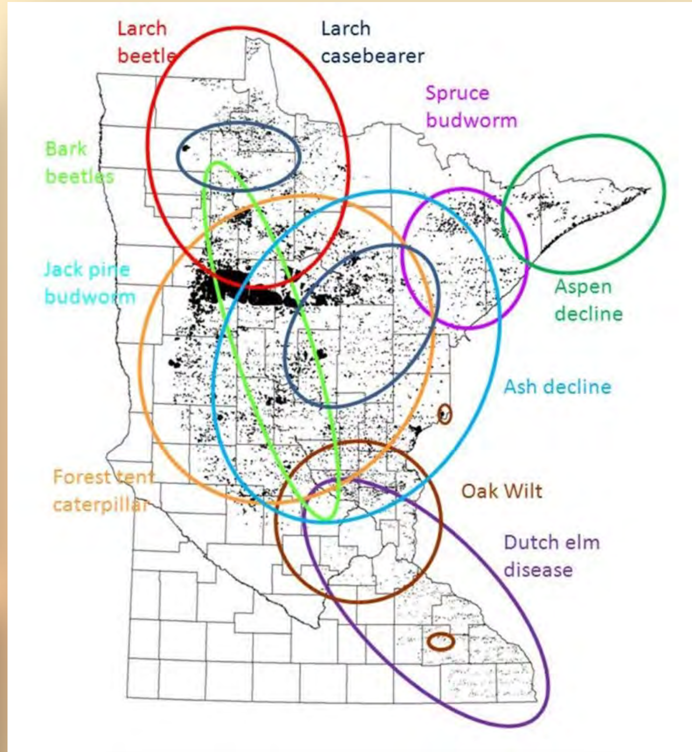
2013
Forest Health Report



MNDNR

The Minnesota Department of Natural Resources Forest Health Report was created by the Division of Forestry Forest Health Unit.

Cover photos clockwise from upper left:
Stormy day on Lake Superior during gypsy moth egg mass survey; map of aerial survey results; bark beetle exit holes; white pine infested by *Pityogenes hopkinsi*

Photo credits: Photos are from DNR forest health staff unless indicated otherwise.

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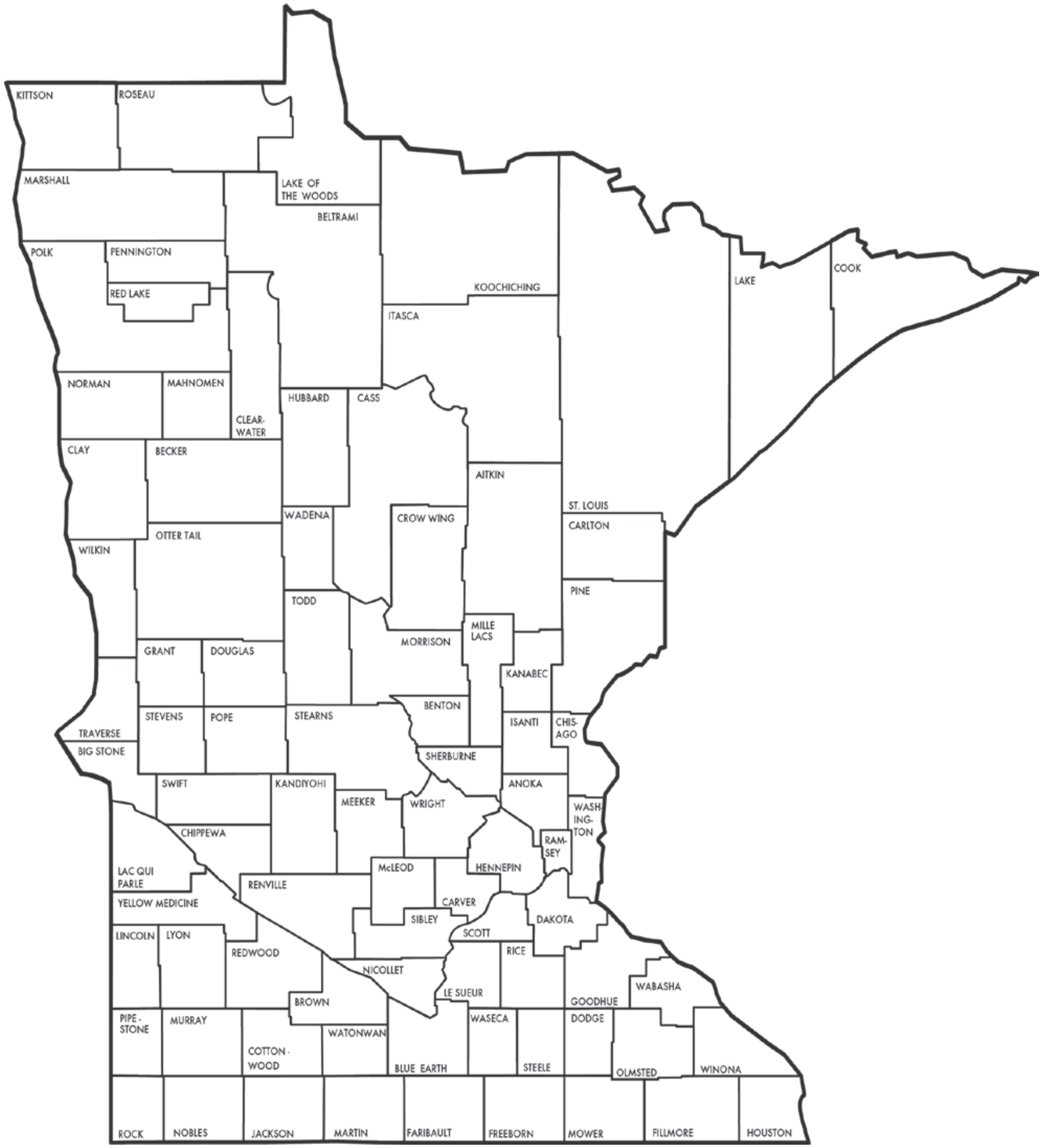
Minnesota County Map



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February 2012-July 2013

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.

Aerial survey results

Since the early 1950s, 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 the Minnesota Department of Natural Resources (DNR) Forest Health and Resource Assessment Units and USDA Forest Service (USFS) Northeastern Area State and Private Forestry (S&PF).

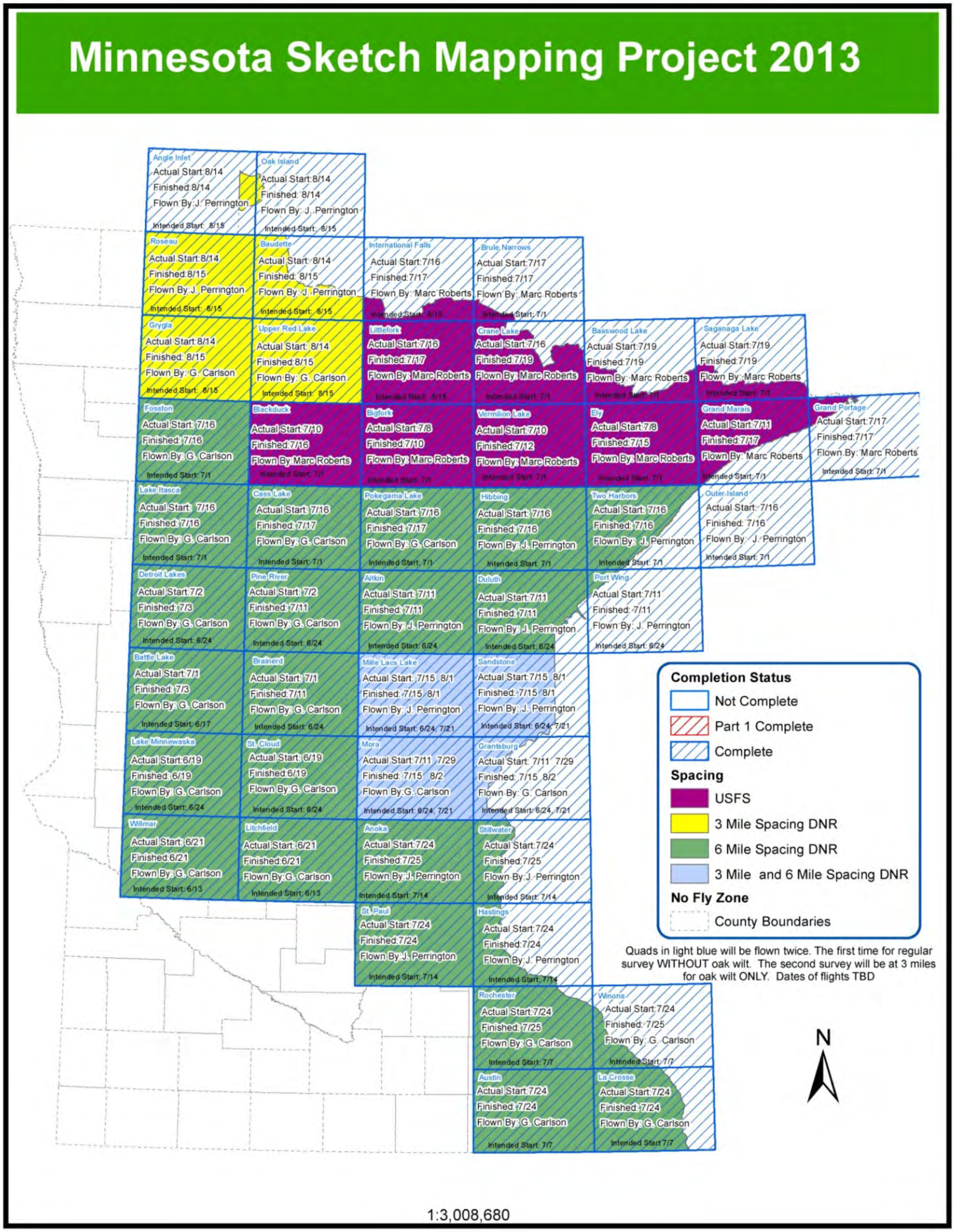
The DNR Forest Health staff plans the scope, timing and intensity of the surveys, trains Resource Assessment staff, provides ground-truthing, analysis, and dissemination of survey data. Resource Assessment staff conducts aerial sketch-mapping on the state quads, digitizes the data and produces digital shape files. For each polygon mapped there are five associated attributes that must be coded and recorded in the air (see p. 10, Cheat Sheet for Coding Damage Polygons in Arcview). USFS State and Private Forestry conducts aerial sketch-mapping on federal land, post-flight map rectification, and holds the final review meeting. Aerial survey results are incorporated into the USFS national database since our procedures and products comply with national standards.

Damage-causing agent	Number of polygons	Number of acres
Ash decline	736	30,707
Aspen decline	341	62,136
Other decline	32	1,990
Bark beetles on pines	56	707
Dutch elm disease	1,105	823
Fire	8	4,491
Flooding	87	2,095
Forest tent caterpillar	2,831	1,073,056
Jack pine budworm	2	324
Larch beetle	2,259	20,624
Larch casebearer	145	16,933
Large aspen tortrix	5	2,552
Leaf rollers of aspen	112	27,928
Oak wilt	1,975	1,473
Spruce budworm defoliation	358	38,029
Two lined chestnut borer	30	22
Fire	8	4,491
Wind damage	34	5,695
Unknown	403	4,839
Grand Totals	**10,519**	**1,294,437**

In 2013, the state portion of the survey began on June 19 and was completed on August 14. The federal portion of the survey began on July 8 and was completed on July 19. Thanks to Resource Assessment's sketch-map team Gentry Carlson and Joel Perrington, who accomplished the aerial survey and data-processing. Thanks also to Marc Roberts, S&PF, for mapping the federal portion of the survey and to Quinn Chavez, S&PF, for post-flight map rectification and the final review meeting. The following three maps illustrated the survey results.

Aerial Survey Plan Map by Quad

Map shows intended and actual start dates and completion dates



2013 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. 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 (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.

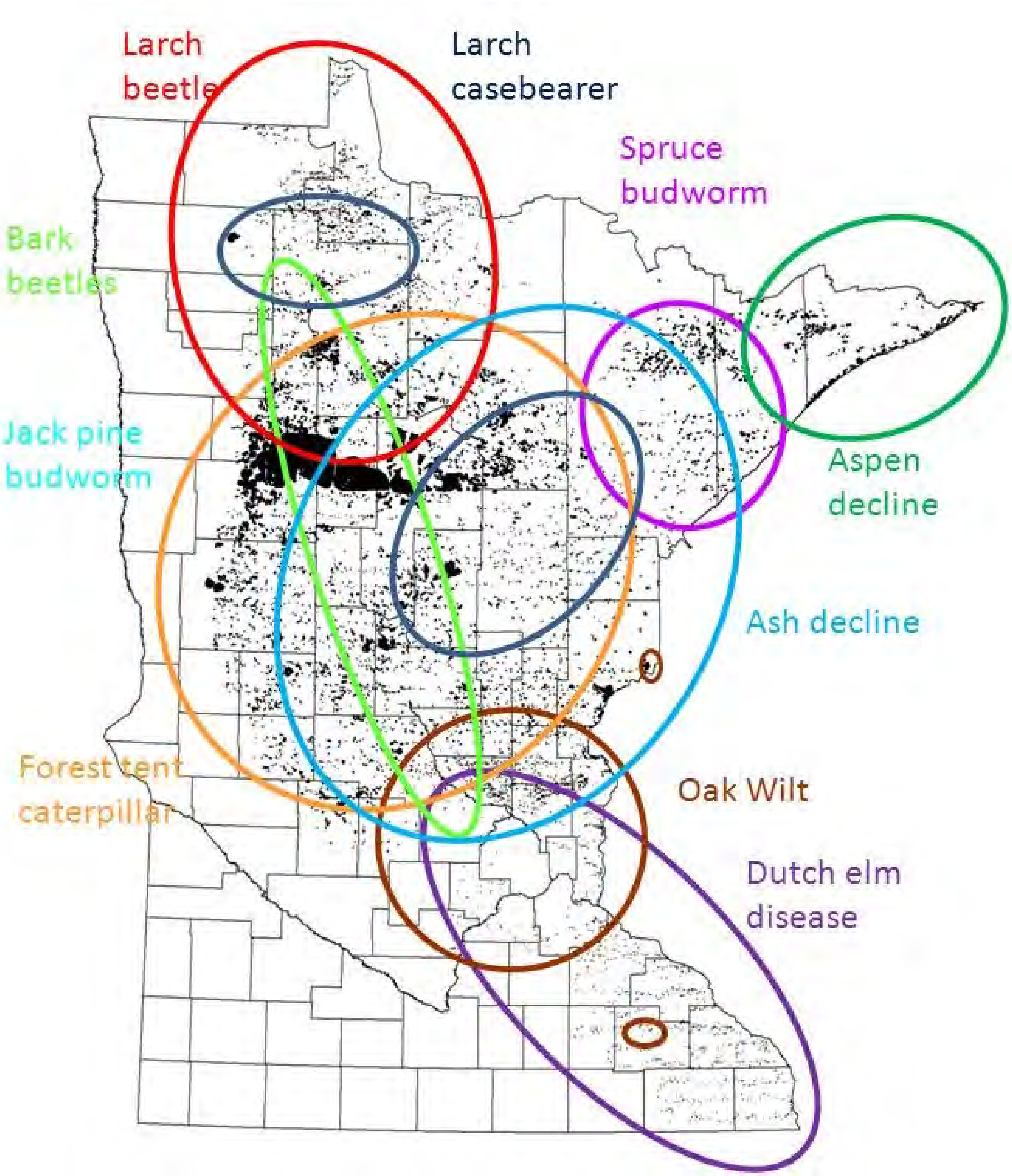
Host code: Following are common; see Handbook for others. Use Hardwoods, Softwoods (conifers) or Both if more than one species is involved. Numeric field, width 4, no decimal.

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.

Acres: Calculate with Theme-Utilities > Calculate Area/Perimeter/Length in DNR Tools. Numeric field, width 16, 2 decimal places. Delete Area, Perfeet and Perimeter fields, retain Acres only.

Map of Aerial Survey Results



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

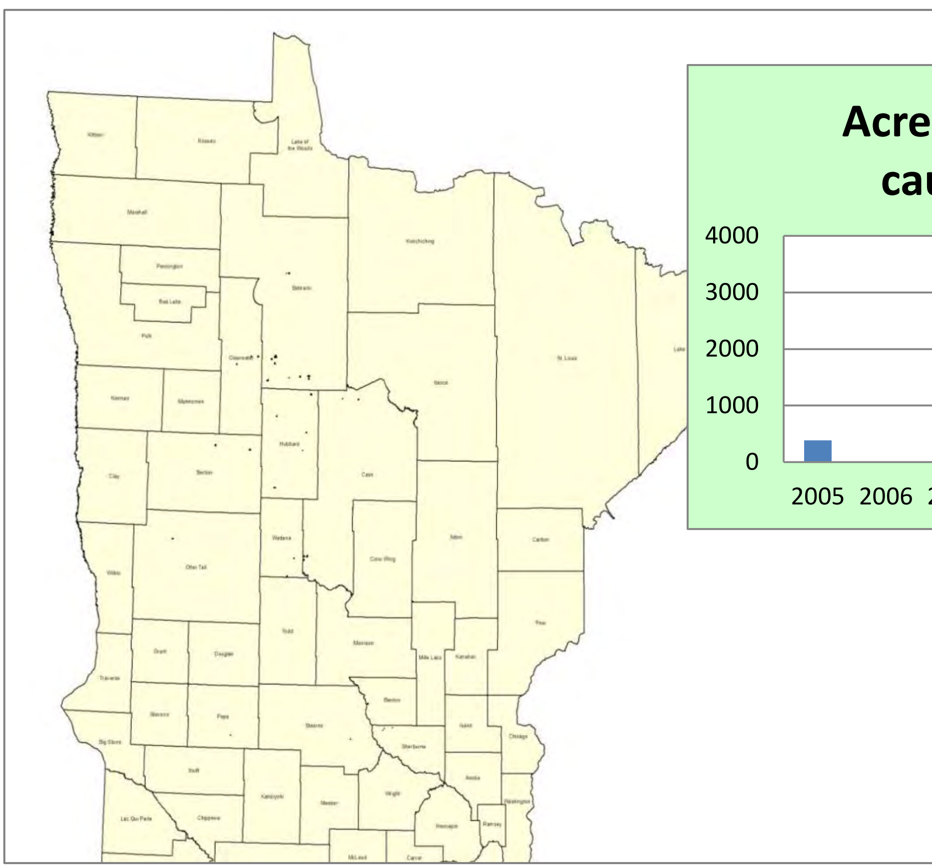
Bark beetles

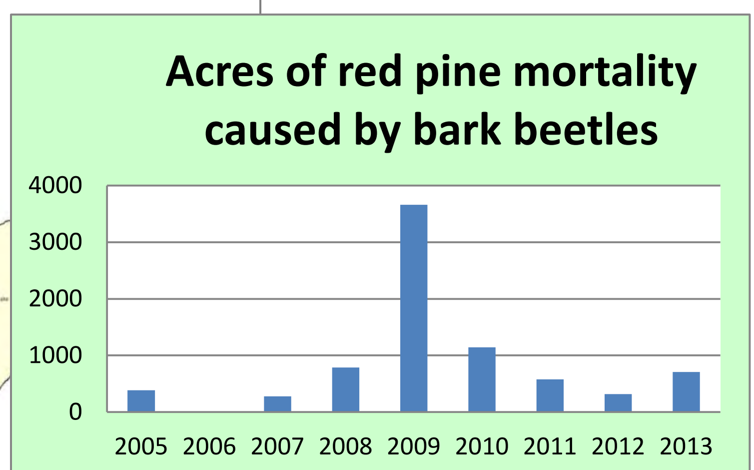
Ips species, *Dendroctonus valens*

Hosts	Red pine and, rarely, jack and white pines
Setting	Rural forests
Counties	See map
Survey method	Aerial detection
Acres affected	707 acres
Damage type	Mortality

More than double the acreage that occurred in 2012. This is likely due to the continued droughty weather in the forested portions of the state, particularly near the forest-prairie border.

