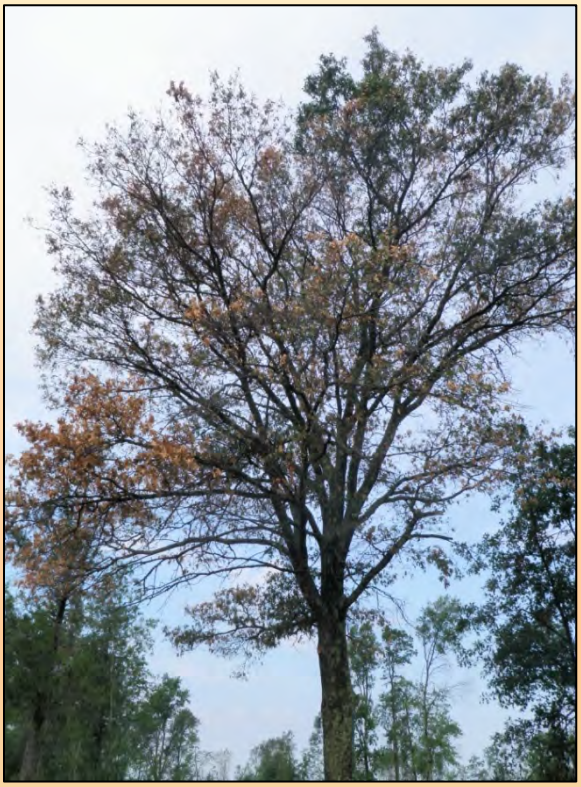
Minnesota Forest Health 2012 Annual Report

Minnesota Department of Natural Resources
Division of Forestry Forest Health Unit



Minnesota
DEPARTMENT OF NATURAL RESOURCES

Cover photos by DNR, clockwise from upper left:
Diagnosing bur oak blight; oak wilt in St. Croix State Park; looking for emerald ash borer in Winona County; symptom of bur oak blight

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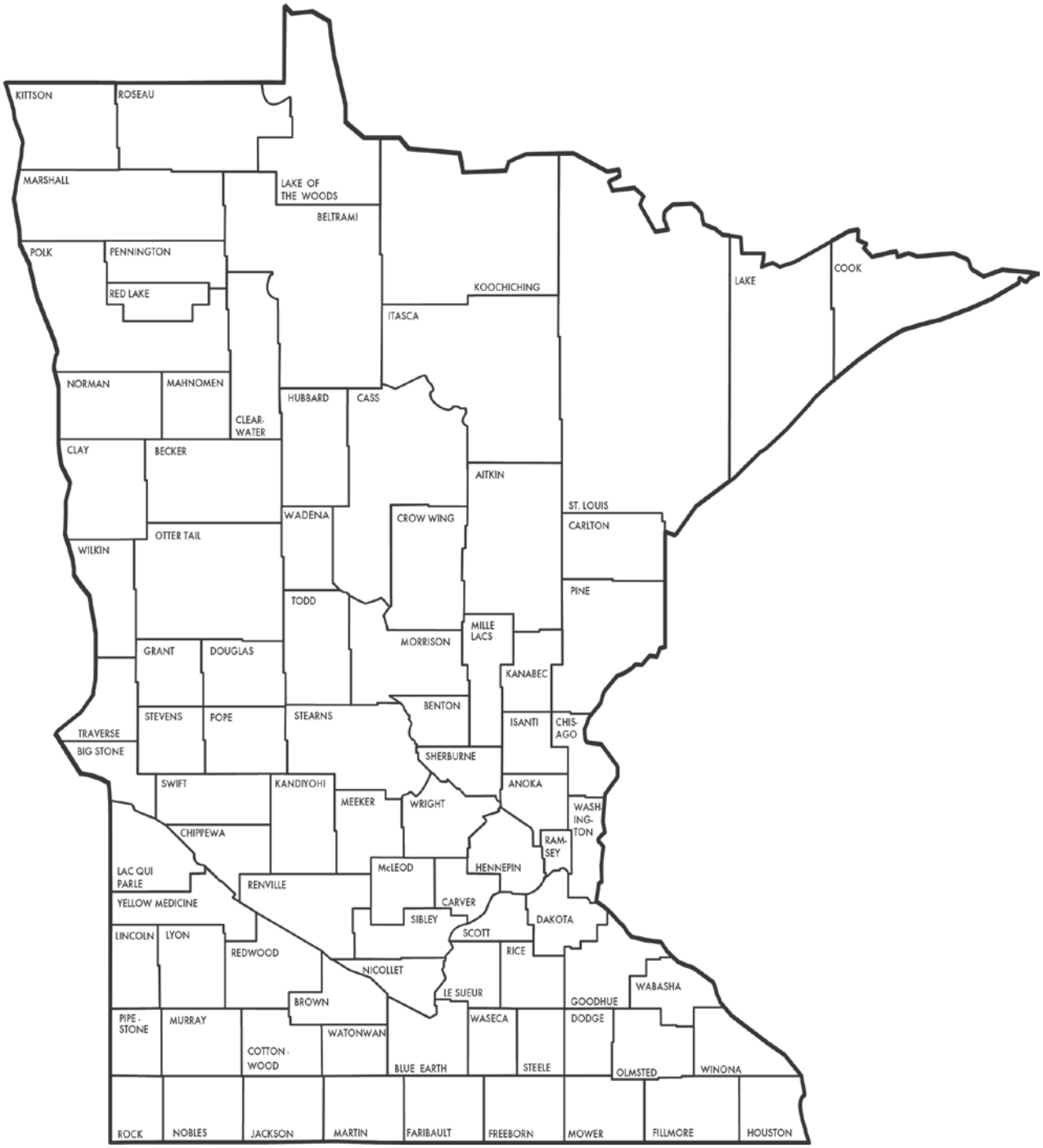
Minnesota County Map



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Minnesota Forest Resources Summary

Minnesota is home to three major ecosystems: prairies in the west, boreal forests in the northeast, and hardwoods running between the two from the Canadian border to the southeastern area of the state. As a result, the forests of Minnesota are many and varied.

Changes in the early years of the 21st century pale compared to the dramatic changes of the late 1800s and early 1900s. During that period, nearly half of Minnesota's forest land was converted to agriculture and other land uses in the wake of widespread logging that peaked in 1905. Since then, the state's forests have been a remarkable story of resiliency and recovery. However, demands on forest resources will continue to increase along with biological threats from native and nonnative diseases, insects and plants. Minnesotans face the challenge of managing forests to make available for use and enjoyment today as well as in the future.

Minnesota's forests sustain damage from a combination of abiotic stressors and native and nonnative pests. Many of the native pests are recurring and cyclic and play an integral role in the ecology of Minnesota forests. With the increasing effects of climate warming, some native pests are causing more losses in both hardwood and softwood forests.

Historically, invasive insects and pathogens have had a large impact on Minnesota's forest health. Diseases such as white pine blister rust and Dutch elm disease greatly altered the health and makeup of Minnesota's forests over the last century. Oak wilt has proven difficult to manage even though we have the tools available to prevent and control this tree killer.

The early detection and treatment of gypsy moth outbreaks and the emerald ash borer, both exotics, has slowed the introduction and spread of these two destructive insects in our state. More threats loom in the continuing fight

against nonnative diseases such as *Diplodia* shoot blight and bur oak blight and nonnative insects such as mountain pine beetle and Douglas-fir beetle.

Monitoring forest damage and surveying for insects and pathogens are crucial to predicting the quantity and quality of Minnesota's future forest resources and to devising ways to manage them.

The U.S. Department of Agriculture Forest Service, through its Forest Inventory and Analysis program and in partnership with the Minnesota Department of Natural Resources Division of Forestry, inventoried Minnesota's forest resources in 1935, 1953, 1962, 1977, 1990, 2003, and 2008. Starting in 1999, annual inventories have been conducted in which a portion of field plots is inventoried each year and a full inventory is completed after five years. Minnesota's first full inventory was completed in 2003, covering 1999 to 2003. The second full inventory, completed in 2008, covers 2004 to 2008. With complete re-measurement of annual inventory plots, we are able to produce better estimates of growth, mortality, and removals, and produce detailed reports on ground land use change.

Excerpt from Minnesota's Forests 2008

The following is an excerpt from the report, *Minnesota's Forests 2008*, UFSF, NRS-50, and summarizes the condition and health of Minnesota's forests based on the 2008 FIA analysis.

Volume and Species Composition

Current volumes can be compared to rates of harvest to help determine the sustainability of current and future harvest levels.

Volume on Timberland

The volume of all live trees on timberland increased from 14.3 billion cubic feet in 1977 to 16.3 billion in 2003 and to 16.8 billion in 2008.

Figure 17 at right shows the change in all live volume on timberland by species for the 12 species having the largest volume in 2008 (76 percent of the total volume). Aspen volumes are near historic levels although there has been a moderate decline as a result of current demand. In the short term, aspen volumes are expected to increase as large areas of regenerated aspen grow into poletimber. Species that increased volume include red pine (25 percent), bur oak (18 percent), American basswood (nine percent), northern white-cedar (nine percent), and northern red oak (eight percent). Species that decreased in volume included paper birch with10 percent decline, quaking aspen (seven percent), and balsam fir (three percent). The decrease in growing-stock volume of aspen from 2003 to 2008 was due primarily to high levels of removals.

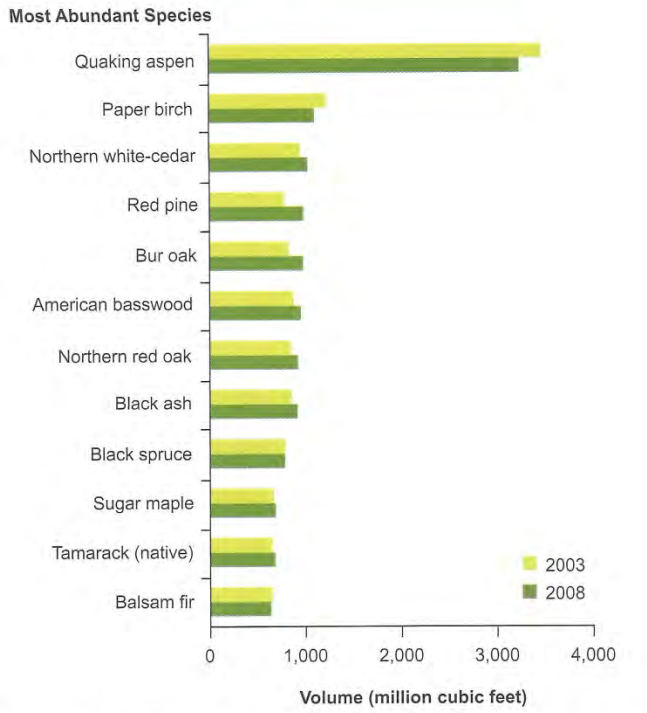


Figure 17.—All live volume by species on timberland, Minnesota, 2003 and 2008.

Volume on Forest Land

Ninety-eight percent of all live-tree volume on forest land (18.1 billion cubic feet) comes from just 26 of the 71 species measured during the 2008 inventory. Leading the list is quaking aspen at 19 percent, followed by paper birch at seven percent, northern white-cedar at six percent, and red pine at six percent.

Tree Mortality

Mortality occurs as a result of adverse weather, disease (native and invasive), insects (native and invasive), senescence, competition, succession, fire, and human and animal activity. Trees that are killed as a result of harvesting or land-clearing are considered removals and are not included in mortality.

The average annual live-tree mortality on forest land for Minnesota in 2008 was 340 million cubic feet, or roughly 1.9 percent of the 2008 volume. Mortality expressed as a percent of volume is presented for the 12 most abundant (by cubic foot volume) species in Minnesota in 2003 (Fig. 29). The mortality rate for balsam fir was the highest at 4.6 percent; the mortality rate for red pine the lowest at 0.3 percent.

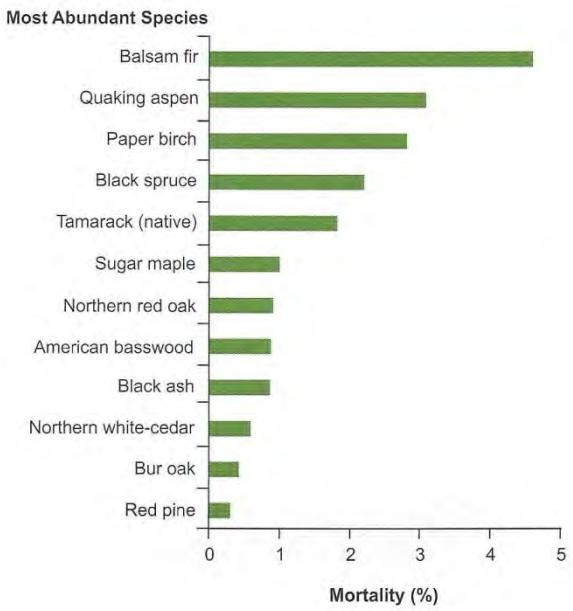


Figure 29.—Average annual live-tree mortality on forest land as a percent of volume for the 12 most abundant species in Minnesota, 2008.

The primary cause of mortality could not be determined in 43 percent of the cases. This is not surprising considering that the trees are revisited only every five years; a tree could have been dead for up to five years when revisited by the field crews. Among the various identifiable primary causes of tree mortality were weather (41 percent), disease (37 percent), insect (eight percent), animal (five percent), fire (five percent), and other vegetation (four percent).

The average annual mortality of live trees on forest land reported in 2008 expressed as a percentage of the 2008 volume is 1.9 percent. The average annual mortality of growing-stock trees on timberland is slightly lower at 1.7 percent of the growing-stock volume on timberland. This is significantly higher than the rate reported for the 1977 inventory (1.2 percent) or for the 1990 inventory (1.3 percent). The rate of 1.7 percent is also significantly higher than the mortality rates for neighboring states, Iowa (1.2 percent) and Wisconsin (1.0 percent).

The mortality rate of live trees on forest land as a percent of current live-tree volume varies by landowner class. The rate is highest for national forests (2.3 percent) followed by state and local governments (1.9 percent) and private landowners (1.7 percent). The spatial distribution of mortality is presented in Figure 30.

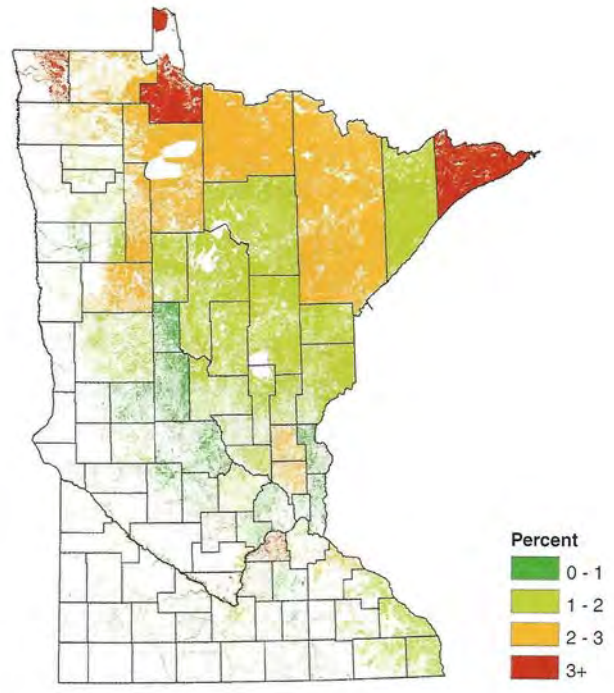


Figure 30.—Average annual live-tree mortality on forest land as a percent of live-tree volume on forest land, Minnesota, 2008.

Tree Removals

The average annual live-tree removals on Minnesota forest land in 2008 was 288 million cubic feet or roughly 1.6 percent of the total tree volume in 2008. Removals expressed as a percent of volume is presented for the 12 most abundant (by volume) species in Minnesota in 2008 (Fig. 31). The removals rate for quaking aspen was the greatest at 3.4 percent while the removals rate for northern white-cedar was the lowest at 0.0 percent.

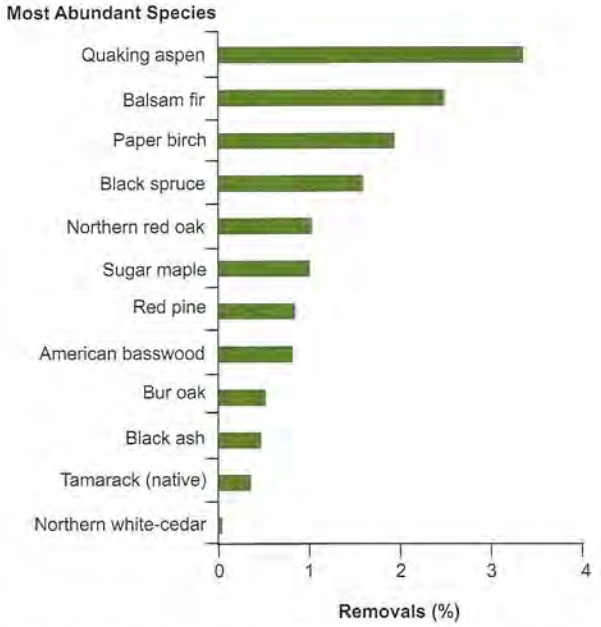


Figure 31.—Average annual removals of live trees on forest land as a percent of volume for 12 most abundant species in Minnesota, 2008.

Landowner objectives have a large impact on removal rates. On average in Minnesota, state and county lands are more actively managed than other ownerships. Removal rates are highest on state and county lands and lowest on federal lands, while per-acre sawtimber volumes are greatest on federal lands and lowest on state and local government lands.

Growth-to-Removals Ratio

One measure of sustainability is the growth-to-removals ratio (G/R). The growth-to-removals ratio is simply the net growth divided by removals where net growth is equal to gross growth minus mortality. A number greater than 1.0 indicates that the volume of the species is increasing. A number less than 1.0 indicates that the volume is decreasing.

Overall, the growth-to-removals ratio of live trees on forest land for 2003 to 2008 was 1.5, indicating that overall volume is indeed increasing. By ownership class, the growth-to-removals rates are 2.5 for the national forests, 2.2 for other Federal ownership, 2.0 for private ownership, 1.0 for county and municipal, and 0.8 for State-administered lands. On a species-by-species basis, the picture is less clear (Table 7). Northern white-cedar has a G/R ratio of over 45; paper birch has a G/R ratio of nearly zero because mortality nearly matches gross growth, resulting in a very small net growth.

Table 7.—Ratio of average annual net growth of live trees on forest land to average annual removals of live trees on forest land for the 12 most abundant species in Minnesota, 2008

Species	Growth/ Removals	Net Growth of All Live Trees on Forest Land (thousand ft³)	Removals of Live Trees on Forest Land (thousand ft³)	Volume of Live Trees on Forest Land (thousand ft³)
Northern white-cedar	45.45	15,549	342	1,074,916
Bur oak	5.80	29,585	5,105	1,008,012
Red pine	5.52	47,315	8,565	1,022,939
Black ash	4.86	21,568	4,441	967,514
Tamarack (native)	4.61	11,206	2,429	690,116
Northern red oak	3.24	31,900	9,853	959,141
American basswood	2.71	21,353	7,880	967,607
Sugar maple	2.08	14,291	6,870	688,044
Black spruce	0.99	13,808	13,940	881,947
Balsam fir	0.84	14,070	16,707	672,489
Quaking aspen	0.63	72,922	116,154	3,464,423
Paper birch	0.04	915	23,796	1,225,827

The average annual removals of growing-stock trees on timberland reported for 2004 to 2008 (294 million cubic feet) was higher than the 249 million cubic feet reported for 1999 to 2003. Harvest removals of growing stock on timberland was estimated at 235 million cubic feet in 2008, an increase of 32 percent over the 178 million cubic feet of harvest removals for the period ending in 2003. Of the three components of change (growth, removals, and mortality), removals is the most directly tied to human activity and is thus the most responsive to changing economic conditions.

Insect infestations, disease, and succession can result in low G/R ratios. Paper birch had a very small G/R because its mortality nearly matched gross growth over the period. High mortality rates for balsam fir due to spruce budworm infestations were partially responsible for a low G/R. Sometimes it makes sense to manage the forest so that a species will temporarily have a G/R of less than 1.0. When short-lived species such as quaking aspen are nearing senescence, it may make sense to try to "capture mortality" (harvest a tree before it dies of old age).

Phase 3 Indicator Summary

Crown Conditions

The overall condition of tree crowns within a forest stand may indicate the health status of forests. For example, a forest suffering from a disease epidemic or an insect outbreak can have low crown ratios, high transparency, and obvious dieback.

Dieback is measured as the percent of dead branch tips in the crown. The categories for the dieback indicator are none (1-5 percent), light (6-20 percent), moderate (21-50 percent), and severe (51-100 percent). Overall, 87 percent of the trees had no dieback, 10 percent had light, two percent had moderate, and only one percent had severe (Fig. 35). The ash species group is the most susceptible to dieback; 14 percent of the trees had light dieback and six percent had moderate to severe dieback in the 2008 inventory.

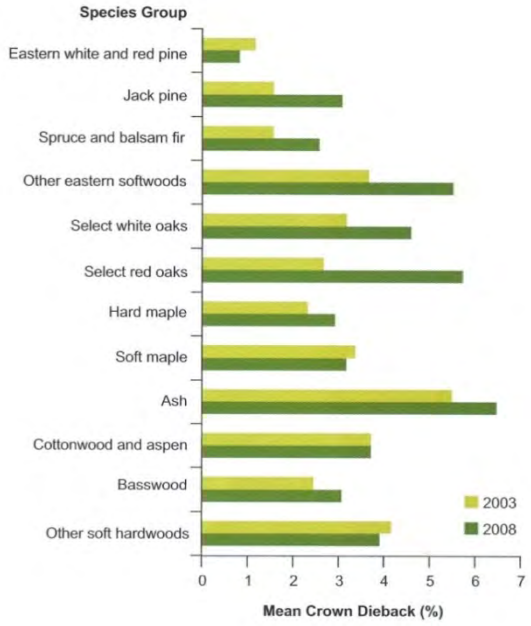


Figure 35.—Mean crown dieback in percent by species group, Minnesota, 200[illegible] and 2008.

Crown transparency is a measure of the proportion of the crown through which the sky is visible. The ash species group had the highest average crown transparency at 23 percent; the spruce and fir species group had an average crown transparency of only 16 percent (Fig. 37). Because crown conditions were sampled on a small subset of forest inventory plots (184 forested phase-3 forest health plots) it is not appropriate to calculate population estimates.

Down Woody Materials

Down woody materials, in the form of fallen trees and branches, fill a critical ecological niche in Minnesota's forests. Down woody materials provide both valuable wildlife habitat in the form of coarse woody debris and contribute toward forest fire hazards via surface woody fuels. Ultimately, down wood materials create duff and soil layers which provide nutrients and hold soil moisture.

The size-class distribution of coarse woody debris by number of pieces appears to be heavily skewed (79 percent) toward pieces less than eight inches in diameter at point of intersection with plot sampling transects (Fig. 39, below). In the decay class distribution of coarse woody debris, there

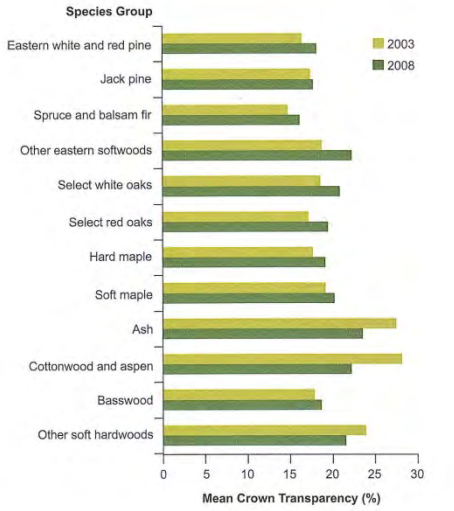


Figure 37.—Mean crown transparency in percent by species group, Minnesota, 2003 and 2008.

appears to be moderate stages of coarse woody decay across Minnesota, 2003 and 2008.

There is no strong trend in coarse woody debris volumes/acre among classes of live-tree density (basal area/acre). Most of Minnesota's forests appear to have more than 400 cubic feet of coarse woody debris volume/acre (Fig. 41).

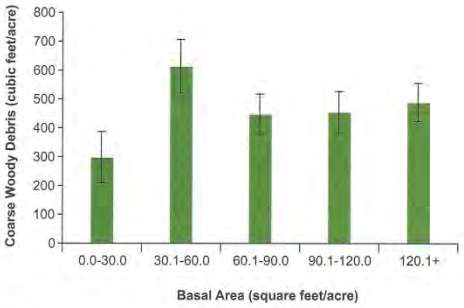


Figure 41.—Means and associated standard errors of coarse woody debris volumes (cubic feet/acre) by live-tree basal area class on forest land in Minnesota, 2008.

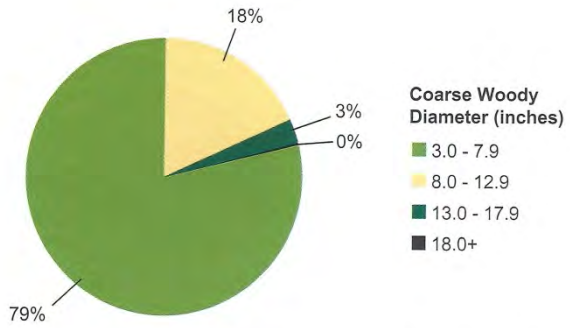


Figure 39.—Mean proportions of total pieces of coarse woody debris per acre by transect diameter (inches) on forest land in Minnesota, 2008.

Wildlife Habitat

Habitat requirements vary by species. Some species require interior mature forests, other species require forest edge, and still others require both habitats at different times of the year or of their life cycle. Broad characterizations of wildlife habitat using FIA data can be made, by looking at several indicators. Information from these indicators may also help to identify areas lacking adequate habitat while establishing a baseline of monitoring data. Mature forests, the presence or absence of snags, the quantity of coarse woody debris, and forest spatial patterns are all important descriptors of forest wildlife habitat.

Diverse stages of stand development are found across the forests of Minnesota. Generally, more mature forests (based on mean tree size and stand density assessments) are found in the prairie areas of Minnesota, whereas younger stands are more typically found in northern Minnesota where removals are highest.

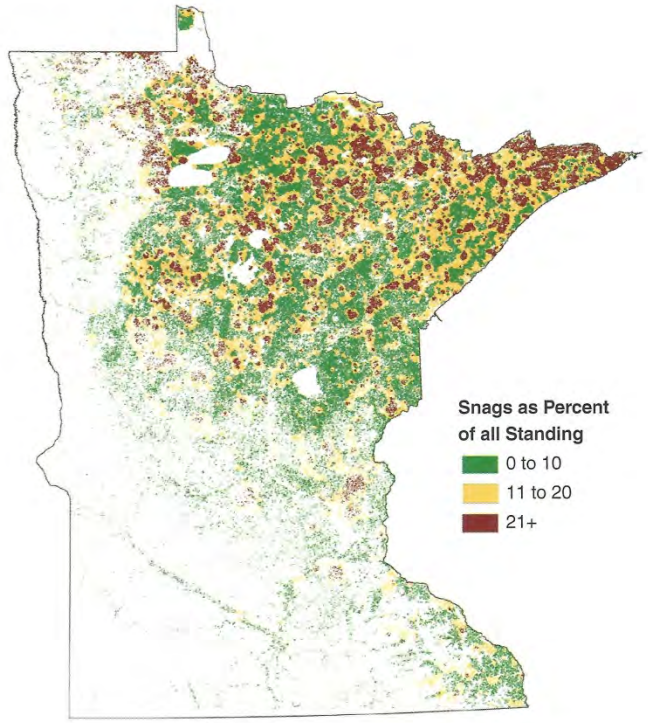


Figure 58.—Interpolated map (inverse-distance weighting) number of standing dead trees as a percent of standing live and dead trees, Minnesota, 2008.

Standing-dead or snag trees are important habitat for birds and mammals. The downy woodpecker and 31other Minnesota forest bird species rely on tree cavities and snags for feeding and nesting. Most cavity-nesting birds are insectivores and help control the insect population. Additionally snags are used as a source of food by 26 mammal species and are a critical component of wildlife habitat. The abundance of snags is highly variable across the forests of Minnesota, although the greatest amounts appear to occur in the northeastern part of the state (Fig. 58, above).

For every 100 live trees more than 5 inches in diameter in Minnesota, there are 14 snag trees; there are 13.6 snags per 100 live hardwoods and 14.8 snags per 100 live softwoods. The percent of standing dead to live trees is slightly higher for national forest ownership (17.9) than for state and local government ownership (13.9), and private ownership (12.5). Part of the reason for this may be differences in stand age. The average stand age for national forests is 58 years, state and local government 55 years, and private ownership 53 years.

Current inventory data indicate diverse and abundant forest habitat (snags, coarse woody debris, and forest patterns) to support numerous wildlife species across Minnesota. However, data are insufficient to project trends or draw conclusions about individual wildlife species. For species that depend on continuous forest cover in mature forests, there is evidence that the area of mature forest is increasing across Minnesota but that there has been a decrease in the area of interior forests. For species that require both the cover of mature forests and foraging areas of non-forest environments, the continued maturation and fragmentation of Minnesota's forests will maintain these habitat intermixes.

Timber Product Output

Timber harvesting produces economic benefits for persons involved in timber ownership, management, marketing, harvesting, hauling, and distribution to processing mills. Approximately 16,048 people are employed in wood product manufacturing (Bureau of Census NAICS code 321) and 12,394 are employed in paper manufacturing (NAICS code 322). The total payroll for these two sectors of the Minnesota forest economy was estimated at $1.3 billion (eight percent of all manufacturing in Minnesota). The value of forest products manufacturing shipments was estimated at $8.8 billion in 2007 (U.S. Census Bureau 2007).

Surveys of Minnesota's wood-processing mills are conducted periodically to estimate the amount of wood volume processed into products (Fig. 59). The last survey was conducted in 2007. The key sectors of the forest products industry include sawmills, pulp and particleboard (flakeboard, waferboard, oriented strandboard, and medium-density fiberboard) mills, and secondary processors. Of increasing importance are cogeneration facilities utilizing wood fiber for energy.

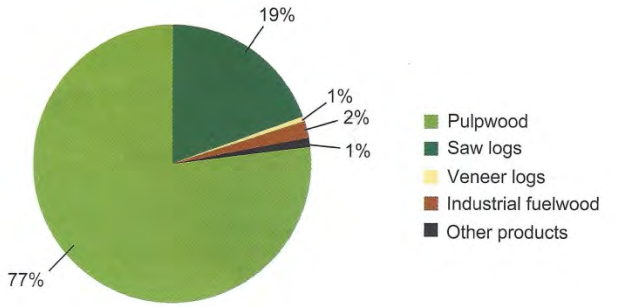


Figure 59.—Industrial roundwood production by product, Minnesota, 2007.

The timber products industry plays a vital role in the economy of rural Minnesota. Based on current volumes and a healthy growth-to-removals ratio of 1.4, there is the biological potential to sustainably increase harvest levels. The extent to which this potential is realized depends on many things including markets, stumpage prices, and landowner objectives.

Nonnative and Invasive Plants

Information about trees obtained from 6,139 forested FIA field plots and information about understory vegetation obtained from 184 forested phase-3 plots measured in 2004-2008 may be used to assess the prevalence of introduced and invasive plant species. A total of 657 species were identified on the 184 vegetative diversity plots. Sixty-seven of these species are not native to Minnesota. Sixty-four of the 184 plots had at least one identifiable invasive or introduced species (Fig. 56 below). Sixty-seven different invasive/introduced species were found on these 184 plots. Thirty-nine plots had three or more introduced or invasive species. The most prevalent invasive species was common dandelion that occurred on 32 of the plots. Twenty-five plots had aster and 17 plots had common buckthorn.

Based on the vegetation diversity indicator, invasive or introduced species are found on just over one-third of the forested plots in Minnesota. The extent to which these introduced or invasive species cause harm cannot be assessed at this time; however, the potential exists for these species to reduce the overall diversity and health of Minnesota's forests. Invasive or introduced species appear to occur on recently disturbed sites or non-forest boundary areas, where low stand densities allow for establishment of new species.

Invasive tree species make up less than one-tenth of one percent of the tree biomass in Minnesota. Still, over time the potential exists for native species displacement and reduction in the value and health of Minnesota's forests.

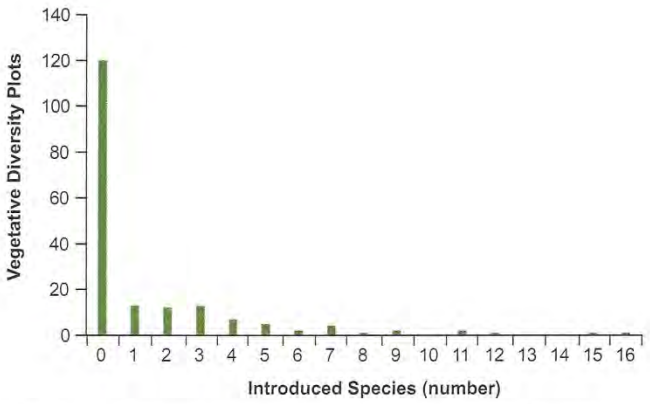


Figure 56.—Number of introduced species found on vegetative diversity plots, Minnesota, 2008.

Aerial Survey Results

Since the early 1950's, aerial survey has been a valuable tool for monitoring the activities of forest insects and pathogens across the 16 million acres of forest land in Minnesota. For the past fifteen years, these surveys have been accomplished through the collaboration of DNR Forest Health and Resource Assessment Units and USFS, State and Private Forestry. The Forest Health staff plans the scope, timing and intensity of the surveys, trains Resource Assessment staff, provides ground-truthing, analysis and dissemination of survey data. Resource Assessment staff conducts the aerial sketch-mapping, digitizes the data and produces digital shape files. In addition to being used in Minnesota, the survey results are incorporated into the USFS national database since our procedures and products comply with national standards. In the map below, number of polygons and acres for spruce budworm mortality are not included in the totals as it would be double-counting the number of acres.

