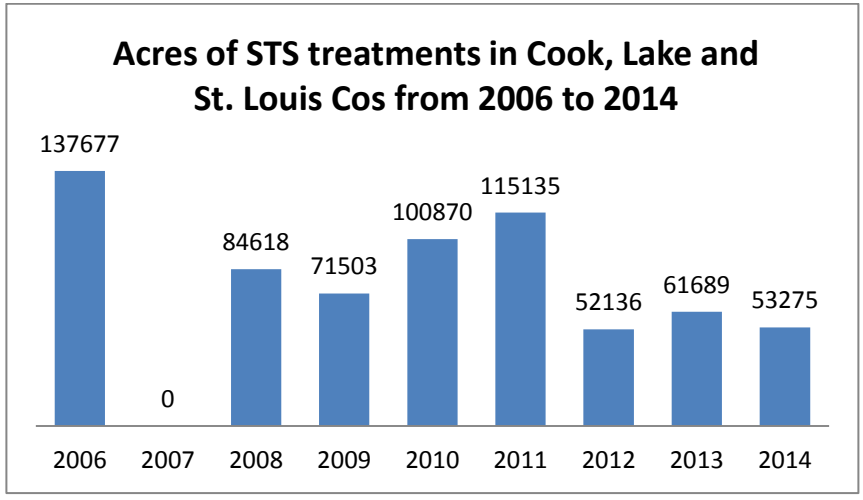
• Management objectives should focus on fish and wildlife habitat and ecosystem health and management, not on the emerald ash borer. The management intent is to maintain habitat value and increase stand resilience.

Gypsy Moth

Gypsy moth (GM) is an exotic insect pest spreading across the United States and Canada. Minnesota became a member of the Slow the Spread (STS) Foundation in 2004 due to the increase in moth captures and expansion of the action zone into Houston and Winona counties. In the fall of 2004, due to increase in moth captures in northeast Minnesota, the action boundary was expanded to include all of Cook and Lake Counties. (See Figure 7.1) The goal of the STS program is not to eradicate gypsy moth but to slow the increase of gypsy moth behind the action boundary and to slow the spread of gypsy moth within and out of the area to surrounding areas. This is accomplished with the use of pesticides such as the biological insecticide Btk (Foray 48B) to kill gypsy moth caterpillars, or through mating disruption using Disrupt II. The first STS treatment in northeast Minnesota occurred in 2006 with the aerial application of Btk on 2,015 acres and Disrupt II on 135,662 acres in Cook County. Treatments in 2008 included Cook and Lake Counties. The first STS program treatment in St Louis County was in 2010 (see Figure 7.1, below).

Figure 7.1. Acres of slow-the-spread (STS) treatments for Gypsy moth Minnesota

This bar chart shows the acres of slow-the-spread treatments in Cook, Lake, and St. Louis counties for the years 2006 to 2014.



With continued increases in moth catches and the finding of alternate life stages such as caterpillars, pupae and egg masses, Cook and Lake Counties were quarantined for gypsy moth by Minnesota Department of Agriculture and the US Department of Agriculture APHIS starting July 1, 2014. Gypsy moth is now considered to be established in both Cook and Lake counties; STS pesticide treatments will no longer be conducted in either county. Information about the Gypsy moth quarantine can be found at http://www.mda.state.mn.us/gmquarantine.aspx

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 Forest Tent Caterpillar could have substantial impacts especially if coupled with drought and over-mature aspen.

Table 7.2. Gypsy moths caught in traps by northeast Minnesota county and statewide

This table displays number of moths trapped for each of Cook, Lake, St. Louis Counties, as well as those three counties combined. The statewide total catch is also displayed for context. In 2013, the combined catch for the three counties was 99 percent of the statewide total.

Year	Cook County	Lake County	St. Louis County	Cook + Lake + St Louis Counties	Statewide Total Catch
1996	0	0	1	1	155
1997	0	1	0	1	261
1998	0	0	1	1	953
1999	33	37	26	96	286
2000	22	6	4	32	182
2001	26	0	3	29	429
2002	23	0	1	24	118
2003	30	2	12	44	535
2004	198	49	39	286	396
2005	1068	114	52	1234	1310
2006	210	71	7	288	412
2007	2583	450	66	3099	3608
2008	3111	2942	1810	7863	12255
2009	5380	14232	7967	27599	27870
2010	435	779	1931	3145	4242
2011	928	2470	1292	4690	5059
2012	5979	4083	290	10352	10445
2013	4130	59823	6002	69955	71258
2014	7	98	236	341	523

Figure 7.2. Gypsy moths caught in traps by county and statewide

This bar chart displays the same data as the previous table. Colored bars represent the data for each of Cook, Lake, St. Louis Counties, as well as those three counties combined. The statewide total catch is also displayed for context.