Ips exit holes





Pityogenes hopkinsi bark beetles

Top-killed white pine was frequently reported around the southern half of the state. Driving from St. Paul to Hinckley to St. Cloud and back revealed hundreds of afflicted white pines. The damage was caused by a very small bark beetle, *Pityogenes hopkinsi*. White pine infested by *Pityogenes hopkinsi* will have lots of resin dripping from tiny, pin-sized holes. Gently peeling back the bark will reveal the small chestnut-brown beetles and their galleries. These beetles prefer to attack the smooth bark of stressed pines, and it would appear that drought triggered an outbreak. Fortunately, only young pines less than 20 feet were being attacked.

Symptomatic white pines

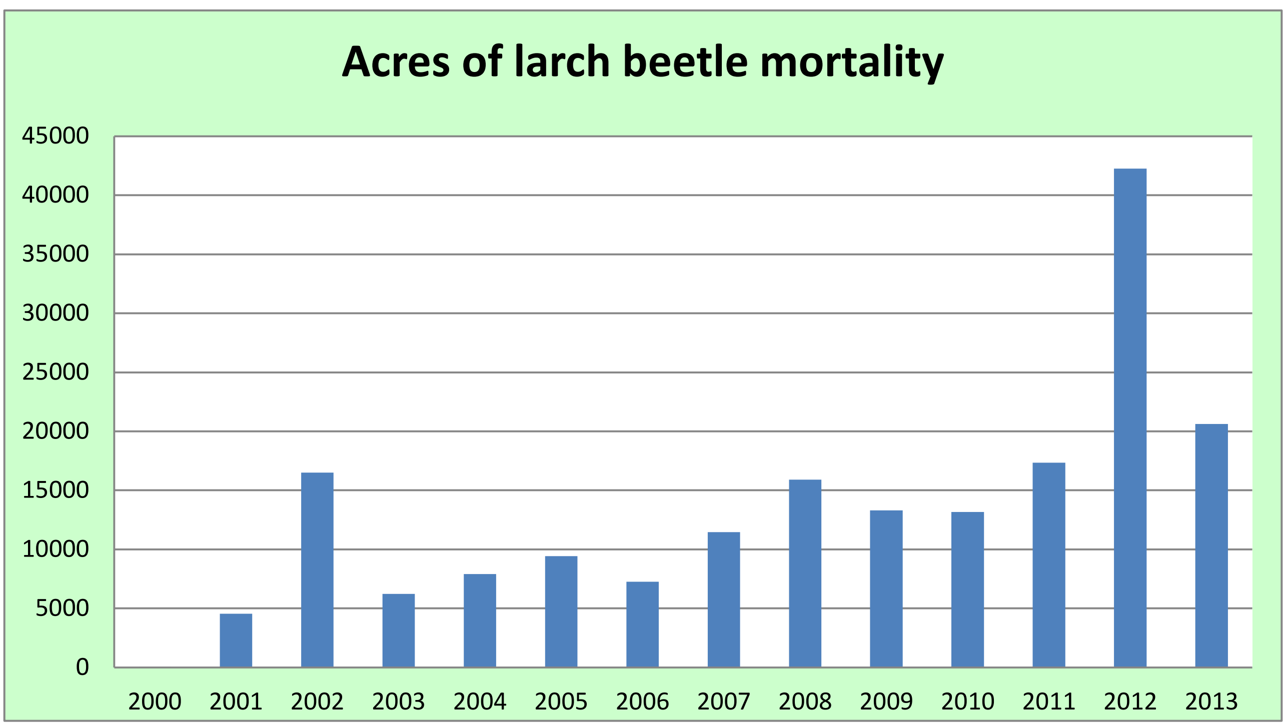
Eastern larch beetle

Dendroctonus simplex

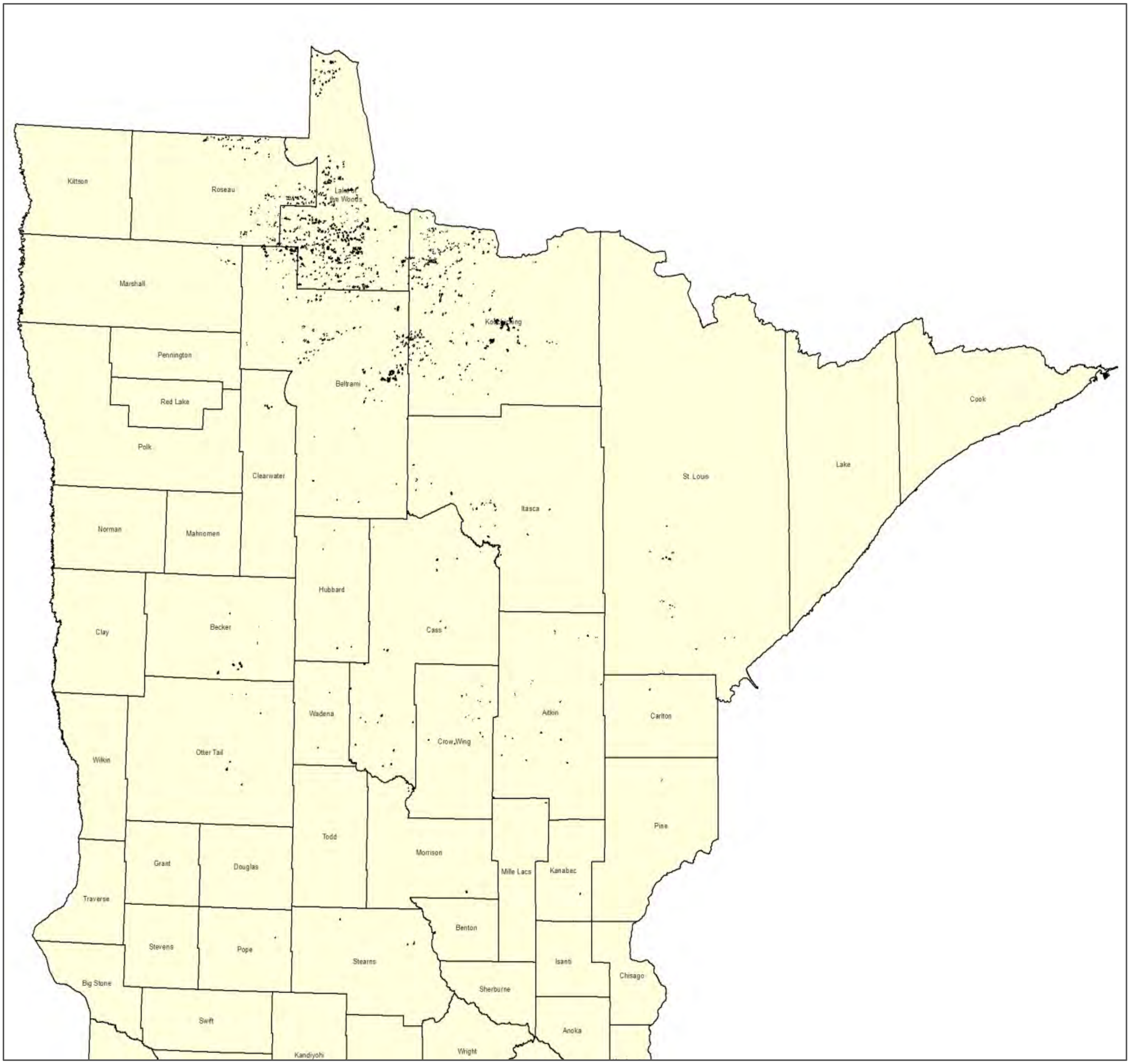
Host	Tamarack
Setting	Rural forests
Survey method	Aerial survey
Acres affected	20,624 acres
Damage type	Mortality

This is the fourteenth consecutive year of the first known outbreak of eastern larch beetle in Minnesota. As of this year, 18 percent of the tamarack acreage is dead due to larch beetle attacks. Most damage has occurred in Lake of the Woods, Roseau, and Koochiching counties. Foresters report that within five years of aerial or ground detection, more than 95 percent of the tamaracks are dead in the stands.

Egg-laying galleries



2013 Locations of Eastern Larch Beetle



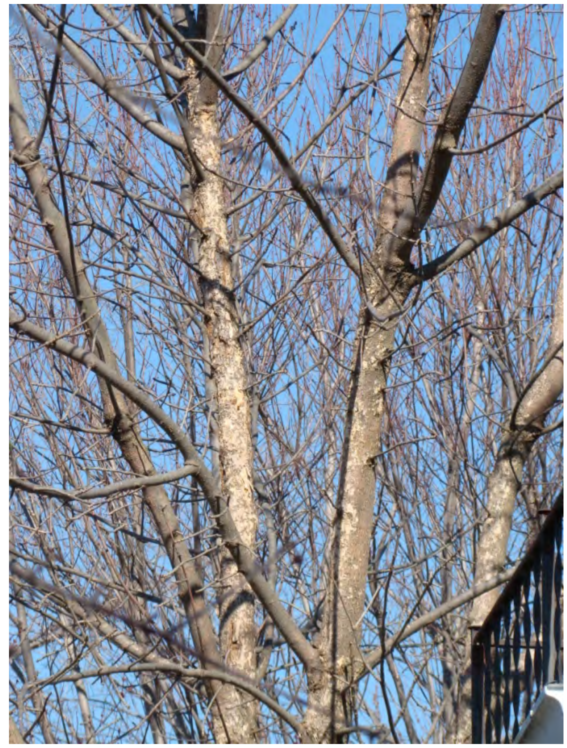
Emerald ash borer

Agrilus planipennis

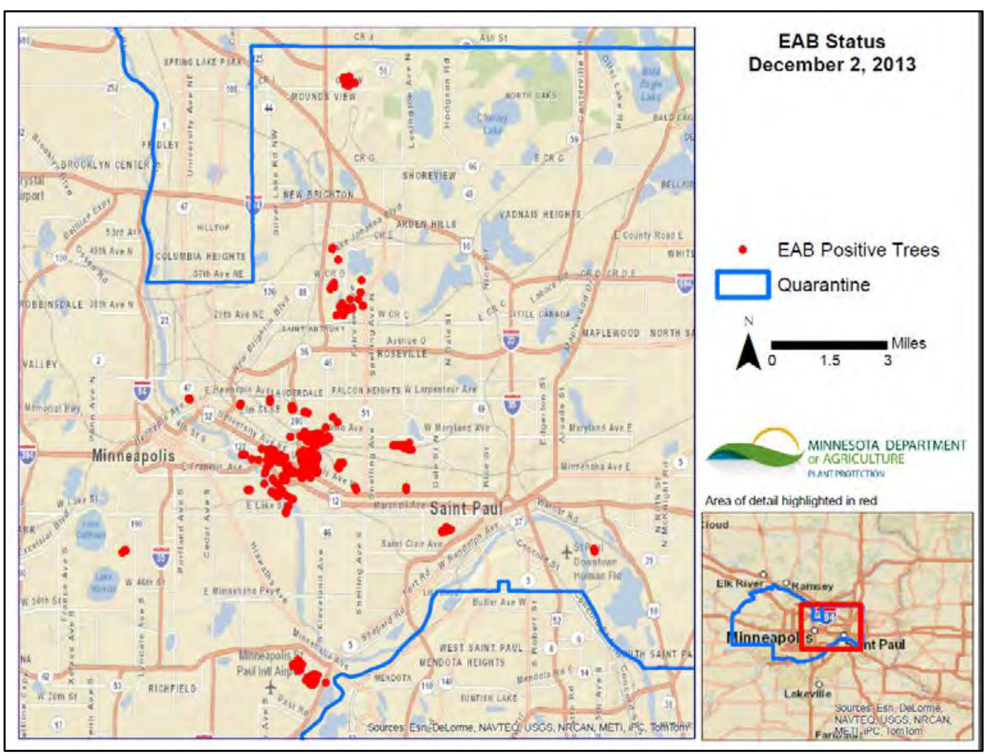
Hosts	Ash species
Setting	Urban and rural forests
Survey method	Ground survey
Acres affected	Not determined
Damage type	Mortality

No new counties were added to the emerald ash borer (EAB) quarantine this year. However, surveys within existing infested counties indicate that EAB is slowly expanding its range. For example, recent finds in the metropolitan area indicate that EAB occurs across a slightly larger area than previously mapped (see map below). In Winona County, tree mortality as a result of EAB infestation indicates that EAB population numbers are increasing in that area.

The only new infestations found were in New Brighton (in Ramsey County and already under quarantine) and in Superior, Wisconsin. Douglas County in Wisconsin is now under quarantine as a result of that infestation. Preliminary surveys in the Duluth area across the bridge from Superior failed to produce any signs of EAB. A more intensive survey will be conducted later this winter when woodpecker damage may be more noticeable.



Woodpecker damage to trees



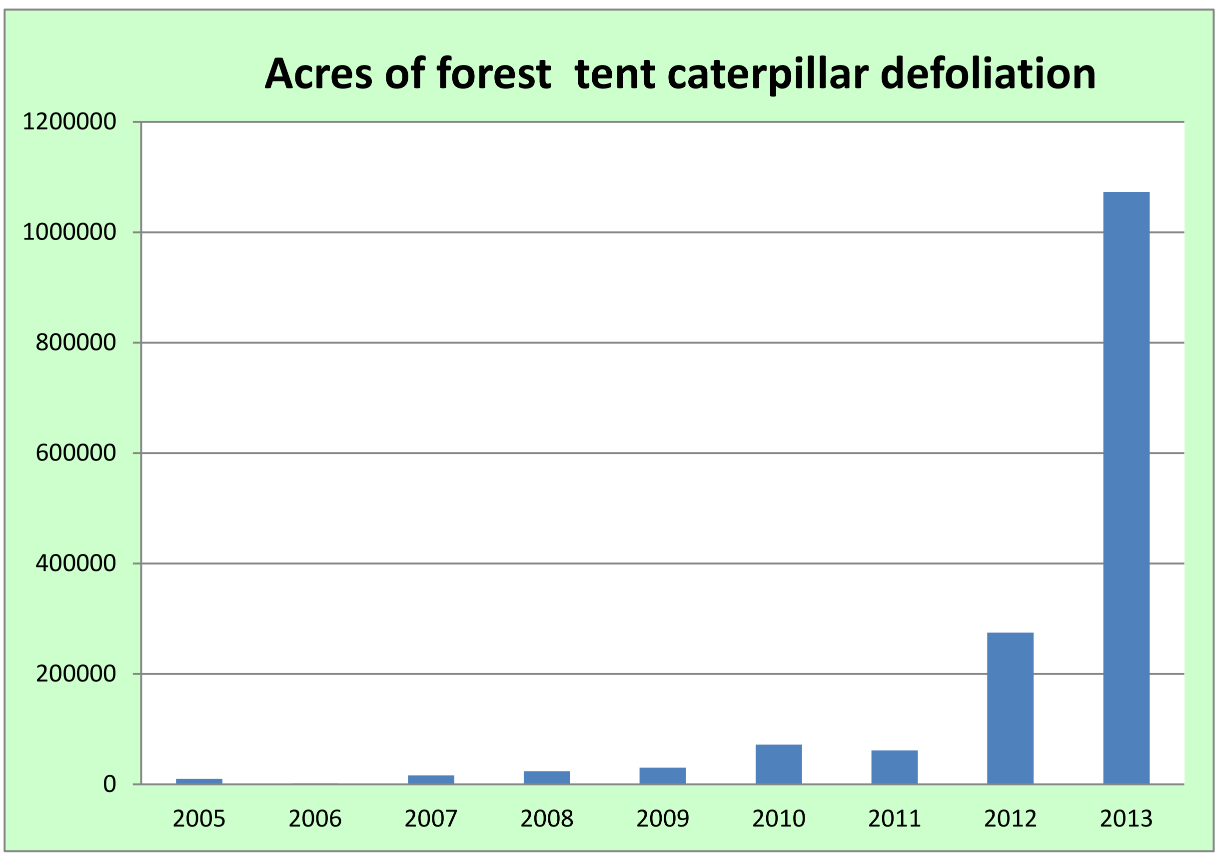
Forest tent caterpillar

Malacosoma disstria

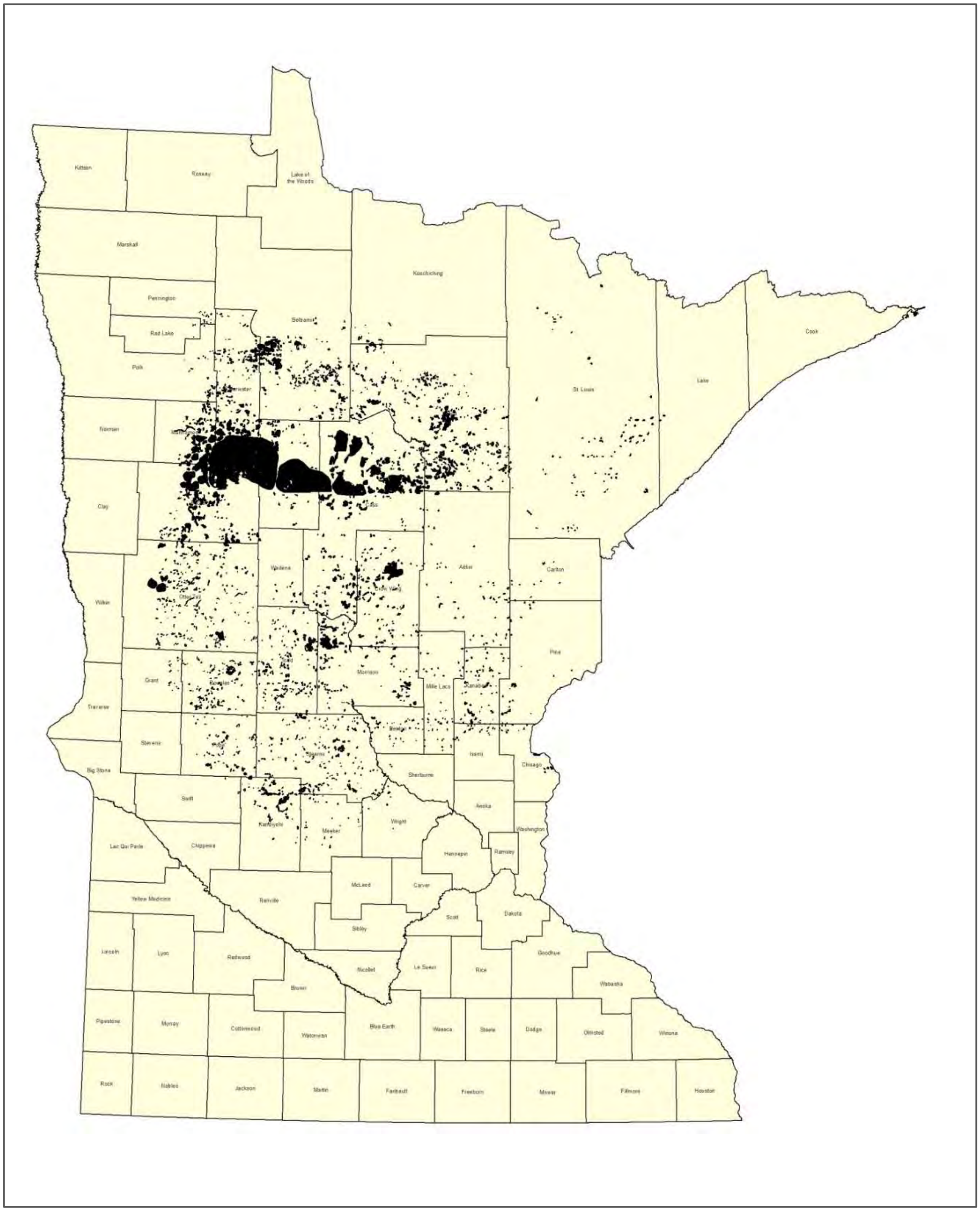
Hosts	Aspen, oak, basswood, birch, willow, other hardwoods, tamarack
Setting	Rural forests
Survey method	Aerial survey
Acres affected	1,073,056 acres
Damage type	Defoliation light, less than 25 percent

Forest tent caterpillar (FTC) populations peak every ten to sixteen years in Minnesota. Looking at recent patterns, 2013 was a building year pointing to a peak in 2014 or 2015. All but one of the forested counties in the state had defoliation by FTC in 2013 (see map on p. 19). Defoliation nearly quadrupled from 2012, when 274,000 acres were defoliated. The last FTC outbreak peaked in 2002 at more than 7 million acres.