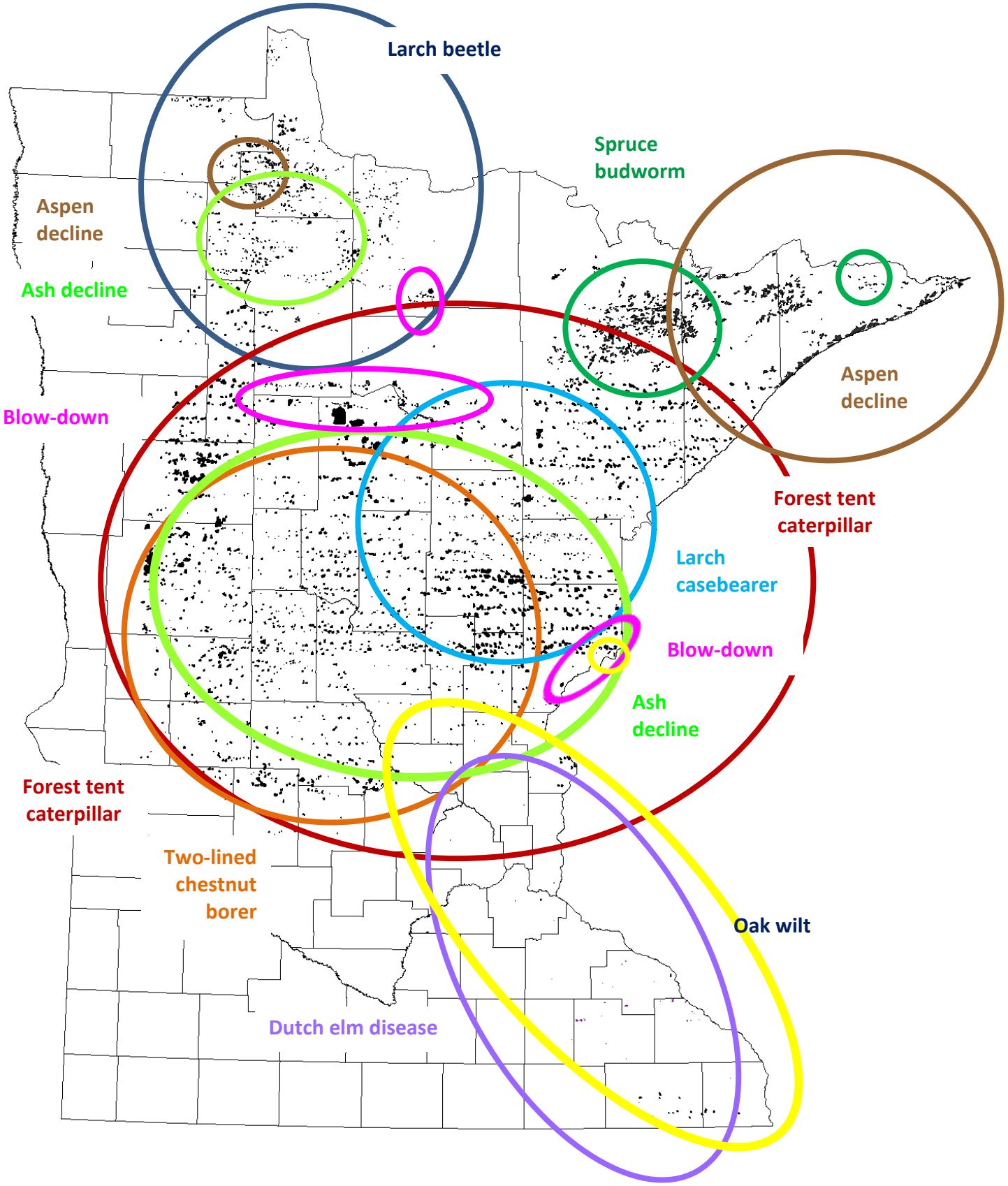
Agent	Number of polygons	Number of acres
Ash decline	374	23,152
Aspen decline	277	89,842
Other decline	2	12
Bark beetles	24	317
Dutch elm disease	659	3,004
Fire	5	553
Flooding	78	1,955
Forest tent caterpillar	1636	274,688
Jack pine budworm	1	7
Larch beetle	927	42,263
Larch casebearer	120	18,443
Spruce budworm defoliation	330	82,770
Spruce budworm mortality	270 *	79,250 *
Two lined chestnut borer	52	1,227
Unknown	182	6,626
Wind damage	150	15,884
Totals	**4817**	**560,743**

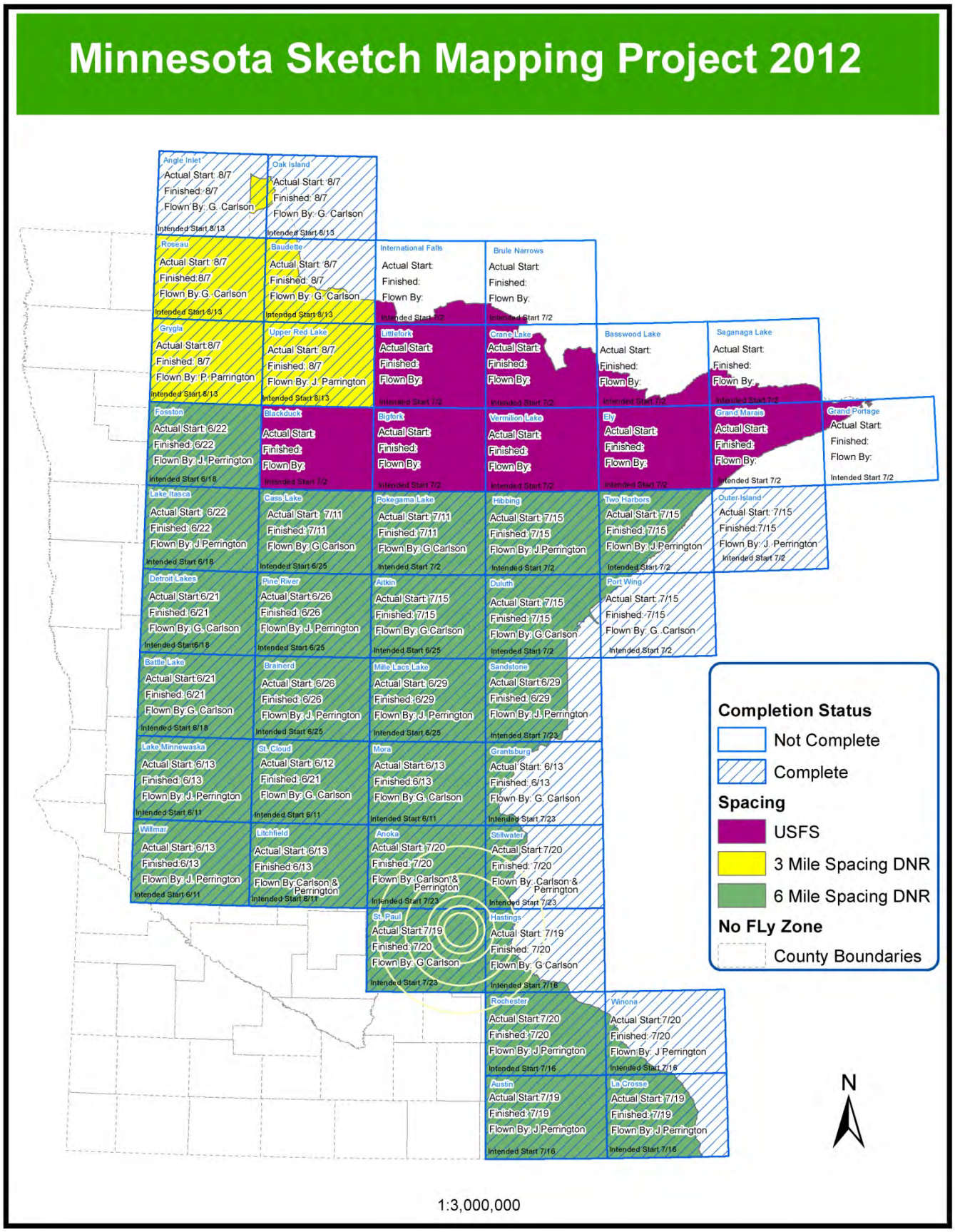
The state portion of the survey started on June 12 and was completed on August 7. The start of the Federal portion of the survey was delayed because all USFS Region 9 aircraft were grounded starting on June 25. The intended start date for the Federal portion of the survey was July 2, but due to the aircraft grounding did not start until July 31. It was completed on August 8. The lateness of this portion of the survey made mapping spruce budworm defoliation and forest tent caterpillar more difficult, but a good map was still produced.

The survey was flown on 6 mile flight lines except for the extreme northwestern part of the state where flight lines were spaced at 3 miles in order to get a more detailed map of tamarack mortality due to eastern larch beetle. The flights in the northwestern portion of the state were also delayed until August in order to be able to see trees being attacked by the larch beetle better.

Thanks to Mike Hoppus, Joel Perrington, and Gentry Carlson, Resource Assessment's sketch-map team, who accomplished this year's aerial survey and data-processing. Thanks also to Marc Roberts, USFS-S&PF, for mapping the federal portion of the survey, and to Quinn Chavez, USFS-S&PF, for post-flight map rectification and the final review meeting.

Map of Aerial Survey Results





Survey by quad showing intended start, actual start, and completion dates

2012 Cheat Sheet for Coding Damage Polygons in ArcView

File Names: Store successive shapefile versions as skm06v01.xxx, skm06v02.xxx, etc. in S:\sketchmp\dmg_polys_06

Items coded: Arrange data fields in the following order and format:

Polygon ID: Name of 1:100,000 quad on which polygon is first delineated , plus 3-digit number: e.g. LakeItasca025. Numbering starts at 001 in every quadrangle. Once assigned, this ID will not change. Character field, width 25.

ID No: Only the numerical portion of Polygon ID above. Numeric field, width 3, no decimal.

Damage type code: Use severest type if more than one may apply. Flight map coding may indicate agent only; e.g. FTC = forest tent caterpillar = defoliation, or OW = oak wilt = mortality. Numeric field, width 2, no decimal.

Defoliation (D) 1	Branch breakage (Br) 6
Mortality (M) 2	Stembreak/uproot (St) 7
Discoloration (Dc) 3	Branch flagging (Bf) 8
Dieback (Db) 4	Other damage (0) 10
Topkill (Tk) 5	Old mortality (OM) 11

State severity code: Coding default is L unless otherwise specified. Character field, width 2.

Trace, 5-25% affected T	Moderate, 51-75% affected M
Light, 26-50% affected L	Heavy, > 75% affected H

Federal severity code: Derived from state severity code. Numeric field, width 2, no decimal.

T, L	1	M, H	2

Pattern code: Coding default is 1 unless otherwise specified. Numeric field, width 2, no decimal.

Where host cover > 50% and damage is:		Where host cover is less than 50% and damage is:
Cg = Contiguous	1	C = Continuous 3
P = Patchy	2	Sc = Scattered 4

Agent code: Following are common; see Aerial Survey Handbook for anything else. Coding default = Unknown (90000) where agent is not specified. Numeric field, width 6, no decimal. Based on Aerial survey gis hdbk apx E Revised 11/2007

Bark beetles (BB)	11000	Dutch elm disease (DED)	24022
Larch beetle (LB)	11010	Fire (F)	30000
Large aspen tortrix (LAT)	12037	Porcupine damage	41006
Spruce budworm (SBW)	12038	Abiotic (A)	50000
Jack pine budworm (JPB)	12041	Flooding ~~(F~~, Fl)	50004
Larch casebearer (LCB)	12047	Snow/ice	50011
Forest tent caterpillar (FTC)	12096	Wind damage (WD)	50013
Two-lined chestnut borer (TLC)	15005	Winter injury (WI)	50014
Decline(DC)	24008	Herbicide damage (HD)	70001
Oak wilt (OW)	24021	Unknown	90000

Agent Name: Common name of causal agent exactly as given in Handbook. Character field, width 40.

Host code: Following are common; see Handbook for others. Use Hardwoods, Softwoods (= conifers) or Both if more than one species is involved. Numeric field, width 4, no decimal.

Host code name	Code		Host code name	Code
Hardwoods (Hw)	001		Scotch pine	130
Softwoods (Sw)	002		White cedar	241
Both	003		Birch	370
Unknown	999	(Don't use unless necessary)	Hickory	400
Balsam fir	012		Ash	540
Tamarack	071		Black ash	543
White spruce	094		Aspen	746
Black spruce	095	(In bogs)	Balsam poplar	741
Jack pine	105		Oaks	800
Red pine	125		Willow	920
White pine	129		Basswood	950
			Elm	970

Host name: Common name of host exactly as given in Handbook. Character field, width 40.

Pest Conditions Report

This report contains pest information on all of the "Major Forest Insects and Diseases" that occur within the state (from a national list) and any other pest that causes significant host damage during the year. The report contains pest data that will be entered into the federal Pest Event Reporter database used to produce the National Forest Insect and Disease Conditions Report.

Insects

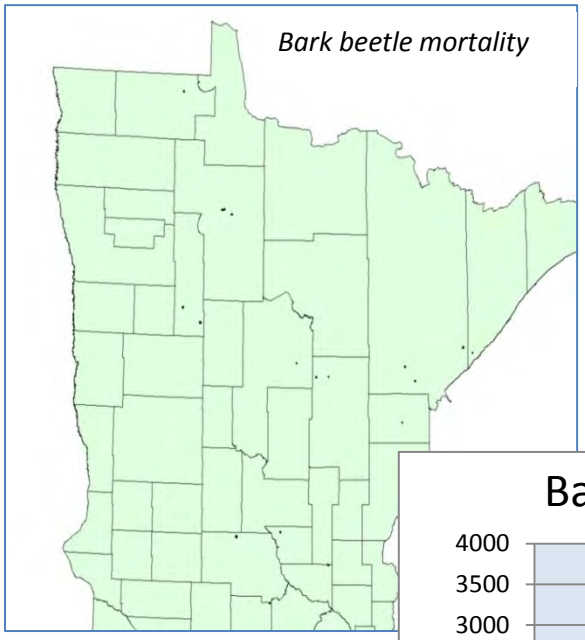
Bark beetles

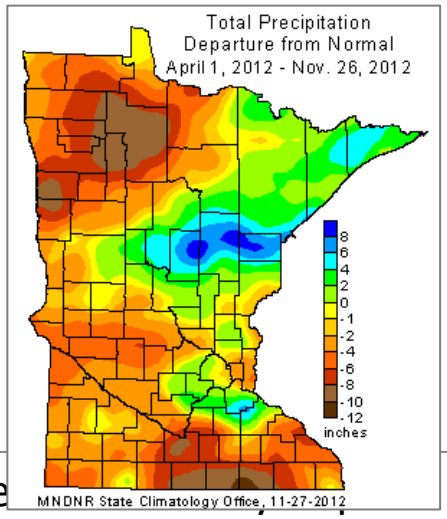
Ips pini and other *Ips* species

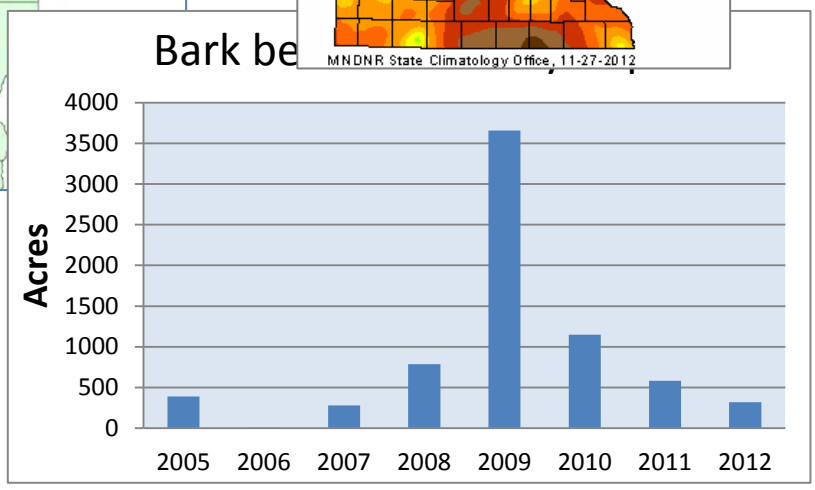
Hosts	Red, jack, and white pines
Setting	Rural forests
Counties	See map
Survey methods	Aerial detection
Acres affected	310 acres
Damage	Mortality

Trend is decreasing from 580 acres in 2011 to 310 acres in 2012. This year's acreage is only 1/10 that of 2009, the peak year. This is fairly surprising given that both 2011 and 2012 were droughty. However, the central portion of the state, where most bark beetle outbreaks occur, apparently had adequate rainfall this year or the vulnerable stands lost trees earlier in the decade.

Pupa, larva and callow adult in galleries
Texas A&M AgriLife Extension Service Archive, Texas A&M University, Bugwood.org







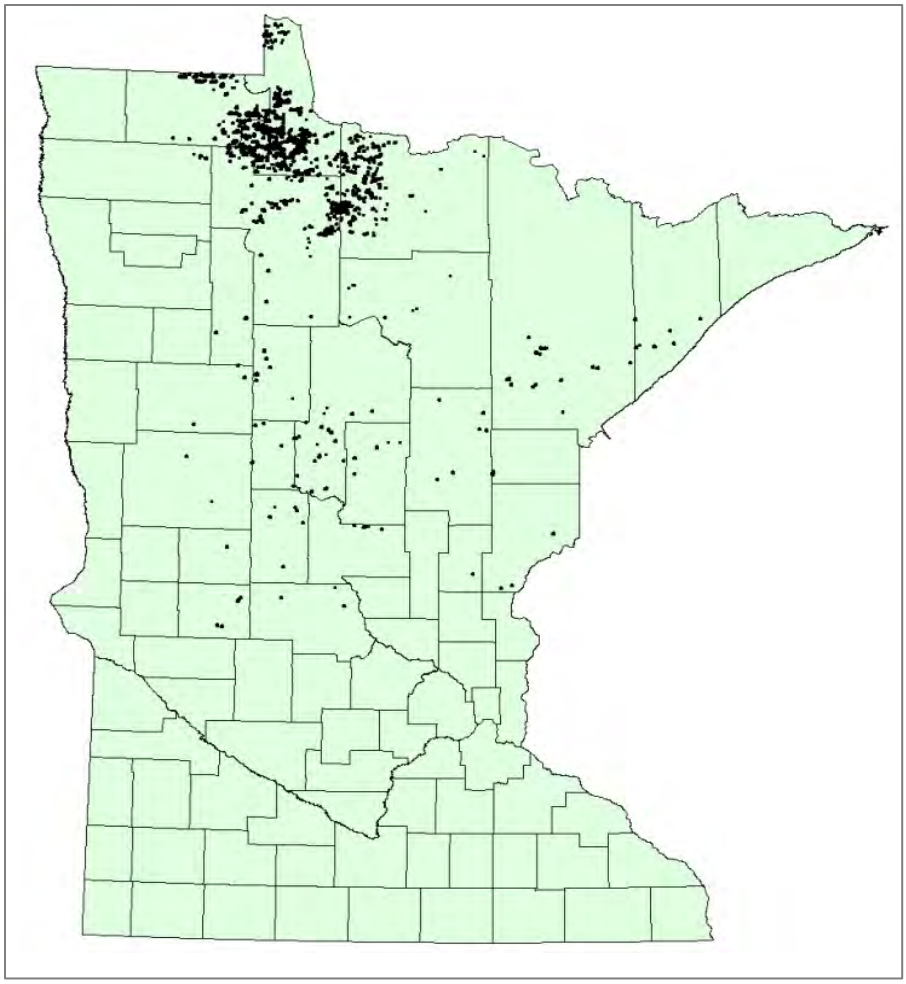
Eastern larch beetle

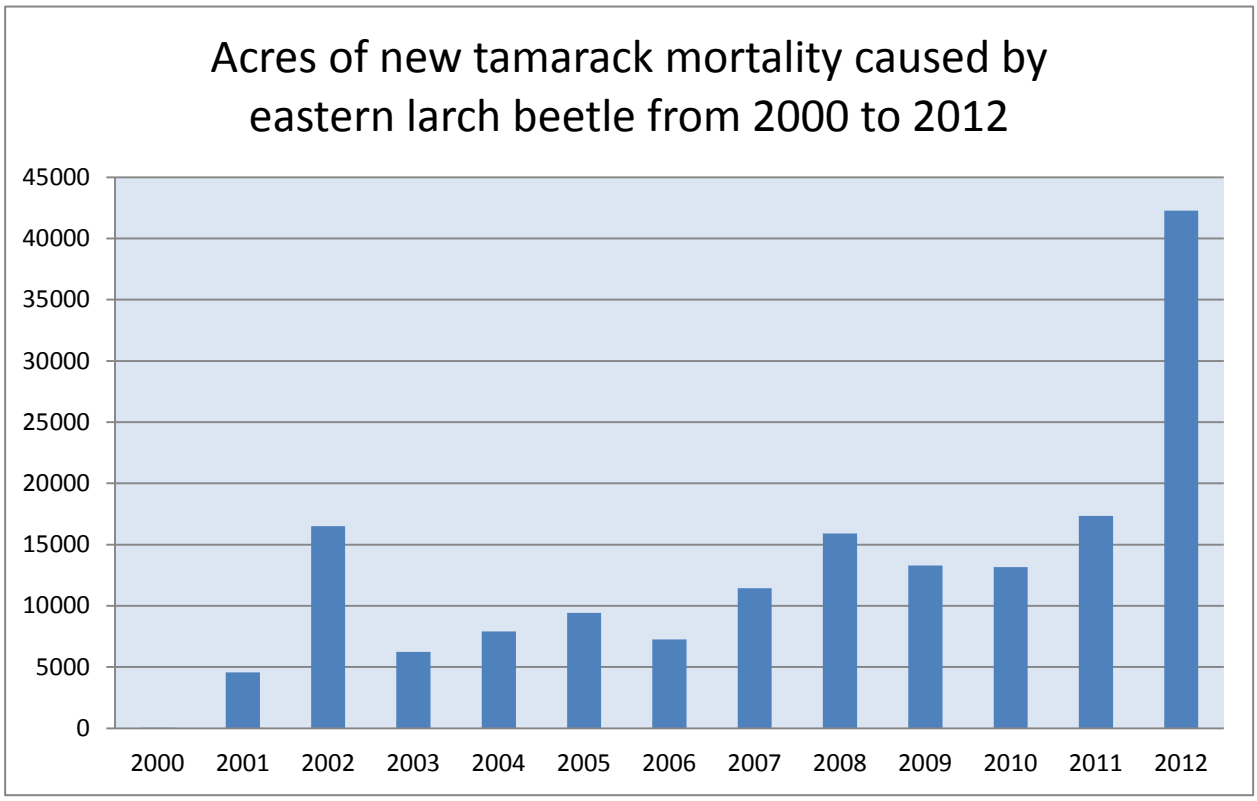
Dendroctonus simplex

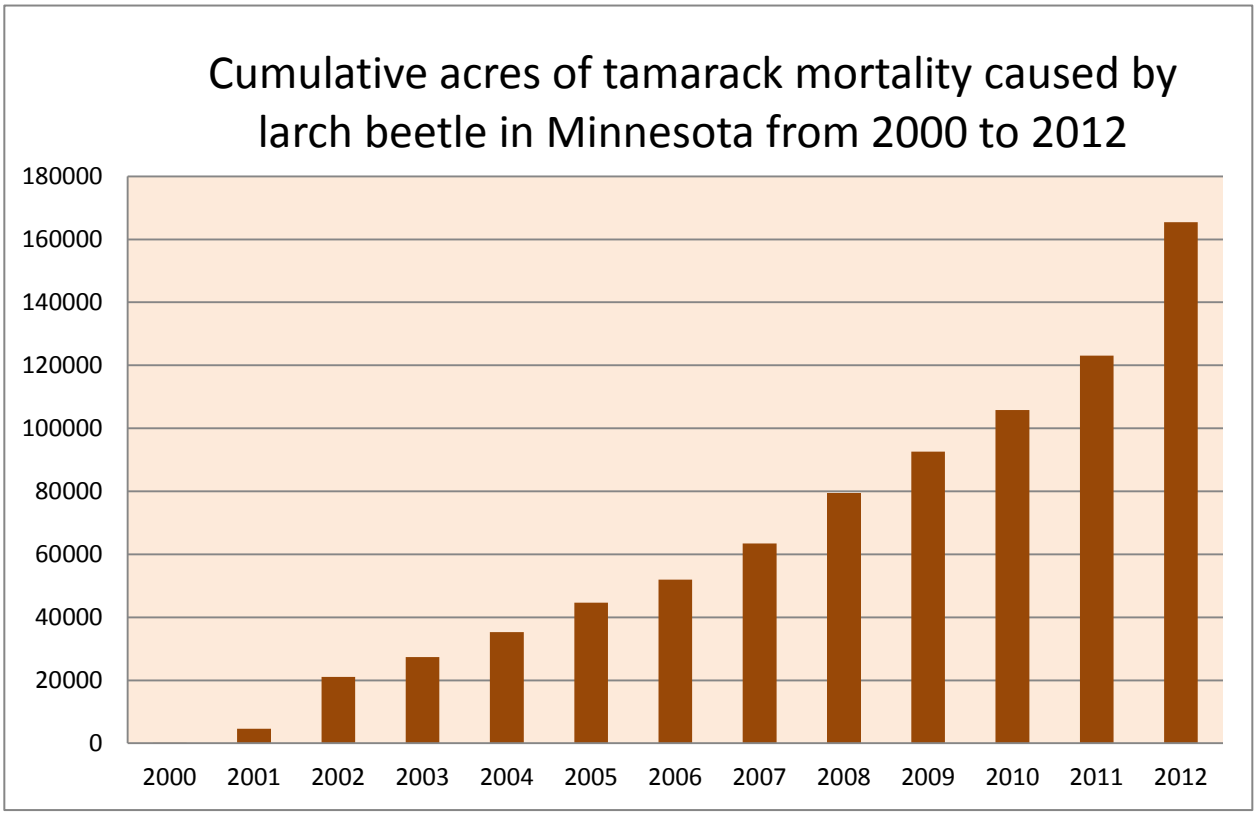
Host	Tamarack
Setting	Rural forest
Counties	See map
Survey method	Aerial detection
Acres affected	42,200 acres
Damage	Mortality

August foliage discoloration in Itasca County occurs on half of attacked tamaracks.

This is the 13th year of the eastern larch beetle outbreak in Minnesota, with a cumulative mortality of 165,000 acres. This year new mortality jumped to 42,200 acres, 2.4 times more than in 2011 (see page 20). For the past few years, most damage has occurred in two extreme northern counties, but pockets of infestation and mortality can be found anywhere tamarack grows in the rest of the state. DNR foresters report that within five years of aerial or ground detection, more than 95 percent of the tamarack is dead in these stands.




Acres of new tamarack mortality caused by eastern larch beetle from 2000 to 2012
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Cumulative acres of tamarack mortality caused by larch beetle in Minnesota from 2000 to 2012
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Emerald ash borer

Agrilus planipennis

Hosts	All ash species
Setting	Urban and rural forests
Counties	Houston, Winona, Ramsey and Hennepin
Survey methods	Trapping, girdled trees, and ground survey
Acres affected	Not determined
Damage	Mortality

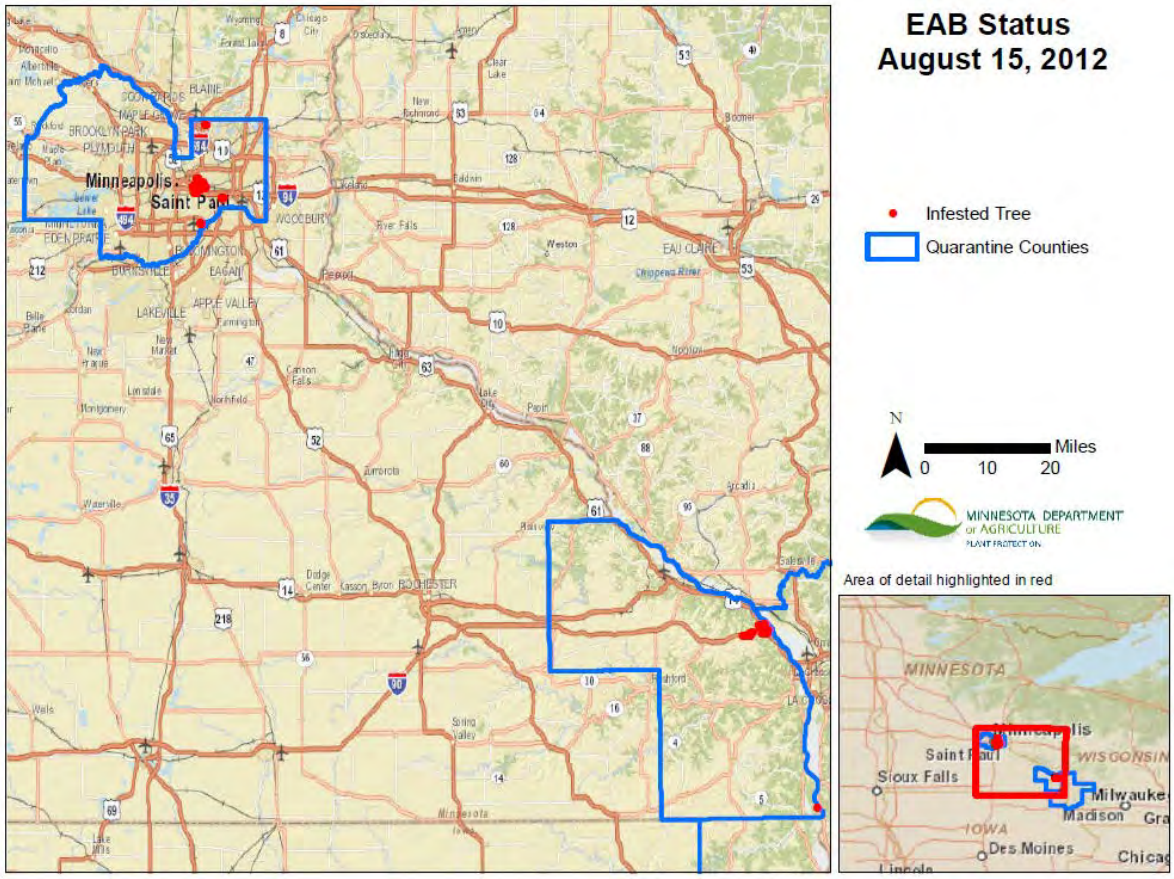
Adult EAB emerging from ash tree

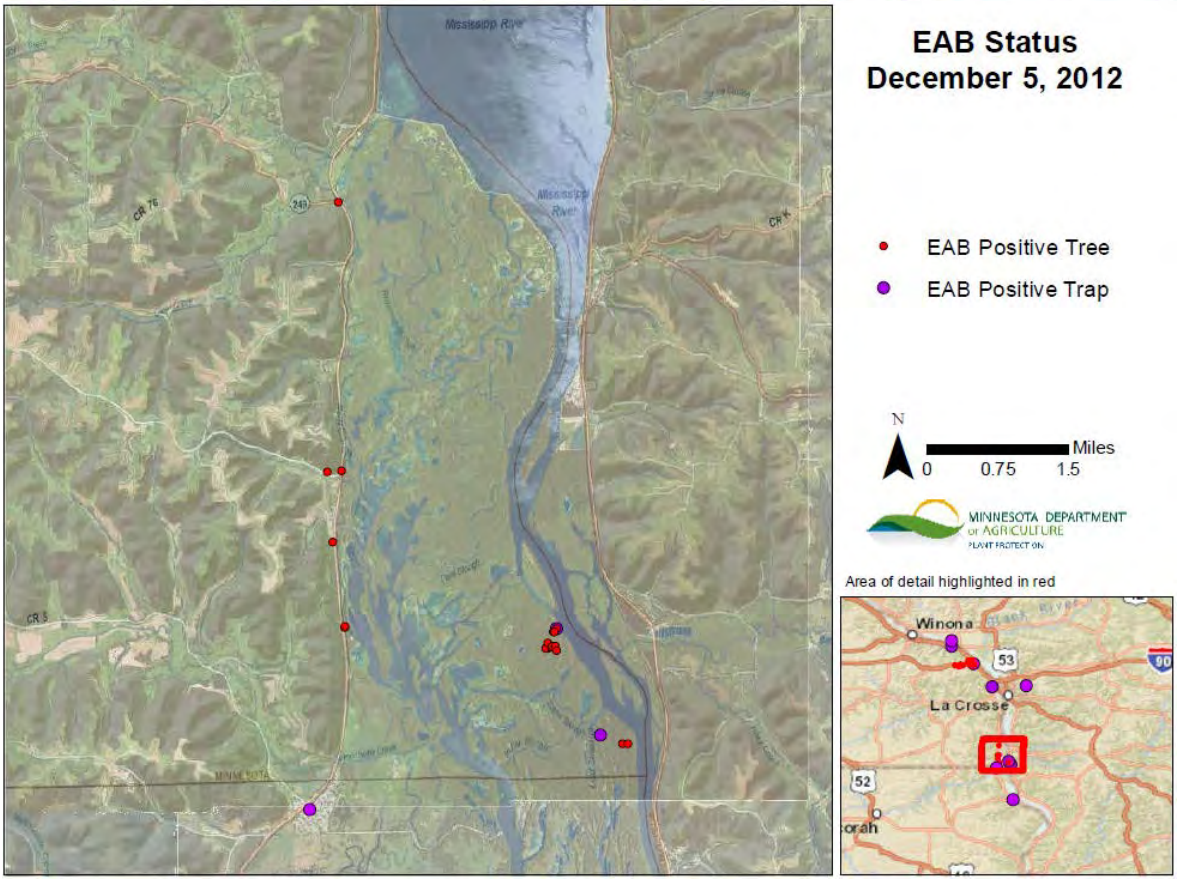
Emerald ash borer (EAB) was first detected in Minnesota on May 13, 2009, by a private arborist in St. Paul (Ramsey County). On February 28, 2010, a separate infestation was discovered in a nearby park in Minneapolis (Hennepin County). On April 28, 2010, EAB was confirmed in Houston County on the Upper Mississippi Fish and Wildlife Refuge. The MDA enacted an emergency quarantine of Hennepin, Ramsey and Houston Counties on May 15, 2009, followed by a formal quarantine on August 17, 2009. The United States Department of Agriculture Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS PPQ) imposed a parallel federal quarantine.