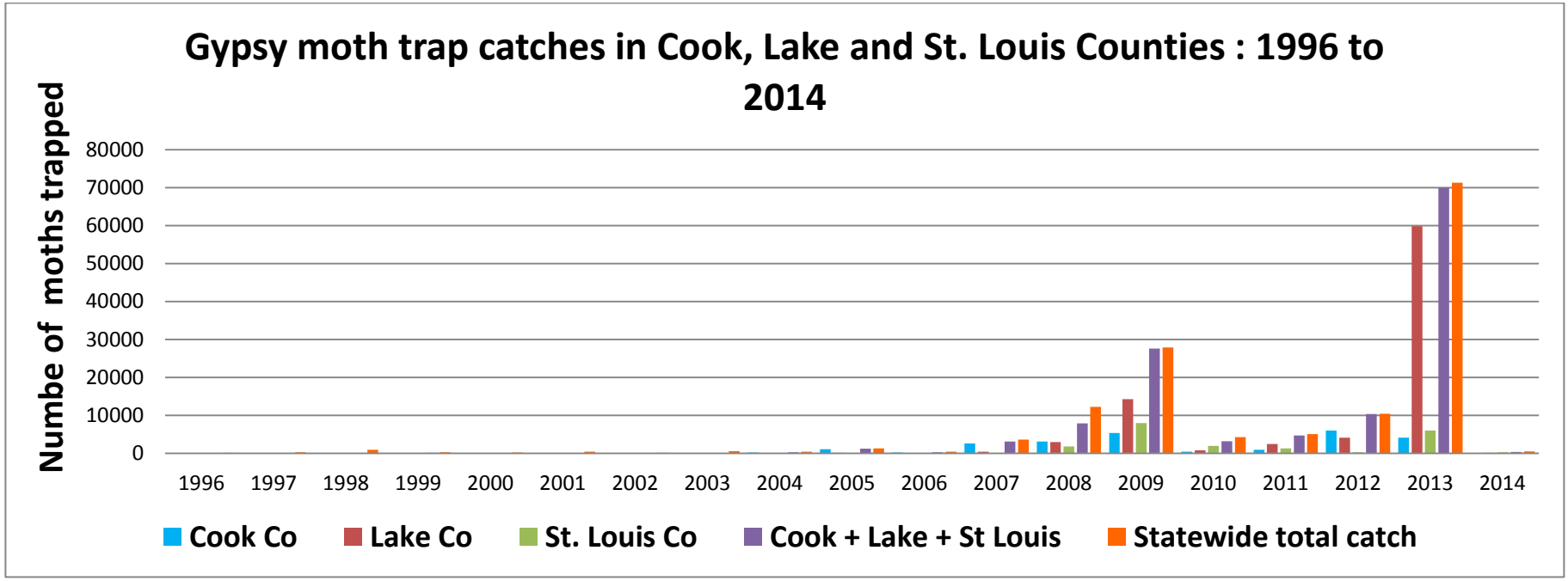
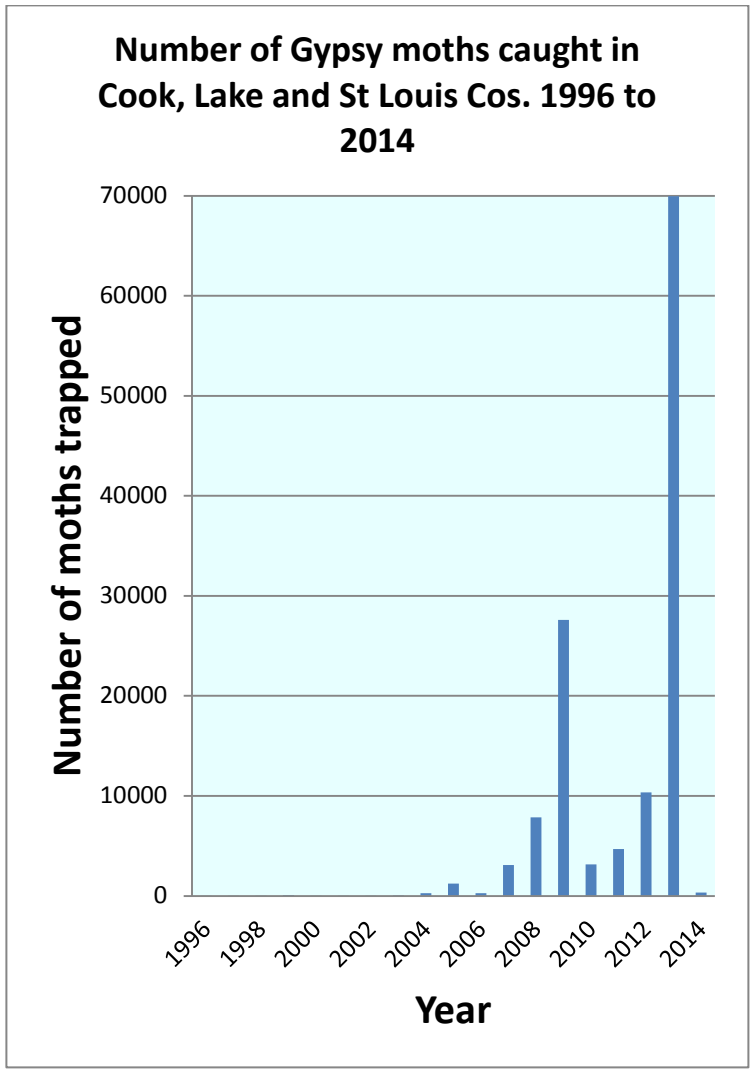


Figure 7.3. Gypsy moths trapped in Cook, Lake and St Louis Counties from 1996 to 2014

This chart is a subset of the previous one, showing only the data for the three counties in the NSU.