FTC masses on aspen stem



2013 Locations of Forest Tent Caterpillar



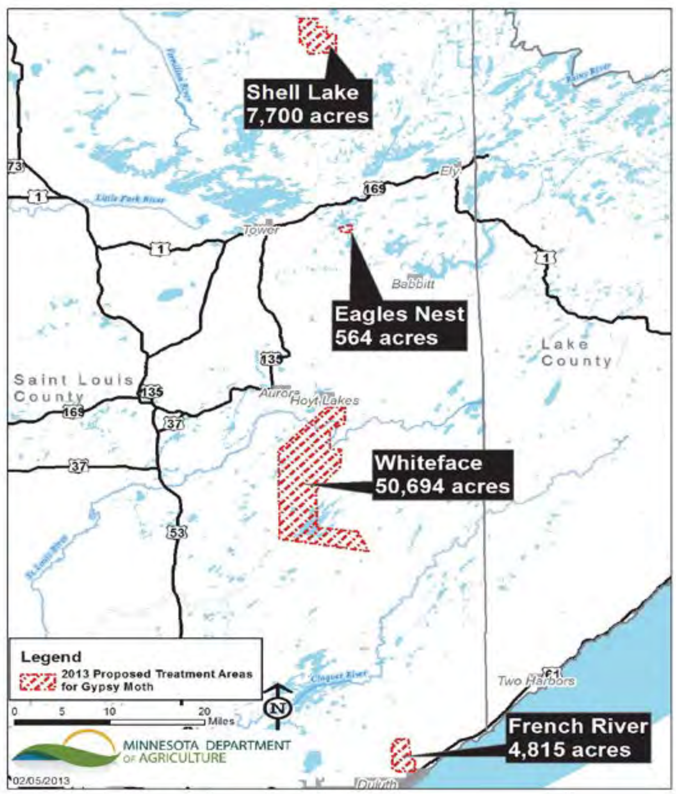
Gypsy moth
Lymantria dispar

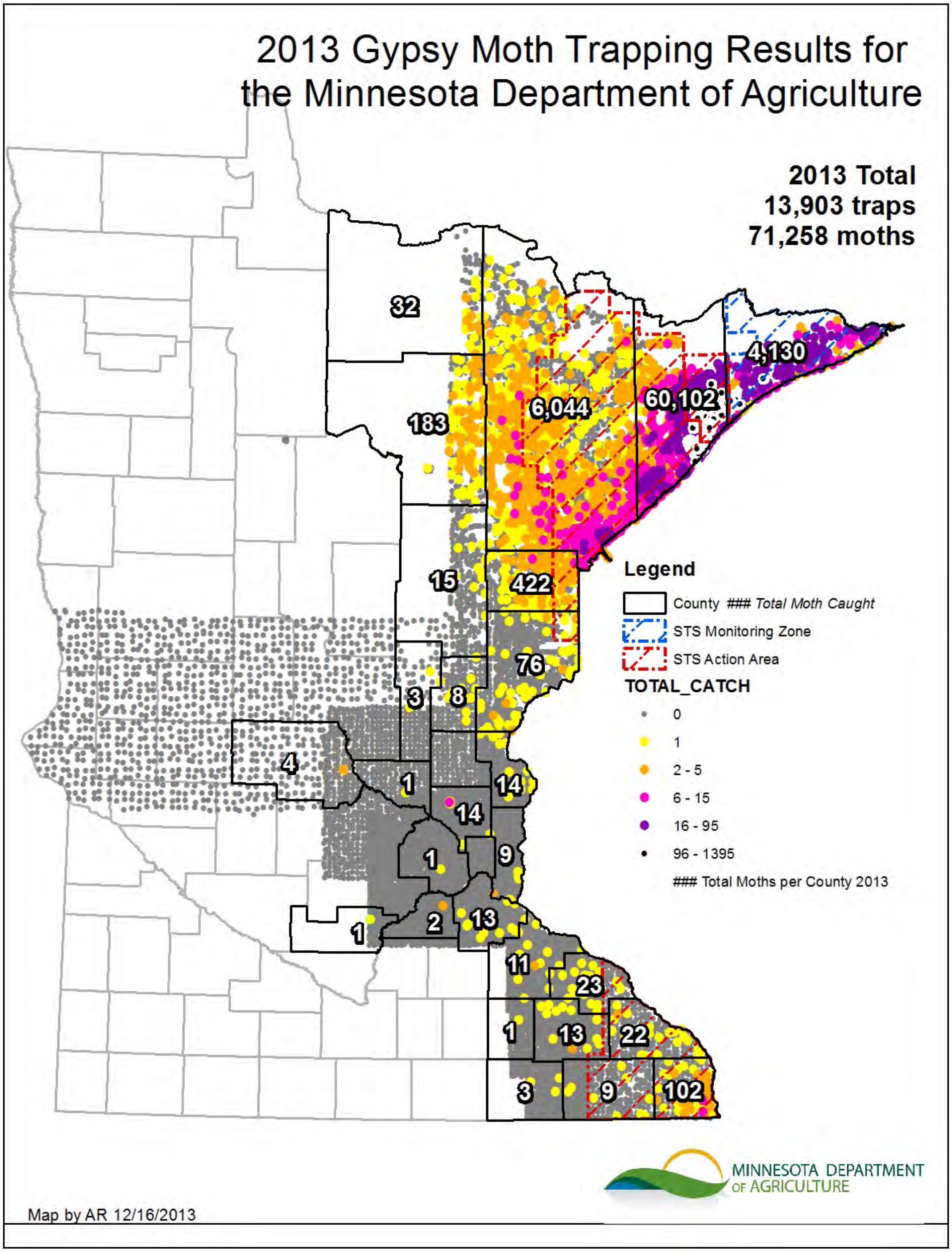
Hosts	Oaks, aspen; other hardwoods
Setting	Rural and urban forests
Survey method	Trapping, ground survey
Acres affected	None
Damage type	None observed

Lake Superior on day of egg mass survey near Split Rock Lighthouse, October 2013

Based on trap captures and life stages found in 2012, the Minnesota Dept. of Agriculture (MDA) treated 57,773 acres from July 23-25 using mating disruption. Treatment blocks are shown in map below.

In 2013, MDA and partners placed13,903 traps across the state and caught 71,258 moths, almost three times the previous record of 28,000 caught in 2009. The presence of a high number of male moths suggests a reproducing population. Nearly all of those caught this year were trapped along the North Shore (see map on following page).

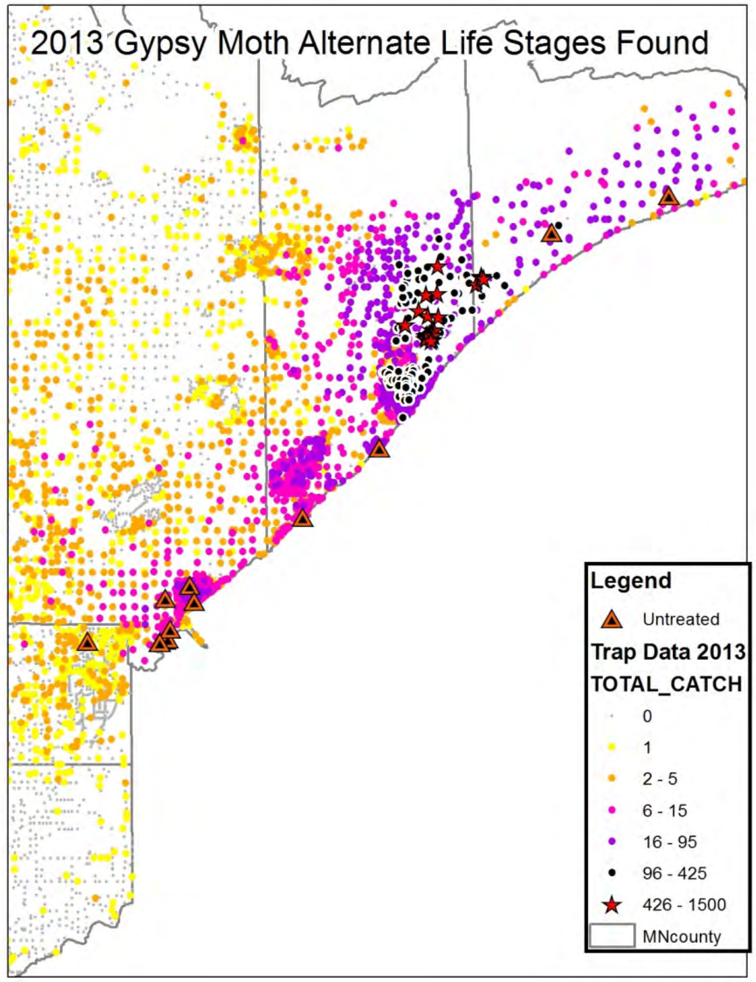




2013 Gypsy Moth Trapping Results for
the Minnesota Department of Agriculture
2013 Total
13,903 traps
71,258 moths
32
183
6,044
60,102
4,130
15
422
76
3
8
4
1
14
14
1
9
1
2
13
11
23
1
13
22
3
9
102
Legend
County ### Total Moth Caught
STS Monitoring Zone
STS Action Area
TOTAL_CATCH
0
1
2 - 5
6 - 15
16 - 95
96 - 1395
Total Moths per County 2013
MINNESOTA DEPARTMENT
OF AGRICULTURE
Map by AR 12/16/2013

Pockets of high moth captures were inspected for signs of alternate life stages. Egg masses, pupae, one adult female moth, and one larva were found at 17 sites.

The combination of high moth captures and alternate life stages along the North Shore prompted two responses. First, the national gypsy moth Slow-the-Spread program adjusted its Action Zone boundaries. The Action Zone has been present in St. Louis County since 2007. This is the zone in which future treatments designed to disrupt gypsy moth mating are most likely to occur. The second response is a recommendation from MDA that Cook and Lake Counties be quarantined in 2014.



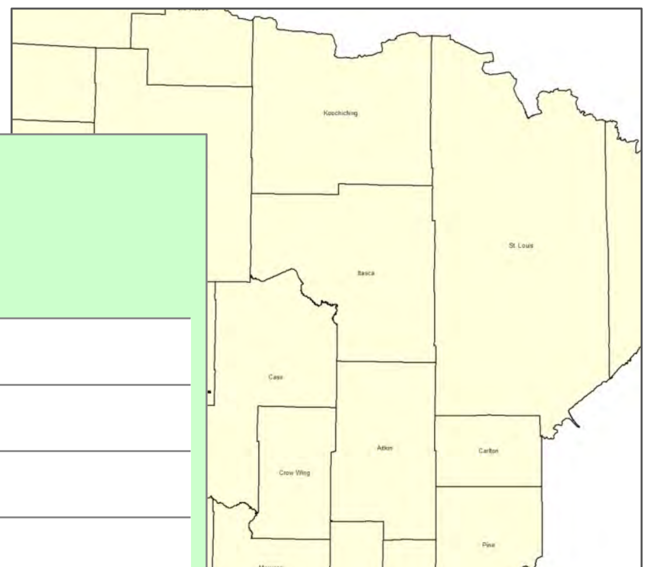
Jack pine budworm

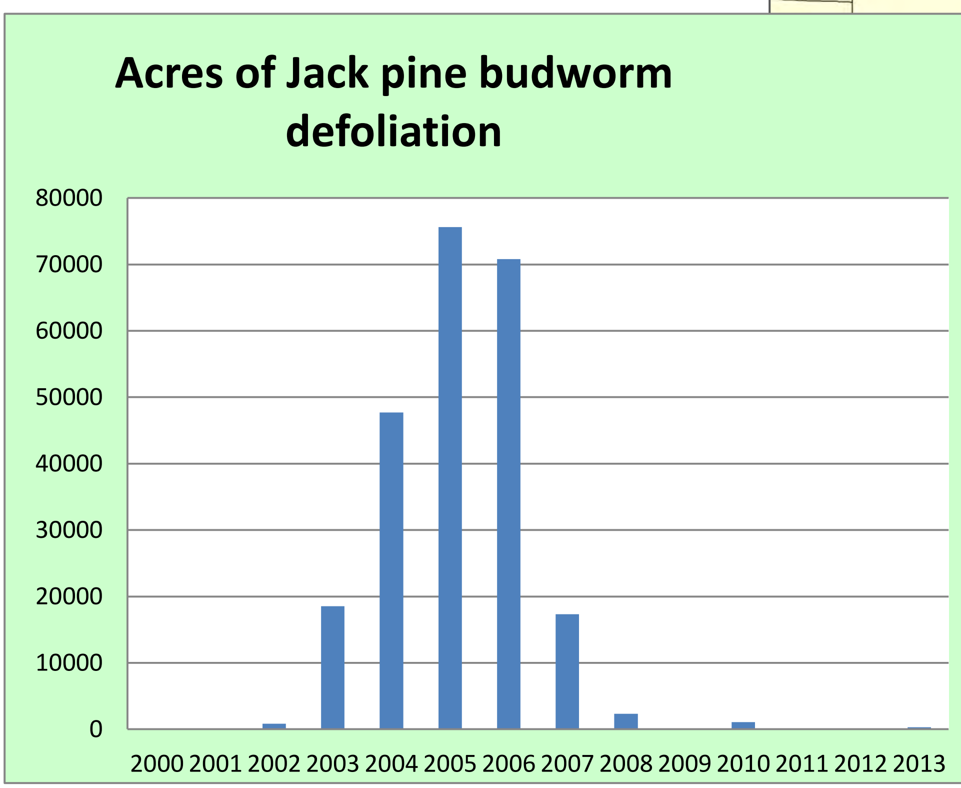
Choristoneura pinus pinus

Hosts	Jack pine, red pine
Setting	Rural forests
Survey method	Aerial survey
Acres affected	324 acres
Damage type	Defoliation

Jack pine budworm pupal cases

We have had virtually no defoliation caused by jack pine budworm since 2007. The small population detected this year (see map, below right) is expected to build over the next few years, primarily in jack pine stands from Beltrami County to Crow Wing County.





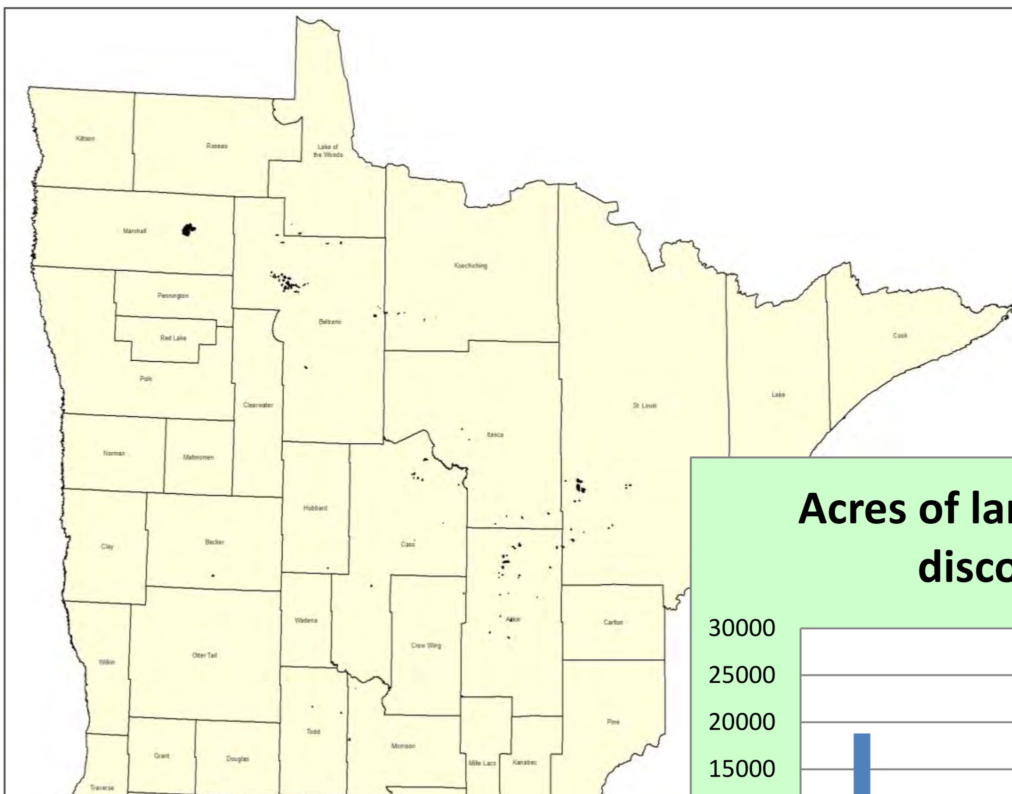
Larch casebearer

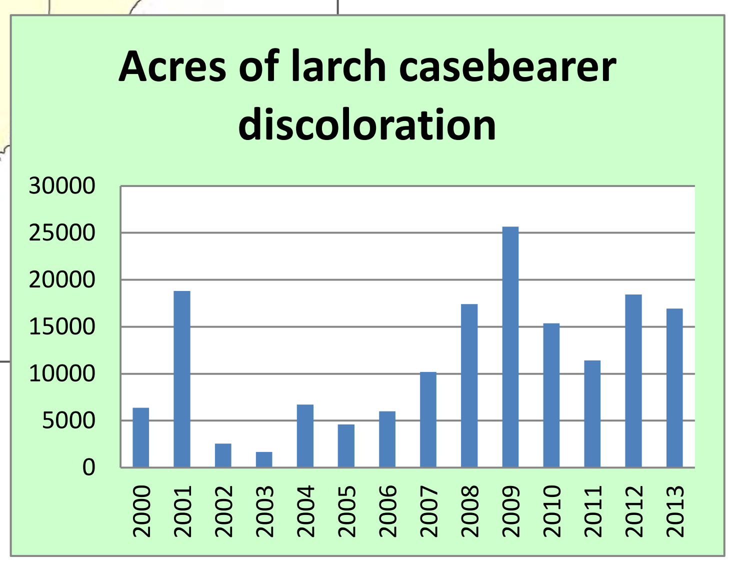
Coleophora laricella

Hosts	Tamarack
Setting	Rural forests
Survey method	Aerial survey
Acres affected	16,933 acres
Damage type	Discoloration

Defoliated acreage is down 1000 acres compared to 2012 (see map below). Larch casebearer defoliation has been mapped on the aerial survey every year since 2000, but no mortality has been observed. 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.