In August, 2011, three positive EAB traps were found along Highway 61 in Houston and Winona Counties. As a result, the quarantine was extended to Winona County. On September 14, 2011, a large infestation of EAB was discovered at the I90 / CR12 interchange in Winona County, and infested trees were subsequently found in Great River Bluffs State Park less than two miles away. Additional small infestations were discovered in 2012, including in Shoreview (Ramsey County), St. Paul, Minneapolis, Houston County, and at the Fort Snelling Golf Course in Hennepin County near the Minneapolis-St. Paul International Airport.

In most cases, state or city officials continue to remove and destroy infested trees during the winter months; however, this is no longer possible at all locations due to site access issues. Some trees were taken to the University of Minnesota quarantine facility to support state-funded research to explore the spread rates and cold tolerance of EAB and three biological control agents. These biological control agents, including one egg parasitoid and two larval parasitoid species, were released by the Minnesota Department of Agriculture (MDA) near most known infestations.

MDA is the lead agency responsible for the detection and management of regulated pests, and the DNR serves a support role in all planning and implementation efforts involving pests impacting Minnesota's natural resources. In 2011, an agreement was made with MDA that DNR Forestry would be available to take a lead role in incident command for EAB infestations found in rural Minnesota outside the seven-county metro area when requested. This year, the DNR assembled an incident command team led by members of county and municipal governments in addition to DNR Forestry and MDA to lead the long-term response to EAB in Winona County.


EAB Status
August 15, 2012
Infested Tree
Quarantine Counties
N
0 10 20 Miles
MINNESOTA DEPARTMENT OF AGRICULTURE
Area of detail highlighted in red
Minneapolis
Saint Paul
MINNESOTA
Sioux Falls
Madison
IOWA
Des Moines


EAB Status
December 5, 2012
EAB Positive Tree
EAB Positive Trap
N
0 0.75 1.5 Miles
MINNESOTA DEPARTMENT OF AGRICULTURE
Area of detail highlighted in red
Winona
La Crosse

Forest tent caterpillar

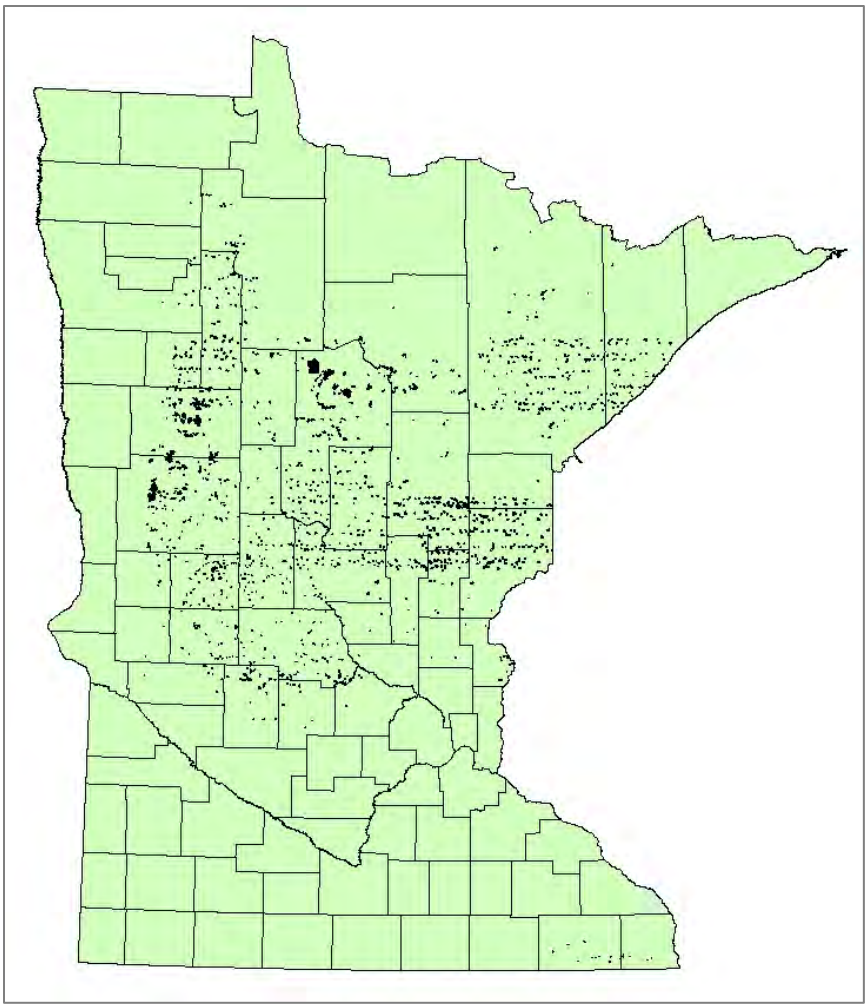
Malacosoma disstria

Hosts	Aspen, basswood, oak, birch, willow and other hardwoods, tamarack.
Setting	Rural forests
Counties	See map
Survey methods	Aerial detection
Acres affected	274,600 acres
Damage	Defoliation

Oak defoliation in west-central counties

Forest tent caterpillar (FTC) populations peak every ten to sixteen years in Minnesota. As indicated by the pattern and amount of defoliated acres this year, populations could be building towards a 2014 or 2015 peak of millions of acres (see map below and chart on page 25).

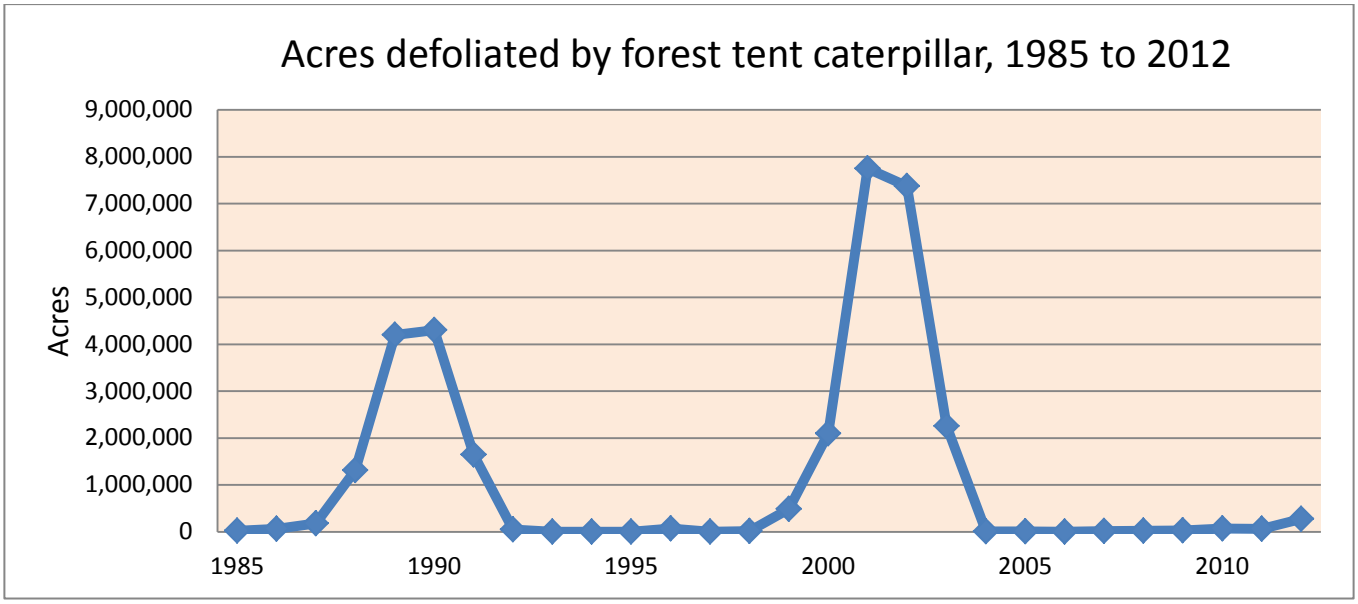
From Beltrami and Lake of the Woods Counties to Cook County, aerial survey was delayed by two months, and very few acres with FTC were mapped, so it isn't known how extensive FTC populations were in the northern counties. We intend to fill in this information gap with the 2013 aerial survey.

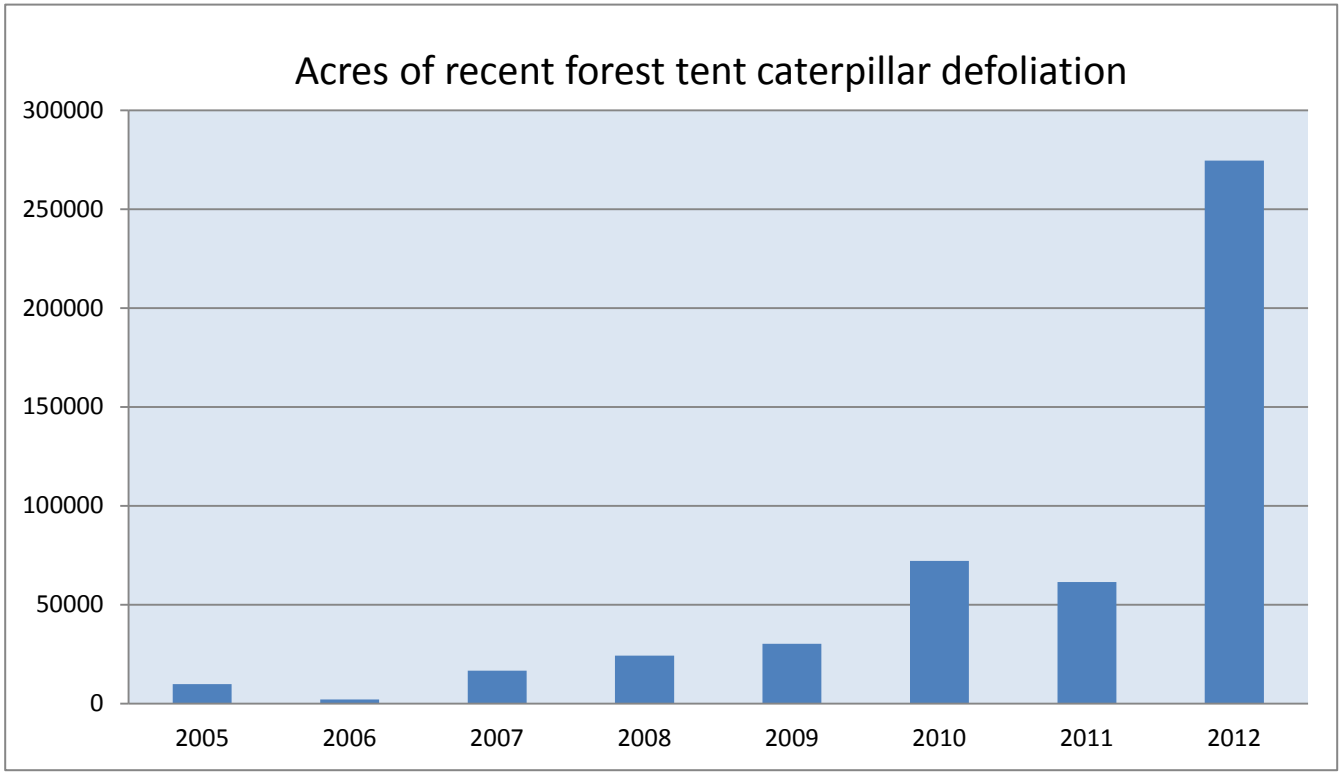


A dozen 60-acre pockets of defoliation were mapped in Fillmore and Houston Counties, which is rare in southeastern Minnesota.

Far from declining, the FTC populations in west-central counties are going strong. Now in the fifth year of the outbreak there, 127,000 acres were defoliated compared to 41,400 acres in 2011. Basswood and oak are the primary targets and both species might be at risk of declining in 2013 due to the duration of the local outbreaks and severity of the drought for the last few growing seasons. Normally, FTC populations build up in small areas and decline rapidly, often within two years. However, some localities in west central counties have had three and four years of defoliation.

We expect to see continued FTC activity in 2013. The twenty-seven year population trend is shown in the chart below. Acres of defoliation are building in west central, north central and northeastern counties.





Gypsy moth

Lymantria dispar

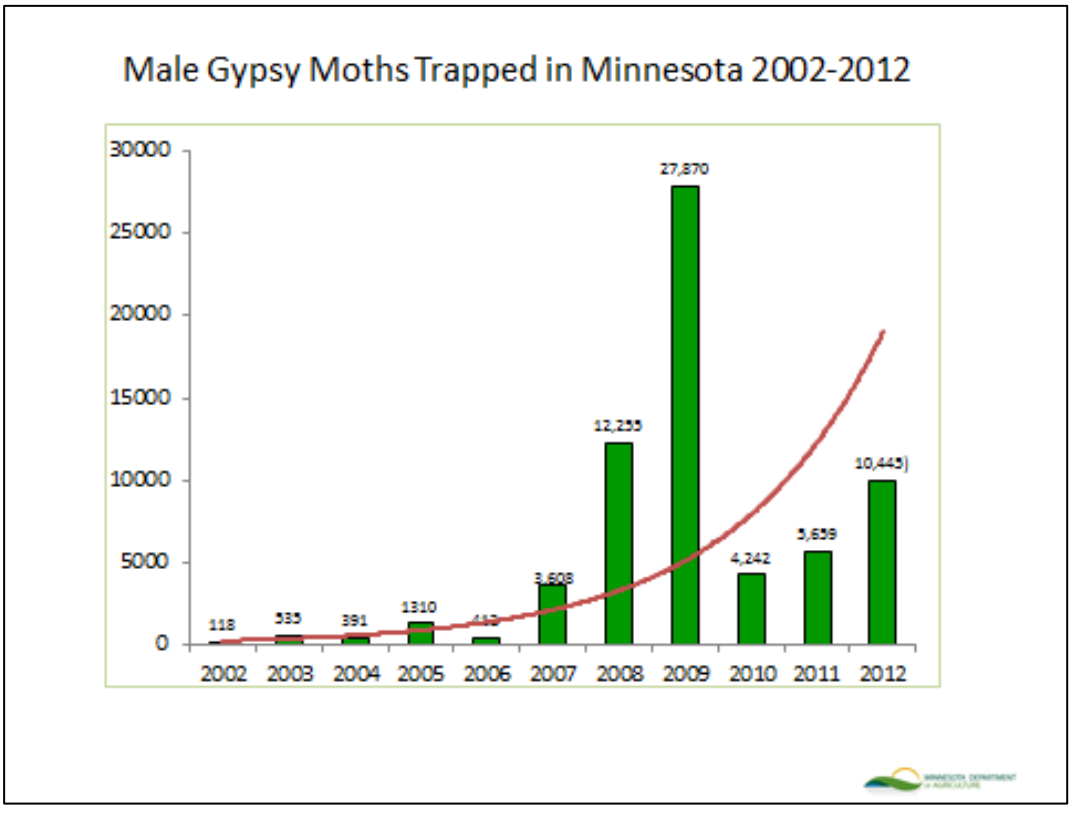
Hosts	Oaks, aspen and other hardwoods
Setting	Rural and urban forests
Counties	See table
Survey methods	Pheromone traps and ground surveys
Acres affected	No defoliation acres
Damage	Defoliation

The gypsy moth detection program is a cooperative effort between state and federal agencies including the Minnesota Department of Agriculture (MDA), DNR, US Department of Agriculture Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS, PPQ), US Forest Service, and the University of Minnesota. With state regulatory authority over invasive species, MDA is the lead agency overseeing the state's gypsy moth effort.

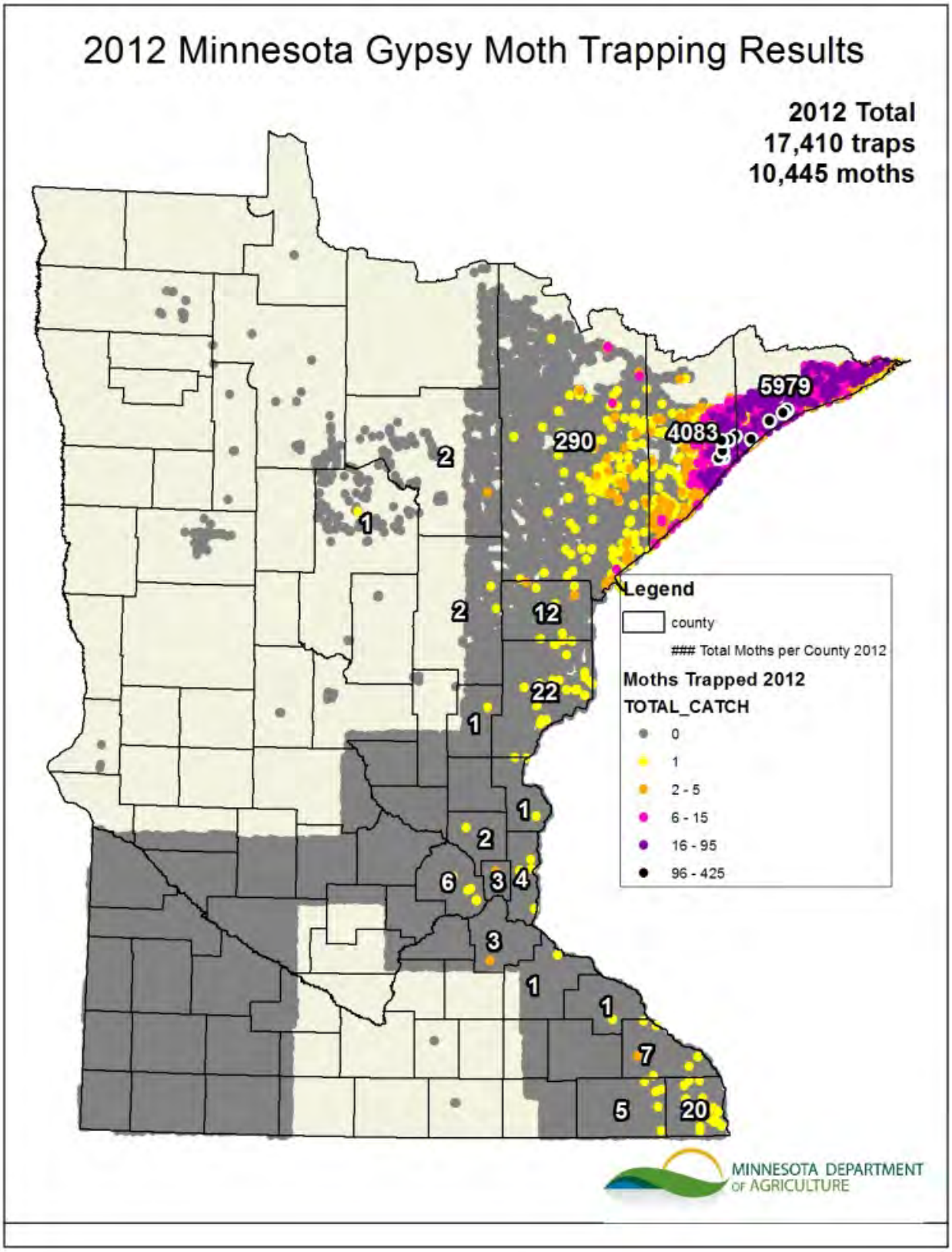
In 2012, MDA and partners placed 17,422 traps around the state using a combination of delta and milk carton-style traps. The larger milk carton traps were used in the areas with a history of high moth captures (primarily Cook and Lake counties), while the delta traps were used at varying grid densities elsewhere in the state. The density of traps placed is based on the risk of introduction and relative distance to the national Slow-The-Spread (STS) action boundaries.

The traps caught 10,445 moths, almost all of which were in the northeastern most counties (Map 1, page 18). That total is down from the record 27,870 moths caught in 2009, but up from the count in 2011(Graph 1, below). The overall trend suggests that low density populations are beginning to build in the Arrowhead region. As a result of the pattern of trap captures and alternate life stages found in Cook County, the STS "action zone" will move slightly westward for the next trapping season (Maps 2 and 3, page 28).

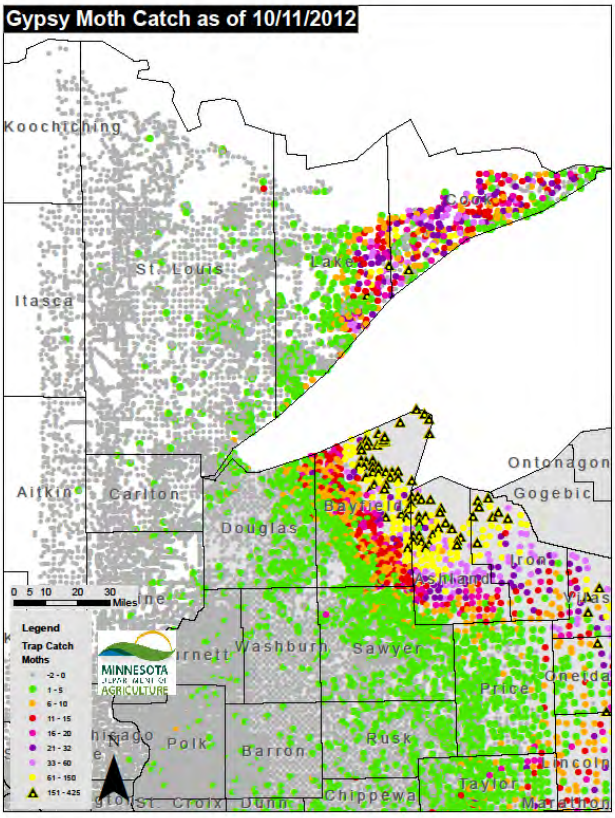
Graph 1



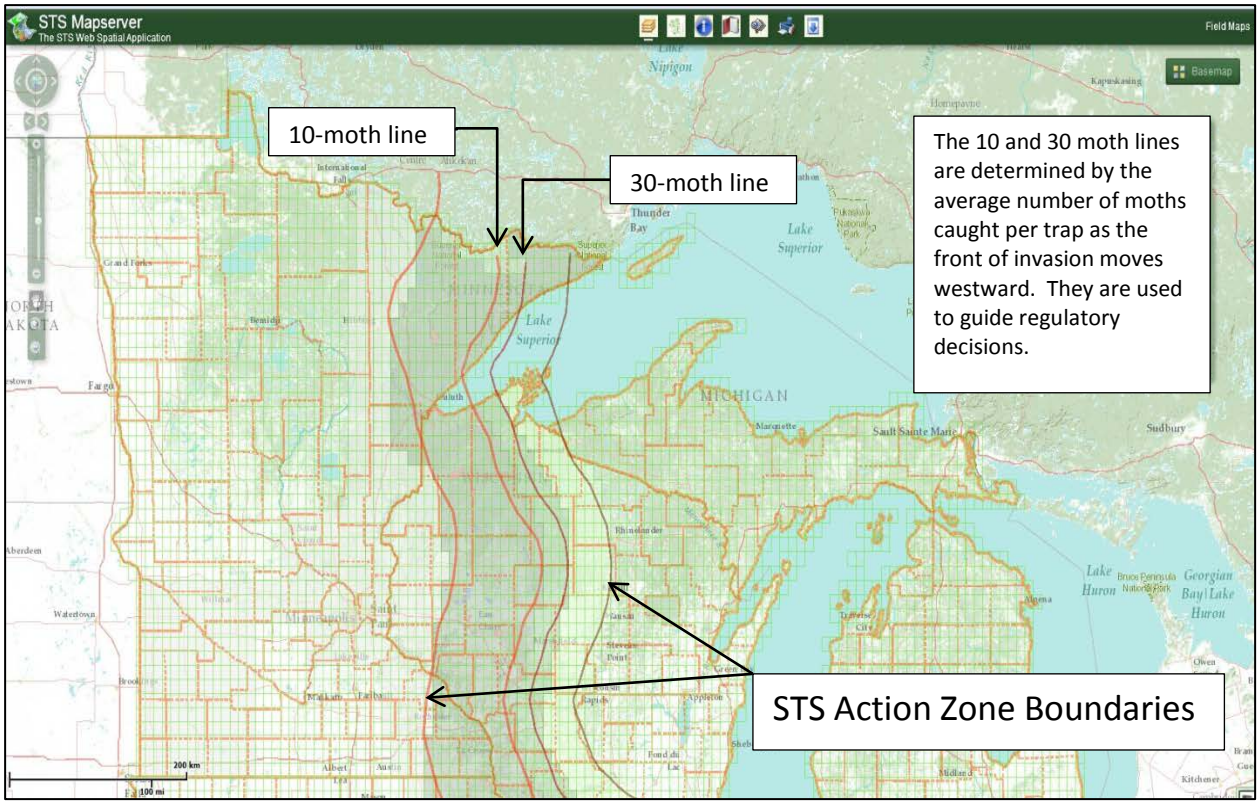
Map 1


2012 Minnesota Gypsy Moth Trapping Results
2012 Total
17,410 traps
10,445 moths
5979
4083
290
2
1
2
12
22
1
1
2
6
3
4
3
1
1
7
5
20
Legend
county
Total Moths per County 2012
Moths Trapped 2012
TOTAL_CATCH
0
1
2 - 5
6 - 15
16 - 95
96 - 425
MINNESOTA DEPARTMENT
OF AGRICULTURE

Map 2


Gypsy Moth Catch as of 10/11/2012
Koochiching
St. Louis
Lake
Cook
Itasca
Aitkin
Carlton
Douglas
Bayfield
Ontonagon
Gogebic
Iron
Ashland
Washburn
Sawyer
Oneida
Price
Polk
Barron
Rusk
Taylor
Chippewa
St Croix
Dunn
Legend
Trap Catch
Moths
MINNESOTA
DEPARTMENT OF
AGRICULTURE

Map 3

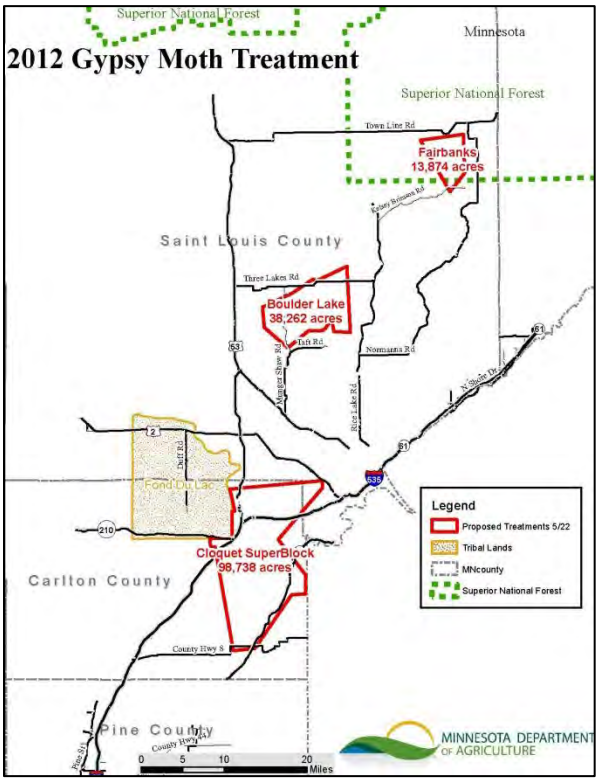

STS Mapserver
The STS Web Spatial Application
Field Maps
Basemap
10-moth line
30-moth line
The 10 and 30 moth lines are determined by the average number of moths caught per trap as the front of invasion moves westward. They are used to guide regulatory decisions.
STS Action Zone Boundaries
MICHIGAN
Lake Superior
Lake Huron
Georgian Bay
Sault Sainte Marie
Thunder Bay
Nipigon
Fargo
Grand Forks
Aberdeen
Watertown
Rhinelander
Wausau
Appleton
Sudbury
Kitchener

Additional trapping was done to monitor the efficacy of treatments carried out in 2011. The treatment block of most concern was in Grant Township (Washington County), where a large number of alternative life stages (egg masses, pupal and larval skins) were found. Treatment success was assessed through additional trapping in the area.

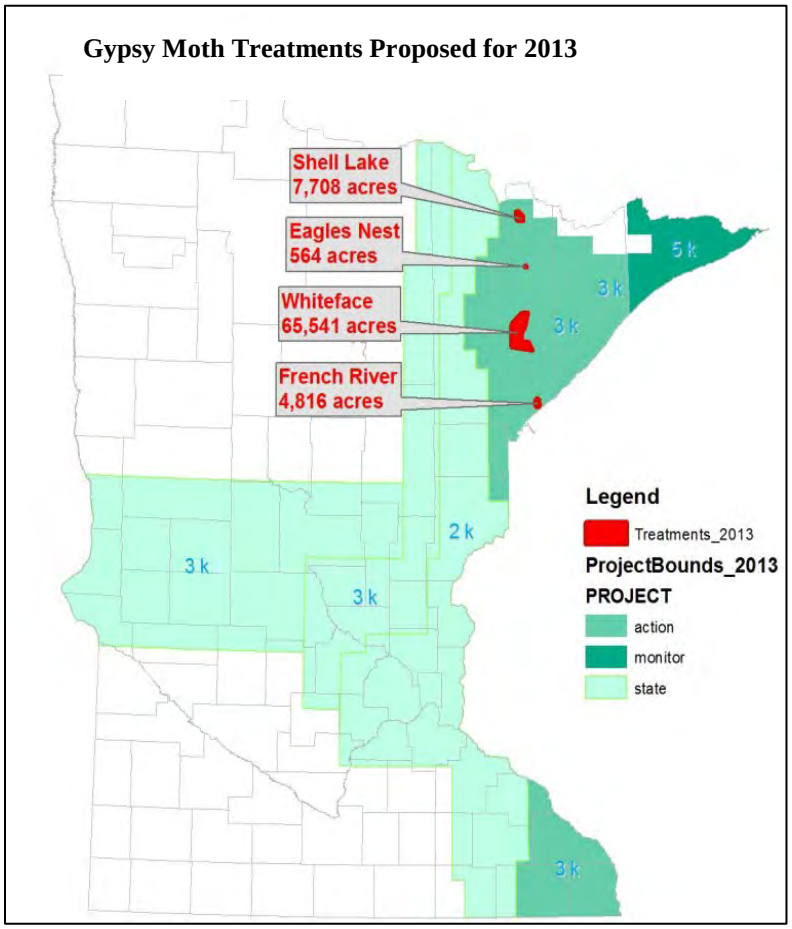
There were three blocks of land treated in 2012 based on 2011 trap captures (Map 4, below left). All three blocks were treated with pheromone flakes designed to disrupt gypsy moth mating (roughly a half-cup of flakes per acre). These areas will be heavily trapped in 2013 to monitor treatment success.

Based on this year's trapping results, four blocks of mating disruption treatment are being recommended for 2013, all in St. Louis County (Map 5, below right). Because of the westward shift of the STS action zone, none of the areas of concern in Cook and Lake Counties will be treated; those areas will be trapped to monitor population levels.

Map 4



Map 5



Larch casebearer

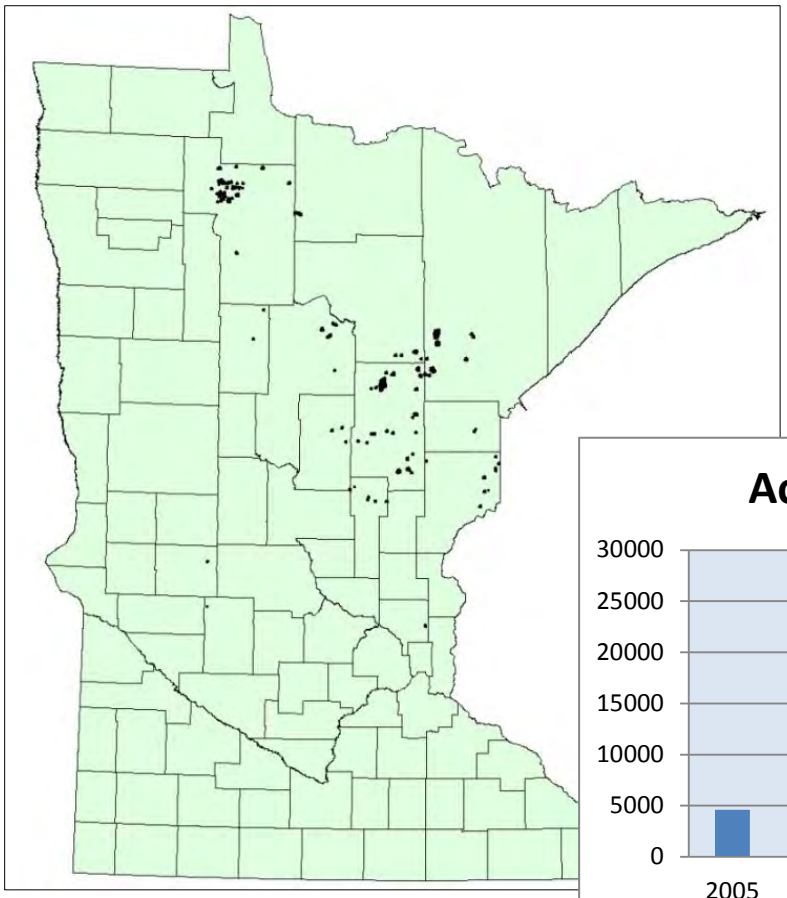
Coleophora laricella

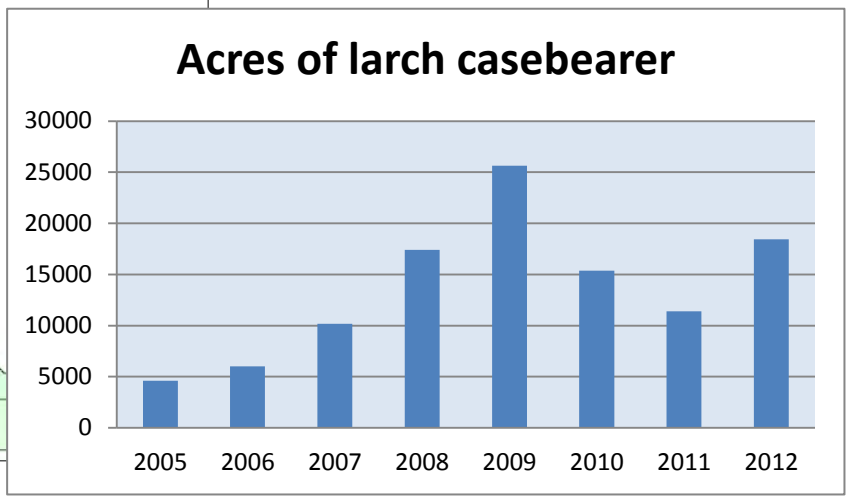
Host	Tamarack
Setting	Rural forests
Counties	See map
Survey method	Aerial survey
Acres affected	18,443 acres
Damage	Defoliation

Discolored foliage due to larch casebearer feeding

Larch casebearer defoliation occurred on 18,443 acres this year. This is a significant increase compared to 11,404 acres in 2011 (see chart and map, below).