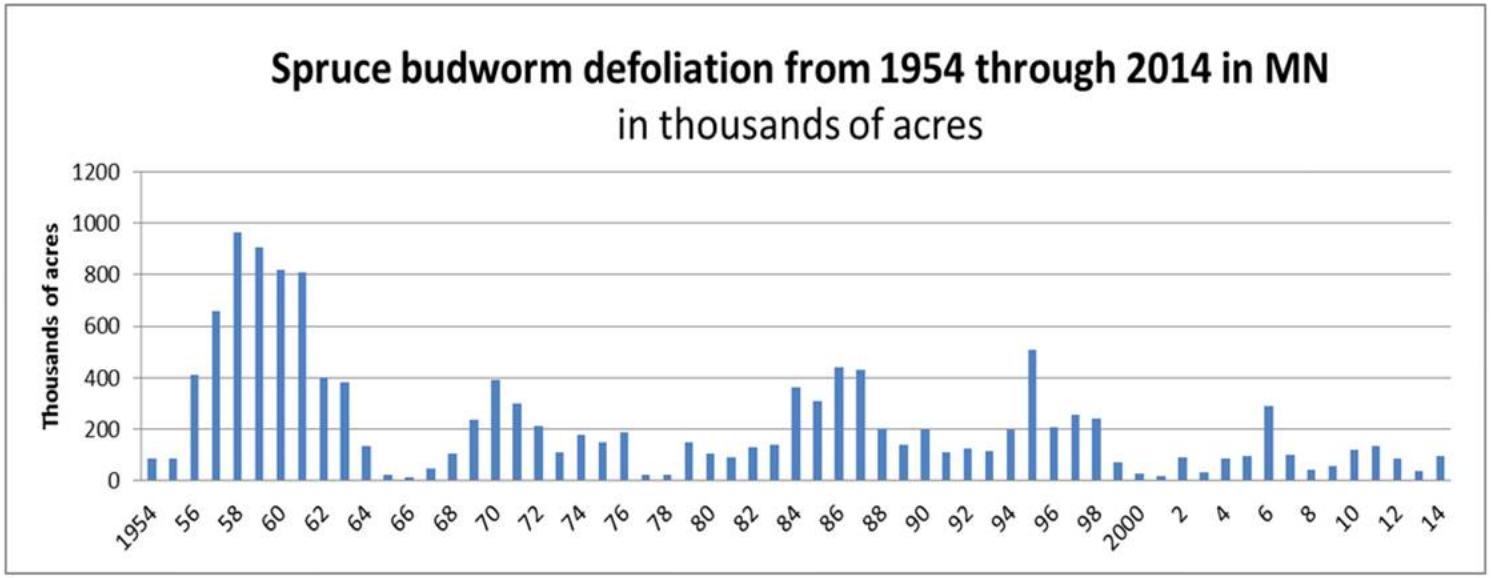


Spruce Budworm

Spruce budworm is a perennial defoliator of balsam fir and white spruce in northeastern Minnesota. Since 1954 there have been continuous outbreaks of spruce budworm (SBW) in northeast Minnesota resulting in defoliation and mortality. See chart below.

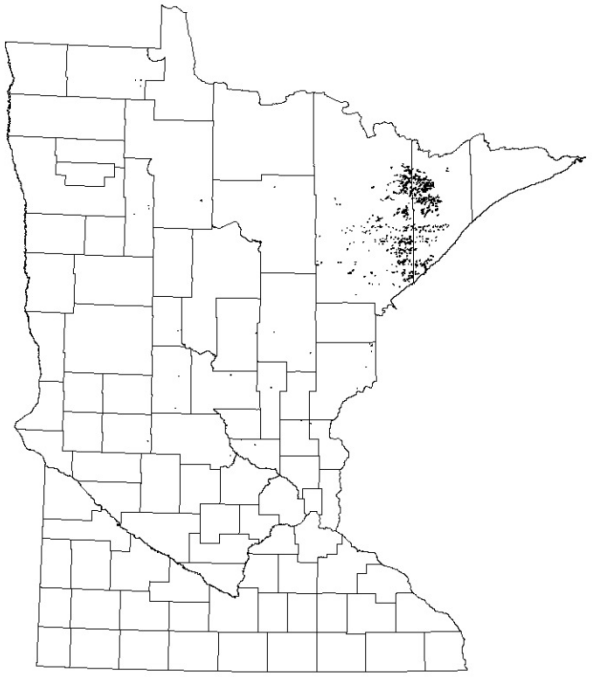
Figure 7.4. Spruce budworm defoliation from the years 1954 to 2014

This figure is a bar chart showing thousands of acres .affected, by year. *Source: Mike Albers, Minnesota DNR Forest Health Unit*



With the recent expansion of the spruce budworm outbreak in the NSU, it would be advisable to accelerate the sale and harvesting of stands with a high volume of merchantable balsam fir. Length of time to harvest fir timber sales should be short because there will be a lot of balsam fir mortality starting soon and it deteriorates rapidly after it dies. On harvest sites that will be regenerated to white spruce and/or balsam fir, neither spruce nor balsam fir should be left as leave trees. In 2014 the defoliated acres more than doubled in Lake and St. Louis counties going from 38,400 acres in 2013 to 96,640 acres at present. Within the NSU, 90,640 acres were defoliated in 2014. Extensive mortality of balsam fir has occurred in northern Lake and St. Louis counties and is just beginning in southern Lake and southern St. Louis counties.

Figure 7.5. Extent of spruce budworm outbreaks in Minnesota (2014)



Spruce budworm is considered the most destructive forest pest of spruce-fir forests in North America. Outbreaks last 7 to 10 years and cover wide geographic areas. Mortality will occur throughout the outbreak and cease about 12 years after the start of the outbreak. Mortality varies greatly from stand to stand but generally ranges from 70 to 100 percent in mature fir stands, and 30 to 70 percent in immature stands. Balsam fir is the preferred host and outbreaks typically collapse due to a shortage of food for spruce budworm larvae. Budworm moths are attracted to the spires of large fir and spruce where they will lay a significant number of eggs. The larvae hatching from these eggs will drop down from these trees onto nearby understory or regenerating trees increasing the damage to the regenerating stand.