Orange needle discoloration caused by larch casebearer



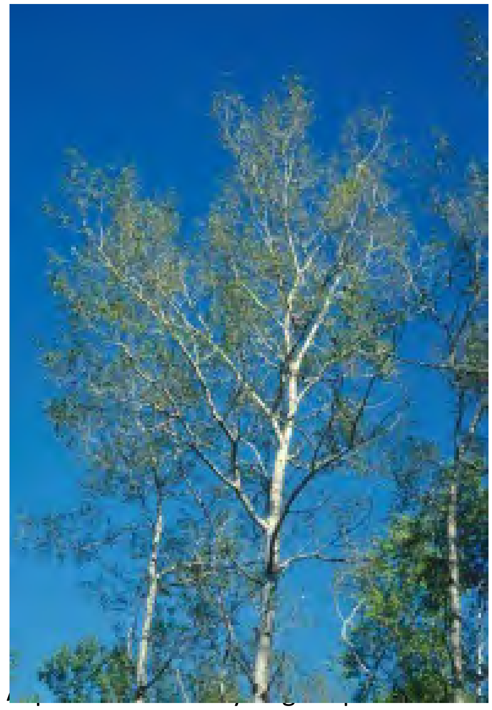


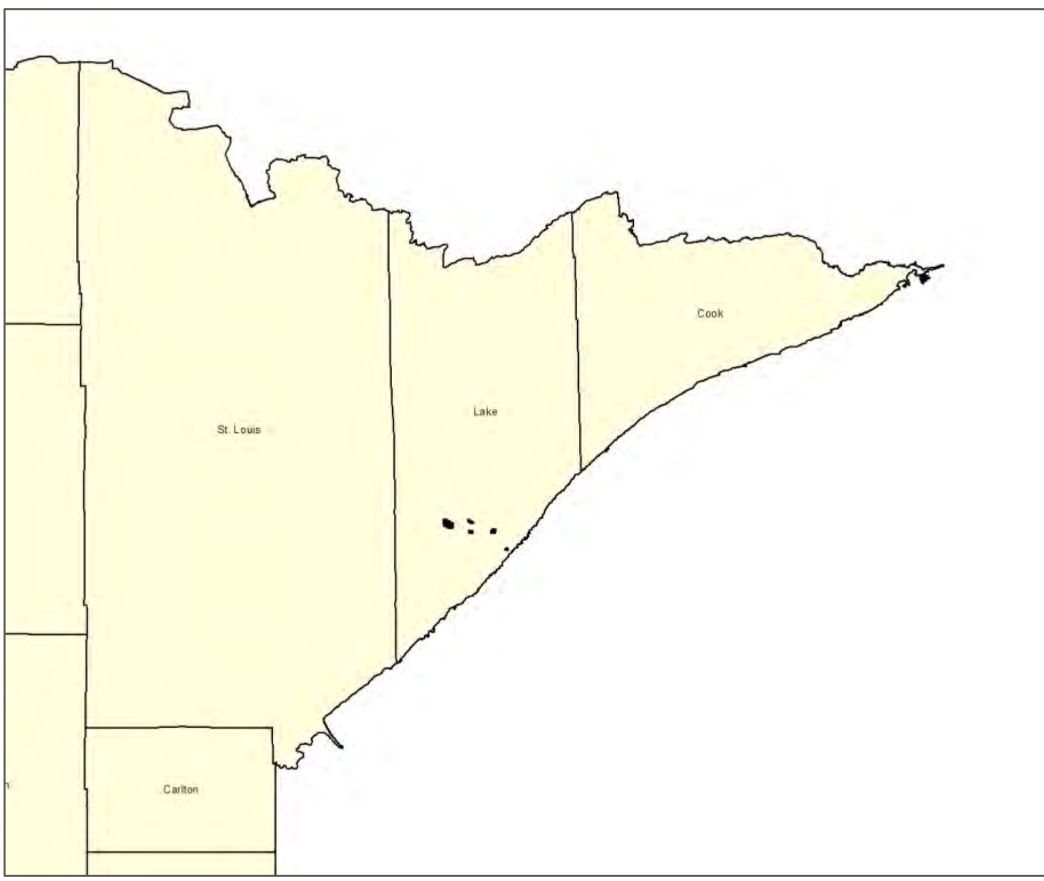
Large aspen tortrix

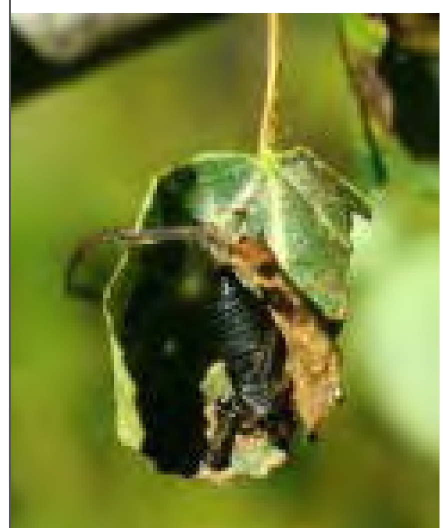
Choristoneura conflictana

Hosts	Aspen
Setting	Rural forests
Counties	Lake
Survey methods	Aerial and ground surveys
Acres affected	2,552 acres
Damage type	Defoliation

Defoliation by large aspen tortrix was observed only in Lake County (see map below). It periodically causes severe defoliation of trembling and big-tooth aspen across North America. With the exception of forest tent caterpillar, no insect is more widespread or consumes more aspen leaves. The last large outbreak of tortrix in Minnesota was in 1999 when 336,000 acres of defoliation were reported primarily along the north shore of Lake Superior.







Large aspen tortrix pupal case

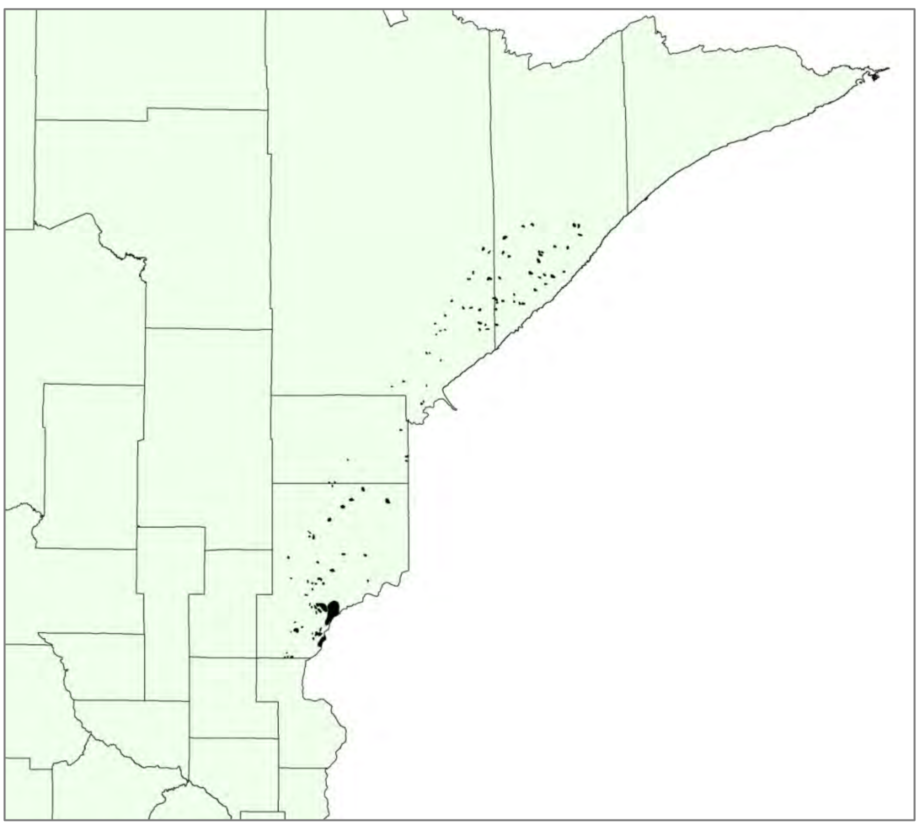
Leaf rollers of aspen

Likely *Epinotia*, *Anacampsis*, *Pseudexentera*, and *Pseudosciaphila* species

Host	Aspen
Setting	Rural forests
Survey methods	Aerial survey
Acres affected	27,928 acres
Damage type	Defoliation

Rolled aspen leaves. Ron Kelley, Vermont Forestry

Commonly, when forest tent caterpillar populations build up into outbreak phase, several other caterpillars do likewise. In this case, leaf rollers were abundant enough and caused enough aspen defoliation to be aerially mapped, below.



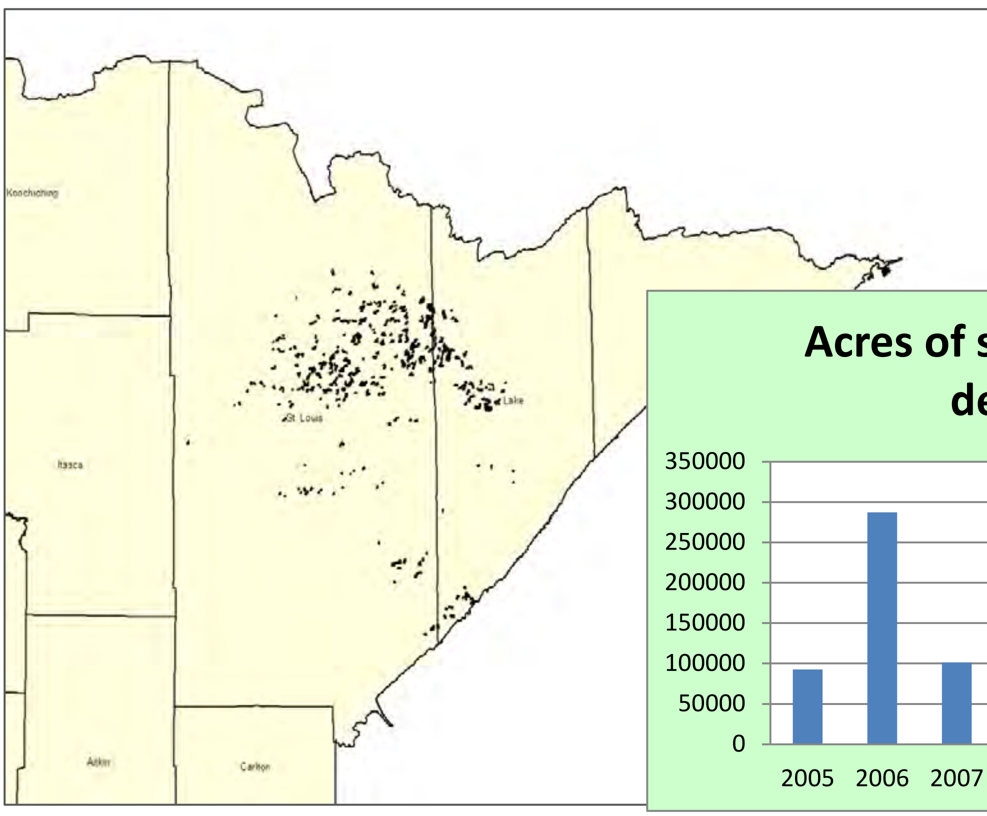
Spruce budworm

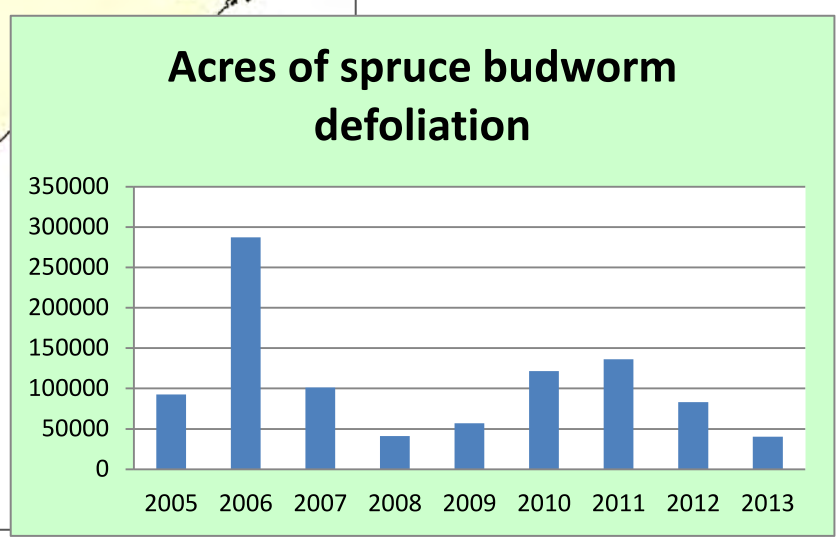
Choristoneura fumiferana

Hosts	Balsam fir and white spruce
Setting	Rural forests
Method	Aerial survey
Acres	Defoliation: 38,029
	Mortality: 34,672
Damage type	Defoliation and mortality

A continuous infestation of spruce budworm has occurred since 1954 in the Arrowhead counties. Most polygons mapped in 2013 had both defoliation and mortality (map below). The acreage trend is decreasing in both defoliation and mortality; however, new areas of defoliation are occurring near the North Shore, a location which has not seen budworm defoliation for more than 30 years.

Defoliation (red crowns) and mortality (grey crowns) of budworm-infested balsam fir



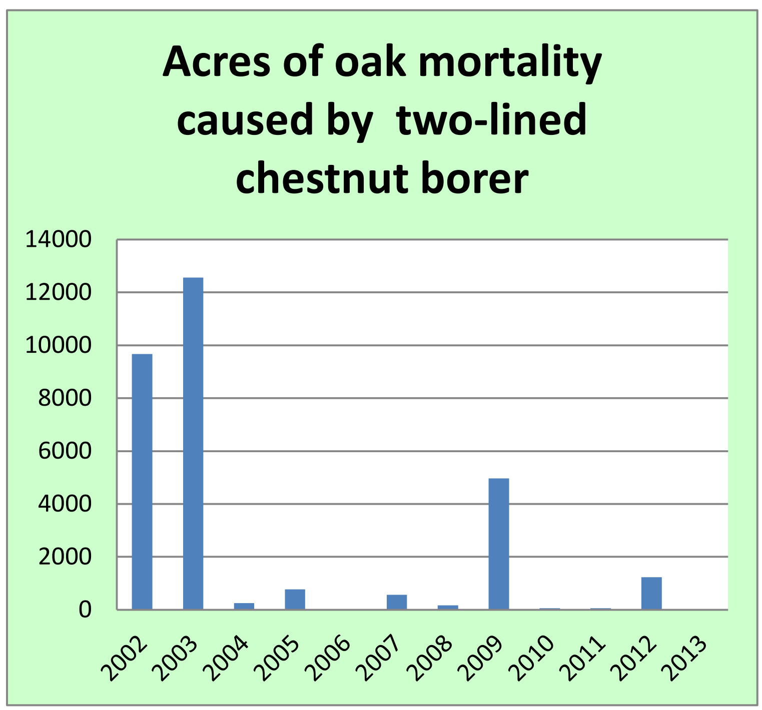


Two-lined chestnut borer
Agrilus bilineatus

Hosts	Oaks
Setting	Rural forests
Survey methods	Aerial survey
Acres affected	22 acres
Damage type	Mortality

In 2012, two-lined chestnut borer caused 1200 acres of mortality (see map below) in oaks, a 20-fold increase over mortality levels caused in 2011. In 2013, mortality levels have dropped back down to nearly undetectable levels.

Crown death after two-lined chestnut borer infestation



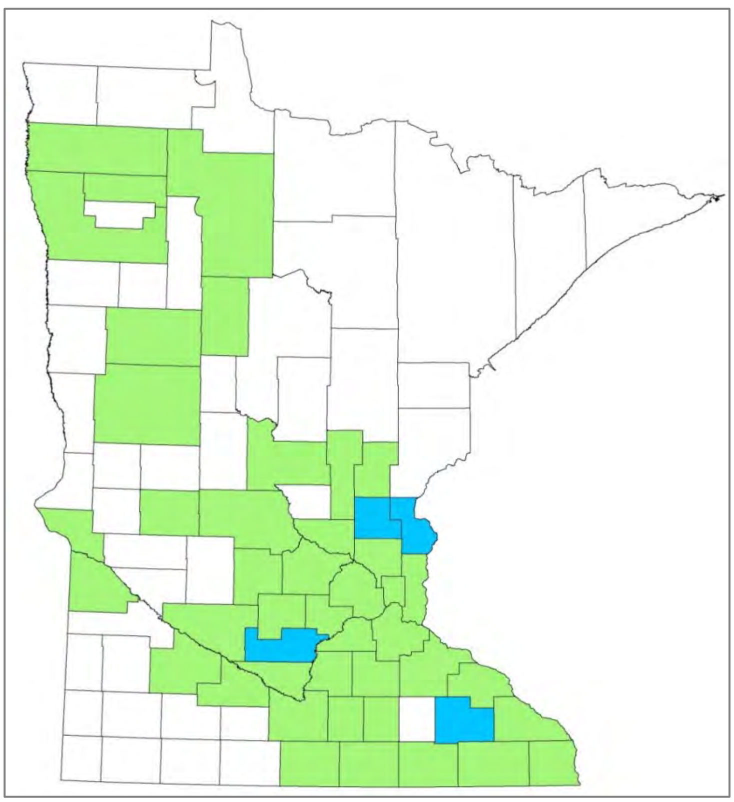
Bur oak blight

Tubakia iowensis

Hosts	Bur oak
Setting	Rural forests
Survey methods	Ground survey
Acres affected	Unknown
Damage type	Discoloration, decline, dieback

Bur oak blight is a recently-named disease and we
the midst of establishing its range. Four new
added in 2013: Chisago, Isanti, Olmsted and Sibley (see map).