Larch casebearer defoliation has been mapped on the aerial survey every year since 2000, but no mortality has been observed due to casebearer defoliation. Between 1977 and 2000, casebearer damage was not noticeable or mapped and was only occasionally found on isolated trees. The reason for the increase starting in 2000 and its persistence has not been determined.





Spruce budworm

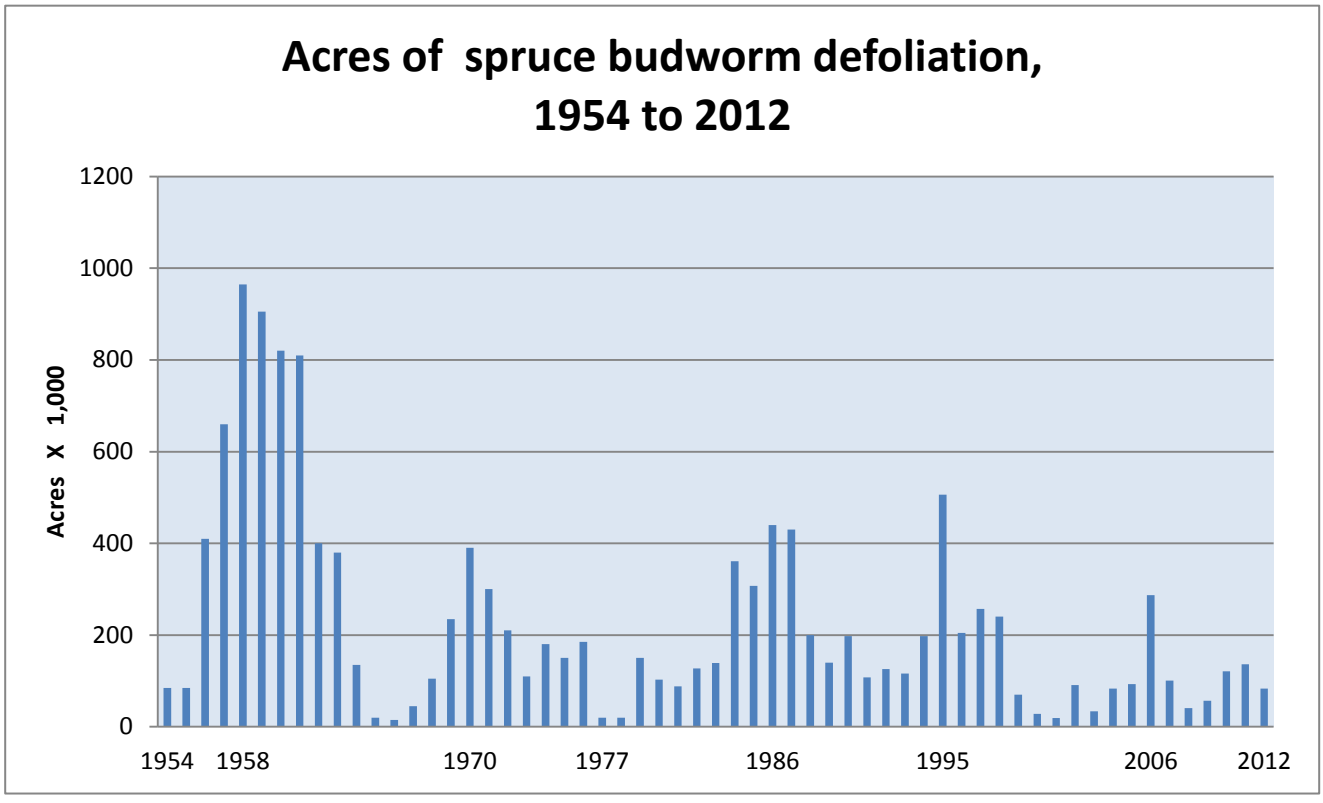
Choristoneura fumiferana

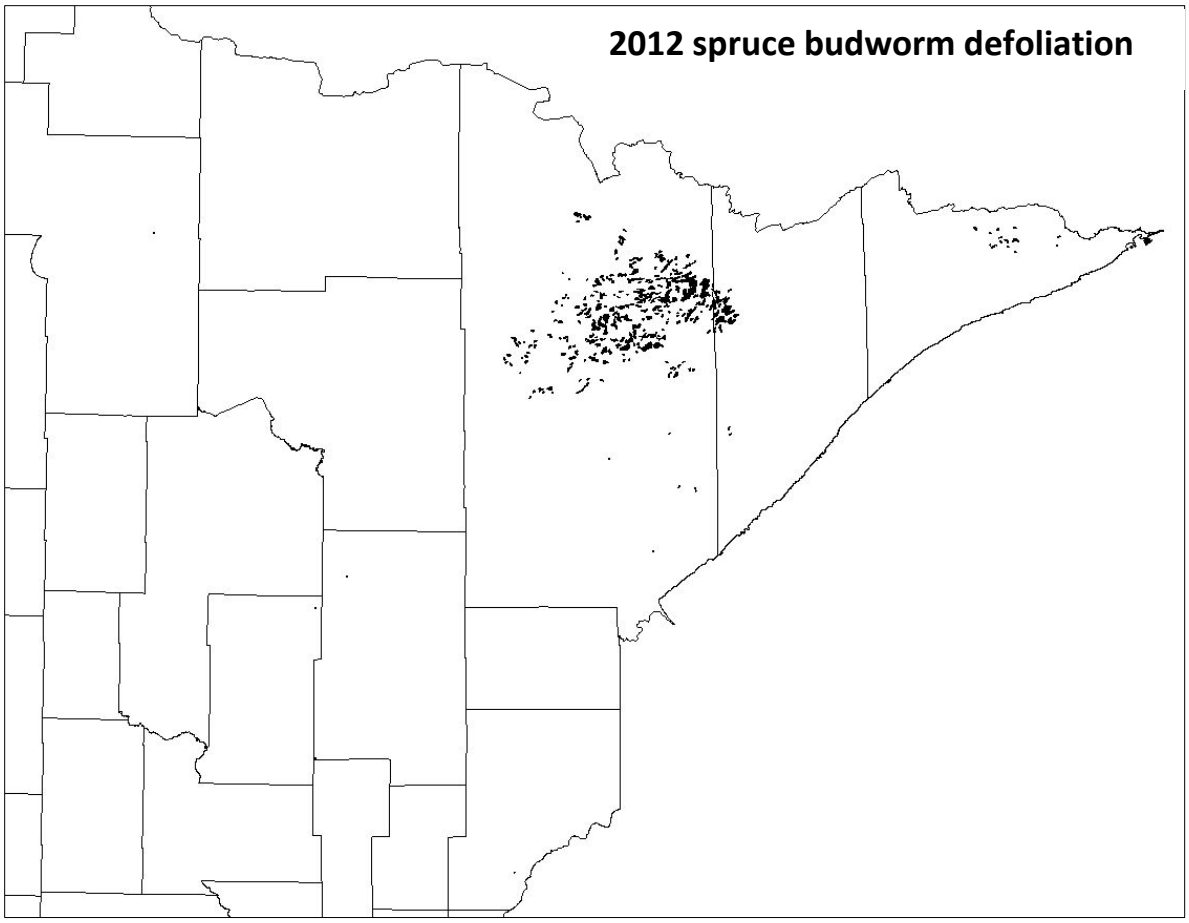
Hosts	Balsam fir and white spruce
Setting	Rural forests
Counties	See map
Survey method	Aerial survey
Acres affected	82,770 acres of defoliation 79,250 acres of mortality

Dead balsam fir due to prolonged budworm defoliation

Spruce budworm is native to North America. Massive outbreaks occur periodically in spruce-fir forests of eastern Canada and the United States. Since 1954, when annual aerial sketch-mapping began, spruce budworm has caused defoliation of balsam fir and white spruce every year in Minnesota. This year, 82,770 acres of defoliation occurred in northeastern counties (see map, page 32). Defoliation was mapped in north central Cook County for the first time since 1996.

The USFS mapped 79,250 acres of spruce budworm mortality in St. Louis and Lake Counties during the general detection survey (see map, page 32). This likely represents the cumulative impact of the last three to four years of defoliation in those counties.




2012 spruce budworm defoliation

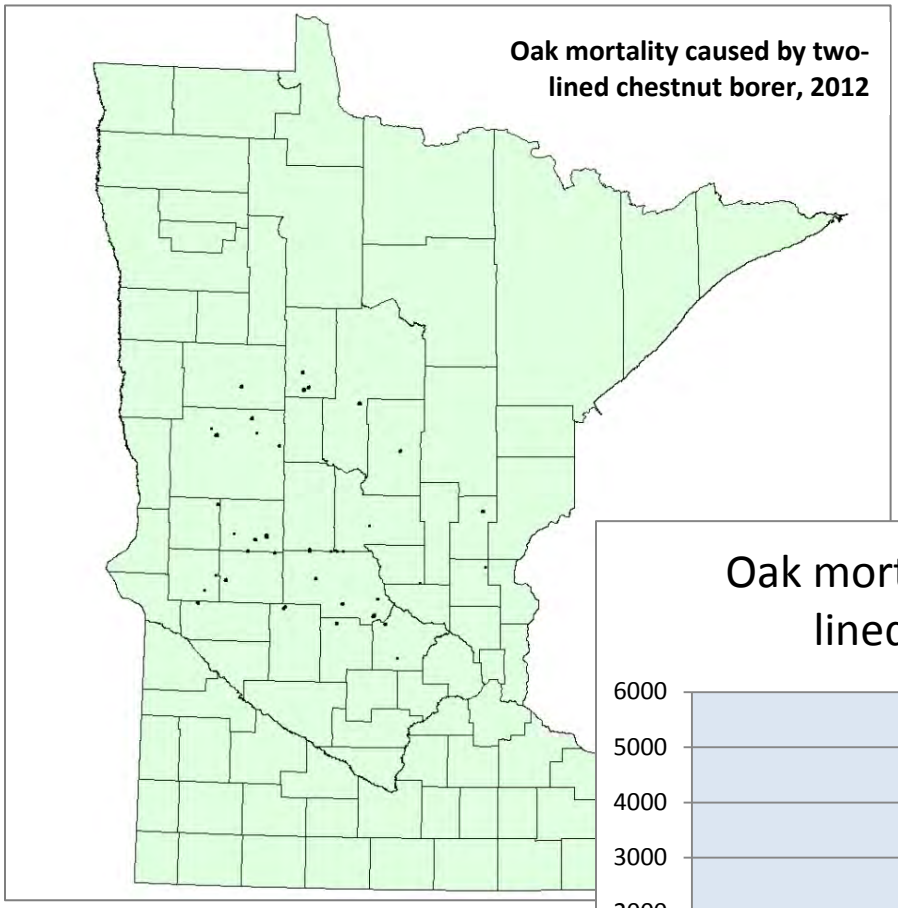
Two-lined chestnut borer

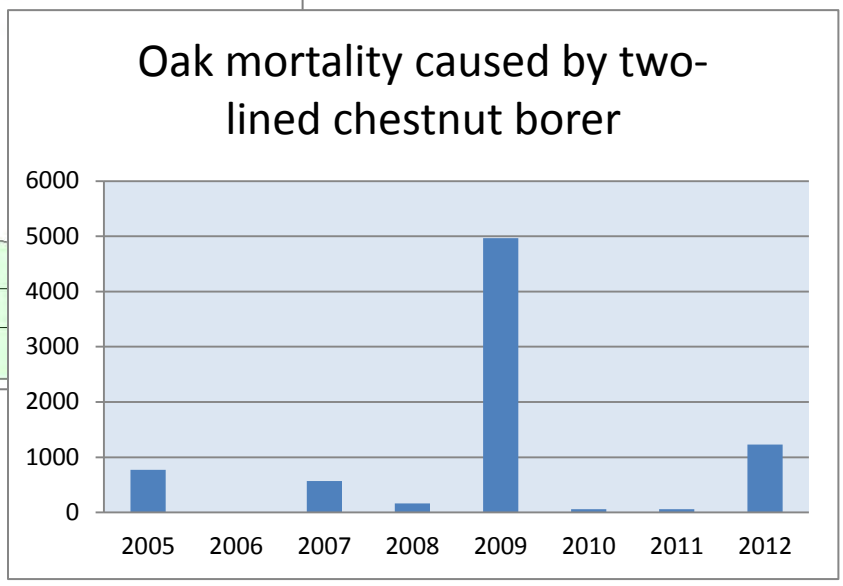
Agrilus bilineatus

Hosts	Red, bur and white oak
Setting	Rural and urban forests
Counties	See map
Survey method	Aerial detection
Acres affected	1,200 acres
Damage	Mortality

The acreage trend increased 20-fold compared to 2011 (see below), likely due to the prolonged drought and persistent FTC defoliation experienced in the central and west-central counties for the past four or five years.

Oaks in Itasca County killed by two-lined chestnut borer





Bur oak blight

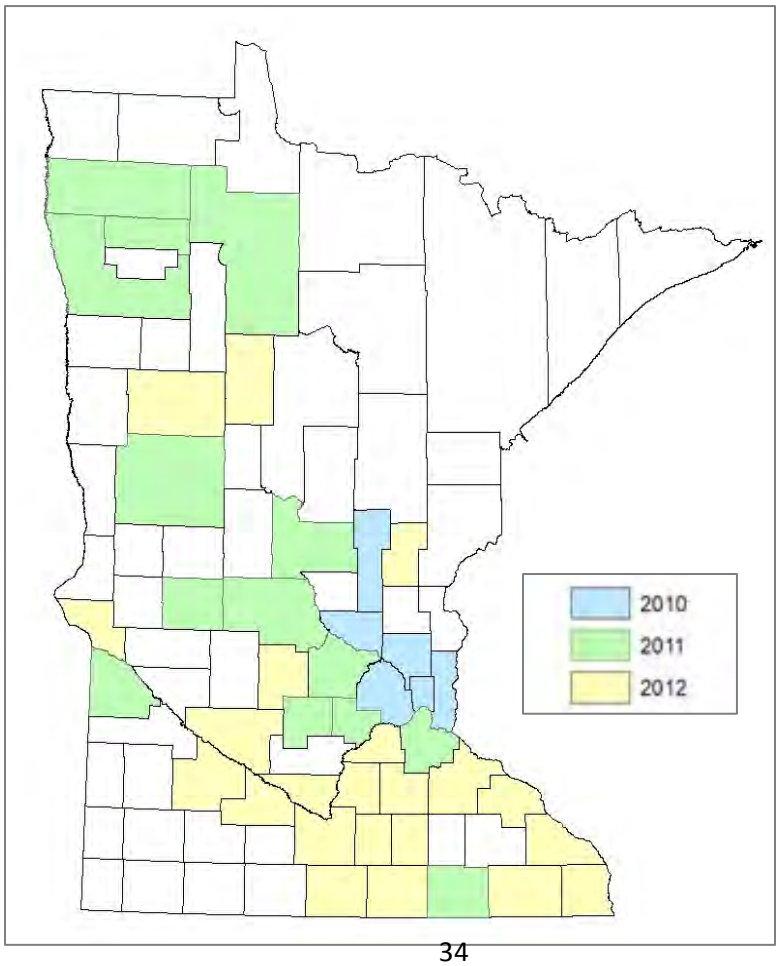
Tubakia iowensis

Host	Bur oak
Setting	Rural and urban forests
Counties	See map
Survey method	Ground
Acres affected	Undetermined
Damage	Dieback and decline

Symptomatic branch on bur oak in Pope County

In 2012, bur oak blight was found in 22 new Minnesota counties (yellow on map below) and confirmed by the University of Minnesota Plant Disease Clinic and Jill Pokorny, Plant Pathologist, USFS.

Diagnosticians in Iowa and Minnesota have found that the presence of four signs or symptoms (necrotic veins, large wedge-shaped leaf lesions, hyphal shields and spores on symptomatic leaves, and petiole pustules) are sufficient for a positive diagnosis of this disease.



Dutch elm disease

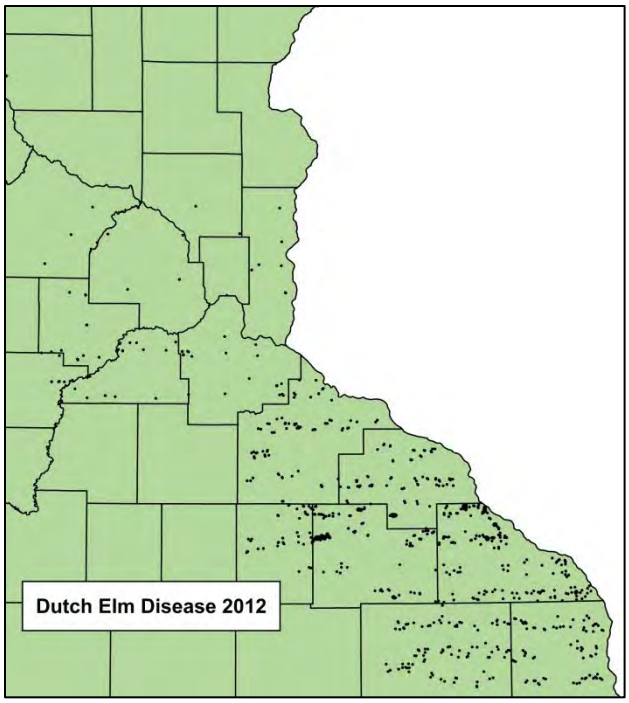
Ophiostoma ulmi, Ophiostoma novo-ulmi

Hosts	Elm, including American, Siberian, red, and rock
Setting	Rural and urban forests
Counties	See table below
Survey methods	Aerial survey
Acres affected	3,000 acres

Dutch elm disease (DED), introduced to North America in the 1930's, is considered to be the most important disease of elms in the U.S. The fungus invades the water-conducting elements of the tree's vascular system causing wilting and death in all native and non-native elm species commonly found in Minnesota. American elm, once the most commonly planted shade and street tree in North America, is particularly susceptible.

First reported in Ramsey County in 1961, DED initially spread slowly through the state, possibly due to poor cold tolerance of the most common vector, the European elm bark beetle (*Scolytus multistriatus*). While the disease spread rapidly in the southern third of the state where the non-native vector was more prevalent, the native elm bark beetle (*Hylurgopinus rufipes*) assisted in a slow spread northward. By the early 1980's DED had been recorded in 84 of Minnesota's 87 counties.

Since that time, losses in urban and suburban areas have decreased substantially, due in part to a drastic decrease in the number of surviving trees, but also due to community DED management programs and the development of systemic fungicide injections for remnant, high-value landscape trees. While most large specimens have disappeared from the natural landscape, losses in rural and forested areas continue steadily as elm regeneration seems to keep pace with the disease. Today, DED incidence is highest in the southeastern part of the state where *Ulmus* species are most abundant.

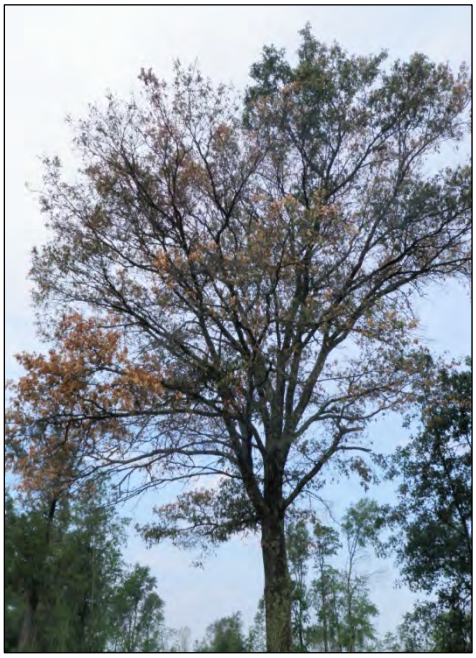


Counties with Dutch Elm Disease in 2012				
Anoka	Dodge	Hennepin	Scott	Winona
Carver	Fillmore	Houston	Wabasha	Wright
Dakota	Goodhue	Olmsted	Washington	

During aerial surveys in 2012, over 3000 acres were identified as being affected by DED. This represents a six-fold increase from 2011. In addition, the average size of affected areas increased significantly. We suspect that these increases reflect surveyor bias and a change in surveyor methodology rather than a very significant increase in disease incidence. In addition, persistent drought conditions resulted in symptoms that could be confused with Dutch elm disease during aerial surveys. While a drastic increase in disease incidence cannot be ruled out, we will await 2013 aerial survey data before confirming any short-term trends.

Oak wilt

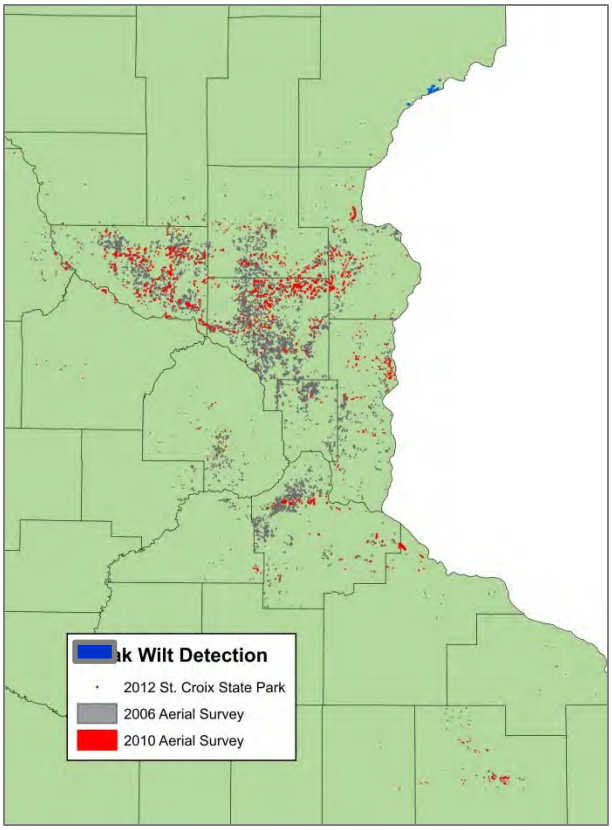
Ceratocystis fagacearum



Hosts	Red oaks and occasionally white oaks
Setting	Rural and urban forests
Counties	See map and table below
Survey methods	Aerial survey/ground detection
Damage	Mortality
Acres affected	3,500 acres

Oak wilt is a devastating disease of oaks caused by the non-native fungus *Ceratocystis fagacearum*. The fungus invades the water-conducting elements of the tree's vascular system causing rapid wilting and death, particularly in red oak species. First reported in five southeastern Minnesota counties in the early 1940's, the disease has spread north and west and can currently be found in 22 counties. During the federally funded oak wilt control program in the Metro area, new infestations spread north at about 7 miles per decade and west at 10 to 14 miles per decade. Control actions are now strictly landowner initiated and funded, so we expect oak wilt disease centers in the currently affected areas to increase in size and abundance.

In July 2012, oak wilt was discovered in St. Croix State Park in eastern Pine County along the St. Croix River. This is the northernmost confirmed report of oak wilt in Minnesota (details, page 28). While oak wilt is known to occur and is prevalent in many areas of the southern and central part of the state, the new finds indicate that oak wilt is continuing to spread. This highlights the need to be vigilant about oak wilt prevention and detection even in areas where oak wilt has not historically been known to occur. Therefore, we plan to intensify monitoring and education efforts along the leading edges of the known distribution of oak wilt, particularly in the northern portion of the disease's range where it appears to be spreading more quickly.



During aerial surveys in 2012, over 3,500 acres were identified as being affected by oak wilt. This acreage is twice that noted in 2011. In addition, the average size of the disease centers increased dramatically. We suspect that these increases reflect a change in surveyor methodology rather than a very significant increase in oak wilt incidence; in particular, large continuous areas of scattered disease distribution were noted this year and individual disease centers were not identified. Since the resulting data portrays an inaccurate reflection of oak wilt distribution, the 2012 data is not shown.

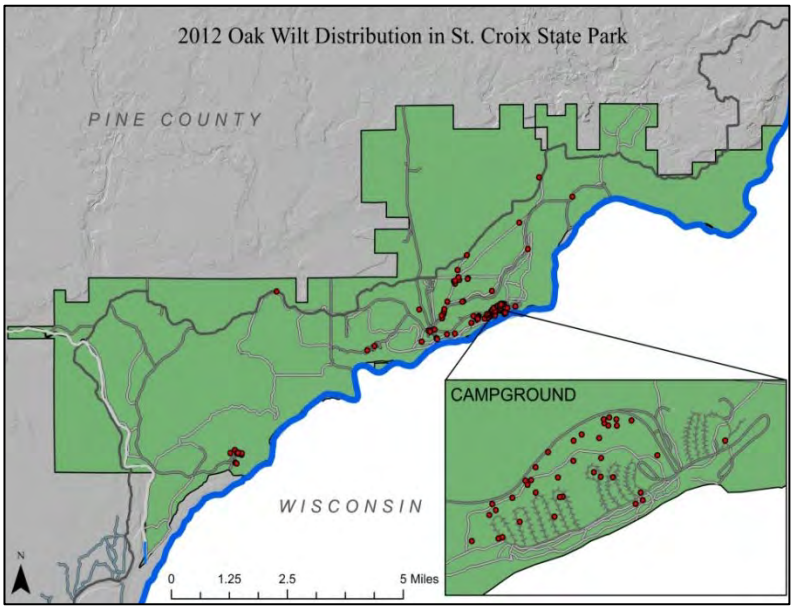
Oak Wilt Positive Counties 2012					
Anoka	Dodge	Isanti	Pine	Sherburne	Washington
Benton	Goodhue	Mille Lacs	Ramsey	Stearns	Wright
Dakota	Hennepin	Olmsted	Scott	Wabasha	

Northern-most oak wilt find in Minnesota

In July 2012 oak wilt was discovered throughout St. Croix State Park in eastern Pine County, the northern-most find of this vascular wilt disease in Minnesota. While oak wilt is known to occur and is prevalent in many areas of the southern and central part of Minnesota, this new find indicates that the range of oak wilt is continuing to expand in the state. Oak wilt was likely introduced to St. Croix State Park following a large storm and blow-down event in July 2011 that destroyed thousands of acres of forests. During the storm, many oaks were severely damaged and an abundance of fresh exposed wounds were available for infection. However, the insect vectors of the fungus usually travel less than a mile in search of fresh wounds, indicating that oak wilt was likely already present in the area, albeit at relatively low levels that escaped detection prior to the blow-down event.

Oak wilt is likely distributed over a larger area than currently reported, and under the right circumstances it can become a very serious issue. Currently St. Croix State Park is attempting to control over 30 known oak wilt disease centers. Disease centers form after a tree is killed and the fungus spreads into the root system and into neighboring trees through root grafts, resulting in an expanding pocket of dead and dying trees. Control of root graft transmission is costly and labor intensive. Therefore it is best to prevent the introduction of oak wilt into an area rather than attempting to manage a much larger problem.

Oak wilt management in the park began in the summer of 2012 when staff from the Division of Parks and Trails and the Division of Forestry conducted a thorough survey of the park to identify all symptomatic trees. Staff from the Forest Health Unit confirmed those trees positive for oak wilt in addition to those that needed to be monitored further. Park staff removed all confirmed positive oaks in late fall of 2012 to eliminate potential sources of inoculum, and will be installing root graft barriers lines with vibratory plows prior to the spring of 2013.



There is a significant risk that movement of firewood from infected trees could accelerate the spread of oak wilt across the state. Firewood permits are commonly issued on many state lands, including at St. Croix State Park. Many firewood harvesters are not aware of the risk posed by oak wilt, and may therefore inadvertently contribute to its spread by cutting and transporting wood from diseased trees. It was essential therefore that permit holders be educated to reduce the risk of spreading oak wilt to new areas. The Forest Health Unit prepared an alert addressing what precautions should be taken when planning to harvest oak firewood. In addition it explains what actions should be taken if oak firewood has already been harvested from an area where oak wilt is known to occur.

Declines and Abiotic Agents

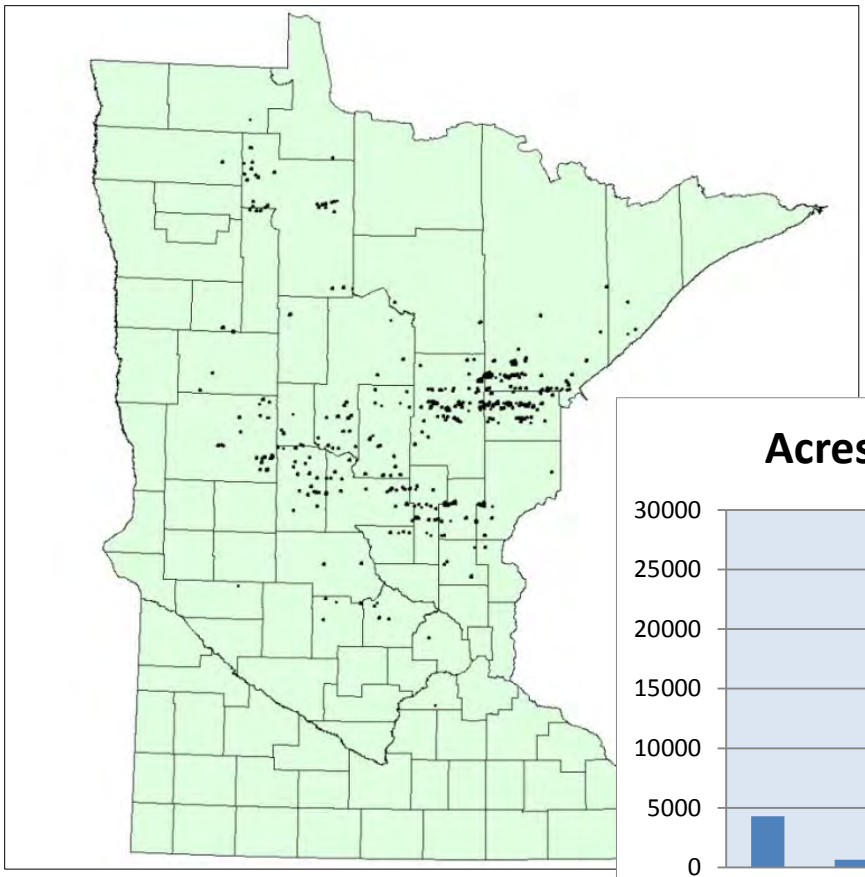
Black ash decline

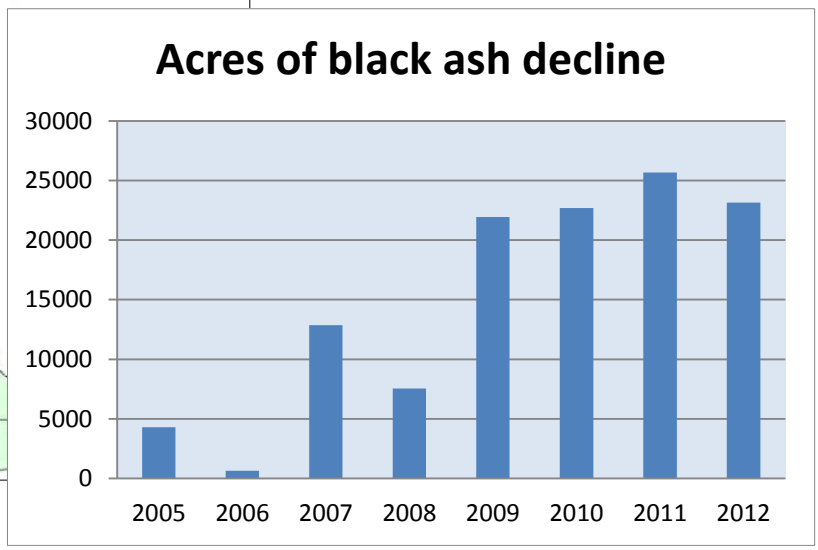
Hydrology changes and stress

Hosts	Black ash
Setting	Rural forests
Counties	See map
Survey methods	Aerial detection
Damage	Dieback and decline
Acres affected	23,152 acres

Ash decline occurred in 374 stands and was detected on 23,152 acres in 2012. Acres of ash decline were similar to last two year's tallies (see map and chart below). This is an ongoing problem in Minnesota. The most significant damage occurs in closed depressions and is thought to be related to bounces of the water table that occur on these sites, affecting rooting depth and available water for the trees. No significant insect or fungi are consistently found associated with declining trees.