During a spruce budworm outbreak, the first priority should be to harvest balsam fir in the most vulnerable stands with the highest merchantable volume. Host trees, especially balsam fir, will die during an outbreak, so land managers should not wait until trees start to die. Pre-salvage is much better than trying to salvage dead trees. In general, high levels of mortality are to be expected in vulnerable stands with the following characteristics:

- Stands with a large balsam fir component/high basal area of balsam fir,
- Mature fir stands, 50 or more years old.
- Small percent of non-host species,
- Stands in which spiked tops of host species protrude above the forest canopy,
- Stands on poorly drained soils that are abnormally dry or wet.

Work done in Minnesota by Batzer and Hasting (1981) found that stand composition greatly influences its vulnerability to spruce budworm. Generally, the more balsam fir there is in the stand the greater the potential balsam fir mortality. And the more species other than fir or spruce in the stand the less damage to balsam fir. Table 7.3 is based on their study on the Superior National Forest. The table shows the potential for dead balsam fir in square feet of

basal area per acre. This table does not include an estimate for dead white spruce because they found that although white spruce may be severely defoliated, they are usually not killed by spruce budworm.

Table 7.3. Potential dead balsam fir basal area/acre

The shaded portion of the table displays estimated basal area of dead balsam fir, in feet per acre, after 5 years of attack by the spruce budworm.

Basal area of other species present (%)	Original balsam fir basal area (ft^2/acre)					
	20	40	60	80	100	120
0	15	35	54	73	93	112
10	11	30	50	69	89	108
20	7	26	46	65	84	104
30	3	22	41	61	80	100
40		18	37	57	76	95
50		14	33	52	72	91
60		9	29	48	68	87

Data source: Batzer, H.O., and A.R. Hastings. 1980. How to rate spruce-fir vulnerability to budworm in Minnesota. North Central Forest Service, St. Paul, MN 55108.

Balsam fir tends to deteriorate quickly following mortality, limiting the time available for salvage. Spruce budworm defoliation results in a sharp decline in sapwood moisture. This may result in more broken stems during harvest, affecting volume and transportation costs. Moisture content of pulpwood for ground wood mills is a critical factor. While trees retaining green needles may be acceptable, trees with only red needles or no needles are unlikely to be usable by these mills. Stain and sapwood rot set in quickly with balsam fir mortality. A study done by Canadian researchers near Whyte Minnesota in the late 1970's found that sapwood rot levels one year after mortality may be high enough to limit salvage opportunities.

A loss assessment of balsam fir and white spruce was conducted by Campbell and Albers in 1983 when spruce budworm was last in this portion of the state. In southern St. Louis and Lake counties, spruce budworm-caused mortality occurred on 185,000 acres. This study found that approximately 500,000

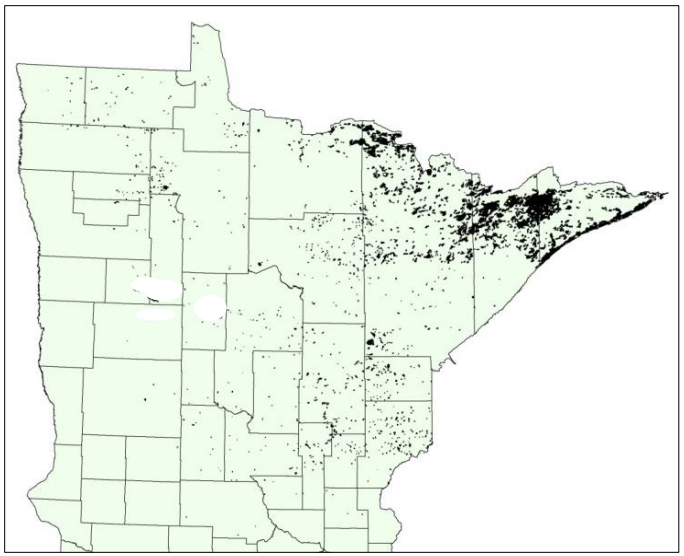
cords of balsam fir and 8,000 cords of white spruce were killed in the years 1977 through 1982. The budworm outbreak in this area lasted from about 1974 through 1986.

Because of the abundance of balsam fir and the persistence of spruce budworm in northeastern Minnesota, the long term impacts of forest management decisions must be kept in mind during planning. Balsam fir is a prolific seed producer and has the ability to persist and even increase in the aftermath of an outbreak. **Long term management strategies that increase the component of balsam fir will only lead to more frequent and more severe spruce budworm outbreaks.** Since the older stands tend to serve as the niches in which the budworm builds up, strategies to retain older balsam fir will only add to the potential for stand-destroying budworm populations to develop

Aspen Decline

Since 2004, aspen with symptoms of decline have been mapped during the Insect and Disease aerial survey in northern Minnesota, especially in the NSU. Symptoms have included a combination of defoliation, discoloration, thin crowns, small leaves, branch dieback, and tree mortality. Dieback is the most common symptom but tree mortality has also occurred. Mortality varies from scattered individual dead trees to patches of 30 to 40 dead trees scattered through stands, to almost 100 percent mortality of the oldest cohort of trees. Ground surveys have found bronze poplar borer as well as *Armillaria* root disease on many of the dead and dying trees. Stands of trees affected are 30 years and older, with most being 45 or more years old.

Figure 7.6. Areas affected by aspen decline in 2003



Many of the affected stands of aspen were stressed by 3 or 4 years of heavy defoliation by forest tent caterpillar between 2000 through 2003. In combination with defoliation they were also stressed by severe summer droughts every year from 2003 through 2009. In addition much of the northern portion of the NSU occurs on the Canadian Shield where soils are often shallow over bedrock. These sites have limited water holding capacity due to the limited volume of the soil over the rock.