Wedge-shaped lesion



Bur oak blight
Blue counties found in 2013
Green counties found from 2010 to 2012

Butternut canker

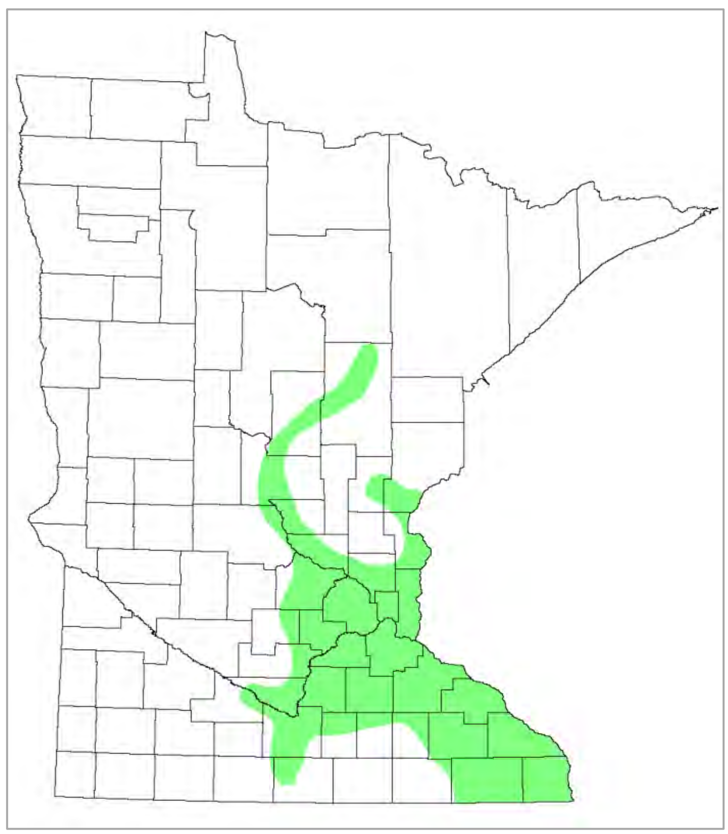
Ophiognomonia clavigigneti-juglandacearum

Hosts	Butternut
Setting	Rural forests
Survey methods	Ground survey
Acres affected	Unknown
Damage type	Mortality

Butternut canker, an exotic fatal disease, has spread throughout the range of butternut species in Minnesota (map below) with the exception of a few outlier locations in Aitkin County. It is generally estimated that more than 99 percent of all butternut trees currently are infected or dead. There is a statewide moratorium on the harvesting of live butternuts and butternut was recently moved up to the Threatened/ Endangered species level.

Crown dieback symptoms due to hundreds of cankers on twigs, branches, and stem

Inky stain on bark above canker in cambium



Range of butternut and butternut canker

Dutch elm disease

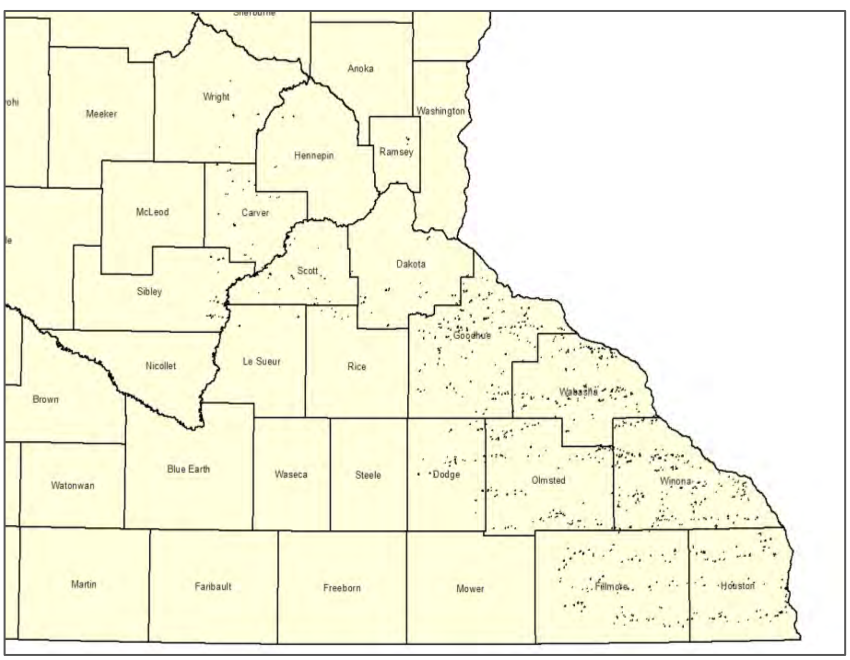
Ophiostoma ulmi

Hosts	All elm species
Setting	Rural forests
Survey methods	Aerial survey
Acres affected	823 acres
Damage type	Discoloration and mortality

Victims of Dutch elm disease

First reported in Ramsey County in 1961, the disease initially spread slowly through the state, possibly due to poor cold tolerance of the most common vector, the European elm bark beetle (*Scoytus multistriatus*). While the disease spread rapidly in the southern third of the state where the European elm bark beetle was more prevalent, the native elm bark beetle (*Hylurgopinus rufipes*) slowly assisted in northward spread. By the early 1980s, Dutch elm disease had been recorded in 84 of Minnesota's 87 counties. Today, all counties have Dutch elm disease. The map below shows areas in southeast Minnesota where Dutch elm disease was mapped in 2013.

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 Dutch elm disease 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, Dutch elm disease incidence is highest in the southeastern part of the state where *Ulmus* species are most abundant.



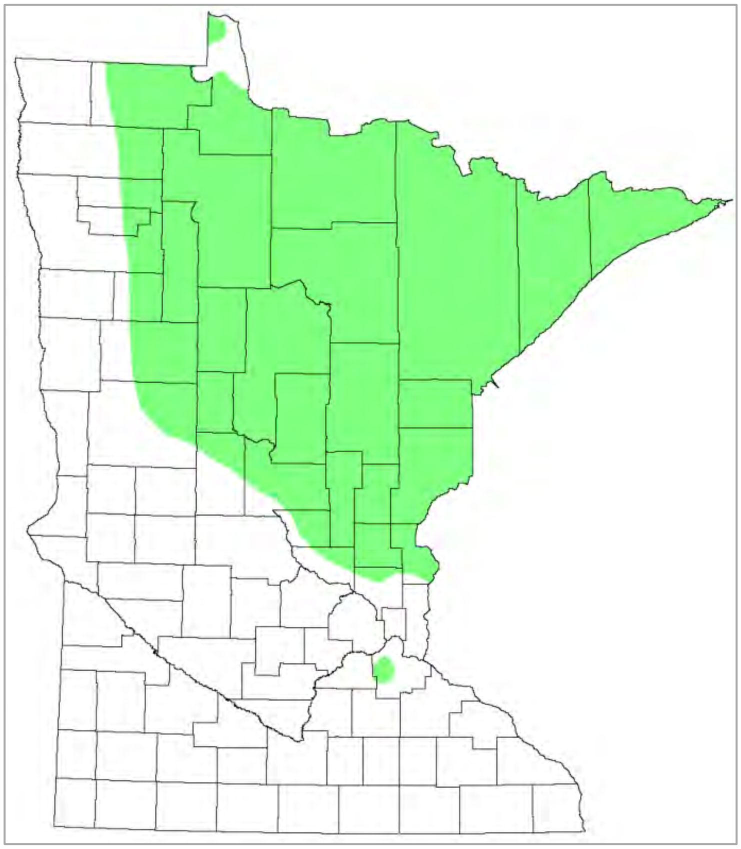
Eastern dwarf mistletoe

Arceuthobium pusillum

Hosts	Black spruce, rarely white spruce and tamarack
Setting	Rural forests
Survey methods	Ground observations
Acres affected	Unknown
Damage type	Mortality

Eastern dwarf mistletoe is a native disease and unlike its western counterparts is always fatal. Timber losses range between zero and 2 percent annually. There are approximately 1,551,000 acres of black spruce in the state and the literature suggests 11 to 25 percent of the black spruce cover type in Minnesota is infested. Losses are not spread equally over the cover type. Infections can be found in unmerchantable stands and along stand edges where the disease has been active for decades or centuries and in new infection centers in timber stands that are roughly circular.

Declining spruce with dwarf mistletoe brooms.



Range of black spruce and eastern dwarf mistletoe

Oak wilt

Ceratocystis fagacearum

Hosts	Red, rarely white oak
Setting	Rural and urban forests
Survey methods	Aerial survey
Acres affected	1473
Damage type	Mortality

Oak wilt was discovered in St. Croix State Park in Pine County in 2012, after the blowdown event in July, 2011 (arrow on map points to St. Croix State Park). Otherwise, oak wilt's distribution is the same as it was in past years.

Oak wilt pocket on edge of stand. Orange trees indicate the leading edge of oak wilt expansion throughout root systems. Photo, Joseph O'Brien, USDA Forest Service

Scab and black canker of willow

We haven't seen this for a while, since the mid-1980s to be more specific. That's when these two exotic diseases swept into and through Minnesota, having been introduced into New York before 1920. Native willow species are rarely affected, so it's the European species that bear the brunt of these diseases. The diseases were widespread and devastating on willows in Cass, Itasca, Crow Wing, Lake of the Woods, Hubbard and Beltrami counties. Two sites in Cass County had 20 to 80-year-old willow trees that looked like the diseases had been active for at least two years before this. Every twig and branch is dying back and the foliage is 99 percent dead. These diseases can kill anything from seedlings to over-mature willow trees, so the prognosis is not good, especially with cool and rainy spring weather.

Symptomatic willows in June, 2013

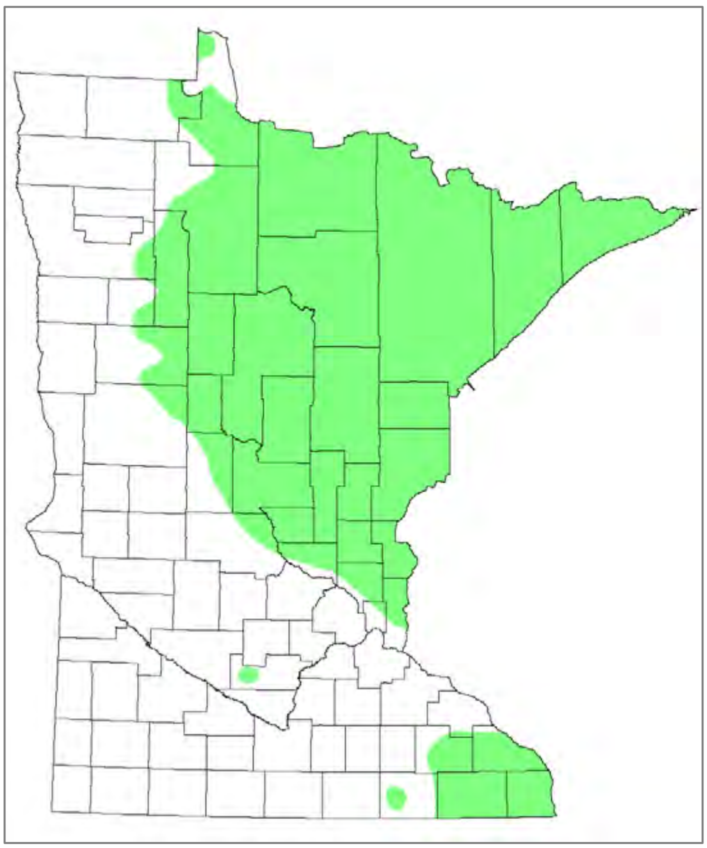
White pine blister rust

Cronartium ribicola

Hosts	White pine
Setting	Rural forests
Survey methods	Ground survey
Acres affected	Unknown
Damage type	Decline, dieback and mortality

An introduced, invasive species, this fungus has disrupted, and in many places, crippled natural and artificial regeneration of white pine, and caused topkill in mature white pines since the 1930s. If climate change predictions are correct, less white pine blister rust could be expected all across the range of white pine in the future.

Most blister rust mortality occurs in seedlings and saplings due to stem cankers



Range of white pine in Minnesota

Declines and Abiotic Stressors

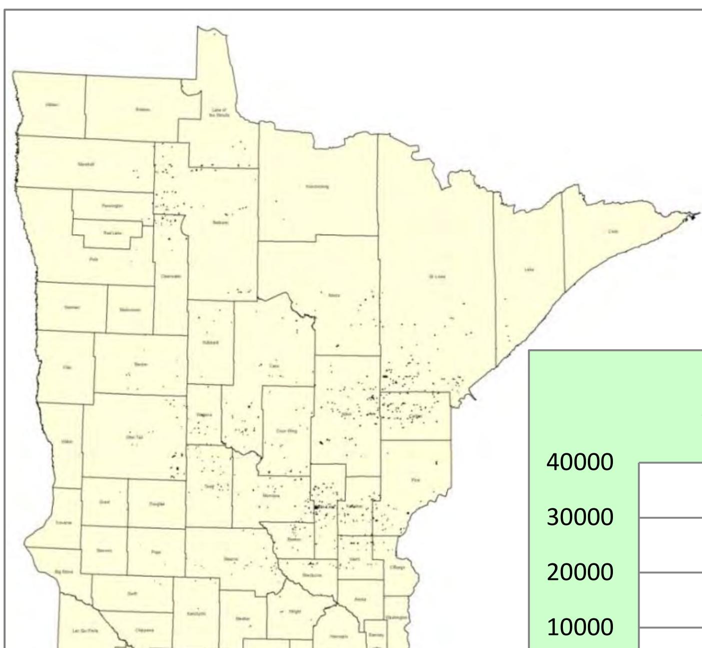
Ash decline

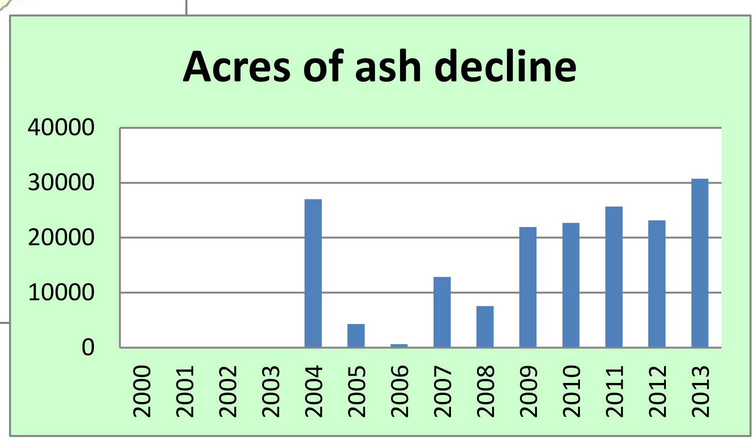
Hosts	Black and green ash
Setting	Rural forests
Survey methods	Aerial survey
Acres affected	30,707 acres
Damage type	Crown decline and dieback

Typical black ash decline symptoms

The incidence of black ash decline increased by7,000 acres compared to 2012 (map below). Decline in ash crowns is reversible with the return of favorable growing conditions on the site. Decline symptoms range from small leaves and discoloration through dieback and top-kill to eventual mortality.

Ash decline is an ongoing problem in Minnesota. The most significant damage occurs on black ash in closed depressions and is thought to be related to the rise and fall of the water table that occur on these sites, affecting rooting depth and availability of water for the trees. No significant insects or fungi are consistently found associated with declining ash trees.



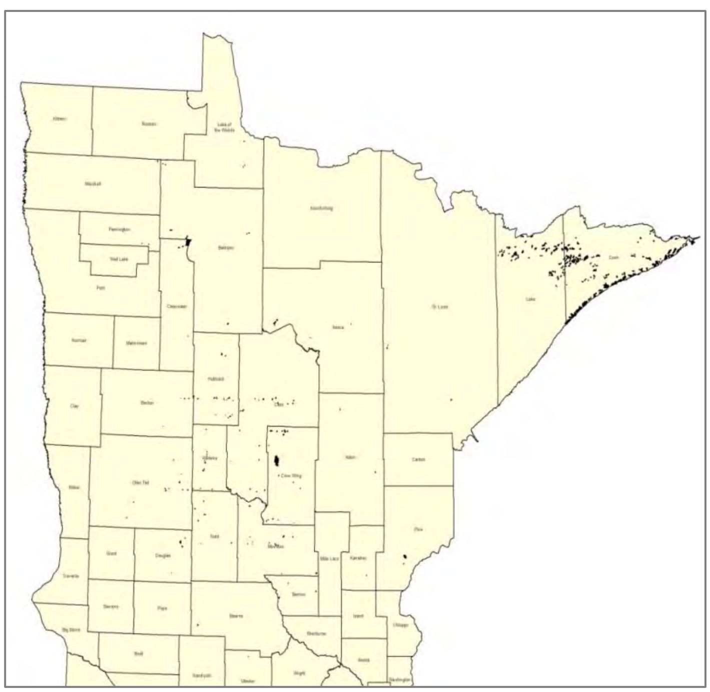


Aspen decline

Hosts	Trembling and bigtooth aspen
Setting	Rural forests
Survey methods	Aerial survey
Acres affected	62,136 acres
Damage type	Crown decline, dieback, and mortality

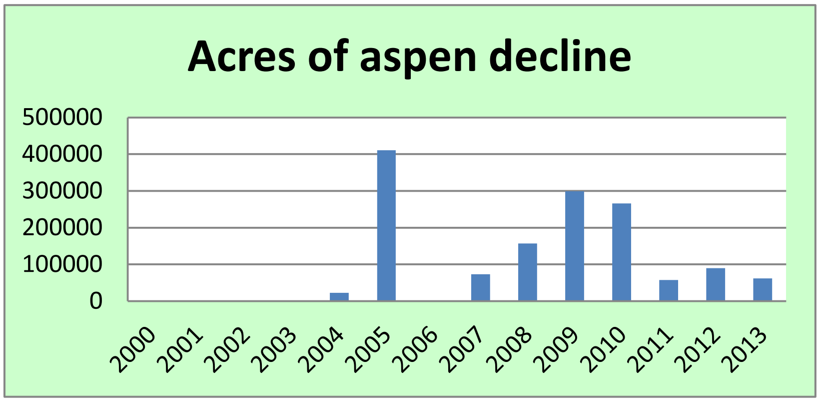
Aspen dieback and mortality in Cook County

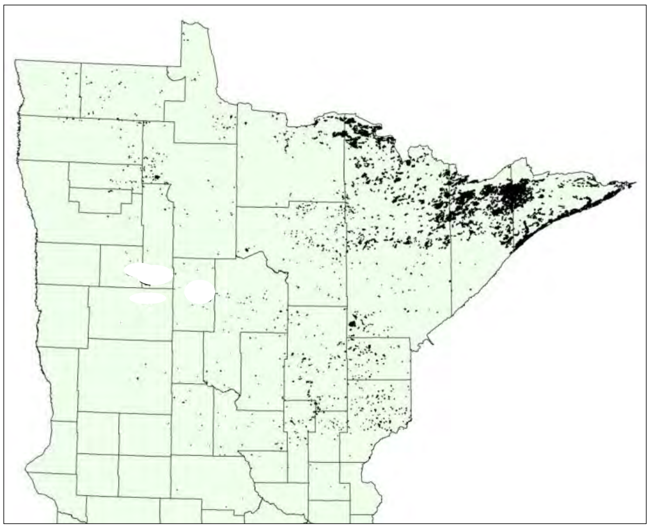
Since 2004, aspen with symptoms of decline have been mapped during the insect and disease aerial survey in northern Minnesota, especially in the Northern Superior Uplands in Lake and Cook counties. Symptoms have included a combination of defoliation, discoloration, thin crowns, small leaves, branch dieback,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

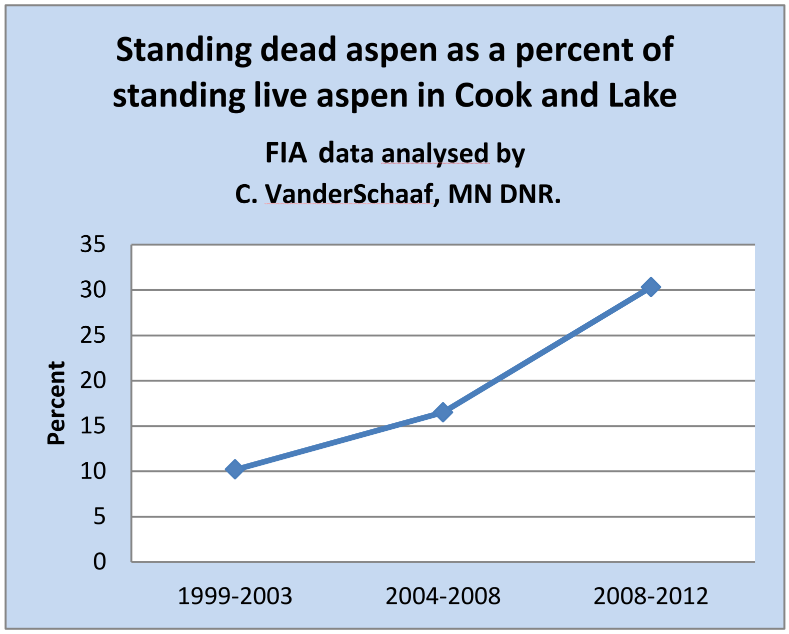


Aspen decline 2013

Many of the affected stands of aspen were stressed by three or four years of heavy defoliation by forest tent caterpillar between 2000 and 2003. They were also stressed by severe summer drought every year from 2003 to 2009. In addition, much of the northern portion of the Northern Superior Uplands occurs on the Canadian Shield, where soils are often shallow over bedrock. These sites have limited water-holding capacity due to the limited volume of the soil over the rock, and are affected by changes in climate such as longer growing seasons that put higher demands on soil moisture and warmer temperatures resulting in more evapotranspiration. Additionally, more summer thunderstorms that are more localized and release higher volumes of rain in shorter periods of time create more runoff, resulting in trees having less moisture available during the growing season. In combination these factors stress the aspen. Insects and fungi like bronze poplar borer and *Armillaria* then attack and kill the stressed trees.