Dieback in black ash, Aitkin County





Aspen decline

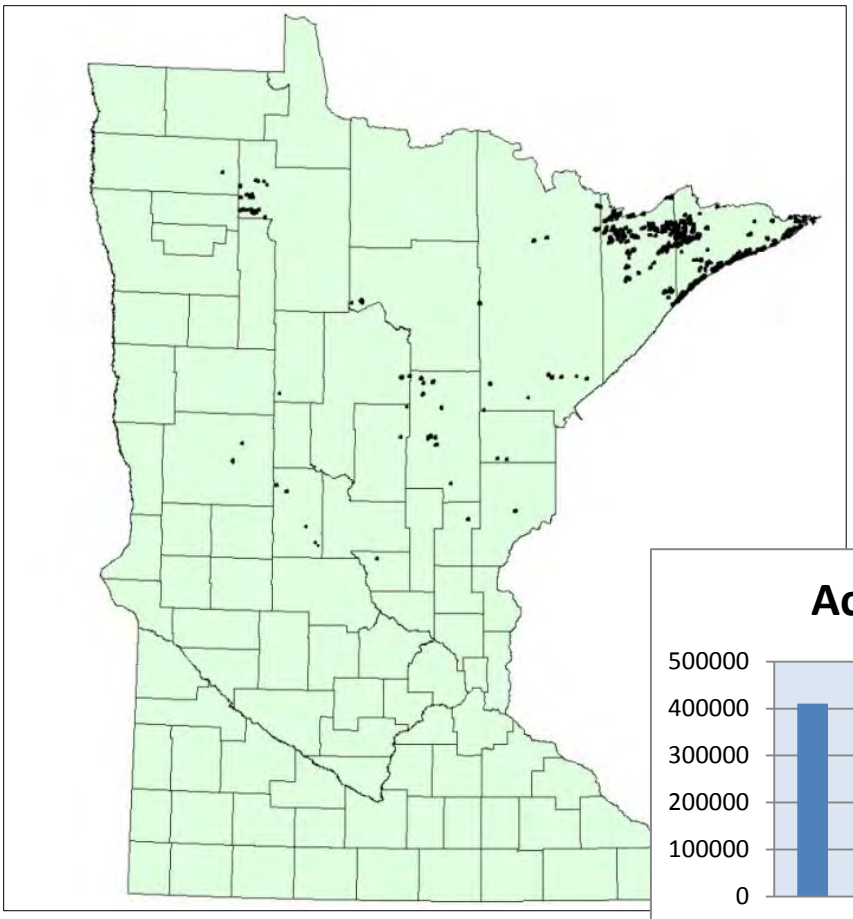
Unknown agent(s)

Hosts	Quaking aspen, paper birch
Setting	Rural forests
Counties	See map below
Survey methods	Aerial surveys
Acres affected	89,842 acres

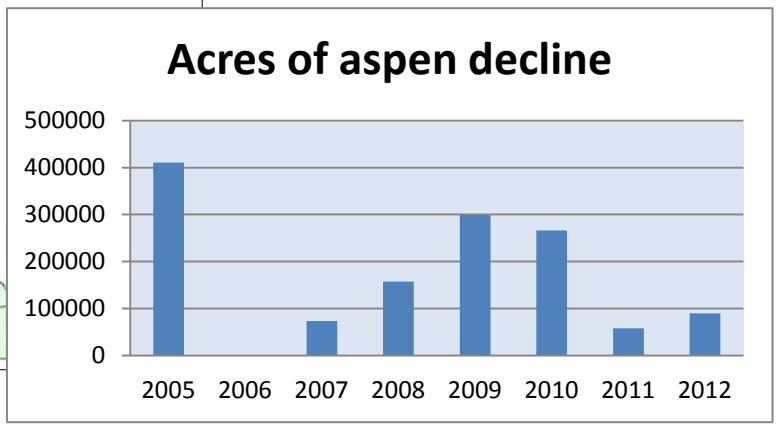
Aspen decline in Cook County

Since 2004, aspen with symptoms of decline has been mapped by aerial survey sketch mappers (see acreage chart below). Symptoms have included combinations of defoliation, discoloration, dieback and mortality. The map below shows 277 polygons of aspen with current symptoms of aspen decline. More acres were mapped with aspen decline this year than last year.

Dieback is the most common symptom but tree mortality has also occurred. Mortality can vary from scattered trees throughout a stand to patches of 30 to 40 dead trees scattered through stands. Trees with dieback often also exhibit small, off-color foliage in the live parts of the crown. Ground surveys have found serpentine galleries of bronze poplar borer on dead trees as well as in trees with extensive dieback.



Most of the dieback has been mapped in the northern tier of counties, especially in St. Louis, Lake and Cook counties. It is thought that severe summer droughts, as well as three to four years of heavy forest tent caterpillar defoliation early in the decade stressed the aspen, resulting in attack by bronze poplar borers.



Drought

Lack of soil moisture

Hosts	All species
Setting	Rural and urban forests
Counties	Statewide; see maps below
Survey methods	Ground survey
Acres affected	88 percent of all lands
Damage	Dieback, decline and mortality caused by opportunistic pests

Leaf desiccation due to drought conditions

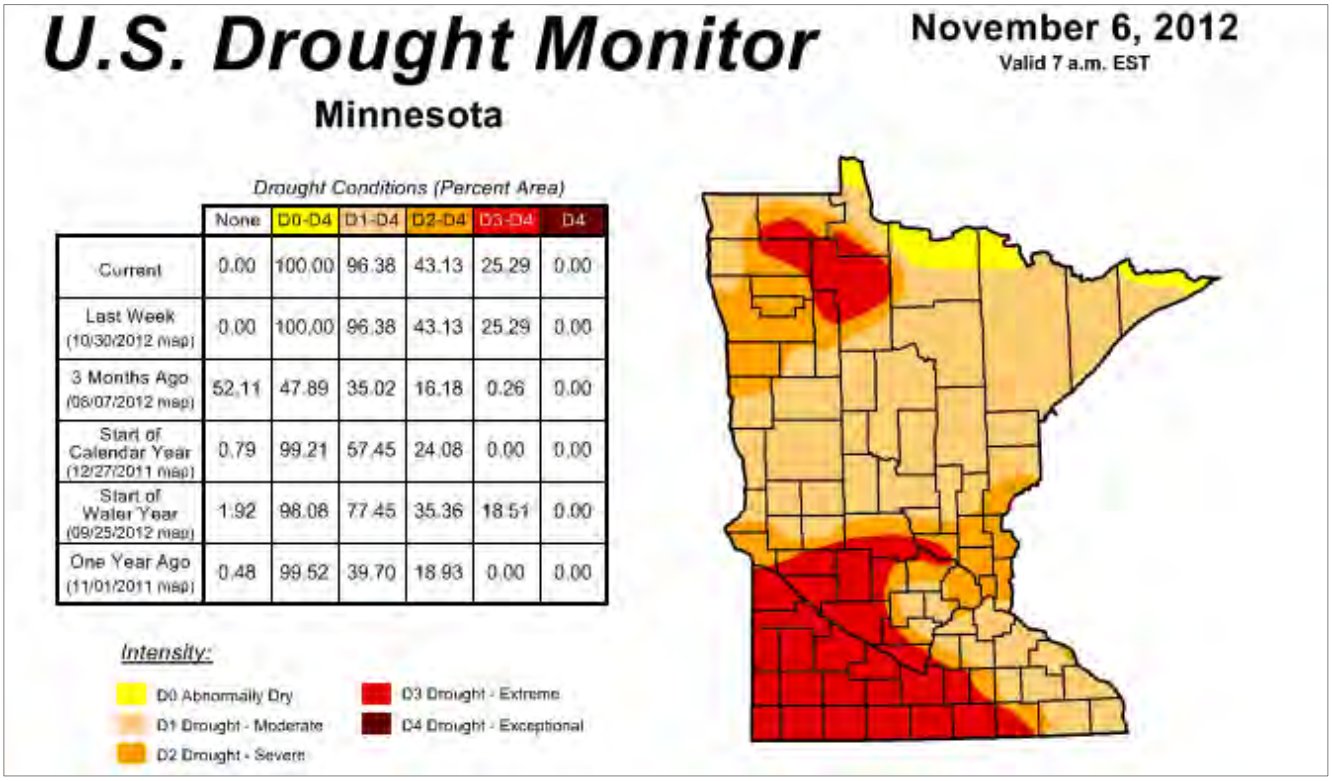
"It is reasonable to assume that the present drought status will remain relatively unchanged throughout the winter. The historical average precipitation over the next three months is a meager two and one-half inches and the topsoil will soon be sealed by frost. Without abundant spring rains, a number of critical drought issues involving public water supply, agriculture, horticulture, and tourism will rapidly emerge in the spring." Greg Spoden, Minnesota State Climatologist.

The U. S. Drought Monitor, released on November 29, places large portions of northwest, west central, southwest, and south central Minnesota in the Extreme Drought category (map below). Over 80 percent of Minnesota's landscape is in Extreme Drought or Severe Drought. Subsoil moisture across 88 percent of Minnesota's landscape was said to be *Short* or *Very Short* as of October 31.

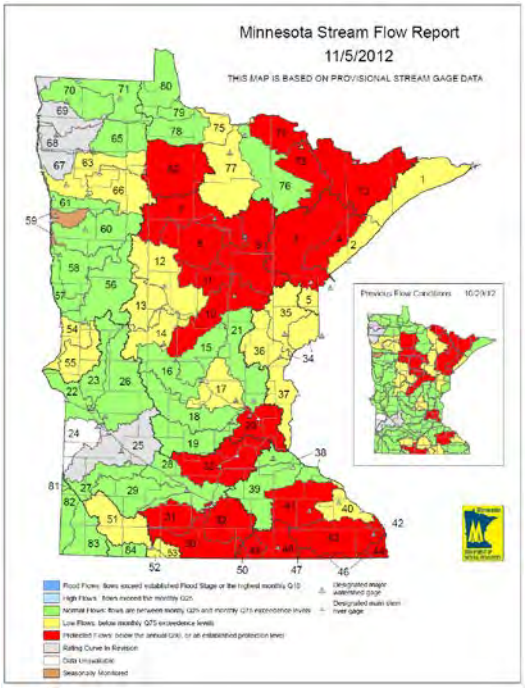
Drought conditions

Minnesota Climatology Working Group

http://climate.umn.edu/doc/journal/drought_2012.htm



Stream flow measurements at reporting stations in the driest areas of the state rank blow tenth when compared with historical data for the date. Those units are mapped in red on the Minnesota Stream Flow Report map at right.

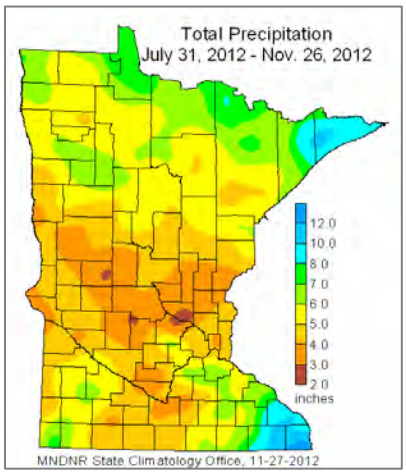


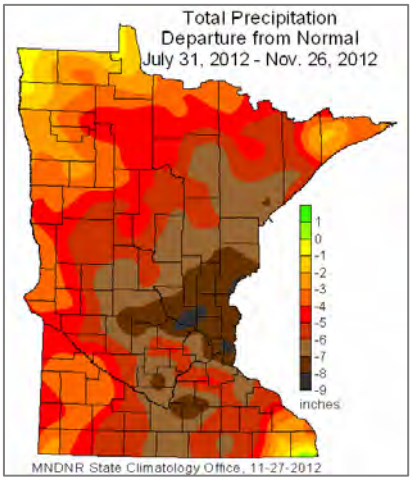
Periods of Drought in 2012

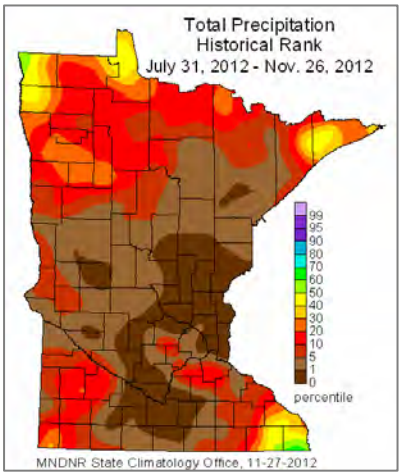
Minnesota's drought is the result of abnormally dry weather over three distinct time periods (maps below). In some communities, precipitation deficits amplified the drought situation during each of these spells of dry weather. In other communities, dry periods were interrupted by wet weather in spring 2012, only to have precipitation shortfalls degrade the situation yet again.

Drought Period #1 - August 2012 through November 2012

Extraordinarily dry conditions during the months of August, September, October, and November caused rapid drought development in areas of Minnesota previously outside of the severe drought regions that developed earlier in the growing season. For those areas already undergoing significant drought, the late-summer/autumn extreme dryness exaggerated pre-existing conditions. Many locations reported less than four inches of precipitation over the four-month month period. For large portions of Minnesota, August through November 2012 rainfall totals ranked at or below the lowest on record.

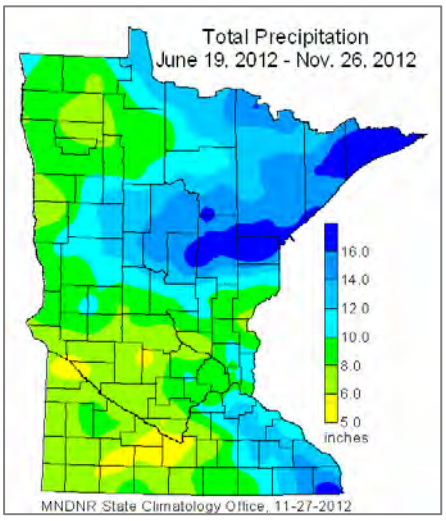


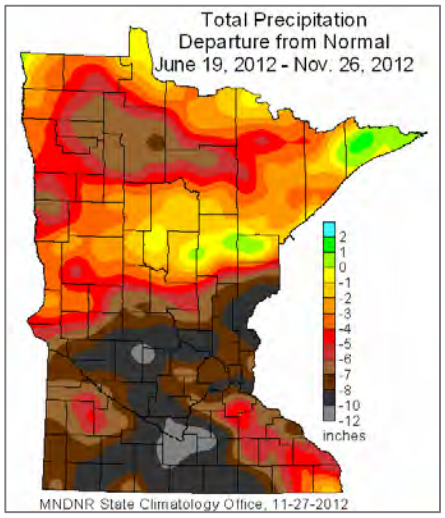


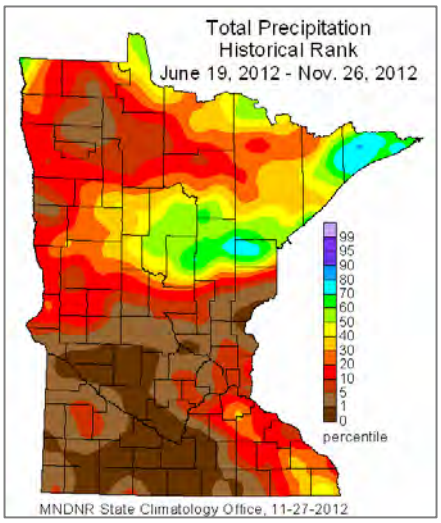


Drought Period #2 - Late June 2012 through November 2012

The moisture deficits in southern Minnesota developed rapidly due to very hot and very dry conditions during the mid-summer and through the autumn. Over the period, rainfall totals in many Minnesota counties fell short of average by six or more inches. This is the climatological equivalent of missing nearly two months of growing season precipitation. In some southern Minnesota communities, mid-summer through autumn rainfall deficits were in excess of eight inches.

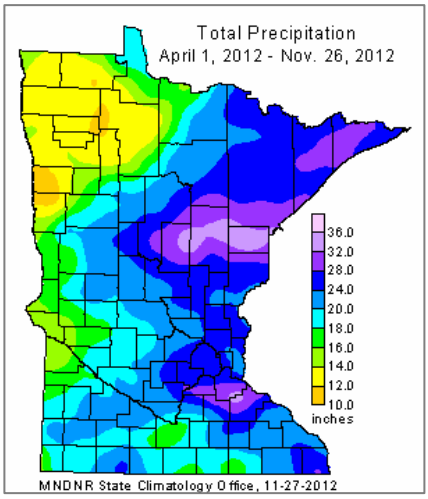


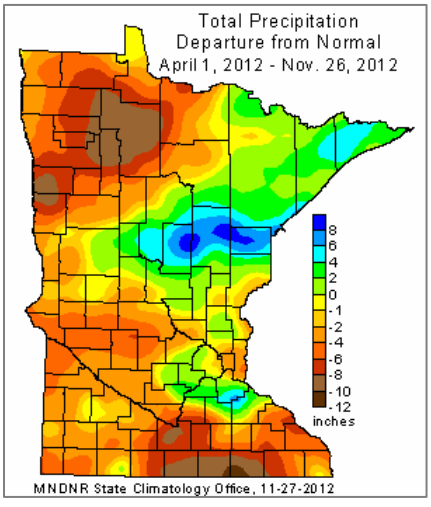


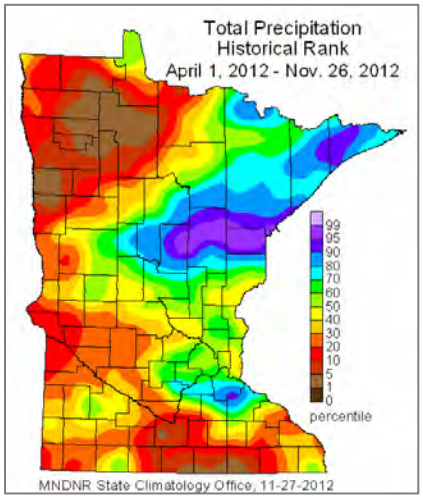


Drought Period #3 - Autumn 2011 through November 2012

The drought situation in northwest Minnesota and in far southeast Minnesota is the result of an historically dry autumn 2011, a snow-sparse winter, and amplified by the dry intervals described above.







Winter Drying

Hosts	Conifer species
Setting	Rural forests
Counties	Cook, Lake and St. Louis
Survey methods	Ground surveys
Acres affected	Not determined
Damage	Discoloration, dieback, possible mortality

Some winter-burn or winter injury of conifers occurs every year. The buds are almost always healthy and by July the damage is covered up by the new growth and mostly forgotten. This year, however, some very severe winter injury including some mortality occurred in the northern portions of St. Louis, Lake and Cook counties.

The damage in northern Cook County was most severe on white spruce with less amounts of damage on balsam fir , jack, white and red pines. The buds on most of the pines were healthy and produced new shoots and needles. The needles on white spruce with the most severe winter burn all turned brown and fell off the trees. A lot of these white spruce had live, healthy buds; however, on some trees, all of the buds were dead. This resulted in some scattered mortality of white spruce.

Parts of NE Minnesota went through the summer of 2011 and into the winter in drought. Warm temperatures during the winter contributed to needle desiccation. On top of that, record-setting warm weather began in March when the ground was still frozen, causing more needle and bud drying. In early May, affected parts of the state were still listed as being in severe drought by the Long Term Palmer Drought Severity Index, reducing the available moisture for trees to start new growth in the spring. This resulted in unusually severe winter-burn and tree mortality in some locations.

Winter-burn in Cook County, early spring

Blow-down

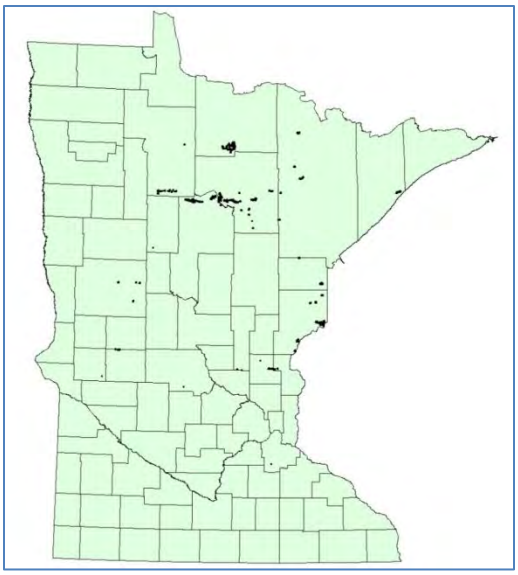
Hosts	All species
Setting	Rural forests
Counties	See map
Survey methods	Aerial detection
Acres affected	15,800 acres
Damage	Stem breakage, wind-throw, mortality

Slash pile and surviving trees from windstorm, Beltrami Co.

The largest blow-down was caused by a *derecho* in early July. The storm started west of Bemidji, traveled through three heavily-wooded counties and went past Grand Rapids. From aerial survey, 7700 acres were mapped immediately after the event.

Another large wind event occurred in Koochiching Co. and affected 2800 acres. In areas affected by blow-downs, the build-up of opportunistic insects can cause mortality for the following two years in pine, oak and birch.

DNR foresters with pine log deck salvaged from fallen trees



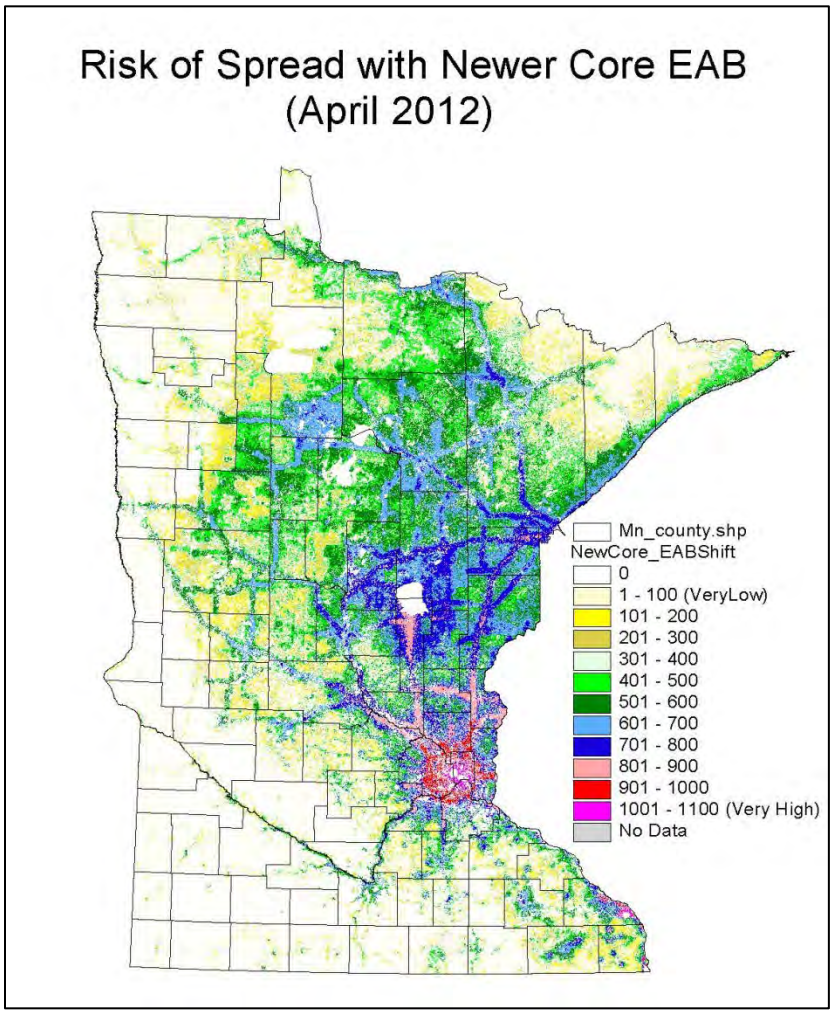
Forest Health Program Special Projects

Emerald Ash Borer Risk of Spread Map for 2012

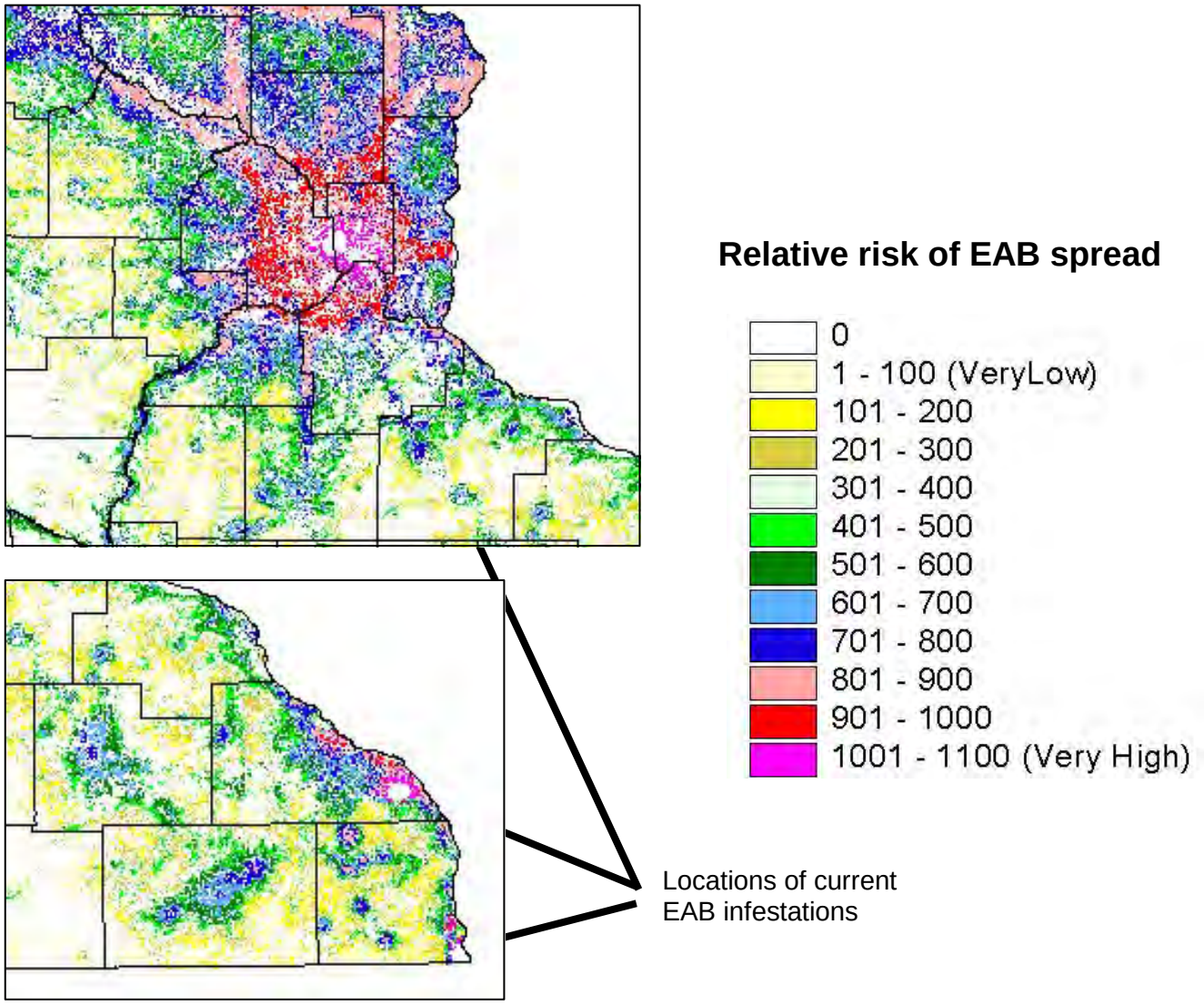
For the past two years, Dr. Louis Iverson and his group at the US Forest Service Northern Research Station in Delaware, Ohio have modeled the risk of emerald ash borer (EAB) spread in Minnesota based on the current known locations of EAB, the distribution of ash species based on basal area and other characteristics listed below:

- Locations of already declining ash stands
- Municipal ash density based on the 2010 survey of tree species
- Locations of EAB traps or trap trees at a high resolution (within 30 m or so)
- Locations where EAB has been identified, with discovery dates for each location
- Topographic dimension of ash species distribution from the ash basal area map
- Locations of wood product industries, along with some estimate of their use
- Firewood vendors by zip code
- Visitor data to State Parks by visitor's home zip code using the most recent data.
- Location of all types of campgrounds including the number of campers who visit each location annually
- Human population density by zip code
- Road network with traffic densities

The output is an ARCMAP layer that is a spatially explicit layer with 30 m resolution (Risk of Spread with Newer Core EAB map, right).



The three infested areas of the state (below) are expanded to show the core area (white) and surrounding areas of relative risk, with1100 being the highest and 0 being the lowest. This map was shared with other Minnesota agencies and aims to aid on-the-ground delimitation of new EAB infestations, annually track EAB population movement, and illustrate areas where the risk of spread is highest.



Jack Pine Budworm Populations Reflect Variation in Jack Pine Populations

"There are three large and separate jack pine population centers in Minnesota. One center is in northeastern Minnesota where jack pine grows on shallow soils blanketing the Canadian shield. In the northwest, jack pines grow on the beach ridges of glacial Lake Agassiz. The largest complex of ridges in Minnesota is near Bemis, but this kind of habitat extends northward to Winnepeg, Manitoba. Minnesota's largest center of jack pine is a large area of glacial outwash in the west-central part of the state. These centers are incredibly different with regard to soils, understory development, groundlayer, diseases, and silvics of jack pine." John Almendinger,Minnesota DNR Ecological Classification System coordinator. From Pine Regeneration Workshop, Aug 21-22, 2012.

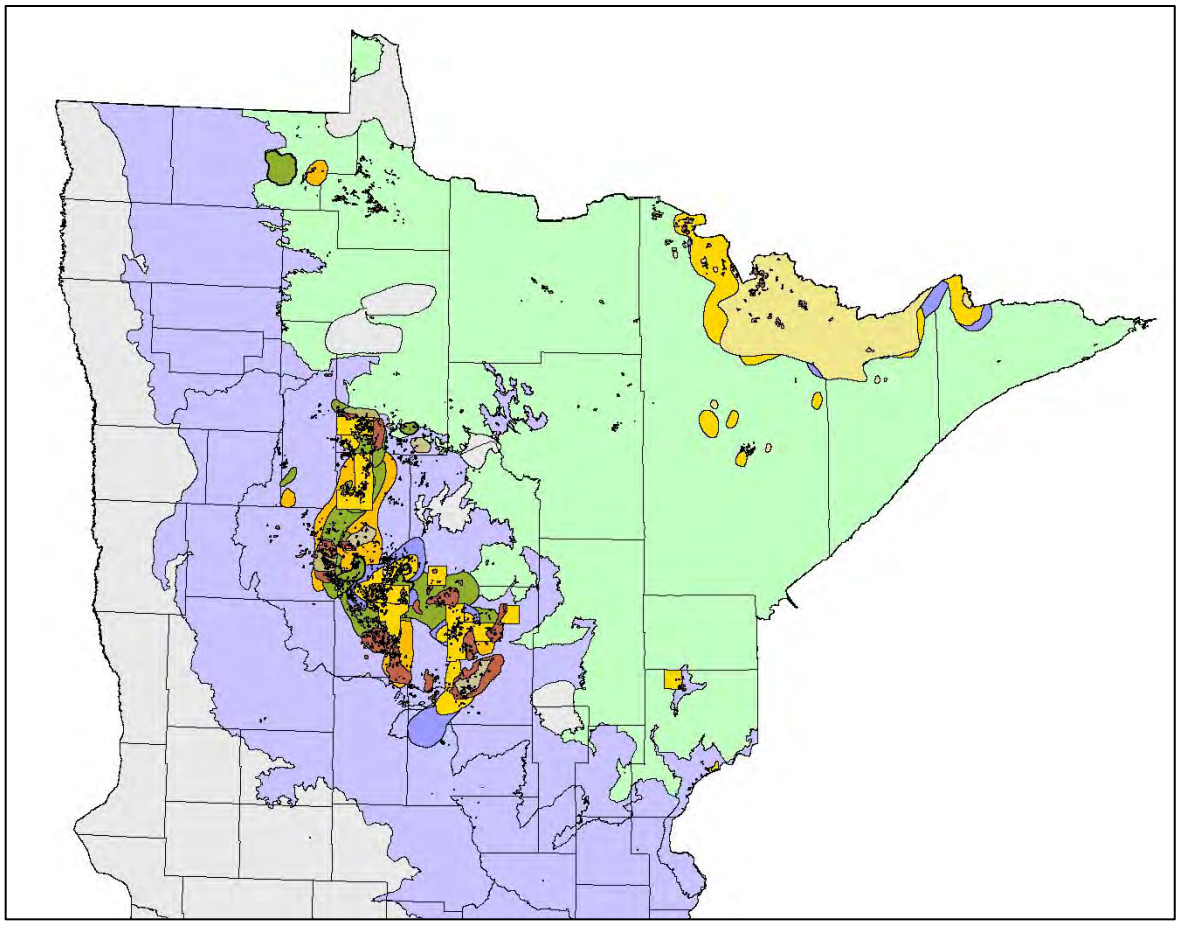
Variation of jack pine characteristics based on Native Plant Community and location in Minnesota

By John Almendinger, MN DNR-Forestry

	Canadian Shield	**Agassiz Beach Ridges**	**Central Outwash**
Location	NE counties, esp. St. Louis, Lake and Cook	Lake of the Woods and Roseau	Beltrami, Hubbard, Cass, Crow Wing, Wadena = West central counties
ECS Province	Northern Superior Uplands	N. Minn. & Ontario Peatlands	N. Minn. Drift & Lake Plains
Main NPCs	FDn22, FDn32, FDn43	FDn12, FDn33	FDc12, FDc23, FDc24, FDc25, FDc34
Paleohistory	Forested since deglaciation	Brush prairie after the basin drained, ridges afforested with jack pine as peatlands formed in the lowlands	Forested after glaciation, but converted to prairie/woodland during the Mid-Holocene. Slowly afforested by aspen and jack pine during late-Holocene
Antiquity	Jack pine forests present as early as 11,000 B.P. and since 8,000	Jack pine present in the east since 6,000 B.P., present in the west since 4,000	Spotty establishment of jack pine as early as 4,000 B.P. but some as recent as 300. Repalced prairie.
Soils	Thin, droughty, stony, poor	Deep poor sands, high W.T.	Deep well-drained sands, ranging from poor to very rich
Understory	Generally open and mossy	Generally open and grassy	Open and mossy to dense shrubs and sods
Groundlayer	Boreal flora	Wet prairie & woodland	Dry prairie & woodland
Insects: Jack pine budworm outbreak return interval	24+ years	10 years	8 years JPBW drives rotation age here.
Diseases: *Diplodia scrobiculata* (blight and canker) Rusts: 1. Pine-pine gall 2. Pine-oak gall 3. Sweetfern 4. Cow wheat 5. Commandra	*Diplodia* impact is low Presence or absence: 1. + 2. - 3. + 4. + 5. -	*Diplodia* impact is low Presence or absence: 1. + 2. - 3. - 4. + 5. +	*Diplodia* impact is high Presence or absence: 1. - 2. + 3. - 4. - 5. +
Silvics	Closed-cone ecotype, forest with dense stocking	Closed-cone ecotype, woodland with 50 to 75% cover	Open-cone ecotype, woodland with 50 to 100% cover
Fire regime: Main events Stand rotation	 50 to 260 yrs 170 to 220 yrs	 50 to 260 yrs 170 to 220 yrs	 10 to 30 yrs 80 to 130 yrs
Maximum stand age	120 yrs	80 yrs	80 yrs
Crown form	Tall, narrow	Tall, narrow	Short, wide
Bark thickness	Thin	Thin	Thick
Cone type	Closed 75-95%	Closed 75-95%	Closed < 50%
Seeding after fire	Heavily, rapid establisment	Heavily, rapid establisment	Very lightly, reestablisment can take > 30 yrs

As it happens, these three areas of jack pine have differing outbreaks and impacts of jack pine budworm (see table below). Figure 1 illustrates the locations of budworm defoliation from 1976 to 2010 and shows that budworm defoliation is highly segregated into the same three areas plus a very small area in Pine County. In Figure 2, simultaneous outbreaks were highlighted by breaking the defoliation events into the four regions and setting them against a time line. Additionally, two, three, or four areas were involved in outbreaks simultaneously but the west central counties were involved in every outbreak since 1940. From that information, outbreak return intervals were calculated for each of the outbreak areas and are indicated in Figure 3.