Climate change can result in trees having less moisture available during the growing season by:

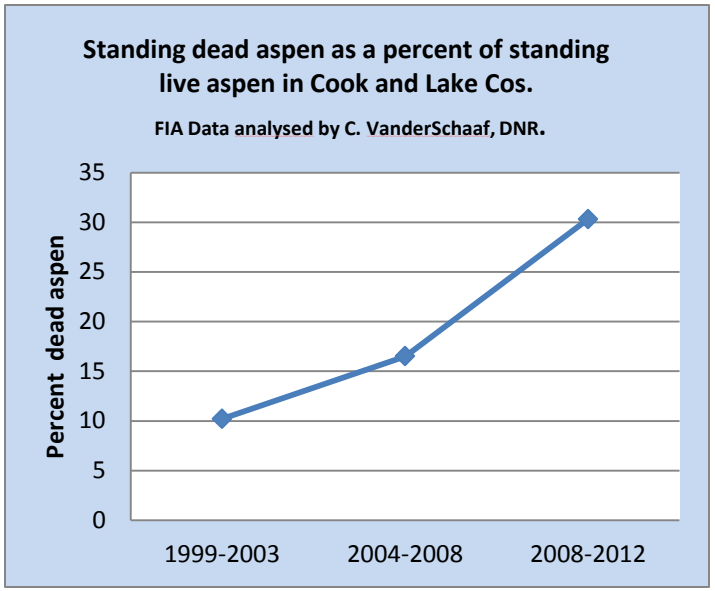
- resulting in longer growing seasons that put higher demands on soil moisture;
- warmer temperatures resulting in more evapotranspiration; and
- increased summer precipitation, coming in in the form of high intensity thunderstorm events that are more localized and release higher volumes of rain in shorter periods of time creating more runoff.

This combination of factors stresses the aspen. Insects and fungi like bronze poplar borer and *Armillaria* then attack and kill the stressed trees.

Additional information about aspen decline can be found in **Recent declines of Populus tremuloides in North America linked to climate. Forest Ecology and Management 299:35-51; Worrall JJ, Rehfeldt GE, Hamann A, Hogg EH, Michaelian M, Marchetti SB, Gray LK. 2013**.

Figure 7.7. Standing dead aspen as a percentage of standing live aspen in Cook and Lake counties

This figure is a line graph showing the linear increase in standing dead aspen as a percentage of standing live aspen in Cook and Lake counties, Minnesota. The periods charted are 1999 to 2003, 2004 to 2008, and 2008 to 2012. The increase over this period was from ten percent to 30 percent.



Eastern Dwarf Mistletoe

Eastern dwarf mistletoe (DMT) is a native parasitic flowering plant that causes the most serious disease of black spruce throughout its range. Black spruce is primarily a lowland species and is often the only commercially important species that can grow on those sites. Therefore it is important to protect black spruce from dwarf mistletoe infection (Baker et al 2006). DMT can reduce the volume of infested stands so much that a harvest is not economically feasible. Anderson (1949) estimated that up to 11 percent of the black spruce type in the Big Falls Management Unit was out of production because of dwarf mistletoe. The area of mortality was up to 19 percent in his survey. A recent study Baker et al., (2012) reported that the FIA survey grossly underestimates the amount of DMT in Minnesota. FIA data lists 11 percent of plots as infested with DMT, whereas Baker found that up to 55 percent of FIA plots actually were infested and that 20 percent of stand area was infested and volume losses were at least 14 percent of the rotation volume.

The acreage of black spruce infested with DMT in Minnesota is increasing over time, as pockets of infection continue to expand. The spread rate through a stand, as indicated by the enlargement of mortality centers, is 4.7 feet per year on average. Birds and other animals spread the sticky mistletoe seeds to

new sites creating new mortality centers. Dwarf mistletoe kills black spruce trees quickly, often within 15 years of infection. Once DMT infests a stand, it remains infested as long as live black spruce trees (of any size) remain on the site. There are no effective insects or diseases of DMT that serve as natural control agents, so DMT is not eliminated from infested sites naturally. Therefore the amount of DMT in black spruce in Minnesota is increasing.

It is important to try to protect black spruce from DMT infection in order for stands to produce enough volume so that harvest is economically feasible. Elimination of DMT from infested sites can only be accomplished if all black spruce on the site are killed at the time of harvest. This is difficult if not impossible to accomplish. In most stands DMT infections remain on sites after harvest. Even prescribed burning of a site following harvest leave areas unburned where potentially infected live black spruce are left to continue the infection of the regenerating stand. The larger the trees and the more trees left on harvest sites the more likely DMT is to be left on the site. The more DMT left on site, the faster infection will spread to the regenerating black trees, the faster mortality centers will develop, and the greater the reduction in volume of wood produced on the site.

The 5-foot cutting rule requiring loggers to cut or kill all black spruce trees 5 feet tall or taller, was instituted as a means of reducing dwarf mistletoe and its spread within a stand. Even implementing this rule seldom eliminates DMT from the site, and follow up treatment is often necessary to further reduce DMT infection on the site. Hand felling as well as shearing after the harvest has sometimes been used to reduce DMT infection in an attempt to ensure production of an adequate volume to allow commercial harvest. A survey of sites should be conducted one year or so after harvest, to determine if follow-up treatment is necessary. 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 controlled in black spruce stands when harvesting and regenerating the stands, the total merchantable acreage of this cover type will decline over time.**