Aspen decline 2004 - 2013

Additional information about aspen decline can be found in Worrall, J. J., G. E. Rehfeldt, A. Hamann, E. H. Hogg, M. Michaelian, S. B. Marchetti, and L.K. Gray (2013). Recent declines of ***Populus tremuloides*** in North America linked to climate. *Forest Ecology and Management 299*:35-51.
This journal article can be accessed at [this Forest Service website.]()

Blowdown

Hosts	All species
Setting	Rural forests
Survey methods	Aerial survey
Acres affected	5,695 acres
Damage type	Stem breakage, up-rooting

Blowdown damage in a pine stand. Photo by M. Lichter, DNR

In areas affected by wind storms, the build-up of opportunistic insects for the two years following the event could cause mortality in pine, aspen, oak and birch. Rapid and thorough salvage of the downed trees and snapped-off trees is recommended.

Drought

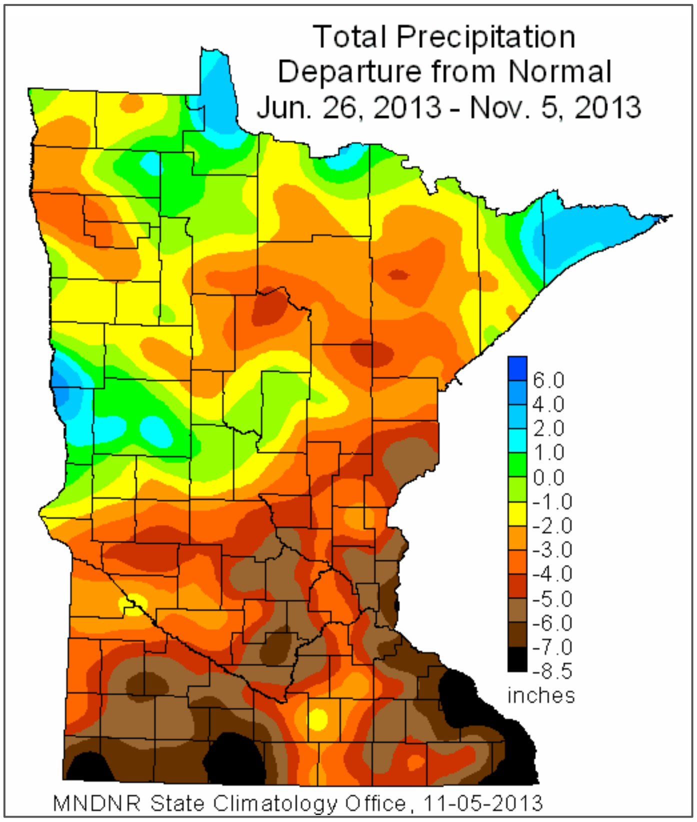
Hosts	All species
Setting	Rural and urban forests
Survey methods	Ground survey
Acres affected	Statewide
Damage type	Decline, dieback, mortality

Spruce and balsam fir dying due to droughty weather

2013 was the third year of record breaking droughts and warm temperatures during the winter, spring and summer. Rainfall was abundant in early spring and late fall, but very low during the growing season in the forested parts of the state.

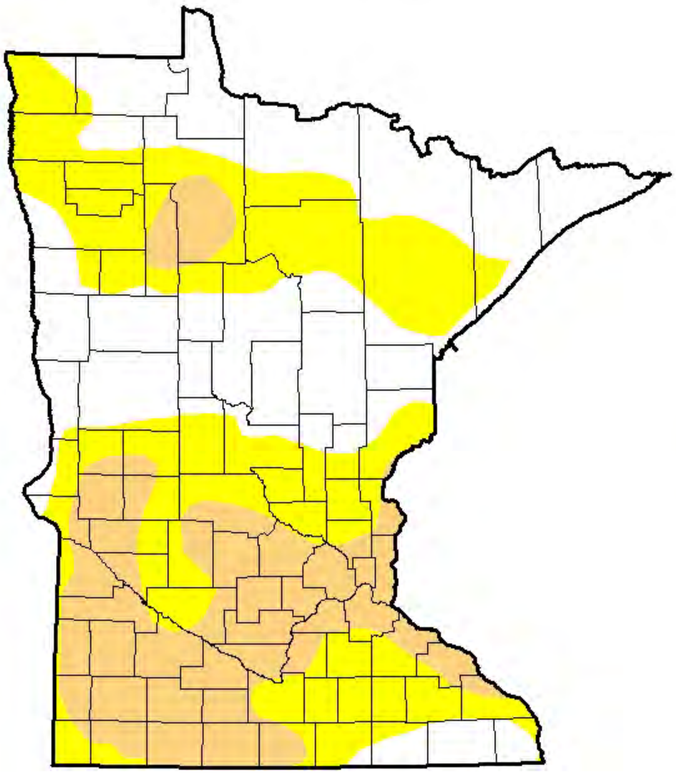
Late June to early November precipitation totals were highly variable across Minnesota. Spring and early-summer precipitation totals were ample to excessive in many locations, especially southeast Minnesota. Precipitation totals from the last week of June through early-November were substantially below average in most counties. The seasonal precipitation map (at right) offers a patchwork pattern of values above and below historical normal.

The Drought Monitor on the following page shows that lingering drought occurs in a broad swath across the northern part of the state and in the south-central forests.



U.S. Drought Monitor

Minnesota



November 26, 2013

(Released Thursday, Nov. 28, 2013)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	38.21	61.79	25.12	0.00	0.00	0.00
Last Week *11/19/2013*	38.21	61.79	25.12	0.00	0.00	0.00
3 Months Ago *8/27/2013*	14.64	85.36	54.90	0.00	0.00	0.00
Start of Calendar Year *1/1/2013*	0.00	100.00	97.84	83.44	25.17	0.00
Start of Water Year *10/1/2013*	27.29	72.71	46.69	8.94	0.00	0.00
One Year Ago *11/27/2012*	0.00	100.00	97.91	83.44	25.25	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Richard Heim
NCDC/NOAA

USDA National Drought Mitigation Center

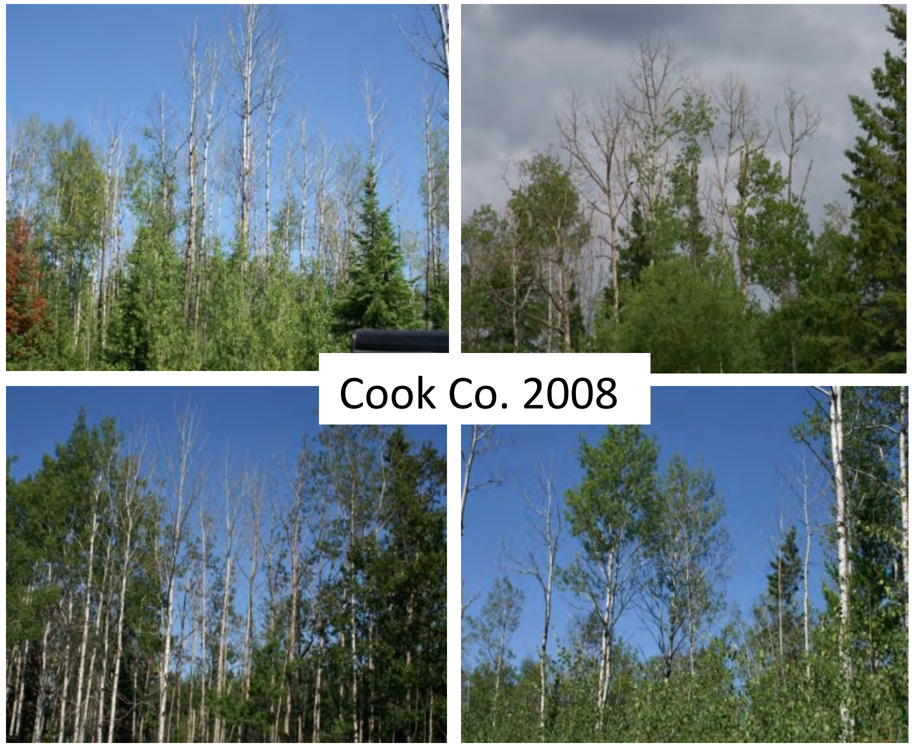
http://droughtmonitor.unl.edu/

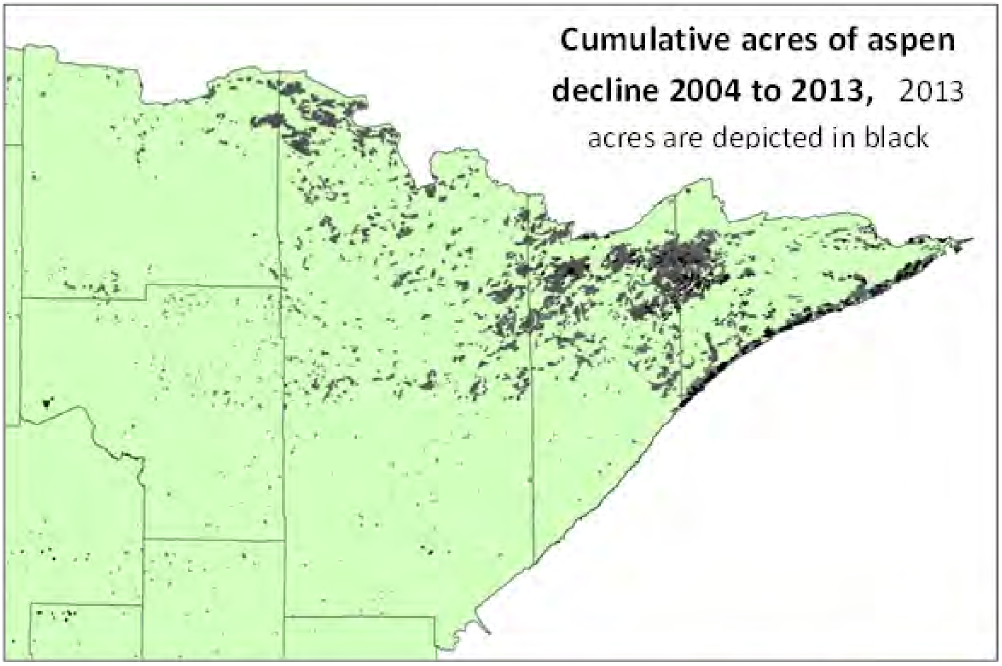
Aspen Decline in Minnesota

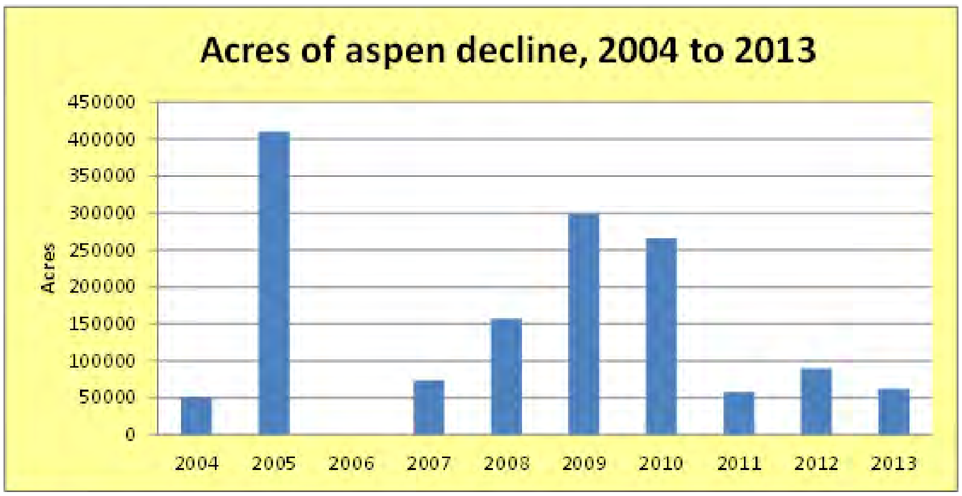
Since 2004, aspen with symptoms of decline has been mapped by aerial survey sketch-mappers (see acreage chart below). Symptoms have included combinations of defoliation, discoloration, dieback and mortality.

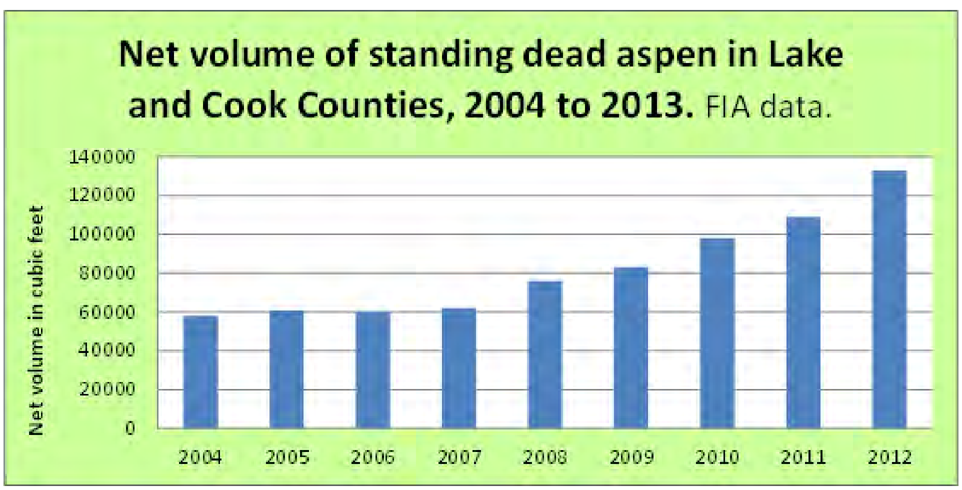
Dieback is the most common symptom but tree mortality has also occurred. Mortality can vary from scattered trees throughout a stand to patches of 30 to 40 dead trees scattered through stands. Trees with dieback often also exhibit small, off-color foliage in the live parts of the crown. Ground surveys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

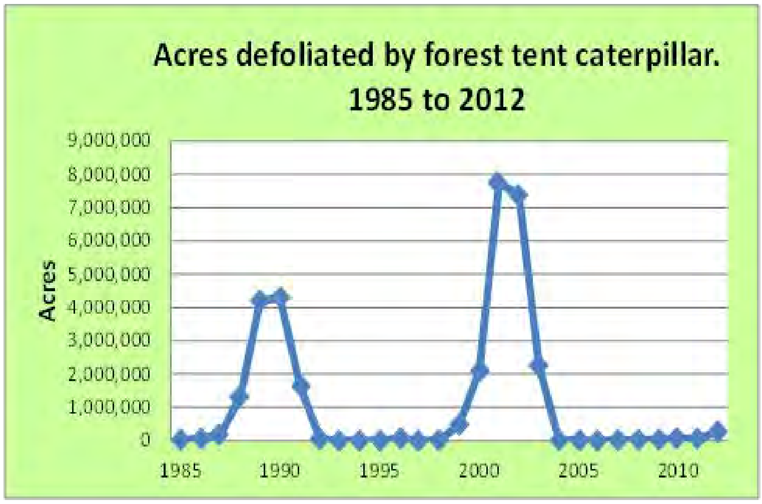


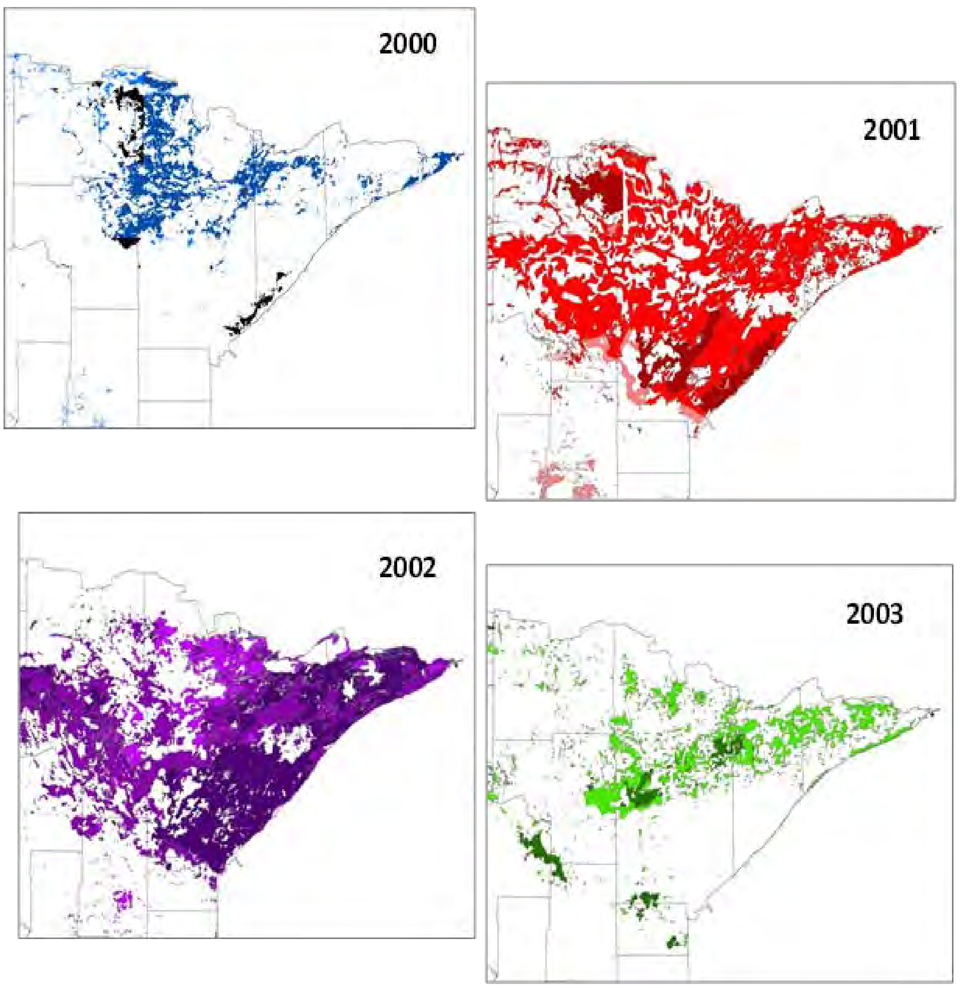

Cumulative acres of aspen
decline 2004 to 2013, 2013
acres are depicted in black


Acres of aspen decline, 2004 to 2013
Acres
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013