Jack pine budworm impact			
	Canadian Shield	**Agassiz Beach Ridges**	**Central Outwash**
Location	NE counties, esp. St. Louis, Lake and Cook	Lake of the Woods and Roseau	Beltrami, Hubbard, Cass, Crow Wing, Wadena = West central counties
Return interval	24+ yrs	10 yrs	8 yrs
Acreage involved	Peaks at 36,000 ac	Peaks at 13,000 ac	Peaks at 70,000 ac
Frequency of occurrence during an outbreak	Few stands involved	Many stands are involved	Many to most stands involved
Mortality	0-5% of trees die	5-40% of trees die	5-40% of trees die, ranges up to 100%
Outbreak naturally controls jack pine life span due to multiple outbreaks in quick succession	No	Yes	Yes
Maximum age of stands, based on PLS and NPC data	120 yrs	80 yrs	80 yrs
Wildfire after budworm	Rarely	Commonly	Very common
Effect on trees	Some topkill, doesn't affect stand density	Topkill and large patches of mortality. Keeps stem density low.	Topkill and large patches of mortality. Keeps stem density low.
Effect on JP regeneration	None	Can directly kill saplings. Pollen depletion and decreased seed production immediately after outbreaks	Can directly kill saplings. Pollen depletion and decreased seed production immediately after outbreaks
Effects of salvage or pre-salvage	None	Can remove remaining live seed trees and delay site regeneration to jack pine	Can remove remaining live seed trees and delay site regeneration to jack pine



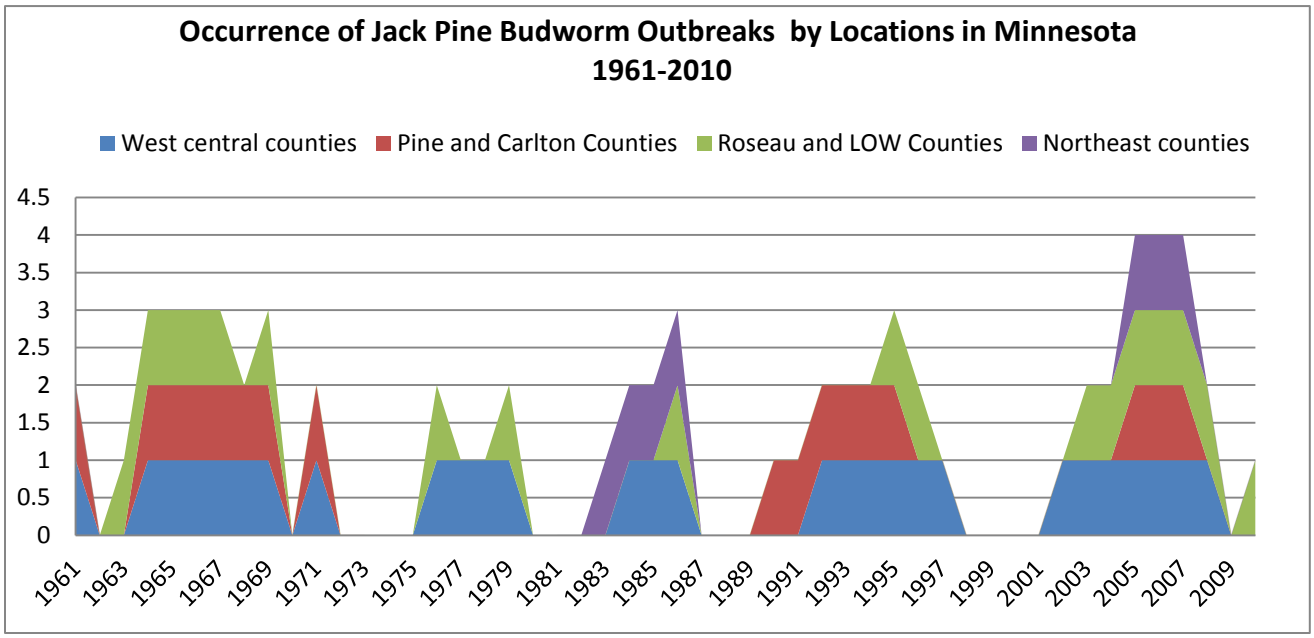


Fig. 2. Number of outbreak areas

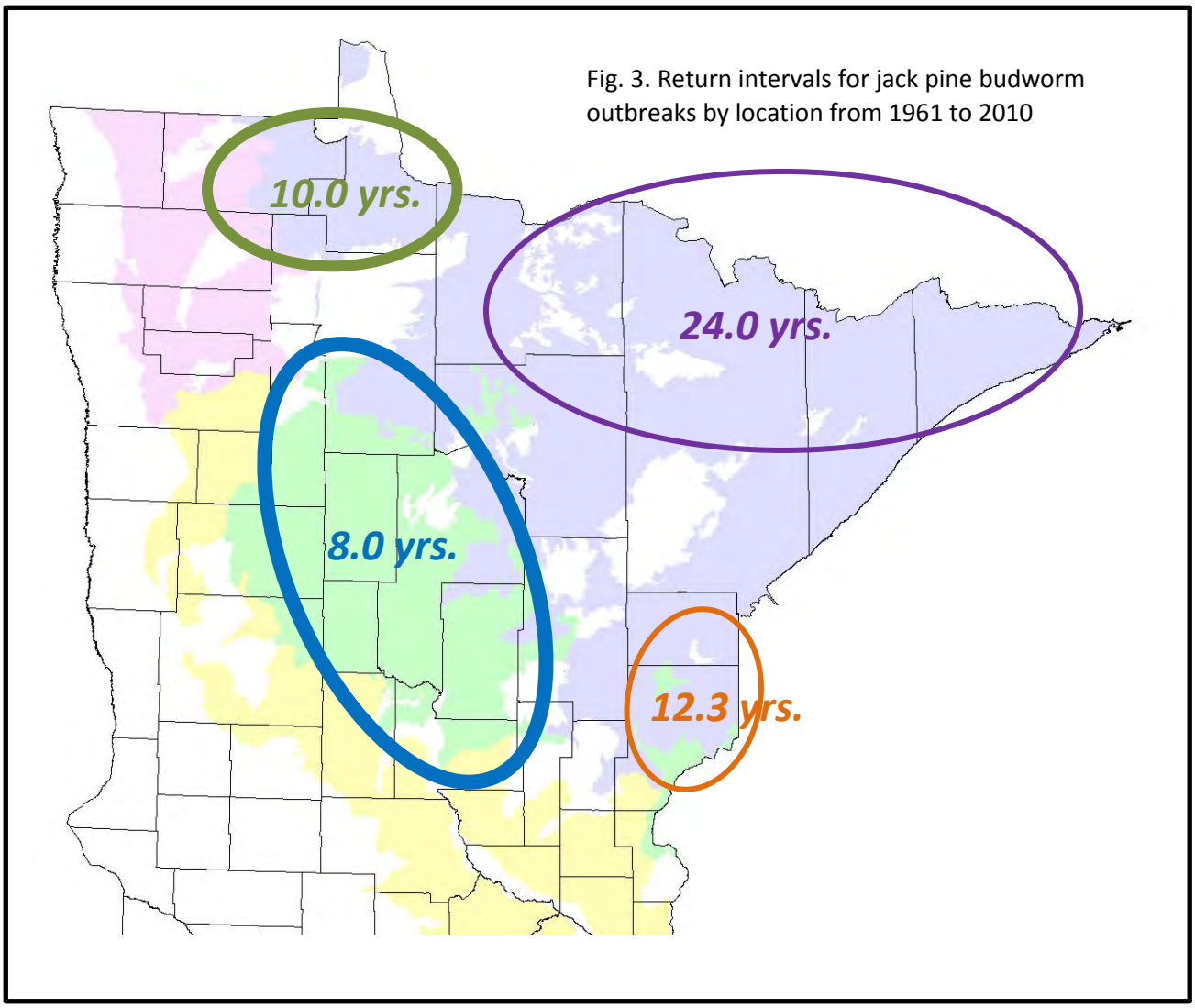


Fig. 3. Return intervals for jack pine budworm outbreaks by location from 1961 to 2010

Jack Pine Budworm Early Larval Survey

Methods

Sampling for jack pine budworm (JPBW) larvae consists of cutting a branch from each of five separate trees. The first 15 inches of the branch are examined for presence of larvae and other signs such as frass and webbing. For each township (Twp.), information is recorded as the number larvae per Vegetative (V) or Staminate (St) shoots. The general abundance of pollen cones and other signs of feeding activity are also noted. Weather conditions were hot and dry during sampling in Lake of the Woods (LOW) and Roseau Counties. Sampling in Beltrami, Hubbard, Cass, Wadena, and Becker Counties was carried out following a wet period. High incidence of PNR was also noted on these samples.

May 25, 2012

SOUTH HUBBARD, CASS, WADENA, BECKER

1. Hendrickson Twp. NESE Sec. 12 N47 12.744 W94 47.835
   St 0/0 V 0/30 Pollen shedding, pollen cones few

2. White Oak Twp. NE NW Sec. 22 N46 36.062 W94 43.092
   St 0/12 V 0/18 Pollen shedding, cones few to common

3. Badoura Twp. NENE Sec. 16 N46 51.744 W94 43.376
   St 0/22 V 0/8 Pollen shedding, cones common, PNR common

4. Badoura Twp. SWSE Sec. 2 N46 51.743 W94 41.455
   St 2/18 V 0/12 Cones common, frass/webbing on 3 shoots larvae in 2nd instar, PNR

5. Badoura Twp. SESE Sec. 30 N46 49.118 W94 45.988
   St 0/15 V 0/15 Pollen shedding, cones common, PNR

6. Badoura Twp. SWSW Sec. 31 N46.48.240 W94 47.141
   St 0/18 V 0/12 Cones common, PNR present

CASS COUNTY

7. Ansel Twp. SWSW Sec. 11 N46 46.779 W94 42.137
   St 0/20 1 V 0/10 Shedding, cones common, PNR common

WADENA COUNTY

8. Huntersville Twp. NENE Sec. 3 N46 48.236 W94 49.793
   St 0/12 V 0/18 Shedding, cones common

9. Huntersville Twp. SWSW Sec. 10 N46 46.721 W94 51.050
   St 0/20 V 0/10 Plantation trees, shedding, cones common

10. Huntersville Twp. SENE Sec. 31 N46 43.937 W94 54.763
    St 0/18 V 0/12 Shedding, cones common

BECKER COUNTY

11. Green Valley Twp. Shipman Lake PA
Sec.15 N46 51.321 W95 12.298
St 0/12 V 0/18 Shedding, cones common

12. Green Valley Twp. Bl. Berry Lake PA Rd.
Sec. 22 N46 50.763 W95 13.300
St 0/8 V 0/22 Shedding, cones few to common

13. Osage Twp. SW Sec 18 N46 57 .309 W95 14..849
St 0/15 V 015 Shedding

14. Two Inlets Twp. SE Sec. 11 N47 32.517 W95 11.905
St 0/16 V 0/14 Shedding, cones few to common

May 30, 2012

BELTRAMI, CENTRAL HUBBARD

15. Eckles Twp. NWNE Sec. 23 N47 31.528 W94 57.349
St 0/24 V 0/6 Pollen cones abundant, PNR Present

16. Eckles Twp. SENE Sec. 16 N47 33.371 W94 58.883
St 0/21 V 0/9 Cones common, shedding, PNR present

17. Eckles Twp. SESE Sec. 8 N47 33.391 W94 59.566
St 0/6 V 0/24 cones few, shedding

18. Lammers Twp. SESE Sec. 36 N47 35.185 W95 03.360
St 0/20 V 0/10 cones few, shedding

19. Lammers Twp. SWNW Sec. 2 N47 34. 921 W95 05. 879
St 0/28 V 0/12 Shedding, PNR present

20. Lammers Twp. NENE Sec. 4 N47 35. 044 W95 07. 528
St 0/12 V 0/18 Webbing on two shoots, cones few

21. Buzzle Twp. NENE Sec. 32 N47 35.871 W95 08.549
St 0/14 V0/16 Cones few to common, shedding

22. Buzzle Twp. SW Sec. 20 N47 38. 864 W95 09. 498
St 0/26 V0/4 Plantation trees, cones few

23. Jones Twp. SESW Sec. 22 N47 26.636 W05 06.638
St 0/0 V 0/30 Cones few, shedding

24. Jones Twp. SE Sec. 27 N47 26.346 W95 06.091
St 0/8 V 0/22 Cones few, shedding, PNR present

HUBBARD COUNTY

25. Lake George Twp. NWSE Sec. 5 N47 13.181 W95 00.091
St 0/21 V0/9 Cones common

26. Lake George Twp. SESE Sec. 16 N47 12.621 W94 59.398
St 0/8 V 0/22 Cones few, shedding

27. Lake George Twp. NENE Sec. 4 N43 14.234 W94 59.071
S.0/20 V0/10 Cones common, PNR

June 4-5, 2012

SOUTH LAKE OF THE WOODS (LOW) AND ROSEAU COUNTIES

1. LOW Sec. 36-159-33 N48 32.514 W94 51.405
St 0/14 V 0/16 Tortoise scale on current shoots, pollen shedding, cones few to common

2. LOW NW 1/4 Sec. 34-159-33 N48 33.271 W94 53.967
St 0/21 V 0/9 Cones common, lower branch mortality on numerous saplings, 3rd year needles dead

3. Santa Anna Trail SWSW Sec. 20-150-33 N48 34 244 W94 55.164
St 0/8 V 0/22 Cones few to common, tip midge common

4. Faunce NW Sec. 18-159-33 N45 35.578 W94 57.117
St 0/23 V 0/7 Cones common, many dead needles on branches

5. Hogsback-O'Brien Trail SW Sec. 18-159-34 N48 35.154 W95 00.677
St 0/7 V 0/23 Cones few to common

6. Faunce Butterfield Forest Rd. NE Sec. 17-159-34 N48 35.151 W96 03.499
St 0/15 V 0/15 cones few to common

7. Norris Camp NW Sec. 3-159-35 N48-37.258 W95 08.503
St 0/12 V 0/18 Cones few to common

8. Norris Campground SE Sec. 8-159.35 N4837.203 W95 09.327
St 0/6 V 0/24 Few cones

9. RlW Headquarter Rd. SW Sec. 4-159-35 N48 36.594 W95 10.783
St 0/23 V 0/7 Cones common

10. RlW to Dicks PW Rd. SE Sec. 6-159-36 N48 35.891 W95 12.593
St 0/24 V 0/6 Cones common

11. Hogsback Forest Rd. NW Sec. 19- 159-36 N48 35.202 W95 13.627

St 0/12 V 0/18 Cones few to common

June 5, 2013
ROSEAU COUNTY

12. Dicks Parkway SW Sec 32-160-37 N48 43.510 W95 19.822
St 0/8 V 0/22 Cones few

13. DNR prop. Clear River NWSW Sec.30-161-37 N48 43.941 W95 19.746
St 0/12 V 0/18 Mature trees near residence site, cones common

14. Bednar Forest Rd. SE Sec.30-161-37 N48 44.486 W95 19.543
St 0/25 V 0/5 Common

15. Bednar-Schwartz Forest Rd. intersection SW Sec. 27-161-36 N48 43.656 W95 17.164
St 0/18 V 0/12 Common

16. Ent. Hayes Lake Park NE Sec. 33-160-35 N48 38.226 W95 32.601
St 0/30 V 0/0 Cones common

17. River Forest Rd. SE Sec.281-160-38 N48 38.900 W95 32.382
St 0/21 V 0/9 Common

18. Winner Forest Rd. SW Sec. 25-160-38 N48 38.872 W95 30.683
St 0/6 V 0/24 15-20-year old repro stand, few cones

19. Black and Winner Rd. intersection SW Sec. 32-160-37 N48 37.511 W95 27.105
St 0/12 V 0/18 Cones few to common

20. Blacks-Winner Rd. N48 40.342 W95 27.858
St 0/15 V 0/15 Cones few to common, pitchy shoots and some webbing on two shoots

21. Blacks-Winner Rd. NW Sec.8-159-37 N48 37.936 W95 27.170
St 0/23 V 0/18 Cones common, pitchy shoots, no frass or webbing

22. Winner Rd. NE Sec. 17-159-37 N48 35.817 W95 26.441
St 0/16 V 0/14 Cones common, two shoots pitchy

23. Winner Rd. SW Sec. 9-159-37 N48 35.881 W95 25.545
St 0/16 V 0/14 Cones common

Northeastern Area Association of State Foresters (NAASF) Forest Health Committee Update

The second annual NAASF Forest Health Committee (FHC) was held February 28-March1, 2012, in Annapolis, Maryland. The purpose of the FHC is to provide technical input, advice, and recommendations to the state foresters on forest and tree pest issues, to promote greater emphasis and support for forest health and invasive pest issues in the 20 states and Washington, DC that make up the Forest Service Northeastern Area (NA), and to strengthen communication between the forest health community, NAASF, and partners. Committee members are generally the forest health supervisors or program coordinators in state natural resource agencies. Val Cervenka, Minnesota DNR Forest Health program coordinator, is in her first year of a two-year term as chair of the committee.

Thirteen states and Washington, DC sent representatives to the meeting. The Forest Service, state foresters, and the NAASF Urban and Community Forestry Committee were also represented. Discussion topics included a legislative update from Steve Koehn, state forester representative from Maryland, an update from the Urban Forestry Committee rep Eric Seaborn, ranking pests on the Priority Concerns list, utilizing the fire compact model to develop a working forest health team, and competitive allocation funding issues. The committee's FY2012 work plan included development and delivery of a pest matrix, identifying the major insect and disease threats to the forest resource in the NA and recommendations regarding the best course of action. Val presented the matrix to the state foresters and included recommendations for Asian Long-horned Beetle funding from the Durham Field Office.

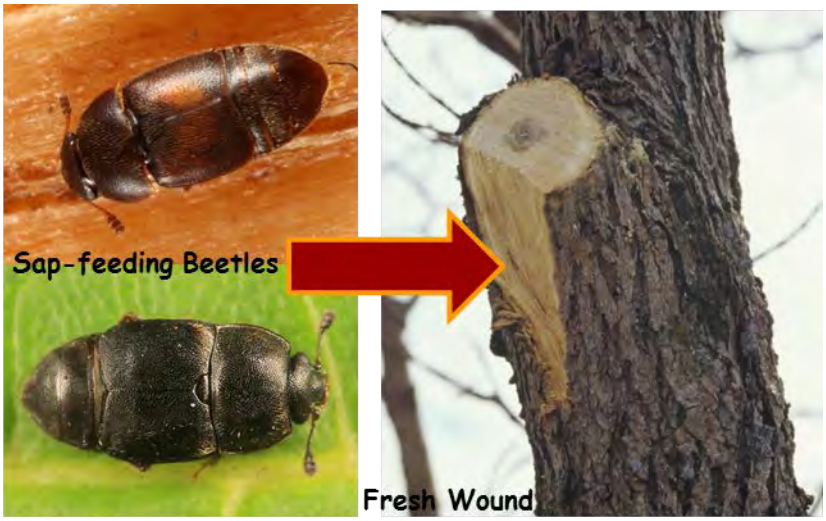
Oak wilt confirmed in St. Croix State Park

Oak wilt was discovered this year throughout St. Croix State Park in Pine County, Minnesota's northern-most find of this vascular wilt disease. Several wilting red oaks were observed in June and July, and while oak wilt had never been observed in the park before, Parks and Trails and Forestry staff recognized oak wilt's characteristic symptoms and reported it to the Forest Health Unit for confirmation. The University of Minnesota Plant Disease Clinic quickly confirmed that samples from suspect trees were positive for the oak wilt fungus *Ceratocystis fagacearum*.

Oak wilt is considered to be the most important disease of oaks in the eastern U.S. and is responsible for killing thousands of oaks each year from Texas to the Lake States. While all species of oaks are susceptible, trees in the red oak group are more susceptible to oak wilt and are killed more rapidly than trees in the white oak group. In Minnesota, black, northern pin, and northern red oak all belong to the red oak group, while bur oak, swamp white oak, and white oak belong to the white oak group.

Oak wilt is caused by a fungus that is now believed to be non-native, although its origin is still unknown and the disease has never been found outside the U.S. The fungus invades the water-conducting vessels of oak trees, and infected trees respond by plugging up their vessels to prevent the fungus from spreading. As a result, these trees are unable to transport water and they quickly begin to wilt. Diseased trees in the red oak group often shed their leaves and die within a few weeks of symptom onset. There are few if any forest pathogens that are capable of killing trees so quickly! Trees in the white oak group may die more slowly over a period of several years.

Oak wilt was first discovered in Minnesota in the 1940s in the southeastern part of the state. Since that time, the disease has slowly spread north and westward, but it has never before been

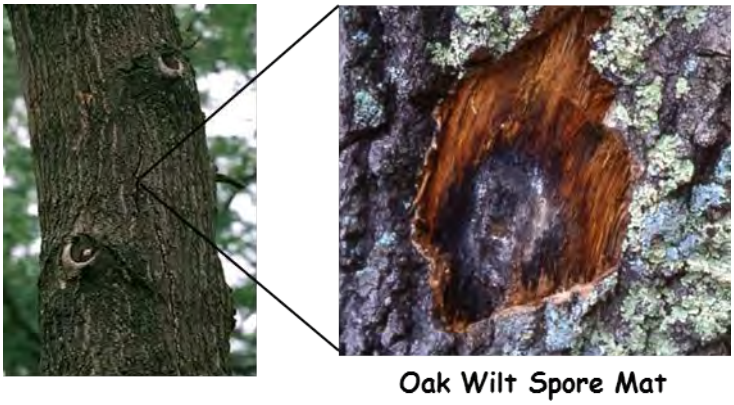


found so far north in Pine County. So how did it reach St. Croix State Park? To answer that, you need to understand how oak wilt spreads.

The most common way oak wilt spreads is when the fungus moves through connected root systems. The roots of trees commonly graft to roots of other trees of the same species, forming a continuous underground network. When an infected tree dies, the fungus spreads through the inter-connected root systems and invades healthy trees. While this only allows the oak wilt fungus to spread relatively short distances through a forest stand, large pockets of wilting and dead trees can form over many years and are known as "disease centers."

After a tree is killed, the oak wilt fungus produces specialized structures called "spore mats" beneath the bark. These mats are dense clumps of fungal mycelia covered in millions of sticky spores. The mats crack the bark open and have a sweet smell like bananas or bubble gum, to lure in certain species of beetles with their delicious aroma. Sap-feeding beetles such as *Colopterus truncatus* and *Carpophilus sayi* are among the most frequent visitors that feed on the fungal mats, and they become covered in oak wilt spores. These beetles also like to feed on the sap oozing from fresh tree wounds. Spores can be transmitted from the beetle to the wound and the fungus will then spread into the tree's vascular system.

In late July last year, a massive storm destroyed thousands of acres of forests in and around St. Croix State Park. Not only were trees blown down, but many were wounded during the fury and chaos of this storm. These fresh wounds likely attracted sap-feeding beetles, contaminated with oak wilt spores from the surrounding area. While no oak wilt disease centers have ever been reported in the vicinity of the park, it is believed that isolated diseased trees or small disease centers are present throughout the region. The blow-down event provided the perfect opportunity for this devastating fungus to spread into the park and infect dozens of the oaks that managed to survive the storm.


Oak Wilt Spore Mat

Because this is currently the northern-most known occurrence of oak wilt in Minnesota, park staff will be aggressively managing the disease not only to limit its impact to the park, but to minimize the risk of additional spread throughout the state. Management in the park will consist of both removing and destroying diseased trees so that spore mats cannot form, and trenching around known disease centers to sever root grafts that might lead to additional spread. While dozens of infected trees have been identified during disease surveys conducted this summer, DNR staff is optimistic that oak wilt can be effectively managed in the park.

The discovery of oak wilt in St. Croix State Park highlights the need to take precautions to prevent the spread of this destructive forest disease throughout Minnesota, including those areas where oak wilt is not currently known to occur. To prevent the spread of oak wilt, follow these management guidelines:

- Only prune oak trees during the winter months
- Avoid wounding oak trees between April and July when sap beetles are actively feeding
- If trees are wounded during the spring and summer months, wounds should be immediately treated with pruning paint.
- Remove diseased oaks before the following spring to prevent spore mat development. It is best to remove trees in the winter to avoid wounding neighboring trees.
- Prior to removing dead and diseased trees, sever root connections to healthy trees by trenching around diseased trees with a vibratory plow equipped with a 5-foot blade.
- Destroy wood from diseased trees on site by debarking or chipping. If wood cannot be destroyed, dry it properly by covering split wood with plastic and bury the edges for at least six months to kill the oak wilt fungus and any insect vectors.

Oak Wilt Alert for Fuelwood Cutters

Oak wilt, a fatal disease of all oak tree species, was recently discovered in St. Croix State Park in eastern Pine County. While oak wilt is known to occur in the central and southern parts of Minnesota, this new find indicates the disease is continuing to spread to other parts of the state. **The fungus that causes oak wilt can be transported in oak fuelwood to new locations such as your yard or woodlot and kill your oak trees.** Therefore, it is important to take precautions when cutting and transporting fuelwood, especially in areas where oak wilt is known to occur, to limit the spread of this devastating disease.

Spores are only produced on species in the red oak group including northern red oak, northern pin oak, and black oak. Only fuelwood from the red oak group needs the following precautions:

If you are going to cut fuelwood or have cut fuelwood in St. Croix State Park after April 1:

- Plan to burn all red oak fuelwood before April 1 of the coming year.
- If that is not possible, cover red oak fuelwood with a tarp, sealed tightly along the bottom edges, during the next growing season (April 1 through September 30) to ensure the fungus is killed and eliminate the risk of creating new oak wilt infections.
- Do not cut trees that have recently wilted or are currently wilting.
- Do not cut trees that were known to have died from oak wilt in the last 12 months.
- Sterilize the cutting surface of your tools by liberally spraying them with rubbing alcohol after use.

Additional steps you can take to keep your trees and neighboring forests healthy:

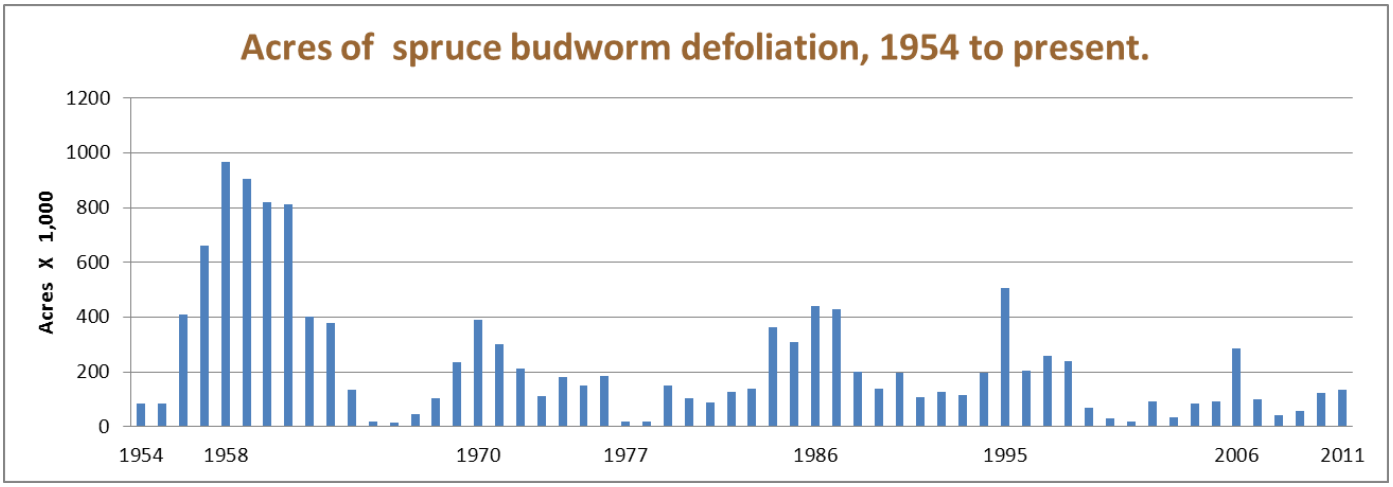
- From April 1 through September 30, strictly avoid pruning or wounding all oak trees to reduce the risk of oak wilt infections.
- If possible, avoid transporting red oak fuelwood more than 25 miles from where it is harvested.
- Monitor all your oaks for symptoms of wilting, unusual changes in leaf color, rapid leaf loss, rapid death, or pockets of dead and dying oak trees.
- To assist the Minnesota Department of Natural Resources (DNR) in tracking the spread of this disease, please contact your local DNR Forestry office if you suspect oak wilt has been found on your property.

2012 Phenology

Date	Event	Location
	Very early spring. Temperatures hit 65°F the week of March 3-9, 71°F the week of March 11-17 and 77°F the week of March 24-30.	Itasca-Grand Rapids
3/19	Few aspen clones with fully-emerged catkins. Tulips are up 5 inches.	Itasca-Grand Rapids
3/22	Pussy willows are out. Spring peepers heard.	Itasca, So. St. Louis and Carlton
3/25	Leatherwood is blooming. Small leaves and flower buds visible on red alder. Lilac leaf buds showing 2 leaves.	Itasca-Grand Rapids
3/27	Pussy willows have leaves. Red maple and elm blossoming is nearly done. Balm of Gilead and red maple leaves are unfurling. Ice is out on Lake Pokegama. This is the earliest reported ice-out on record from 1962 through 2012. Median ice-out date is April 27.	Itasca-Grand Rapids
4/24	*Amelanchier* beginning to bloom	Cass, Hubbard
4/ 24	Forest tent caterpillar (FTC) not hatched yet in 2011 outbreak area.	Becker
4/26	Just beginning to bloom: dandelions, bloodroot, Jack-in-the-pulpit, large bellwort. Trillium already in bud stage. Basswood leaves 1-2 inches long.	Ottertail, southern.
5/9	Crabapples starting to bloom. Marsh marigolds in bloom.	Itasca-Grand Rapids
5/16	Spruce budworm larvae 1/8 to 1/4 inch long. Some balsam fir shoots 1 inch long but needles not starting to flare yet.	St Louis- Chisholm
5/ 16	*Melampsora* species fruiting as stem cankers on willow sprouts.	Beltrami-Bemidji
5/16	Jack pine needle rust fruiting on needles.	Itasca- Squaw Lake
5/29	FTC larvae 1 ½ to 2 inches long.	Pine- Hinckley
5/31	Emerald ash borer emerging at Great River Bluffs State Park.	Winona
6/ 9	FTC beginning to spin cocoons.	Itasca –Cohasset.
6/15	FTC pupation 5 percent	Aitkin- Big Sandy Lake
6/15	FTC pupation: West of Leech Lake = 1 percent on aspen and oak. Diamond Point = 5-10 percent East of Leech Lake = 1 percent Battle Point = nearly 100 percent South of Bena = 1 percent In bloom: white lady slippers, wild roses, pink *Monesis*.	Cass, Itasca
6/26	FTC 100 percent pupated, 84 percent parasitized	Crow Wing- Brainerd
6/27	Spruce budworm moths 100 percent recently emerged.	St Louis - Tower
6/ 28	FTC parasitism: Diamond Point = 77 percent East of Leech Lake = 28 percent	Cass

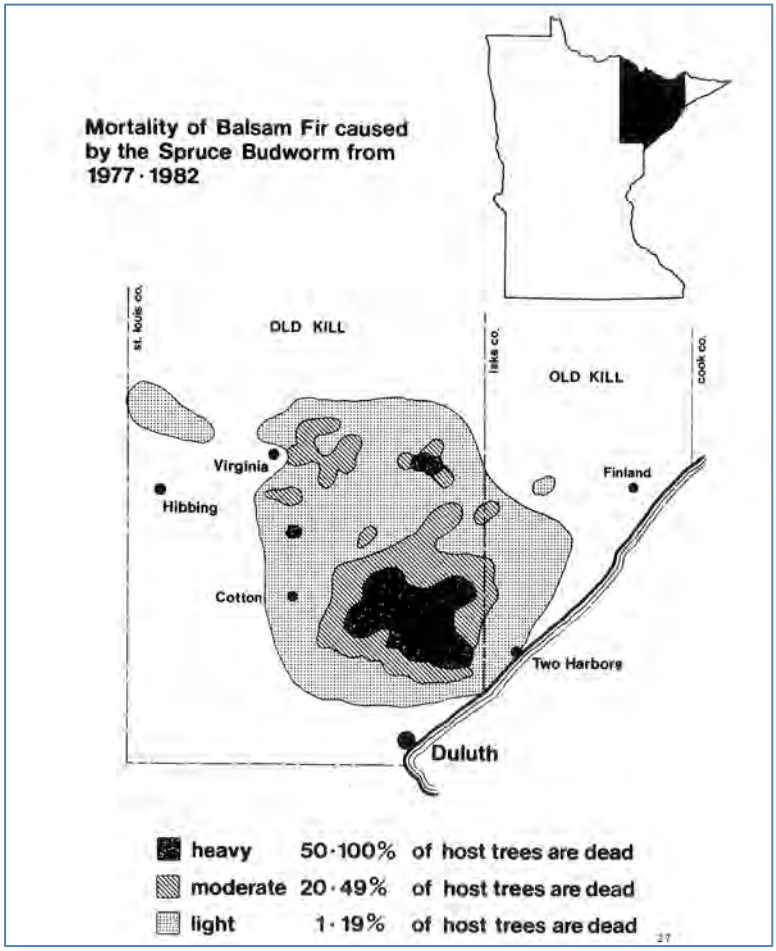
Spruce Budworm Mortality levels Updated for the National Insect and Disease Risk Map

In 2012, we are participating in the National Insect and Disease Risk Map (NIDRM) mapping effort and would like to add a mortality component for spruce budworm (SBW) that was lacking in the previous model. We suggest that since the SBW is currently moving into southern Lake County in the same area where it was 35 years ago (see chart below), we can use both the polygon shape and the acreage of mortality from the 1983 study in the new model.



Northwide S. Lake Co. Cook Co. N. St. Louis S. Lake Co.