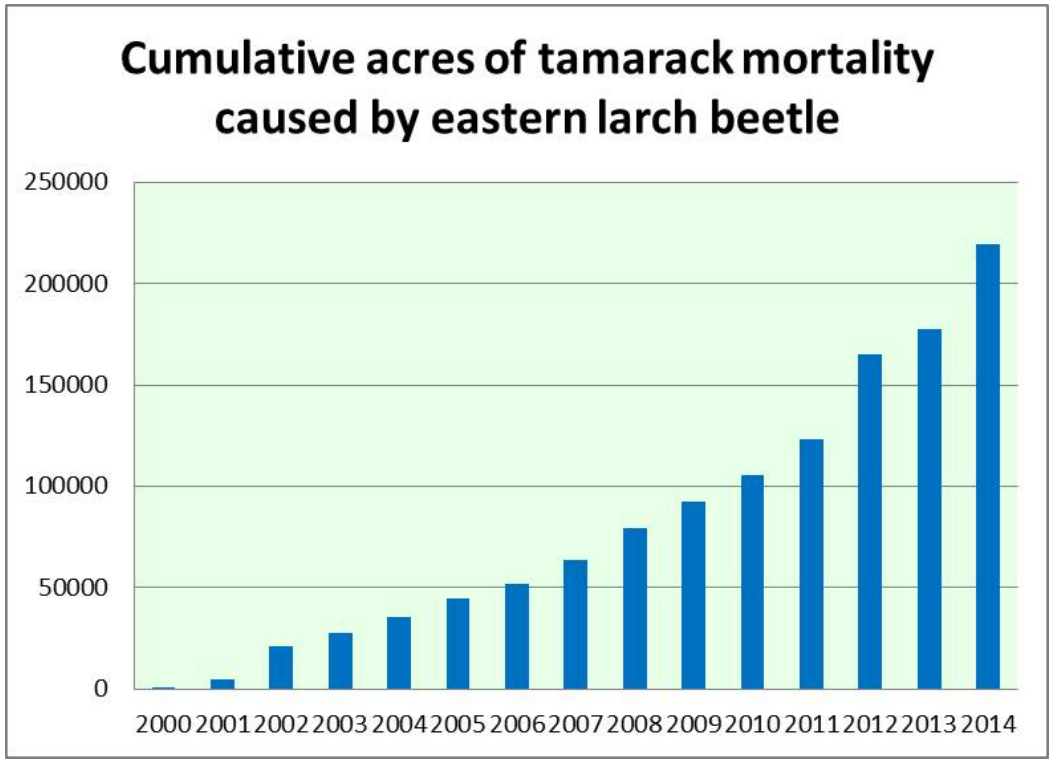
Additional information about Eastern Dwarf Mistletoe can be found in **THE INCIDENCE OF DWARF MISTLETOE IN MINNESOTA BLACK SPRUCE STANDS DETECTED BY OPERATIONAL INVENTORIES; BAKER, HANSEN, SHAW, MIELKE, SHELSTAD 2012**.

Eastern Larch Beetle

Currently, Minnesota and neighboring Canada are experiencing an outbreak of eastern larch beetle *Dendroctonus simplex* (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 Alaska, 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 the end of 2013, most of the tamarack trees larger than 4 inches DBH had been killed on 180,000 acres; 42,000 acres of tamarack mortality was caused by larch beetle in 2014 (see Figure 7.4). No widespread predisposing factor such as drought, flooding, defoliation, or off site conditions have been found to explain the cause or extent of the outbreak. It appears that changing climate resulting in longer growing seasons and warmer winters has allowed the eastern larch beetle to develop larger populations that overwhelm even health tamarack and kill them. Mortality has occurred on lowland sites, upland sites, and in pure and mixed stands of tamarack.

Figure 7.8. Cumulative acres of tamarack mortality

The bar chart in Figure 7.7 shows the number of acres of tamarack forest killed by eastern larch beetle during the period 2000 to 2014; the total is approximately 200,000 acres.



At this time the outbreak continues, 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. 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. Beetle-killed stands should be surveyed to evaluate regeneration and to determine whether aerial seeding or some other effort is needed to ensure the regeneration of the site. Even though seed trees left on harvest sites are killed rapidly by the beetle, this practice should be continued. It will not increase the problem.

Figure 7.9. Eastern larch beetle defoliation in 2014

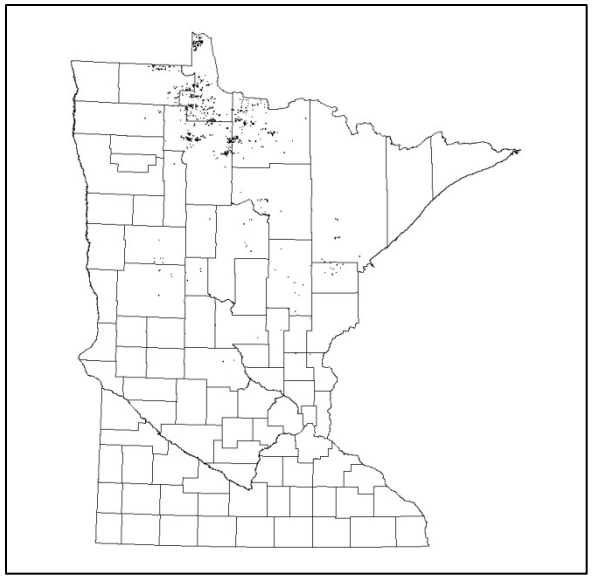
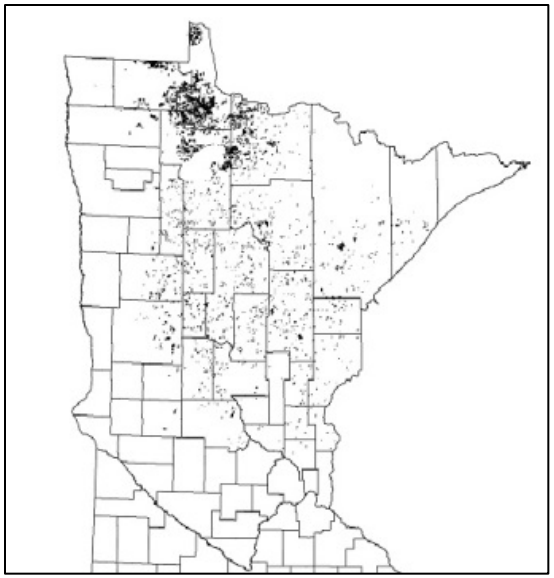


Figure 7.10. Cumulative Eastern larch beetle-caused mortality 2000-2014



Invasive Plants

Introduction

This is an overview of invasive plants that pose a significant threat to forest communities in the NSU Section. The plants included here do not include every invasive plant present; they are examples of those capable of adversely affecting long-term forest sustainability. There are many other invasive plants present in the Section.