Net volume of standing dead aspen in Lake
and Cook Counties, 2004 to 2013. FIA data.
Net volume in cubic feet
140000
120000
100000
80000
60000
40000
20000
0
2004
2005
2006
2007
2008
2009
2010
2011
2012

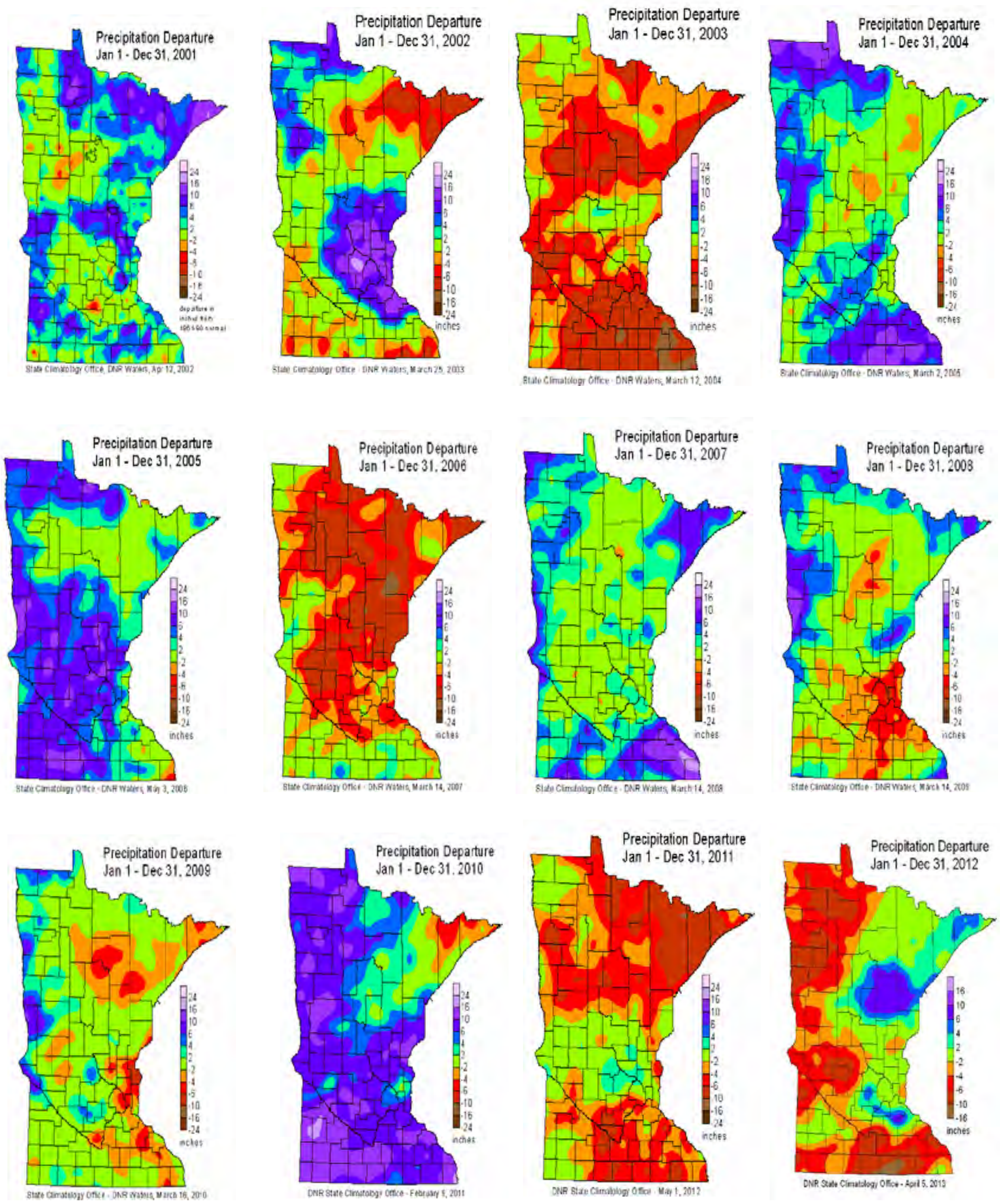
Forest tent caterpillar outbreak





Three to four years of heavy forest tent caterpillar defoliation early in the decade stress aspen.

Droughty weather on shallow soils



Severe summer droughts stress aspen.

Climatic factors influencing outbreaks of eastern larch beetle (*Dendroctonus simplex)* in Minnesota

Abstract presented by Fraser McKee at the annual meeting of International Union of Forest Research Organizations in Banff, Alberta. August, 2013

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Susan J. Crocker, Forest Inventory and Analysis, USDA Forest Service, St. Paul, MN
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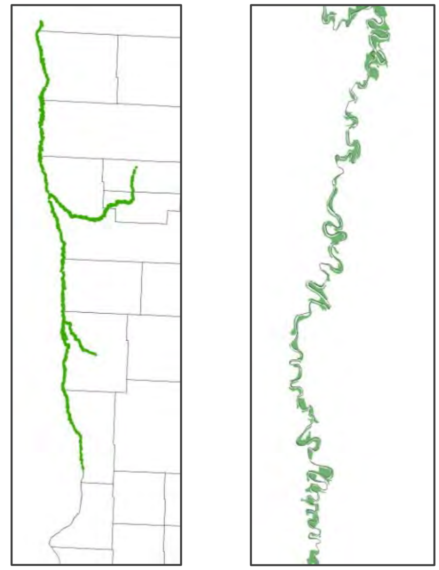
Jana Albers, Division of Forestry, Minnesota Department of Natural Resources, Grand Rapids, MN
Fraser R. McKee, Department of Entomology, University of Minnesota, St. Paul, MN

The eastern larch beetle, *Dendroctonus simplex*, is a specialist on eastern larch or tamarack, *Larix laricina*. Eastern larch extends all across the boreal forest of northern North America. The southern part of its range stretches through Minnesota within the Great Lakes region, where this native insect has been documented since 1938. Outbreaks of eastern larch beetle in North America are typically sporadic and short-lived, but a large outbreak has been occurring in Minnesota since 2000. Currently, more than 63,000 hectares have been affected. Defoliation is frequently a predisposing factor to trees undergoing attack by eastern larch beetle, but defoliation activity has not been apparent prior to the current outbreak. Here, we identify climatic factors associated with outbreak activity of this insect in Minnesota. Using aerial survey data gridded to 10km resolutions, we found that tree-killing activity is related to outbreaks in surrounding forests at 25 km scales and local outbreak activity within the previous two years. After accounting for this spatial and temporal dependence, spring climatic variables affecting beetle phenology could also be identified at the landscape-level. We hypothesize that a changing climate may be influencing propensity to outbreak along the southern extent of this native insect's range.

Determining the forested acres and volume of green ash along the Red River

David Johnson, Private Forest Management Forester from Detroit Lakes, suggested a project to determine the volume of ash trees in the Red River Valley that could die suddenly during a future emerald ash borer infestation. Since Red River floods can carry tremendous amounts of trees which threaten infrastructures such as bridges, dams, and river diversions, a preliminary look at FIA volumes was deemed necessary. Resource Assessment provided the specific FIA data from both Minnesota and North Dakota and it was analyzed by Region 1 Forest Health Specialist Jana Albers. FIA data from 11 plots visited from 2007 to 2011 were used to calculate volumes and areas. For comparison, data was used from a similar study along the Red River Valley in 1988 that looked at elm losses after Dutch elm disease swept through.



Project area along the Red River on left and close-up of the river below Moorhead on the right. The project's southern boundary was the mouth of the Bois de Sioux River and the northern boundary was the Canadian border

Results

It appears that Minnesota's forests have less than 20 percent of the trees as measured by volume, vulnerable to potential mortality caused by emerald ash borer (EAB) in the flood plain and terrace forests in the Red River Valley. The total volume of live green ash growing along the Red River Valley of the North is 9,799,000 cubic feet; of that, 1,637,000 cubic feet are growing in Minnesota.

If you use the Native Plant Community Field Guide *Prairie Parkland and Tallgrass Aspen Parklands* there are two native plant communities possible along the River: FFn67, floodplains with annual flooding, ice floes, and stem damage due to flooding; and FFn57 on slightly higher terraces that floods less often. These two communities often grade into each other and have similar composition in the western reaches of the Prairie Parkland and Tallgrass Aspen Parklands. It is likely that the volumetric ratio of 4 bur oak: 2 boxelder: 2 basswood: 1 green ash holds true for both communities. If so, 1/9 of the total volume present is green ash in the riparian communities.

Since 1988, the volume of green ash has remained virtually the same on the Minnesota side—16 percent of the forest composition. Green ash did not reclaim the riparian habitats vacated by American elm after they succumbed to Dutch elm disease. Boxelder, willow and basswood seem to have reclaimed those sites, at least on the Minnesota side.

Estimated area of forest land and estimated net volume of live trees (2013)

	Total corridor	*Minnesota*	*North Dakota*
Area of forest land in acres	26,259	5,945 (22.6%)	20,314 (77.3%)
Net volume of all live trees in cu ft	61,407,962	11,763,318	49,644,644
Volume of live green ash in cu ft	9,799,654	1,637,755	8,161,899

Estimated volume of live trees (at least 5 in DBH) in cu ft (2013)				
Species	*Minnesota*		*North Dakota*	
	Volume	*Percent of volume*	*Volume*	*Percent of volume*
Bur oak	4,099,102	34.8	15,945,168	32.1
American elm	265,420	2.2	19,061,518	38.5
Green ash	1,637,755	13.9	8,161,899	16.4
Boxelder	2,705,103	22.9	6,476,057	13.0
Basswood	2,601,508	22.1	0	0
Willow	410,072	3.8	0	0
E. hop hornbeam	44,358	0.3	0	0
Hackberry	0	0	0	0
Cottonwood	0	0	0	0
Total cubic feet	11,763,318		49,644,644	

Note:
In 1988 inventories by state personnel, both hackberry and cottonwood were found on both sides of the rivers and were less than 4.0 percent of trees tallied.

Additional data for green ash: Ave. DBH = 12 inches (with a std dev of 6 in; range = 4.5 to 23.0 in)

Estimate of stocking of live trees based on area of forest land in acres (2013)						
	Minnesota			*North Dakota*		
	Over-stocked	*Fully stocked*	*Medium stocked*	*Over-stocked*	*Fully stocked*	*Medium stocked*
Acres	0	5,945	0	6,534	8,160	5,621

Estimate of stocking volume of live trees by stocking category and by species in cu ft (2013)				
Species	*Minnesota*	*North Dakota*		
	Fully stocked	*Over stocked*	*Fully stocked*	*Medium stocked*
Bur oak	4,099,102	0	15,945,168	0
American elm	265,420	10,267,763	4,684,440	4,109,315
Green ash	1,637,755	2,510,474	3,651,157	2,000,269
Boxelder	2,705,103	1,161,424	3,062,832	2,250,802
Basswood	2,601,508	0	0	0
Willow	410,072	0	0	0
E. Hop hornbeam	44,358	0	0	0
Hackberry	0	0	0	0
Cottonwood	0	0	0	0
Total	11,763,318	13,939,661	27,343,597	8,360,386

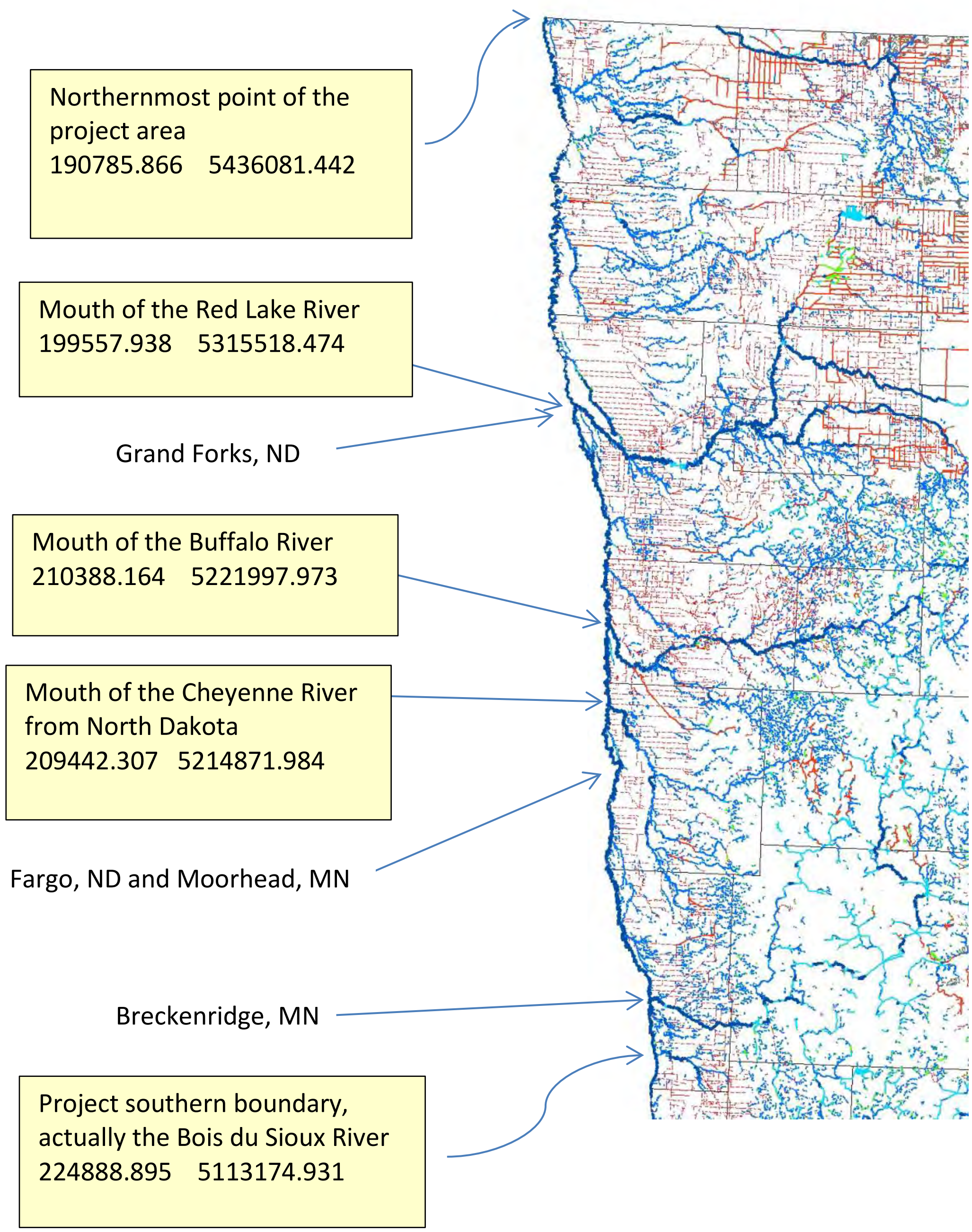
Comparing data from Dutch elm disease survey in riparian forests of Red River Valley (final report: 1988) to the FIA results from 2013.

Comparison of total corridor and states between studies in 1988 and 2013						
	1988			*2013*		
	Acres	*Number of stands*	*Total volume (cu ft)*	*Acres*	*Number of stands*	*Total volume (cu ft)*
Total corridor	17,315	462	10,742,120	26,259	992	61,407,961
Minnesota	9,660	247	6,442,030	5,945	575	11,763,318
North Dakota	7,655	215	4,301,193	20, 314	417	49,644,644

Volume by species from 1988 and comparison of percent of total volume by species between two measurement periods, 1988 and 2013					
Species	*1988*			*2013*	
	Volume in total corridor (cu ft)	*Percent of volume in total corridor*	*Percent of volume in Minnesota*	*Percent of volume in total corridor*	*Percent of volume in Minnesota*
Bur oak	3,001,160	28 %	29 %	32.6 %	34.8 %
American elm	4,132,560	38	38	31.5	2.2
Green ash	1,752,630	16	15	15.9	13.9
Boxelder	328,020	3	4	15.0	22.9
Basswood	822,220	8	6	4.2	22.1
Willow	-	-	-	0.06	3.4
E. Hop hornbeam	-	-	-	0.007	0.3
Hackberry	406,330	4	5	-	-
Cottonwood	299,200	3	3	-	-

Red River of the North Project: Ash assessment along both sides of the Red River and up three of its tributaries: Cheyenne, Buffalo, and Red Lake Rivers

Map of the Minnesota side of the river; locations are in UTM coordinates



Forest tent caterpillar defoliation: Predicting levels using trends in local observations

Forest tent caterpillar (FTC) populations typically follow a pattern that allows predictions to be made from local observations during the past growing season and trends over the past few years. Use the table below to compare population levels and number of years of defoliation with your observations in order to predict the level of defoliation next summer.