In 1983 we cooperated in a federal study to determine the acreage and volume of timber lost due to spruce budworm in southern St. Louis and Lake counties from 1977 to 1982. We mapped 185,800 acres of balsam fir and or white spruce stands with detectable mortality within the boundaries as shown on the map to the right. Aerial mapping was followed up by a random ground survey of 34 stands where we measured these parameters for balsam fir and white spruce based on the stands' mortality category: basal area and volume of live and dead trees and calculated percent dead trees. Results of the ground-check of dead balsam fir and white spruce are shown in the table below.



Summary of ground survey based on aerial survey mortality categories, 1977-1982.		
Mortality category	*Basal area Ft^2/ac*	*Percent dead host trees*
Heavy	59	58
Moderate	43	22
Light	32	28

Although we do not know exactly how long budworm will stay and the actual extent of the infestation, this boundary and acreage is a reasonable prediction of the mortality we could expect in Minnesota from 2012 to 2027 that meets NIDRM criteria.

Our reasoning behind the recommendations:

The physical evidence

We have 57 years of aerial survey data for spruce budworm defoliation in Minnesota, unlike other areas of the Midwest and northeastern US, and found that:

- Spruce budworm has been in northeast Minnesota since 1954 and likely before.
- Defoliation is episodic at return intervals of 5 to 24 years.
- Balsam fir is the main host. It takes three to five years of moderate to heavy defoliation to kill an individual fir tree.
- Surprisingly, only 30-100 percent of the individual balsam fir in the canopy are killed while below, younger balsams survive. In northeastern Minnesota, "spruce budworm begets balsam" is the common wisdom.
- Growing in relatively pure stands, balsam fir can be defoliated and killed by 25 years of age.
- In mixed-wood stands with aspen, it can be defoliated and killed as soon as the balsam crowns clear the aspen canopy, anywhere from 40 to 70 years.
- In mixed-wood stands there is a synchrony between aspen and balsam fir and defoliation by forest tent caterpillar and spruce budworm in northeast Minnesota.
- Budworm can be defoliating a wide swath of land in a county, but a 15-mile-wide strip inside the swath will have heavy mortality while the rest of the area has lighter levels of mortality.

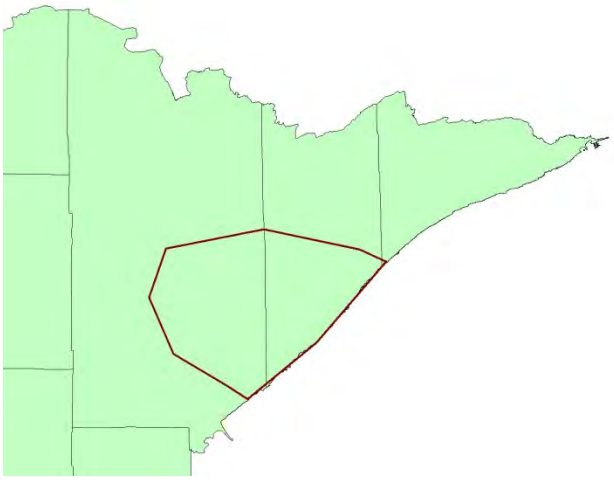
Anecdotal evidence from foresters in affected areas of northeast Minnesota

Comments from DNR foresters:

- Bob Heisel, Tower Office (Bob has been in that office for 30 years): "SBW will be in Tower then go away for about 10 years and return. Hits some areas hard but misses others, in terms of mortality."
- Randy Roff, southeast St. Louis County: "SBW kills trees of all ages, from three feet tall to five sticks (eight-foot length of wood) tall. At Briar Lake, 30-year-old balsam is getting hit really hard this year."
- Mike Hanson, Cook Office (Mike has been in Cook over 30 years): "When SBW moves through this country, it killed a lot of 25 to 30-year-old stands, but didn't really kill much of the 15-year-old stands…I am currently working on a timber sale on the Ash River Trail with lots of balsam fir on the ground killed six to eight years ago but the stand still has five cords/acre of four stick balsam. No budworm in there right now, but there is nothing to keep it from killing these trees when it moves through the area next time."

Suggested NIDRM polygon and acreage for Spruce Budworm mortality losses anticipated from 2012 to 2027 in Minnesota

We've created a polygon in southern St. Louis County and southern Lake County where we anticipate future mortality losses due to spruce budworm. The shape of the polygon is based on historical outbreak edges from1977 to 1986. As for the acreage of impact, we suggest using 185,800 acres for the amount of balsam fir and white spruce inside the polygon that would be killed at greater than 25 percent. This acreage is based on the 1983 study that assessed mortality on the ground inside polygons determined from aerial surveys in that same area.



Storm Damage to Trees: Advice for Homeowners (news release)

Cleanup following a windstorm can be a daunting task for homeowners. Knowing which trees to save and which should be removed can impact your safety and the survival of your remaining trees.

Information and advice on tree care, proper pruning techniques, overall tree health, and considerations for removing a damaged tree are available on the DNR website at www.dnr.state.mn.us/treecare/maintenance/stormdamage-prevention.html.

Forest health specialists offer the following tips.

- Carefully inspect standing trees for damage; deal with hazardous trees first.
- Seek the help of a professional when deciding which trees to remove. If more than 50 percent of the trunk circumference or live branches in the tree crown are damaged, or the tree is leaning with evidence of root lifting or breakage, the tree should be removed.
- Watch for detached or loosely hanging branches and split or cracked trunks that can cause injury or further damage.
- Use proper pruning techniques, but limit pruning to making the tree safe. Incorrect or over-pruning will further damage a tree that is under stress.
- Water stressed and damaged trees to help them repair and rebuild, but be careful not to overwater, especially in heavy clay soils. In dry conditions, trees need ½ to 1 inch of water per week during the growing season.
- Use mulch to help conserve water in the soil to keep the soil cool, prevent soil compaction, and encourage more root growth. Keep mulch at least four inches away from the tree's trunk, maintain a depth of two to four inches deep, and cover an area at least two to three feet in diameter around small trees. Increase the diameter for larger trees.

- Don't try to save or repair a broken branch or fork of a tree with tape, wire, bolts, or other wraps. It will not heal, and the split will invite decay and further weaken the tree. Cabling or bracing should only be performed by a certified arborist and inspected annually.
- Don't use rope, wire in a garden hose or any narrow band of material when staking a tree to avoid damaging the trunk. Instead, use a broad strap or other fabric at least one inch wide. Date the staking and remember to remove it next year.
- Don't top trees. Doing so removes large portions of leaves needed for food production, makes the tree more susceptible to insects and disease, and may result in new branches that are weakly attached.
- Don't try to save a leaning tree that is more than 15 feet tall, especially if you see the soil has been raised on the side opposite of the lean. This usually indicates broken roots. Very young trees less than 15 feet tall may survive if they are gently pulled back into place. Be sure to press out air spaces in the loosened soil, water the entire root system twice each week in the absence of rain, mulch, and carefully stake the tree for the first year. Tree staking is not usually recommended when planting new trees but is of value for a tree that has been bent or blown over.
- Don't panic and remove all of your living healthy trees. Consider the value of these trees for aesthetics, property values, and cooling shade.
- Don't be rushed by bargains from an inexperienced vendor. Improper pruning or removal can cost you more money from damages and result in the removal of healthy trees.
- Don't allow the use of climbing spikes on a tree you want to save.
- Don't fertilize damaged trees. The tree's root system may not be able to support the extra growth.
- Don't use paint or wound dressing to cover wounds as these materials may actually interfere with the natural wound-sealing process. An exception is using latex-based paint to seal the wounds on oak trees during the months of April, May, and June in areas that experience oak wilt (in and near the Twin Cities).

Storm Damage to Forests: Advice for Landowners

Background

Natural disturbance events such as tornados, hailstorms, and floods wreak havoc on the best of forest management plans. They can also result in major economic losses and create significant forest management problems. Some effects of having large numbers of downed trees include:

- Fuel build-up resulting in future forest fire hazard
- Loss of economic value
- Potential for future loss due to increased susceptibility to insects, decay, future storm damage, etc.
- Changes in aesthetic values and forest objectives
- Damaged or blocked roads, culverts, and ditches
- Safety hazards for landowner and forest workers
- Changes in fish and wildlife habitat

Q. As a landowner, am I required to clean up downed trees and forest debris (slash) caused by a storm?
A. No. However, salvage and clean-up is desirable to reduce the future potential for wildfires and insect infestations. Salvage and clean-up will likely be necessary to encourage natural regeneration of the forest trees and plant communities.

Q. What is a salvage harvest?
A. Salvage harvest is a type of logging method used in forested areas to remove trees, stems and stubs that have been damaged by a natural disturbance such as a wind storm. Healthy, sound trees with full crowns are retained. A tree needs at least a quarter to a third of its height in foliage to be considered healthy.

Q. What should I do first in a salvage harvest?
A. Conduct a thorough damage assessment:

- If physically possible, walk the entire property (wear your hard hat and other safety gear)
- Make a simple map showing extent and type of damage. Note general locations of trees with broken tops, broken limbs, fallen trees, severely bent trees, blocked roads and trails; take photographs
- Note where invasive plants are growing so they can be dealt with before or during salvage operations.

Q. How can I get the help with the damage assessment?
A. For a more detailed assessment to determine value losses and how to set up and conduct a timber sale, contract with a private forestry consultant. The consultant will know reliable loggers, local market conditions, and regulatory requirements. Visit the website below for a listing of private consultant foresters near you: http://www.paulbunyan.net/users/norfor/members.htm.

Q. What is involved in timber salvage and clean-up operations?
A.

- Working in storm-damaged areas is very hazardous, and it is strongly recommended that only professional loggers or landscape companies work in these areas. These people have the necessary expertise and equipment to accomplish the work in as safely as possible.
- The volume and value of the salvable timber on your property will be almost impossible to determine until the harvesting operation begins. Value will be dependent on many factors, such as markets, access, amount and type of damage, and size and quality of timber.
- Standards and procedures normally completed prior to harvesting operations, such as timber volume and value determination, property line establishment, and sale regulations might not be as accurate as those for pre-storm sales. Work with neighbors to establish property boundaries.
- Salvage operations require good coordination with adjacent landowners, close sale supervision, and contracting only with reliable companies like those who have completed the Minnesota Logger Education Program.

- We strongly recommend that you have a written contract with anyone who works with you as a consultant or on salvage and reforestation operations. Always make sure the consultant has insurance for the type of work they are undertaking on your land. For salvage operations, the contract should cover timber values and who determines them, scaling method and sale regulations.

Q. How much time do I have before the trees deteriorate and lose economic value?
A. Timelines for wood deterioration, insect infestation and preventing insect spread to healthy trees:

- Pine: The primary concern is pine bark beetles, which can kill trees directly and introduce blue stain fungus. Damaged jack, white and red pines and pine slash and cut products provide ideal breeding grounds for pine bark beetles. During the spring and early summer, all downed timber, large slash, and cut products should be removed, burned, destroyed or debarked within three weeks of the storm to prevent the build-up of bark beetles. Bark beetle populations can build rapidly and kill nearby pines next year, especially during droughty weather. There are no chemical controls for a bark beetle outbreak. Blue stain can reduce the value of sawtimber by two-thirds, but is not important in pulpwood. Blue stain will be a problem within two to three weeks of the storm for broken stems and tops and within 6six weeks in damaged but living trees and stubs (i.e. bowed down, leaning and root-sprung trees).

- Aspen and red maple: some value will be lost in downed timber anytime after the spring of the next year. Major value loss in aspen will happen in stems that are not salvaged after two summers.

- Oaks: Quality red oak timber must be harvested by October to maintain maximum sawtimber value. At this time, oak wilt is not a concern in northern Minnesota.

Q. Do any of my trees have value for wildlife?
A. Consider retaining a few storm-damaged trees (large-diameter reserve trees, mast and cavity trees, snags, and coarse woody debris) for wildlife habitat. Species that may benefit are the red-headed, black-backed and three-toed woodpeckers, northern flickers, and several species of bats. Reasons to remove dead trees may include where the tree presents a hazard to human health and safety, where the tree interferes with regeneration operations, or where leaving the tree would interfere with methods to control insect and disease outbreaks. If a complete salvage combined with a clear-cut of residual trees is undertaken, consider allowing natural regeneration (new tree growth from natural seed, roots or stumps) to occur or plant trees to speed up the process.

Q. Should I be concerned about streams, ponds, and wetlands?
A. These natural features are important habitats for frogs, toads, salamanders, turtles, fish, and many invertebrates as well many species of birds. When harvesting, DNR guidelines recommend keeping trees and slash out of all streams, ponds, wetlands and lakes. If there are downed trees in streams, wetlands, or ponds, wait until the soil is frozen to move through them with heavy equipment. In the meantime, travel around these features when skidding wood to the landing.

Q. Should I be concerned about the presence of invasive plants or possible invasions after the salvage operation?
A. Salvaging activities can encourage the growth of invasive plants because tree removal has created more available sunlight, more open space, and soil disturbance. Prevent new introductions of invasive species by including specifications in your contract stating that the logger must arrive with clean equipment. If invasive plants are already present, it's best to control them prior to the salvage operation. If that's not possible, harvest infested areas last so weed seeds are not spread to new areas. Put those specifications in your contract as well as a requirement that the logger clean his equipment before leaving your property to help protect the next landowner. Ensure rapid re-vegetation of the site by seeding with native plant species. This will help keep any new infestations from moving into the disturbed areas.

For information on how to treat existing infestations of invasive plants, see the following websites: http://www.dot.state.mn.us/roadsides/vegetation/pdf/noxiousweeds.pdf or http://mipncontroldatabase.wisc.edu/.

Q. Can I use the salvaged wood for firewood?
A. Yes, but we recommend that pine and oak firewood is cut, stacked and tightly covered with tarp. It is very likely that insect pests of pine and oak will rapidly infest the firewood. To prevent them from infesting nearby healthy trees, either burn the firewood prior to April 1 next year, or leave the pile covered until next September.

Q. Where can I get advice on site preparation and reforestation?
A. Many tree species regenerate naturally following harvest, including aspen, oak, basswood and maple. Jack, white and red pine may not regenerate naturally. Contact a consultant forester or your local DNR forester since your salvage harvest methods and timing may limit regeneration options. Evaluate the harvested area after two to three years for supplemental planting that may be needed.

Q. Where can I get seedlings to plant after the harvest?
A. Seedlings may be purchased from the DNR nursery or private nurseries. The DNR recommends replanting with native species suitable to your site. Contact General Andrews State Nursery at 800-657-3767 or http://www.dnr.state.mn.us/forestry/nurseries/index.html for advice.

Tamarack: Tree with a troubled past

At the time of the Public Land Survey in the late 1800's, tamarack was the most abundant tree in Minnesota with lots of it on upland sites. Today it ranks as the sixth or seventh most abundant tree. So what happened?

With over 120,000 acres of tamarack mortality in the last 11 years, you might think eastern larch beetle was the likely culprit, but it was actually the larch sawfly. Larch sawfly (*Pristiophora erichsonii*) was first reported in North America in 1880. The first record of larch sawfly in Minnesota was in 1909. It's reported that between 1910 and 1926 an outbreak killed one billion board feet of tamarack in Minnesota. There is another report claiming that between the late 1940s and 1970s, 40 percent of the tamarack in Minnesota was killed by the sawfly. The outbreaks in North America during the twentieth century occurred across the continent wherever tamarack grew with similar losses reported. For example, an Ontario report on tree decay in the 1950s stated that no studies were carried out on stem decay in larch because mature trees were so rare due to severe decimation by the larch sawfly, and some doubt that the species would ever be of commercial importance in the future.

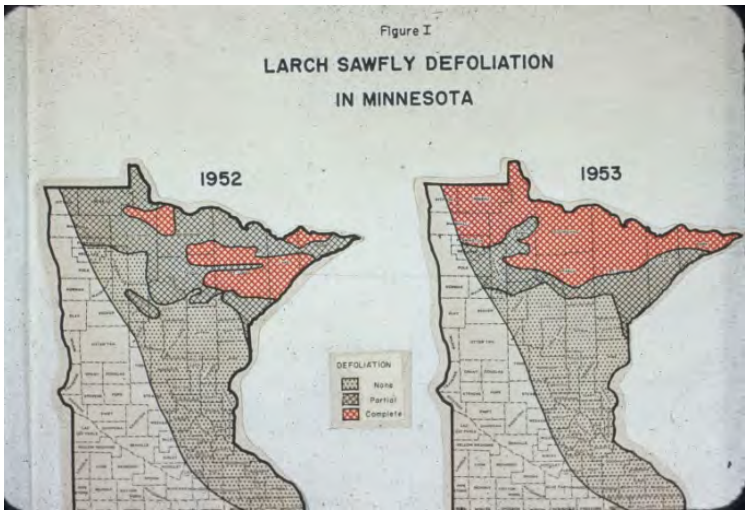
Larch sawflies occur around the world wherever *Larix* species naturally grow. There has long been debate about whether or not larch sawfly was native to North America. Most researchers now agree that there are a number of strains in North America and some of these are native and other were introduced.

Larch sawfly has one generation per year. It overwinters in cocoons in the ground, and adults emerge in the spring and summer. The female lays eggs in slits she cuts into the growing shoots. Larvae emerge and eat the tamarack needles. When full grown in late summer, larvae drop to the ground and spin silken cocoons in the litter to overwinter. Since tamarack are deciduous and drop their needles each fall they are able to withstand

defoliation better than other conifers. However, repeated years of defoliation eventually results in mortality.

Larch sawfly research has been conducted by many different researchers in North America. Studies in the early 1900s indicated that a lack of natural enemies might be why large and damaging outbreaks were occurring. Because of this idea, the parasitic ichneumon wasp *Mesoleius tenthredinis* was collected in England and released in Canada in 1913. The wasp spread and is thought to have been important in ending the outbreaks in the late 1920s. However, sawfly populations soon became resistant to the wasp, resulting in more outbreaks. It is believed that a resistant population of the sawfly was accidentally introduced along with *M. tenthredinis* from England. Parasitism declined into the early 1940s, resulting in more outbreaks and mortality. Arnold Drooz reported 65 percent parasitism of sawfly in Minnesota in 1935, but low levels by 1952 indicated the wasp could no longer be depended on as an important control factor.

In the1957, Canadian entomologists introduced additional wasps, using a Bavarian population of *M. tenthredini*, to which the North American sawflies were not resistant. In 1961 a second ichneumonid from Europe, *Olesicampe benefactor*, was introduced into central and eastern Canada. In 1970 and 1972, the University of Minnesota collected these two wasps in Manitoba and released them in Lake of the Woods, Beltrami, Koochiching and Itasca counties. Spread and effectiveness of these parasitic wasps were studied up to the late 1970s. With the lack of widespread outbreaks of larch sawfly in Canada or Minnesota in the past 35 years, the latest releases of parasitic wasps appears to have been successful, but whether this relationship will continue remains to be seen.



Minnesota Department of Agriculture, Dairy and Food Report on Forest Insect and Disease Conditions in Minnesota 1952-1953. J.W. Butcher, A. C. Hodson, and D.W. French.
Red areas denote complete defoliation; gray denotes partial defoliation.

Tamarack in Minnesota: Investigating mortality from eastern larch beetle

Tamarack in Minnesota: Investigating mortality from eastern larch beetle using Forest Inventory and Analysis data

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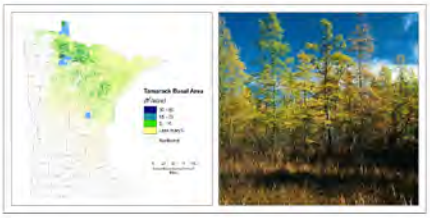
Abstract

Prior to European settlement, tamarack dominated the bogs, peatlands and uplands of Minnesota's 'North Woods'. Still a major component of Minnesota's forests, the extent and volume of tamarack has since waned. Mortality of tamarack has increased over the past decade. The majority of this mortality has been attributed to the activity of the eastern larch beetle (ELB), *Dendroctonus simplex* LeConte (Coleoptera: Curculionidae: Scolytinae), a pest native to North America. Outbreaks of ELB have been documented in Minnesota since 1938. Largely separated by decades, the current outbreak has been ongoing since 2000. While conditions that predispose stands to ELB attack are not well understood, physiological stress is often associated with infestation. For example, ELB frequently colonizes trees weakened by defoliators. However, within the current infestation, no predisposing factors are apparent. Drought, which has been a fixture in 9 of the past 10 years, could be playing an important role.



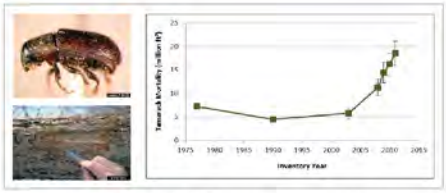
Distribution of tamarack, Minnesota, 2011. Image by Steven Katovich, USFS, www.bugwood.org.

Methodology

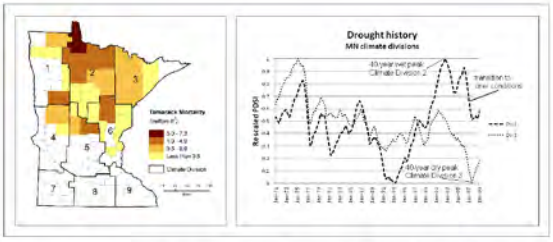
Data from the Forest Inventory and Analysis (FIA) program of the USDA Forest Service was used to analyze trends in tamarack mortality between 1977 and 2011. Additionally, tamarack mortality was aggregated by climate division to examine the relationship between mortality and drought.

Aerial tamarack mortality due to ELB. Image by Fraser McKee, Univ of MN.

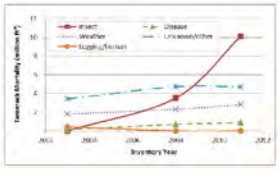
Results



Average annual mortality of tamarack growing-stock by inventory year, Minnesota. Image citation: Darren Blackford (top) and Steven Katovich (bottom), USFS, www.bugwood.org.



Tamarack mortality by county and climate division, 2011 (left). Drought history by climate division, 1971-2009 (right).



Average annual mortality of tamarack growing-stock by damaging agent, 2003-2011.

Next Steps

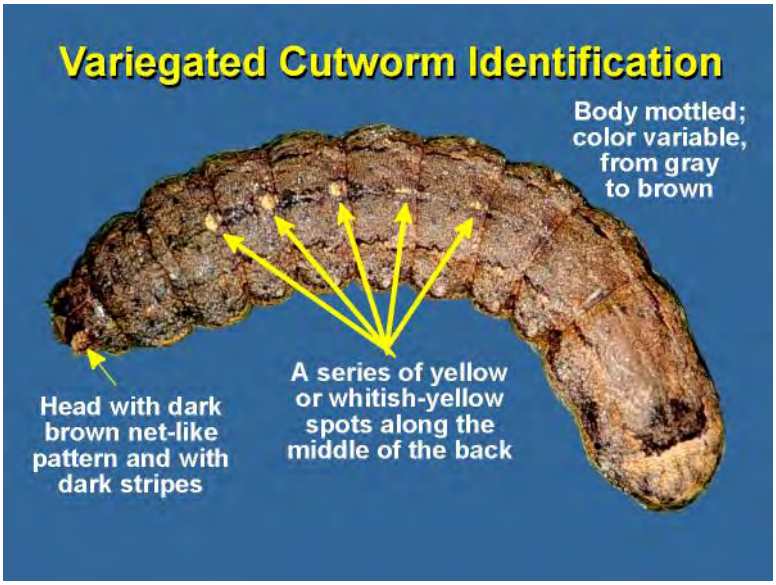
Future work will include spatial and temporal analysis of climate variables and their influence on tamarack mortality and an examination of drought, at multiple scales, as it relates to spatial patterns of tamarack mortality.

Contact Susan Crocker for additional information: scrocker@fs.fed.us

Variegated Cutworm Press Release: Where did all these eggs come from, and what are they?

It started out innocently enough in early May. Homeowners in Sandstone and Two Harbors wondered what these clusters on windows were and if they were detrimental. They're insect eggs, but what laid them? More reports of hundreds of egg masses laid on house siding, windows, and even laundry drying on the line came in from locations like Grand Marais, Side Lake and Duluth and from Cook County to Itasca County. Homeowners were scraping them off, hosing them off, some even using power washers. We'd never seen anything like them before and neither had forest health specialists from northern Wisconsin who were being flooded with questions, too. Extension entomologist to the rescue: Phil Pelliteri, Wisconsin Extension, identified them as eggs of the variegated cutworm, *Peridroma saucia* (photo of eggs from http://somethingscrawlinginmyhair.com/2010/07/31/moth-reared-from-eggs-found-on-house-siding-variegated-cutwormpearly-underwing/)

Apparently variegated cutworm moths from outbreaks in southern states were blown north over a period of a few weeks in May and eggs were laid at night on emerging crops, gardens, fence posts, buildings, trees and almost anything that held still long enough.



The eggs will hatch, yielding tiny translucent caterpillars with a few dark hairs and over-sized, black heads. They will be hungry, and they have an extremely wide host range: most vegetable garden plants, fruit trees, rhubarb, raspberries, strawberries, ornamental plants, shrubs, hostas, canola, wheat, corn, sunflower, clover and other row crops. Weeds are considered "not preferred" foods. Cutworms feed at night and rest during the day so it is hard to find them, but the damage will be easy to spot: seedlings nipped off at the ground line and large holes eaten out of leaves all season long.

The variegated cutworm is also called the climbing cutworm because mature caterpillar stages will spend both days and nights on their host plants in contrast to most other species of cutworm that spend the day in the soil. After feeding, they pupate in the soil, emerge as moths and start another generation, likely in July. Adults from this generation will migrate south in October to other states to overwinter (cutworm photo from http://entomology.unl.edu/charts/vcwchart.shtml)

We don't know if this invasion of cutworms will result in damage to gardens, ornamentals or crops, so monitor your plants over the next few weeks. If they are causing a problem, hand-picking in the late evening is suggested. Apply any pesticides in the evening as well. Neem products and pesticides such as carbaryl are effective.

Only use products labeled for the plant species you are growing and read label for re-entry and safety, especially for food crops.

More information about variegated cutworm can be found on these websites:
http://bayfield.uwex.edu/2012/05/17/pest-bulletin/
http://www.ag.ndsu.nodak.edu/aginfo/entomology/entupdates/Lawn_Ornmntl/variegated_ctwrm.htm
http://www.extension.umn.edu/distribution/horticulture/m1225.html

White spruce thinning study: 10-year results

A white spruce plantation thinning study was initiated in 1999 in cooperation with the USDA Forest Service (USFS) State and Private Forestry and the University of Minnesota with the assistance of a Federal Focus Fund Grant. The study was developed to look at thinning of white spruce plantations affected by spruce budworm defoliation to determine how the thinning affects growth and survival of the trees. One goal was to see if thinning could be used as an alternative to insecticides to reduce the impact of spruce budworm. Unfortunately, spruce budworm activity declined statewide while this study was being established, so only two of the stands in the study experienced moderate or heavy levels of defoliation, while the others experienced light or no defoliation.

The study involved 10 plantations on DNR, Blandin and USFS lands. The plantations were thinned between 1999 and 2002, and all plots were measured annually for the first 5 years. A final re-measurement was made of all plots 10 growing seasons after thinning. The last measurement was completed in the fall of 2012. Data on spruce budworm defoliation levels was collected on all plots each year in the fall.

The five-year results of this study were published in 2011:

D'Amato, A.W., S. J. Trombly, M. R. Sanders, K. J. Puettmann, & M. Albers. 2011. Five-year response of *Picea glauca* plantations thinned following spruce budworm outbreaks in Minnesota. *Northern Journal of Applied Forestry 28:72-78*, or http://silviculture.forestry.umn.edu/Publications/index.htm.

The ten-year re-measurements are currently being analyzed.

Forest Health Program Training Accomplishments

2012 Forest Pest First Detector

Now in its fifth year, the Forest Pest First Detector program continues to train dozens of volunteers to respond to reports of exotic forest insects and diseases called in by the public to the Minnesota Department of Agriculture (MDA). Trained First Detectors are contacted by MDA to connect them to a caller located in their part of the state, and the First Detector responds to help diagnose the issue and report back to MDA.

Seven workshops were held in locations around Minnesota, including the University of Minnesota Landscape Arboretum in Chaska (February 22), Whitewater State Park in Altura (February 28), U of MN Northwest Research and Outreach Center in Grand Rapids (March 1), Technology and Information Education Services (TIES) building in St. Paul (March 6), the Duluth Entertainment and Convention Center (March 9), and at the Alexandria Technical and Community College in Alexandria (March 14). An additional workshop was held in September at Minnesota State College Southeast in Red Wing. Training topics in 2012 included Asian long-horned beetle, emerald ash borer, gypsy moth, brown marmorated stink bug, thousand cankers disease of walnut, Oriental bittersweet, and managing firewood. Continuing education credit is offered for the International Society of Arborists, the Society of American Foresters, and Minnesota Tree Inspectors.

The First Detector team consists of agency partners who organize registration, take turns giving presentations, and proctor the Tree Inspector Certification exam at the various workshop locations. Currently the team includes Mark Abrahamson, Monika Chandler, Bob Koch, Kathy Kromroy, and Lucy Hunt (MDA); Brian Aukema (Department of Entomology, University of Minnesota); Val Cervenka and Ken Holman (DNR); and Mary Kay Ferguson, Angie Gupta, Jeff Hahn, Dean Herzfeld, Gary Johnson, Mike Reichenbach, and Gary Wyatt (University of Minnesota Extension).
Each year the workshops attract interested citizen volunteers as well as individuals from all areas of forestry-related fields including private consultants, soil and water conservation districts, city and county employees, tribal foresters, tree care companies, master gardeners, tree care advisors, and master naturalists. In 2012 the team trained 84 individuals.

Information about the workshops can be found on the MyMinnesotaWoods website, at http://www.myminnesotawoods.umn.edu/forest-pest-first-detector .

Northwest Region Training

Formal presentations		
Title	*Audience and location*	*Attendees*
MN State Report	USFS Cooperator's meeting in St. Paul	32
Climate Change	PFM meeting at DECC in Duluth	60
Climate Change and Forest Health	Climate Change Symposium for CFANS at Cloquet Forestry Center	40
FH update	Walker, MN for DNR, CNF and LLBO	65
FH update	Forest History Center for MFRP	35
FH update-webinar	Univ. of MN Extension	+
Oak pest management	Oak Symposium, CFANS, at St. John's University, St. Cloud	70
FH update	Leech Lake Band of Ojibwe in Cass Lake	30
Timber Sale Design School	DNR class at Cloquet Forestry Center	10
MN State Report	North Central Forest Pest Workshop	120
FIA – Insects and Diseases	FIA contractor training at Resource Assessment	21
Common I & D problems	Forest landowners in Cross Lake	40
CSA - I & D	CSA contractor training at Resource Assessment	9
Total attendees		**532 +**

Northeast Region Training

Formal presentations		
Title	*Audience and location*	*Attendees*
Woodland Owners' Workshop	NROC Grand Rapids, private forest landowners	35
EAB update	PFM Statewide meeting CFC	70
White spruce thinning and management	Orr White Spruce Field Day, DNR Foresters	20
I&D Training Day	Cloquet Forestry Center	37
I&D update	Silviculture meeting	20
I&D training and field trip	Superior National Forest Grand Marais	15
I&D field training	Big Falls	2
I&D training for FIA	FIA contractors, Forest History Center, Grand Rapids	25
Invasive species seminar	Itasca Community College	22
Douglas-fir beetle in MN	UMISC La Cross WI	30
What's Bugging Your Trees	Cross Lake Community Center Chautauqua	40
I&D training for CSA inventory	DNR Resource Assessment contractors	10
I&D Update	Statewide Silviculture workshop CFS DNR Foresters	50
Total attendees		**375**

Central Region Training

Formal presentations		
Title	*Audience and location*	*Attendees*
Oak Wilt: Diagnosis	Minnesota Shade Tree Short Course	50
Forest Health Update	DNR Area Rochester Meeting	20
Oak Wilt: Prevention	DNR: Parks and Trails	20
Forest Health Threats	Carver/Scott Master Gardeners	45
Forest Health Update	DNR Cambridge Area meeting	15
EAB Management	Winona County Initial Response meeting	30
Chemical Control of Oak Wilt	Midwest Invasive Species Conference	100
Oak Wilt: Silviculture	Silviculture Program Meeting	75
Forest Health Update	Little Falls Area Meeting	15
Total attendees		**370**

Forestry Invasive Species Program

General Program Accomplishments

Development and acceptance of circular letter 6500-6 (internal division policy) occurred in late 2011. Outreach to inform field staff in how to apply the policy and how to use the resources provided continued into early 2012. The circular letter covers the roles and duties of all personnel involved in field site management including development and enforcement of contractual agreements. Related resources included a decision table to assist field staff in determining when certain specifications were needed to address site-specific circumstances.

In October, the Minnesota Invasive Species Advisory Council and the Midwest Invasive Plant Network (MIPN) hosted a large multi-state conference in La Cross, Wisconsin. Posters and presentation topics included all aspects of aquatic and terrestrial invasive species management. Over 400 land managers attended, including representatives from most of the DOF management areas

Under guidance from the Operational Order 119 steering committee, DOF updated their ash management guidelines (developed in 2011) and EWR developed theirs. Approval of Operational Order 119 and distribution to field staff is expected in early 2013. To help raise the awareness of field managers to ash management options, a workshop in Aitkin County was planned for early 2013.

1. Management of Emerald Ash Borer (EAB)

With the EAB find and quarantine of Winona County in 2011, an incident command structure was put in place to address outreach to area businesses and residents and to facilitate sanitation on effected public lands. These included MNDOT lands along Interstate 90 and DNR lands within Great River Bluffs State Park. The Division of Forestry (DOF) and MDA staff formed a unified command, guiding local efforts. Several public meetings were held in the area. Sanitation efforts were completed over the 2010-2011 winter season. In October 2011, DOF flew the state park and surrounding area, including a long stretch of Hwy 61 along the river to detect and map declining ash. In 2012, the interpreted photographs were distributed to area partners and ground-truthed. No new infestations were found using these photographs. However, later that summer, DNR Parks and Trails staff found several small infestations scattered around the park.

Based on a previous agreement with MDA, DNR took the lead to identify members and authorize a local incident command to address pest management at a landscape scale. The DNR hosted a stakeholders' meeting and provided an overview of the current situation, implications and potential management options. Then attendees were asked for their input on representatives to a local unified command. State, county and city representatives were identified. Over the 2012-2013 winter, representatives were authorized with the first meeting and a county-level response plan scheduled for early 2013.