Impacts associated with invasive plants

By their very nature invasive plants have a competitive edge over native plants, which is what allows them to become invasive. Habit, physiology, phenology, absence of adapted herbivores, reproduction, and dispersal traits can contribute alone or in combination to allowing these plants to dominate certain native plant communities.

A few of the more common traits that can provide a competitive edge include:

- Longer season of growth, allowing invasive plants a better chance at critical resources like water, light and nutrients. Examples: buckthorn, black locust, honeysuckle
- Dense foliage able to shade out competition. Examples: buckthorn, black locust, honeysuckle
- Heavy vines capable of breaking or smothering native plant growth. Example: Oriental bittersweet
- Berry production favoring seed scarification as well as dispersal by animals. Examples: Oriental bittersweet, buckthorn, Japanese barberry
- Abundant seed production, increasing the odds of seed survival and dispersion. Examples: garlic mustard, wild parsnip, spotted knapweed
- Multiple dispersal strategies, increasing the odds that seed will find a suitable habitat. Examples: garlic mustard (seeds float & stick to fur, hair and clothing), Canada thistle (seeds, rhizomes and root pieces)
- Perennial life-cycle able to resprout from strong root systems. Examples: Japanese barberry and other woody species
- Nitrogen fixing, providing critical nutrients that might otherwise be limiting. Example: Siberian peashrub
- Allelopathic root exudes that can suppress other plants. Example: spotted knapweed

Of critical importance in forest settings is the ability of invasive plants to 1) outcompete regeneration needed to ensure the success of future stands, or 2) disfavor key species required to maintain stand functions. An example of the latter is the interaction between buckthorn and exotic earthworms which alters soil chemistry and disfavors sugar maple and basswood in northern hardwood stands.

In the NSU, woody invasive plants are the species most likely to impact long-term forest sustainability. Currently a number of woody species are present in the section. In some cases, entire stands are thoroughly infested such that local eradication is no longer feasible, at least not without substantial work. But those cases are relatively rare and isolated. Overall, the Section is relatively free of invasive plant species when compared to southeastern Minnesota.

Invasive plants to know

Common buckthorn

Common buckthorn (*Rhamnus cathartica*) is a tall understory shrub or small tree that can grow up to 25 feet tall. Often multi-stemmed, the branches have no terminal bud and instead have a thorn at the tip of each stem. With broad rounded leaves that emerge early in the spring and go dormant late in the season, buckthorn can easily shade out small native plants including tree seedlings and sprouts. In dry upland sites, common buckthorn can create dense thickets which eventually eliminate native species growing beneath them. The seed, four to each black drupe, are attractive to birds, but give them diarrhea when eaten. As a result, viable seeds are quickly dispersed. Because buckthorn was originally introduced from Europe as an ornamental landscape plant, infestations are generally associated with urban areas or flight corridors moving away from urban areas. The species is listed as a Minnesota noxious weed in the “Restricted” category. That means it cannot be sold, planted or transported (except to a disposal site) without a permit

from the Minnesota Department of Agriculture. However, eliminating the plants or controlling reproduction is not required by law. Given the wide-spread nature of the infestation in the southern half of the state, requiring control isn't feasible. In the NSU, the worst infestations are in the Duluth and Two Harbor areas, and along nearby river corridors. Isolated infestations have been reported elsewhere, but plants are occurring as scattered 4 to 10 foot tall plants rather than dense uniform thickets.

Glossy buckthorn

Glossy buckthorn *(Frangula alnus)*, also from Europe, has been sold by the nursery trade in three different forms. The cultivar *Columnaris* has a narrow and tall form; the cultivars *Aspenifolia* and *Ron Williams* have narrow leaves that give them a fern-like texture. This buckthorn aggressively invades wetlands including acidic bogs, fens and sedge meadows. However, it is much less common than common buckthorn. Only a handful of infestations have been reported in the Northern Superior Uplands. Because glossy buckthorn prefers better quality sites, restoration once glossy buckthorn has been removed may be easier. Even after removing dense thickets, replanting or reseeding may not be needed, while replanting or reseeding is almost always needed after removing dense thickets of common buckthorn. Because their preferred habitat and phenology are similar to native alder, detection can be more difficult. Recent detection projects have produced far more false positives than infestations of glossy buckthorn. Like common buckthorn, glossy buckthorn is a restricted noxious weed.

Japanese Barberry

Like the buckthorns, Japanese barberry (*Berberis thunbergii*) was introduced as an ornamental landscape plant. Its unique structure, fall color and ornamental berries have made it a popular ornamental shrub for sale in landscape nurseries in Minnesota and elsewhere. Unfortunately, it is showing signs of being capable of damaging native habitats much like buckthorn. It is forming dense understories in forests in southern Minnesota. The shrub is relatively small, growing to no more than 3 to 6 feet tall. It produces small tear-drop shaped leaves clustered around spines along the stem. In autumn, the leaves turn red to purple; easily seen through the woods. The berries are bright red when mature and are borne in pairs at each leaf node. The stems are arched and can re root when they touch the ground. The thorns make passage through barberry thickets nearly impossible, and control is difficult. Japanese barberry is a "specially regulated plant" under the Minnesota state noxious weed law. The nursery industry is gradually phasing out cultivars that are prolific seed-producers. At the end of the phase-out period, the listed cultivars will become restricted noxious weeds, regulated like buckthorn. Currently there is only one known, serious infestation in the Two Harbors area. But there is barberry in a number of the other communities, poised to spread into surrounding forests. Before this species becomes permanently established in native habitats, there is an opportunity to address the threat to northern forests.