Also in 2012, new finds were discovered in east St. Paul, west Minneapolis, and La Crescent in Houston county. These infestations are all being addressed under the collaborative leadership of MDA.

2. Gypsy Moth Management

DNR staff participated in all advisory committee meetings, treatment incident command (calls held weekly) and life stage surveys after the moth trap results were in. DNR staff was instrumental in aerial safety and radio communications between flight and ground crews. A more detailed summary of the year's activities can be found elsewhere in this document.

The evolution of moth populations along the North Shore is noteworthy. Moth captures were high along the shore creating a continuous arc of reported moths extending from northwestern Wisconsin across the lake and up through the middle of Lake County, Minnesota. Alternate life stages were also found near the border of Cook and Lake counties. Based on these developments, technical advisors to the federal program supporting treatments within Minnesota recommended that Cook and Lake counties be quarantined and that trapping be cut back to a 500 km

grid. To discuss their recommendation and possible Minnesota responses, a meeting of the statewide executive committee (GMSEC) was scheduled for early 2013.

3. Ecological and Water Resource Grant Management

Every year, the DNR Division of Ecological and Water Resources (EWR) distributes requests for proposals for invasive species work on state lands. Field staff submits proposals from all over the state. With state general funds, EWR awards grants to each of the landed divisions based on priorities set within each division. The Division of Forestry (DOF) has been successful in obtaining through EWR in each of the last several years. As our budgets continue to decline, we are grateful for their contributions.

The majority of the funds over the years was spent in three areas. These were first to equip each of the major forestry field offices with power washers (2009) and purchasing duplicate water bags for the helicopters used in fire suppression, one for use in infested waters and one for use in uninfested waters (2010). Second was to inventory all rights-of-way along maintained roads within state forest boundaries (2009-2010). This included all public and privately owned roads. Third was to inventory all DNR administered gravel pits and to treat active gravel pits to help control noxious weeds like spotted knapweed (2010-2011). The majority of the other spending was on buckthorn management ahead of harvest operations to knock back heavy infestations of the shrub to ensure sufficient hardwood regeneration.

EWR Grants Fiscal Years 2008-2013

Category	FY08	FY09	FY10	FY11	FY12	FY13
Woody invasive spp. mgmt.	0	$ 31,287	$ 62,100	$ 21,500	$ 16,850	$ 33,200
Noxious weed mgmt.	0	$ 6,525		$ 45,000	$ 5,450	$ 1,800
Inventory/detection	$ 22,000	$ 95,487	$ 79,000	$ 20,000	$ 15,000	$ 5,750
Cleaning equipment	0	$ 90,653	$ 12,657	0	0	0
Outreach	0	0	0	$ 11,200	$ 3,800	$ 3,393
Total	$ 22,000	$ 223,952	$ 153,757	$ 97,700	$ 41,100	$ 38,393

In fiscal year 2013, the division received EWR grants totaling $38,393.00. Three of the field projects started this year will focus on buckthorn management at the area level. Treatments consist of stump and basal bark treatments using Garlon. One will tackle spotted knapweed along forest rights-of-way. The other two will match USFS grant funding, $3,393 toward the outreach campaign branded as **PlayCleanGo: Stop Invasive Species in Your Tracks**, and $5,750 toward a large buckthorn detection project in central Minnesota. All fiscal year 2013 projects funded by EWR are scheduled for completion by June 30, 2013.

4. USFS Grant Management

Forestry's invasive species program has been fortunate to be awarded four USFS grants within the six years of its existence. These include:

- 2008 – Addressing the relationship between outdoor recreation and the spread of terrestrial invasive species. This included a series of nine focus groups and a large phone survey to describe the knowledge, attitudes, and behaviors of recreationists. Based on the survey results, an education plan was developed to guide development of an outreach campaign. This project was completed in 2010.

- 2010 – Inventory and management of invasive species within the Kettle and St. Croix Scenic Riverways. This included inventory and management of woody invasive species and garlic mustard within these critical riparian corridors. In 2012, the wall-to-wall inventory of woody invasive species on participating state and private lands within the Kettle and St. Croix Scenic Riverways was completed and the data distributed among participating landowners.

- 2012 – **Expanding PlayCleanGo: Stop Invasive Species in Your Tracks** to disrupt the link between outdoor recreation and the movement of terrestrial invasive species. In 2012, a marketing contractor was

hired to develop and implement a marketing plan and an interagency group assembled to serve as the core team overseeing the project. The marketing plan includes the first annual **PlayCleanGo Day** to be held at six state parks on June 8, 2013.

- 2012 – Addressing buckthorn along the leading edge of invasion. This project uses methods developed using EWR funds to detect and map buckthorn infestations using aerial photography. The goal of the project is to describe infestation levels along the zone of transition from generally infested to sparsely or uninfested areas and then use the photography to prioritize and tackle key hot spots of infestation with the goal of slowing the spread of buckthorn. Over 350,000 acres were flown in early November and aerial photography obtained. Photo interpretation is scheduled for completion in early 2013.

5. DNR Firewood Program

The statute that initiated the DNR firewood program was passed in 2006. With the bill signing in mid-April, 2007, division staff had a month to design, implement and populate the public interface through which Minnesota campers could identify DNR approved vendors near their intended camping area. While the program has made huge in-roads toward changing pubic behavior (reduced the number of campers bringing firewood from home from approximately 60 percent to nearly 20percent), managing the program behind the scenes has been a challenge.

The statute gives the DNR Commissioner the authority to approve firewood for use on DNR administered lands. The statute does not apply to the use of firewood on other lands, nor does it apply to the sale of firewood within the state of Minnesota.

Firewood allowed on DNR administered lands is defined in a Commissioner's Order. Currently there are four types of firewood that can be brought into a state park:

1. Clean, kiln-dried scrap lumber, free of nails, paint and varnish
2. Firewood to be used on-site, purchased directly from the state park.
3. Untreated firewood harvested within 50 miles of the state park where it is to be used and purchased from a DNR approved firewood vendor
4. Firewood treated in a MDA certified kiln and purchased from a DNR approved firewood vendor

Clean, kiln-dried lumber need not be purchased from a DNR approved vendor. It can come straight from home or a construction site. Firewood can be purchased at any DNR state park that allows camping. The parks can cut firewood on their own lands to be sold to park visitors or purchase their firewood through local suppliers. Bid specifications exclude ash and any wood harvested more than 100 miles from that state park.

Firewood vendors can become DNR approved by submitting a complete application to the nearest FOR Office (or Camden State Park, if in SW Minnesota). They can be approved if: A) their wood was harvested within 50 miles of the park for which they'd like to be approved or B) their wood was treated in an MDA certified kiln and they provide that documentation along with their application.

In the firewood industry, contracts and/or agreements are typically made in the fall to supply firewood for the following camping season. Then the wood is cut over the winter and delivered the following spring. Based on that time-line, the DNR went to a system of annual renewal beginning each fall. That way, DNR approved firewood vendors (currently numbering 780) know they will be approved for the wood they plan to cut and deliver before the next camping season.

This year the DNR added a system of renewal that allowed those vendors working on the same land from year to year to renew their application using a return addressed post card. The system seemed to work well and saved considerable time. Internally, the system has been improved through a series of canned reports that summarize DNR approved vendors by facility or by county. The reports are updated before April of each camping season, so park staff knows whose wood is approved for their facility.

Program Update

In early 2007, the DNR Division of Forestry (DOF) initiated its invasive species program with funding from the state fish and game fund (Outdoor Heritage) by hiring a coordinator to develop division guidelines for invasive species management. At the time, the focus was terrestrial invasive plants so the program was housed within the forest management unit. Since then the program has evolved considerably. It now oversees all aspects of terrestrial invasive species management, including insects and diseases of trees, and invasive plants. In that, the program is unique. Only one other program within the DNR, Ecology and Water Resources, has a similar focus, concentrating on invasive land animals instead of invasive tree pests.

With the inclusion of invasive tree pests, the DOF invasive species program was moved to the forest protection unit where staff works closely with the forest health team. However, invasive species program funding and management remain separate and distinct from the forest health program.

The goals of the Forestry Invasive Species Program are to

- protect Minnesota forest resources and mitigate potential forest impacts through outreach, prevention, inventory and management of terrestrial (land-based) invasive species (TIS),
- prevent the accidental introduction or spread of TIS during DNR field operations,
- help ensure forest sustainability on lands managed by DOF by controlling TIS infestations which threaten forest regeneration, structure or function, and
- ensure compliance of all state and federal invasive species regulations by all staff, contractors and volunteers working on lands administered by DOF.

Duties and responsibilities

State funding covers 1.5 FTEs. While both positions are located in the metropolitan area, one is the statewide program coordinator and the covers half of the duties carried out by the central region forest health specialist. The other half of that position is paid for by the annual USFS cooperative forest health grant.

Program responsibilities include:

- Develop and implement the division's invasive species program, which includes
    - Developing and facilitating compliance of division invasive species policies
    - Developing and delivering staff invasive species trainings
    - Writing and posting permit, lease and contract specifications for use by field site administrators
    - Technology transfer, which includes monitoring and reporting changes in development in invasive species occurrences, impacts, research and management tactics
    - Facilitating field efforts to control invasive species impacting forest sustainability
    - Exploring and pursuing outside funding to address division forest management priorities.
- Department lead for the DNR firewood program. Forestry provides oversight of the overall program and implements the DNR approved firewood vendor approval process. The division of Parks and Trails is responsible for enforcing department policies at state recreational facilities.
- Department lead implementing operational order 119, directing each landed division to develop discipline specific guidelines for ash management in the face of potential impacts from the emerald ash borer (EAB).
- Department liaison for the interagency gypsy moth, emerald ash borer and cooperative agricultural pest (CAPS) programs (all under MDA's lead).
- Division lead for DNR activities related to the gypsy moth and emerald ash borer programs.
- Division lead (central region forest health specialist) for DNR activities related to thousand canker disease and oak wilt.
- Division liaison for the noxious weed program (under MDA's lead), cooperative weed management program (under BWRS's lead) and the Minnesota Invasive Species Advisory Council (co-chaired by MDA and the DNR).

- Division liaison on the department's invasive species oversight team (Operational Order 113).

PlayCleanGo: Stop Invasive Species in Your Tracks

Project Proposal and Launch
Very little outreach has been carried out on any scale regarding the impact of terrestrial invasive species on natural resources and recreational areas. As a result, the public is largely unaware of their role in spreading terrestrial invasive species. Among the Minnesota recreationists surveyed, only 34 percent could name a terrestrial invasive species, while most had heard of one or more aquatic invasive species. Since 2006, the *Stop Aquatic Hitchhikers!* campaign has been successfully extended through a partnership of multiple organizations across Minnesota, Wisconsin, and Iowa. Surveys show that boaters and anglers exposed to the campaign's brand and messages were much more aware and likely to take future action at water accesses (97 percent).

By building on what has been learned from the *Stop Aquatic Hitchhikers!* campaign, resource managers can help slow the spread of terrestrial invasive species moving through recreational pathways. State funding and interagency cooperation resulted in the branding and release of **PlayCleanGo: Stop Invasive Species in Your Tracks** (developed by the same contractor who developed the *Stop Aquatic Hitchhikers!* brand for the Fish and Wildlife Service) with the goal of disrupting the link between outdoor recreation and the spread of terrestrial invasive species. The Forestry division hired.

The outreach campaign built on the education plan developed with help from a 2008 USFS competitive grant. A website was built and established, with simple steps for recreationists to follow to help stop the spread of terrestrial invasive species. Campaign materials were mailed to forest health and invasive plant specialists across the country resulting in a dozen new **PlayCleanGo** partners.

To measure "treatment success" and provide information to guide future efforts, the baseline survey of Minnesota recreationists will be repeated. The survey will describe participant attitudes at the end of the project and the change in recreational behaviour that help protect forest resources.

Strategic Application
The *2008 Minnesota Statewide Conservation and Preservation Plan* lists invasive species among the top six drivers of change that negatively impact our natural resources. The *2010 Minnesota State Forest Resource Assessment and Strategies* (aka the "Minnesota Action Plan") lists maintaining forest health and productivity and maintaining the strong tradition of recreation as two of the top ten issues currently facing the state. The document goes on to highlight challenges and opportunities to "identify, manage and reduce the threats to forest and ecosystem health", among them being the association between recreational activities and the spread of terrestrial invasive species.

As noted in the state action plan, "Minnesota has always had a strong tradition of nature-based outdoor recreation with participation in outdoor activities well above the national average, especially in hunting, fishing and boating. These activities and increasingly bird-watching, motorized and non-motorized activities all rely on access and interaction with abundant natural resources such as forest lands, lakes, rivers, blufflands, grasslands and parks and recreation facilities. The state is committed to preserving and enhancing outdoor recreational use for both present and future generations to enjoy." The state is also committed to preserving forest health and that means disrupting the association between recreation and the spread of terrestrial invasive species. Specific strategies listed in the

Minnesota action plan to address these issues include: 1) Work with partners to identify opportunities for forest protection; and 2) Manage to reduce the spread of invasive species.

Partners and Roles

The following organizations will be committing staff time to the core team of advisors guiding the project (the group had not yet met at the time of this writing):

- Minnesota Tourism (Explore)
- Minnesota Department of Agriculture (MDA)
- Minnesota Department of Transportation (DOT)
- University of Minnesota (UMN)
- Minnesota DNR Forestry (DOF)
- Minnesota DNR Ecological and Water Resources (EWR)
- Minnesota DNR Parks and Trails (PAT)
- Minnesota DNR Creative Services (OCO)
- USDA Forest Service, State & Private Forestry (USFS)

Forestry staff oversaw development of the brand and soft launch of **PlayCleanGo: Stop Invasive Species in Your Tracks** in 2011. The same staff will administer the FY13 USFS grant. To date a marketing contractor has been selected and the contract executed to develop and implement a hard launch of the outreach campaign.

EWR contributed time to incorporate **PlayCleanGo** into the DNR 2012 state fair invasive species exhibit and helped develop the marketing RFP. EWR staff will continue to be a key partner in on-going outreach efforts.

OCO staff contributed time to incorporate **PlayCleanGo** into DNR 2012 state fair invasive species exhibit.

The campaign then became a focal point in a large new invasive species Minnesota State Fair exhibit installed in the DNR building in August. The exhibit, put together by Forestry and EWR staff, included four major stations: earthworms, aquatics, terrestrial invasive plants and a "Crime Scene Investigation" station that focused on diagnostic techniques used in detecting Asian carp, oak wilt, zebra mussels, emerald ash borers, Asian long-horned borers and brown marmorated stink bug. The exhibit was very popular with fair goers, attracting approximately 500,000 visitors over a 12-day span. Staff from all of the partners listed above helped at the various stations in the exhibit.

The core team is schedule to meet with the marketing contractor in January 2013.

Project Timeline

Year One:

- Develop marketing and communications plan
- Develop, design, layout and print all outreach materials
- Develop web-based materials
- Develop a table top display and identify up-coming events where a booth would be appropriate
- Distribute posters and brochures through current partners
- Develop and distribute media as outlined in the marketing plan.

Year Two:

- Install trail and campground signage
- Expand partners to include private campgrounds, resorts, retailers and sporting goods manufacturers
- Participate in recreational events around the state
- Distribute posters and brochures through events and expanded list of partners

Year Three:

- Continue to expand list of participating partners
- Continue to participate in recreational events around the state
- Continue to distribute posters and brochures through events and partners
- Implement phone survey using methods developed previously to measure "treatment success".

Deliverables Completed to Date

- Developed initial website (see www.playcleango.org)
- Developed partners packet including a brochure, poster and rack card and distributed it to Forest Health and Invasive Species Cooperators.
- Developed and distributed RFP for marketing contractor and executed contract
- Initiated weekly briefing with internal DNR partners
- Assembled core team members and scheduled initial meeting with the marketer to take place 1/3/13.
- Added USFS Northeastern Area logo to list of PlayCleanGo partners on our website.

Deliverables in Progress

- Managing enquiries and requests generated by mailing to forest health and invasive species cooperators.
- Preparing for display at DNR Round Table Jan. 4-5, 2013.
- Preparing for initial meeting of the PlayCleanGo core team.

Terrestrial Invasive Species Program Special Projects

Addressing the Leading Edge of Buckthorn Invasion Across Minnesota

Project Overview

The invasive plant common buckthorn (*Rhamnus carthartica)* has been in Minnesota for over one hundred and fifty years. During that time it has spread into many of the state's forests, pushing out native species, reducing forest regeneration by competing for space and nutrients, contributing to soil erosion and helping spread certain pests and pathogens. Detecting and mapping buckthorn in a timely and cost effective way is essential to the effort to slow its spread and mitigate its negative effects in high value forests.

Over the past four years, MN DNR forestry has developed and tested an aerial detection method that has been found effective for mapping the existence of buckthorn by taking advantage of the fact that buckthorn leaves remain bright green and attached to branches for one to two weeks after most over story species have dropped their leaves. Aerial photos at relatively small scales can then be acquired and interpreted for buckthorn. The interpreted detail is then transferred to an ortho-rectified photo which provides both a photo image and an accurate map of buckthorn location suitable for navigation in the forest to locate and remove the invasive buckthorn plants. Once confirmed, survey results can be incorporated into a set of shape files shared with partners through the MNDNR's data deli.

This project aims to utilize those methods to describe the leading edge of buckthorn invasive. With that data, we propose to identify infestations along the leading edge where treatment success is likely and slowing the spread of invasive is possible. A combination of state and private funds would be used to implement management practices.

Strategic Application

The 2008 Minnesota Statewide Conservation and Preservation Plan listed invasive species among the top six drivers of change negatively impacting our natural resources. The 2010 Minnesota State Forest Resource Assessment and Strategies highlighted challenges and opportunities to "identify, manage and reduce the threats to forest and ecosystem health." Chapter four of that document lists, among others, three strategies that can address

invasive plants: *1) Work with partners to identify opportunities for forest protection (page 33); 2)Manage to reduce the spread of invasive species (page 50); and 3) manage to control and reduce existing invasive species populations* (*page 50*).

NA Strategic Plan for FY 2008-2012 Goal 1 is *Promote Sustainable Forest Management. Objective 1.C: Maintain the health and vitality of forest ecosystems at risk from potentially damaging agents* (Page 14).

Partners and Roles
St. Paul DNR Forestry personnel administer the grant. DNR Forestry and Wildlife field staff will oversee ground-truthing and the implementation of management practices. DNR Forestry Resource Assessment is responsible for all photo acquisition and interpretation.

Planned Timeline
Year one:

- Fall and winter 2012 – At the end of October, acquire 1:22,000 scale, stereo aerial photography of eight state forests and one large wildlife management area (total of 257,500 acres) using a 25MB color camera and a 16 MB CIR camera. Photo acquisition will consist of parallel flight lines flown one-half mile apart. Interpret the data and generate digital layers and field maps**.**
- Spring and summer 2013 - Ground-check a subset of the polygons mapped to provide a formal accuracy assessment of the photo-interpretation and statistically valid input into multi-stage estimates of the buckthorn population densities. Evaluate the results of ground surveys. Determine the need (if any) for additional aerial photography. Identify isolated or newly expanding buckthorn infestations along the apparently leading edge of invasion. Line up the work to take place during the fall and winter treatment season.

Year two:

- Fall and winter 2013 – If needed, acquire additional photography to complete the coverage. Interpret any new data and generate digital layers and field maps. Initiate pest management in the top priority sites.
- Spring and summer 2014 – Complete any remaining ground-checks to complete the survey work. Inspect winter treatment sites and determine the need for spot treatments. Initiate spot treatments as needed. Line up the work to take place during the fall and winter treatment season.

Year three:

- Fall and winter 2014 – Complete assessment and description of the leading edge of buckthorn invasive. Continue pest management practices in high priority sites.
- Spring and summer 2015 – Inspect winter treatment sites and determine the need for spot treatments. Initiate spot treatments as needed. Identify areas still needing treatment and outline next steps to continue the work to slow the spread of buckthorn invasion.

Deliverables Accomplished to Date

- Identified program coordinator for the DNR Division of Fish & Wildlife
- Identified state land areas to be flown.
- Took aerial photography over approximately 350,000 acres.
- Photo interpretation has been initiated, but is not complete as of this writing.

Deliverables in Progress

- Photo interpretation is in progress and is expected to be complete by March, 2013

Project Challenges
Fall colors occurred two weeks earlier than expected. Weather for flying was off-and-on during the flight window; however, all flights were completed as intended.

Central Region Invasive Species Team

To assist the Regional Management Team (RMT) and region staff with implementation of Operational Order 113 related to invasive species, a regional management team was formed in July 2012. The Invasive Species Team consists of representatives from the Divisions of Forestry, Parks and Trails, Lands and Minerals, Ecological and Water Resources, Fish and Wildlife, Enforcement, and Operational Services. The team has five primary objectives:

1. Focus on improving invasive species management at work sites
2. Assist Region 3 divisions in developing practices and focused approaches to implementing Operational Order 113
3. Division representatives will serve as points of contact to field input on Operational Order 113 implementation challenges from staff
4. Division representatives will relay feedback from field staff regarding implementation of Operational Order 113 to the RMT
5. Align discipline guidelines and review documents to determine where they complement and conflict to ensure staff from each discipline does not have conflicting BMPs and management strategies with Operational Order 113

Invasive Species Inventory and Management along Critical River Corridors

Project Overview

Buckthorn is widespread in southern Minnesota and is now expanding its range into the northern half of the state. Garlic mustard is much less common, but occurs in scattered pockets in southern Minnesota and in the Twin Cities. In the northern half of the state where they are known to occur in scattered pockets, garlic mustard and buckthorn are found along two important river corridors, the Kettle and St. Croix rivers along the Wisconsin border. In a two-pronged approach we intend to protect and restore forest habitat within these critical riparian corridors along the eastern edge of Minnesota. We will use a combination of survey methods to map these species on all lands occurring within state statutory boundaries and where they occur in small isolated infestations, we will apply a combination of mechanical and chemical treatment methods to eliminate the infestations. We will prioritize and manage larger infestations to contain them and reduce their impact on the forest habitat. We will support work in the Soil and Water Conservation Districts to prioritize and suppress infestations on private lands within these corridors and using private funds restore key forested habitats.

Strategic Application

The project addresses *2010 Minnesota State Forest Resource Assessment and Strategies* to "identify, manage and reduce the threats to forest and ecosystem health." Two specific strategies listed include: 1) Manage to reduce the spread of invasive species; and 2) manage to control and reduce existing invasive species populations (page 50). It also addresses the goals of the state wild and scenic river program in managing invasive species on private lands within designated program boundaries and thus helping to sustain those critical resources.

This project addresses *NA Strategic Plan for FY 2008-2012 Goal 1: Promote Sustainable Forest Management; Objective 1.C: Maintain the health and vitality of forest ecosystems at risk from potentially damaging agents, Page 14*. The project also addresses the goals of the National Wild and Scenic River Program by protecting critical watershed habitat.

Partners and Roles

- St. Paul DNR Forestry personnel will administer the grant. Division field staff had intended to implement buckthorn management on state forest lands, but the 2010 government shut-down, 2011 blow-down and 2012 floods usurped field time.

- DNR Division of Ecological and Water Resources contributed staff time and funds to manage invasive species on Scientific and Natural Areas.
- DNR Division of Parks and Trails contributed staff time and funds to manage invasive species in state parks
- DNR Forestry Resource Assessment implemented all inventory work on state lands.
- Washington County Conservation District administered the county grant, pass-through grants to private landowners and inventoried all participating private lands in the county
- Chisago Soil and Water Conservation District also administered the county grant, pass-through grants to private landowners and inventoried all participating private lands in the county
- National Park Service (contributions not included in the grant match) served on advisory team developing best management practices and awarding private land grants.
- Private landowners (includes two communities) contributed time and money to manage invasive species on their lands.

Planned Deliverables

- All state lands (park, forest, and scientific and natural area) within 100 meters of the Kettle and St. Croix rivers were surveyed, and existing populations of garlic mustard, common and glossy buckthorn were described and mapped. This included portions of the St. Croix State Forest as well as the St. Croix, Wild River, William O'Brien, and Afton State Parks and the Lost Valley Scientific Natural Area. The data was stored in the DNR database for terrestrial invasive species and the DNR "data deli" shared with all DNR employees and outside partners.

- Existing infestations occurring on state land will be treated using a combination of mechanical cutting (through mid-May), hand pulling (through June) and early and late chemical treatments. The treatments will include the Banning State Park river access located in the city of Sandstone. Biocontrol agents are not yet available for release, so they will not be used as part of this project. However, survey data will be assessed for future potential use of biological control. A system of monitoring and assessment will be set up and initiated for all treatments carried out on state land. Treatments are not complete and have not yet been summarized.

- A cost-share program was developed utilizing existing partners to control buckthorn and garlic mustard occurring on private lands in Chisago and Washington counties. Within that program, infestations were identified and mapped. A system of prioritization was developed to identify where management was feasible and most likely to produce positive results. Sites controlled within the last three years will be surveyed to describe the rate and make-up of recovering plant communities. The system already established to monitor treatment results will be continued on any new treatments applied under this grant.

Deliverables Accomplished to Date

- Project management documents were developed.
- Grant application and management guidelines were developed.
- County contracts were signed to administer work on private lands.
- Private land RFP was distributed and nine private landowner agreements were signed.
- State lands within our project boundaries were inventoried.
- All participating private lands were inventoried.
- Inventory data was proofed and uploaded into the department invasive species database.
- The first tier of management work on private lands was completed in 2011.
- Management work was initiated for the 2012 fall/winter treatment season.

Describe Deliverables in Progress

- Management activities on state lands and within the City of Sandstone are not yet complete. An extension of the grant period is being requested to complete the remaining work.

Project Challenges
The state government shut-down in 2010 cost us about half of our inventory season the first year of the grant.

In 2011, a major storm knocked down a large swath of timber through the St. Croix State Forest and St. Croix State Park (within the project area). Field staff across the state was diverted to help with clean-up efforts and mark damaged stand for salvage. For the remainder of that growing season, those areas were inaccessible for invasive species inventory due to downed trees.

In 2012 flood waters inundated the Kettle and upper St. Croix rivers mid-season. Inventory crews had to wait for waters to recede before continuing the project. Once work resumed, it was clear that some areas had been washed out, potentially removing visible evidence of infestation.

The Resource Assessment Unit within the Division of Forestry went to a new business model the first year of the project. In the new model (outlined after the service level agreement for this project was signed), 100 percent of their costs are charged against their projects. Past projects had been subsidized by the Forestry Division. Without that subsidy, their cost overruns were nearly twice what they had originally quoted us for the project. The overruns will be figured into the final report as matching dollars.

Invasive Species Grant Projects

Every year, both the USFS and the DNR Division of Ecological and Water Resources (EWR) distribute requests for proposals for work on invasive species. The Division of Forestry has been successful in obtaining three USFS competitive grants in as many years, as well as funding through EWR in each of the last several years. As our budgets continue to decline, we are grateful for their contributions. The following is a summary of the work this year funded through those organizations.

Ecological and Water Resources Grants
In Fiscal Year (FY) 12 (ending June 30, 2012), Forestry received $41,000.00 from Ecological and Water Resources (EWR), down from a high of $276,000 in 2009. Six field projects and a portion of an outreach project were funded with this grant. Two field projects were devoted to buckthorn detection and management based on detection methods developed under earlier EWR grants. Aerial photography was taken over approximately 19,000 acres in the Sand Dunes and Fond du Lac State Forests, and Jay Cooke State Park. The areas were flown in early November after oak leaf drop, but before buckthorn leaves had changed color. Even under pine plantations, buckthorn plants as small as four or five feet tall can be detected from the air. Spring ground-truthing helped eliminate false positives so fall management practices can be planned and prioritized.

Twenty acres were treated with herbicides in two road-side noxious weed projects in Aitkin and Littlefork. Seventy-five acres were treated for buckthorn management. Aitkin area used a cut-stump approach on roughly 40 acres, while Lake City grazed goats on a rotation basis on 32 acres of woodlands. Monitoring during FY13 will help determine treatment success.

EWR outreach funding supplemented Forestry funding to develop a brand identity for **PlayCleanGo** (see page 40 for full article), a new outreach campaign developed for the purpose of disrupting the link between outdoor recreation and the spread of terrestrial invasive species.

The division received another EWR grant in FY13 of $35,000.00. Three of the projects started this year will focus on buckthorn management at the area level. One will again tackle noxious weeds along forest rights-of-way and one will supplement USFS grant funding for a large buckthorn project.

Forest Service Grants
In 2010, a three-year grant was received from the USFS to address woody invasive species along the Kettle and St. Croix scenic waterways. Because of the 2011 blow down and 2012 flood, the three-year project was extended to June 30, 2013. In 2012, the last of the state lands within a 100-mile buffer of either river was inventoried along with

fourteen tracts of community or privately-owned land within the Scenic River boundaries. At times using river accesses to shuttle from spot to spot, crews of two to five walked side-by-side up each section of the river that could be walked (major bluffs were excluded), to map all woody invasive species and garlic mustard infestations. County staff did the same for the various community and private land participants. Federal funds were then matched through management projects carried out on those state, city and private lands found to be infested.

Two new USFS grants were received in FY12 and the projects started in FY13. The first is a large buckthorn project to survey and map buckthorn on state lands along a wide swath of the state running roughly between Sandstone and Detroit Lakes. Based on existing data, this area seems to be the "leading edge" or transition zone between areas heavily infested with buckthorn and areas with little to no buckthorn within their native plant communities (community forests are another matter and a source of infestation for neighboring lands). Approximately 300,000 acres of state forest and wildlife lands were flown in October. Photo interpretation will continue through early spring, with management projects to start next fall.

The second project is the formal launch of **PlayCleanGo**. An initial "soft" launch was done in FY12 when the website went live. Several ads were aired on local TV channels 5 and 45 and the program was featured in a large new invasive species exhibit in the Minnesota State Fair DNR building. Through a broad mailing to cooperators in forest health and invasive species management, organizations were invited to become **PlayCleanGo** partners. Partners, given full access to **PlayCleanGo** graphic and media resources, now include several state and federal agencies and two recreational organizations. The USFS grant will be used for a formal launch this next spring. A marketing plan will be developed and executed over the next two years, and then in the third year, a large phone survey will be conducted to assess knowledge and behaviors among Minnesota recreationists. The survey results will be compared with baseline survey data obtained in 2009 under an earlier USFS grant to determine the success of the outreach campaign and how it can be expanded in the future.

Winona County Emerald Ash Borer Extended Response Team

Emerald ash borer (EAB) was first detected in Winona County in August 2011 on two prism traps located near Lamoille and Dakota, Minnesota. Subsequent surveys revealed that emerald ash borer was widely distributed throughout the area; however, the highest EAB populations were located within Great River Bluffs State Park and near the intersection of Interstate 90 and County Road 12.

The Minnesota Department of Agriculture (MDA) is the lead state agency responsible for preventing the introduction into and dissemination within Minnesota of terrestrial invasive species. The Minnesota Department of Natural Resources (DNR) serves in a supporting role to the MDA, and as such, was designated to lead an initial EAB response team in Winona County. That team, whose members included representatives from the cities of Winona, La Crescent, Goodview, and St. Charles, Winona County, University of Minnesota Extension, Minnesota Department of Transportation, Minnesota Department of Natural Resources including the divisions of Forestry, Parks and Trails, Ecological and Water Resources, and Fish and Wildlife, MDA, US Fish and Wildlife Service, USDA APHIS, and USDA Forest Service State and Private Forestry, was responsible for outlining the structure and membership of an extended EAB response team in the region. The initial EAB response team met in October 2012, and attendees were briefed on the history and status of the current infestation, regulatory and operational responses to date, and potential management options to be considered prior to designating the extended response team.

The responsibility of the Winona County EAB Extended Response Team (ERT) is to develop local and landscape level EAB management strategies applicable across all land ownerships in the region for the foreseeable future. The structure of the ERT consists of five members representing various stakeholder groups and land ownerships including the city of Winona, Winona County, DNR, and MDA. The fifth member is the DNR's regional forest health specialist who serves as a liaison between the ERT and the state unified command. The structure and membership of the ERT was finalized in December 2012 and the team began meeting monthly in January 2013.

As part of developing local and landscape-level EAB management strategies, the ERT will be coordinating surveying and monitoring activities, available resources for management activities, community preparedness and response plans, disposal and utilization options, mitigation and outreach activities, and information and education in Winona County. Currently the members of the ERT represent the various stakeholder groups with responsibility for the management of lands currently infested by EAB. Additional members to fill supporting roles on the ERT may be added as the need arises and as EAB infests additional land ownerships.

Winona Invasive Species Working Group

Due to a multitude of invasive species issues in southeastern Minnesota, a local working group based in Winona County was formed in April 2012 to help address terrestrial invasive species concerns such as emerald ash borer and oriental bittersweet. The idea was to create an informal group that can discuss preparedness and response options to better inform management decisions. The group includes the city foresters, representatives of Winona County, local experts such as a Master Gardeners, regional representatives of University of Minnesota Extension, Minnesota Department of Transportation, Minnesota Department of Natural Resources, Minnesota Department of Agriculture, Winona County Soil and Water Conservation District, and the U.S. Fish and Wildlife Service. In addition, because Houston County also faces many of the same invasive species issues and resides in a similar geographic area, representatives from Houston County also participate in the working group. The group meets monthly at the Winona County Government Center.

Activities and Accomplishments

1. Forum for sharing information, plans, and activities related to invasive species issues among various stakeholder groups and agencies
2. Provide updates to working group members on invasive species distribution, new finds, pest activity, and latest research.
3. Organization of staging and disposal areas for ash and other woody plant materials
4. Organization of training opportunities for citizen volunteers (e.g. Master Gardeners and First Detectors)
5. Organization of invasive species detection and delimit surveys (e.g. Oriental bittersweet)
6. Information and education on invasive species issues at public events such as fairs, conferences, open houses, farmers markets, and special interest meetings.
7. Providing landowners with information on available cost-share programs and other resources available for invasive species management.
8. Development of informational, educational, and notification materials for public distribution.
9. Share information and educational materials among working group members from various agencies and stakeholder groups.
10. Better coordinate and streamline the reporting process for invasive species
11. Notification of funding opportunities available to public agencies for invasive species-related projects.
12. Improve communication to and engagement with the general public about emerald ash borer and other invasive species issues.