Japanese Knotweed

Japanese knotweed (*Polygonum cuspidatum*) is sometimes referred to (incorrectly) as ornamental bamboo. It is a large shrub that can grow 10 to 15 feet tall (and as wide) with stout reddish stems and large leaves alternating on swollen leaf nodes. The flowers are small and white, borne in clusters at the leaf

axils. Knotweed spreads primarily through root sprouts or root pieces that can float down stream to take hold and start another clump. These clumps, often united in one giant root ball, can get quite large. Because of the interconnected root ball and ability to sprout from small root pieces, this plant can be very difficult to control. Fortunately reproduction by seed is minimal, so infestations are not common except along riparian corridors downstream of an ornamental planting. Japanese knotweed and its cousin giant knotweed (*Polygonum sachalinense*) are "specially regulated plants". Sale as an ornamental plant is allowed as long as distributors affix a warning to the plant indicating that it is inadvisable to plant within 100 feet of a water body, stream or flood plain. There are only a handful of infestations known to occur in the NSU. Two are within communities, and two are on private lands within state forest boundaries. Because of the potential to move downstream, it is important that these areas be monitored, and any infestations destroyed while they are small.

Exotic Honeysuckles

There are three species of exotic honeysuckle (*Lonicera tartarica*, L. *morrow,* and L. x *bella*), which are difficult to tell apart unless they are in bloom. The flowers in early summer are fragrant. The leaves are opposite and oval to oblong. Berries are red or yellow borne in pairs at each leaf node. Each fruit contains many seeds, which are spread easily by birds. Seed germination is highest on open ground, or where the understory is sparse. The shrubs can grow from 5 to 12 feet high. Like buckthorn, exotic honeysuckle has a longer growing season than many native plants and can produce thickets that exclude native plants and tree regeneration. While thickets are not common in the NSU at this time, they are common in other parts of Minnesota. Exotic honeysuckles have been reported more broadly than buckthorn across the NSU. Because control methods are the same, buckthorn and honeysuckle can be targeted in the same treatments where they occur together. Exotic honeysuckles are not currently regulated and *L. tartarica* is sold in a few Minnesota nurseries. The Noxious Weed Advisory Committee recommended listing the three species as restricted noxious weeds, which would end sale. If the Minnesota Department of Agriculture commissioner accepts that recommendation, they would become restricted noxious weeds in 2017.

Common tansy

Common tansy (*Tanacetum vulgare*) is a perennial herbaceous plant. It can grow up to 3 feet tall and has yellow button-like flowers. Common tansy is toxic to humans and livestock so infestations reduce the amount of livestock that land can support. Tansy can outcompete desired vegetation, which can make reforestation and restoration efforts difficult. Tansy was introduced to the United States for medicinal and horticultural uses; through purposeful plantings and natural spread, common tansy is now present across most of the northern United States and in Canada. In the NSU, it is common along roadsides and abandoned farmyards and along the north shore of Lake Superior. South sloping open areas are most vulnerable. Common tansy is a prohibited noxious weed on the "control" List in Minnesota, meaning that control is required by law. Efforts must be made to prevent the spread, maturation and dispersal of seeds.

Knapweeds

Spotted knapweed (*Centaurea stoebe* spp. *micranthos*) is a biennial or short-lived herbaceous perennial plant. It grows 2 to 3 feet tall and has pink to purple flowers. Spotted knapweed can be a skin irritant, so cover your skin when working with it. Spotted knapweed is poisonous to other plants and can dominate an area, spreading rapidly in artificial corridors, gravel pits, agricultural field margins and overgrazed pastures. It especially threatens dry prairie, oak and pine barrens, dunes and sandy ridges. Spotted knapweed is common in the NSU, and there are three other knapweed species that are either uncommon in Minnesota, or found in the Midwest, but not found in Minnesota. These include diffuse knapweed (*C. diffusa*), meadow knapweed (*C. x moncktonii*), and brown knapweed (*C. jacea*).Knapweeds can hybridize making identification challenging and potentially resulting in "superweeds" that combine properties of multiple species. Spotted knapweed is a prohibited noxious weed on the "control" list in Minnesota, meaning that control is required by law (efforts must be made to prevent the spread, maturation and dispersal of seeds). Brown knapweed and meadow knapweed are prohibited noxious weeds on the "eradicate" list, meaning that the plants must be eradicated (all of the above and below ground parts of the plant must be destroyed).

Reed canary grass

Reed canary grass (*Phalaris arundinacea*) is a perennial cool season grass that grows 2 to 6 feet tall. One of the first grasses to sprout in the spring, it can reproduce vegetatively through horizontal stems (rhizomes) that grow beneath the soil surface. This creates a thick impenetrable mat that makes growth difficult for other species. Reed canary is a major threat to wetlands, out-competing most native species and forming single-species stands. It can become more abundant when soil is disturbed such as through ditch building, stream channeling, sedimentation, and intentional planting. Reed canary grass has been widely planted in the United States for forage and erosion control. Many organizations no longer plant reed canary grass, but it is still planted in Minnesota and is common in the NSU. There are no laws prohibiting the planting of reed canary grass or mandating its control.

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