Predicting defoliation levels caused by forest tent caterpillars based on trends in local observations

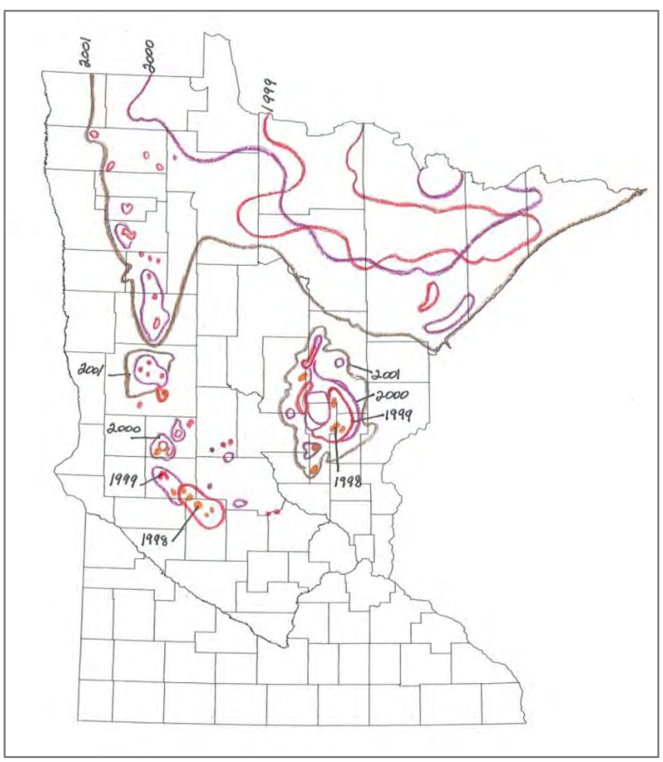
Observations from last summer	***FTC population levels***				
	Very low	***Low***	***High***	***Peak***	***Collapsed***
Severity of defoliation What percentage of the leaves on oak, basswood, aspen and birch trees were eaten by FTC in late June.	Minimal < 25%	Moderate 25-50%	High 50-75%	Complete 75-100%	None 0%
Caterpillars typically observed During a short walk, how many caterpillars did you see?	1 or 2	Several	Hundreds	Thousands	None
Cocoons typically observed Were cocoons observed on buildings or in shrubbery during a short walk?	None	Few	Many	Dozens	None
Friendly flies typically observed During a short walk, how many friendly flies did you observe?	None	None	Dozens	Hundreds	Dozens
Nuisance moths observed Did you have to sweep up the dead moths on patios, sidewalks or driveways?	None	None	Few	Many	None
Egg masses found near well-lit areas Did you observe egg masses on trees or buildings?	None	1 or 2	Few	Several	None
Predicted FTC defoliation levels for the upcoming summer	Trace to Light	Moderate to High	High to Complete	Complete 100%	None

How forest tent caterpillar populations build outbreaks

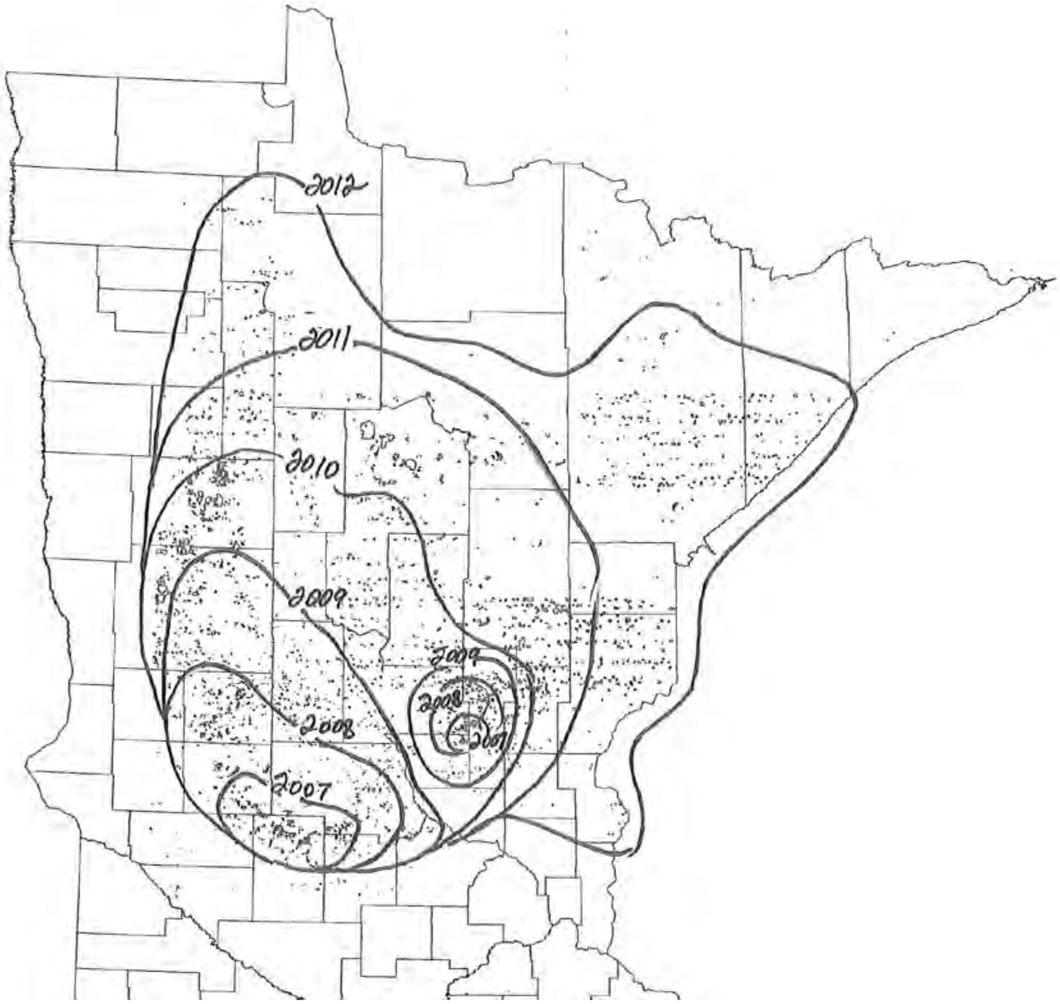
We always knew that the really large forest tent caterpillar (FTC) outbreaks in the northern forests were synchronized with simultaneous outbreaks in northwest Ontario, Wisconsin, and Michigan, but we didn't realize how the FTC populations near Lake Mille Lacs and along the west-central counties contributed to the big picture until our aerial survey started mapping individual stands in 1995. Since then we've been able to follow the progress of two FTC outbreaks as they are building up.

What we're finding:

- There are always some populations of FTC active every year in the west-central counties, usually in oak and basswood stands. Outbreaks usually don't last very long in these stands.
- There are two locations in central Minnesota where populations build up and spread out in advance of the north-wide outbreaks: northern Kandiyohi County and along the southeastern shores of Lake Mille Lacs and in the Rum River Forest in Mille Lacs County.
- North-wide outbreaks seem to spill out of the districts in northwestern Ontario and southeast Manitoba into the northern counties of Minnesota, somewhat like waves of an invasion that causes defoliation in aspen and birch forests.
- Several years prior to a north-wide outbreak, the east central population builds up and intensifies locally. The west-central populations leap-frog north from Kandiyohi into Pope, then Ottertail, Becker and Polk counties.
- Just about that time, the north-wide outbreak begins and within a couple of years, Minnesota forests experience 2 to 7 million acres of FTC defoliation.
- Then the entire population collapses right before our eyes and all we are left with is a few billion friendly flies and some tiny FTC populations down in Pope and Kandiyohi counties still causing defoliation.



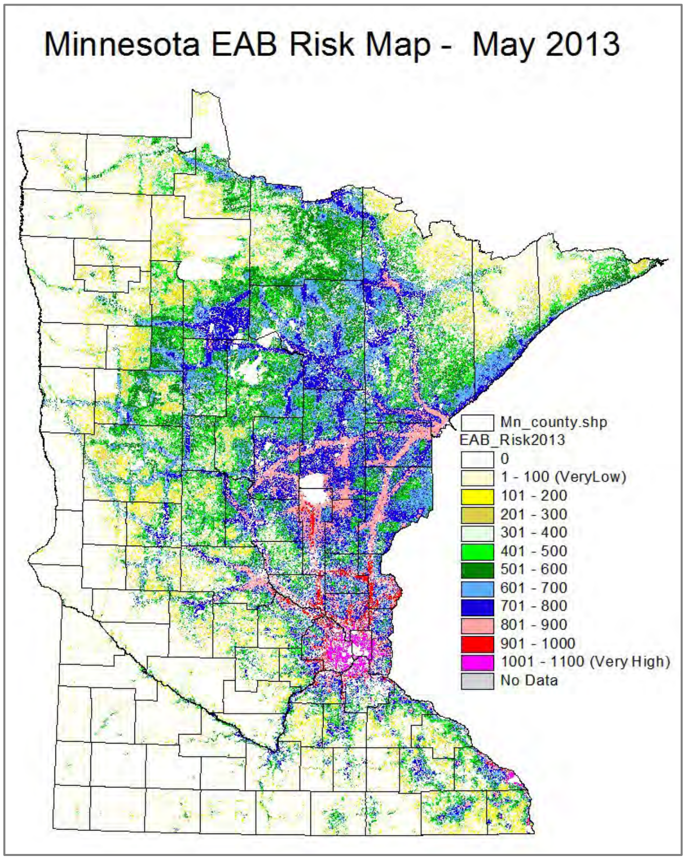
Forest tent caterpillar outbreak, 1998-2001

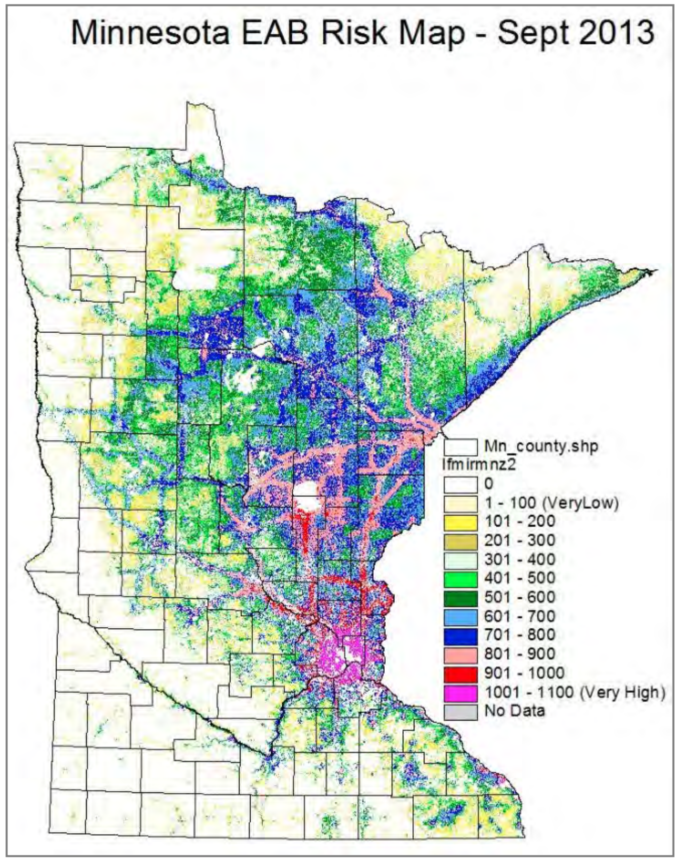


Forest tent caterpillar
outbreak: 2007 - 2012

Risk-of-spread maps for emerald ash borer

For the past three years, USFS-NRS researchers have produced these maps for Minnesota DNR and MDA. This year, they produced an additional map after emerald ash borer (EAB) was found in Superior, Wisconsin, which borders Duluth, Minnesota. Prior to this the existing risk of spread in the northern half of the state was relatively low (below, left). After the find in Superior, the risk jumped dramatically along transportation routes emanating from Duluth with elevated risks noted in Orr, Grand Rapids, Bemidji and Little Falls (below, right).





Regional temperatures associated with tamarack mortality due to eastern larch beetle in Minnesota, USA

Susan J. Crocker[1], Brian H. Aukema[2], Greg C. Liknes[1], Fraser R. McKee[2] and Jana S. Albers[3]

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Introduction

Pure stands of tamarack (*Larix laricina*) help to define the forests of Minnesota's 'North Woods'. Although tamarack continues to be a dominant component of northern Minnesota forests, a history of major anthropogenic and biotic disturbances, such as harvesting associated with European settlement and outbreaks of eastern larch beetle (ELB), *Dendroctonus simplex* LeConte (Coleoptera: Curculionidae: Scolytinae), have altered the extent of tamarack on the landscape. Native to North America, ELB has been documented in Minnesota since 1938. While outbreaks are typically sporadic and short-lived, the most recent outbreak of ELB has been ongoing since 2000. Defoliation is frequently a disposing factor to trees undergoing attack by ELB, but defoliation activity has not been apparent prior to the current outbreak. Hence, we studied whether climatic factors such as recurring periods of drought and changing temperatures were associated with outbreaking populations of ELB in Minnesota.

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

Methodology

Study Area

Mortality Analysis

Data from the USFS Forest Inventory and Analysis (FIA) program was used to analyze trends in tamarack mortality between 1977-2012.

Model

Metrics describing tamarack presence and annual mortality due to ELB, and temperature variables related to beetle emergence and developmental threshold were summarized by 10km grid cell (Table 1). Spatial autoregressive models were then employed to examine ELB mortality as a function of annual change in temperature between 2000 and 2012.

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

Results

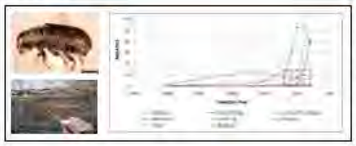

Fig. 1. Ratio of annual mortality volume to annual growth volume for select counties, Minnesota, 1990-2012. Image citation: Darren Blackford (top) and Steven Katovich (bottom), USFS, www.bugwood.org.

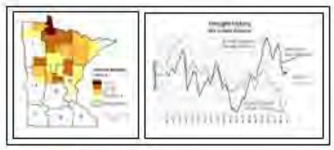

Fig. 2. Tamarack mortality by county and climate division, 2012 (left). Drought history by climate division, 1971-2009 (right).

Variable	[illegible]	[illegible]
Spatial		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
Temporal		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
Environmental		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Table 1. Probability of outbreak in a 10x10km grid cell with tamarack in Minnesota, 2000-2012. Footnote: Variables reflect marginal fits (i.e., after accounting for effects of all other variables). All variables are significant at $P<0.005$.

Conclusions

- Within the current outbreak, there is an increase in mortality following successive years of drought.
- Spatiotemporal autologistic models indicated that tamarack mortality due to ELB increased when:
  - the 1st frost-free day occurred in late spring the previous year, and
  - the 1st day < 10 degrees C occurred in late spring of the current year
- These patterns likely reflect synchronous emergence of beetles and attack of tamarack with frozen root systems.

Next Steps

Continued analysis of temperature as it relates to spatial patterns of tamarack mortality and ELB activity will help to further elucidate historic patterns of ELB outbreaks and inform future management practices.

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

Estimating impacts of Eastern larch beetle (*Dendroctonus simplex* LeConte) induced mortality on tamarack (*Larix laricina* (Du Roi) K. Koch) harvest amounts in Minnesota

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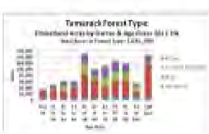
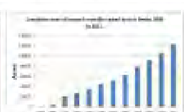
Introduction

Tamarack has been an important component of Minnesota's forests for the past 3,000 years; however, it has been experiencing significant and accelerated insect-caused mortality over the past decade, largely due to the eastern larch beetle (ELB). At the time of European settlement in Minnesota, tamarack was the most abundant species in the state composing 16.9 percent of Minnesota's original Public Land Survey (PLS) bearing trees. In 2011, tamarack represented only 3.8 percent of all trees in the state's Forest Inventory and Analysis (FIA) system. Minnesota at one time had close to 6 million acres of tamarack forests. Many factors have contributed to the decline, for example land conversion itself has resulted in a reduction of over half of this original amount. In 2011, FIA estimated that there were 1,024,000 acres of tamarack cover type in Minnesota, of which the state manages nearly half.

Tamarack is used by various forest products industries. It is principally used for pulpwood, but also for lumber, posts, ties, etc. The greatest opportunity for increasing development of high volume markets appears to be energy markets, particularly for dead and dying tamarack. Ongoing insect-caused mortality means an absence of a large, relatively stable future supply. This will have major impacts to marketing efforts.

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

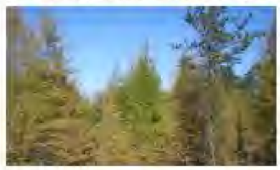




Estimated amount of acreage containing tamarack mortality caused by ELB

Methods

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



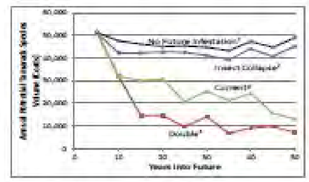
The objective of this current study is to determine how different assumptions about the rate of tamarack mortality caused by the ELB and their interaction with varying Desired Future Conditions (DFC) impact long-term potential volumes on state administered lands. Within Woodstock, the objective function is to maximize total potential cordwood volume across all species and cover types relative to a set of management constraints or goals.

Scenarios were modeled assuming that first, the current annual rate of ELB infestation in the state will remain constant (Current); second, the current annual rate of ELB infestation in the state will double (Double); third, the current annual rate of ELB infestation in the state will collapse within five years (Insect Collapse); and fourth, an estimate of volumes associated with no future ELB infestation in the state (No Future Infestation).

Cover Type	Total Number of Harvestable Acres	Cover Type Percentage	Acres Assigned ELB Mortality: Current	Double	Collapse
Ash	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lowland Hardwood	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aspen	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Birch	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N. Hardwoods	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oak	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
White Pine	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Red Pine Natural	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Jack Pine	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
White Spruce Natural	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Balsam Fir	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Black Spruce [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Black Spruce Poor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Black Spruce Medium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tamarack Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tamarack Bad	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lowland [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RP Plantation	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WS Plantation	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]		[illegible]	[illegible]	[illegible]

Results and Discussion

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



[illegible]

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

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

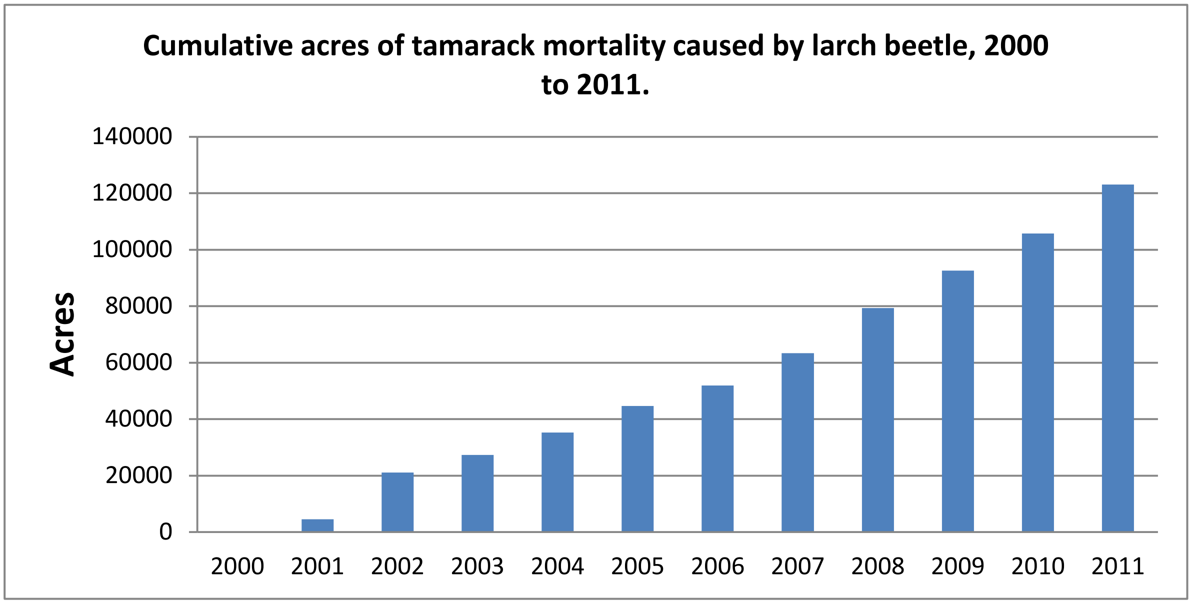
Our most recent estimate (using a combination of data from 2008, 2009, and 2010) of annual harvest amounts showed that 72,000 cords of tamarack was harvested across all ownerships in Minnesota. We only present estimates of potential harvested volume on DNR lands and these volume estimates are based on the assumption of no change in management or accelerated harvesting. Thus, purposeful management to increase the harvest amount of tamarack on DNR lands will result in greater harvest amounts than depicted in the chart above. A recent sustainable harvest analysis conducted by the DNR using 2005 FIA inventory data estimated that around 115,000 cords of tamarack could be harvested sustainably on an annual basis ACROSS ALL OWNERSHIPS (see page 39 of MNDNR's report on Minnesota's Forest Resources at the following link: http://files.dnr.state.mn.us/forestry/um/forestresourcesreport_11.pdf). This estimate did not directly account for ELB and other mortality causing factors of tamarack, and thus might be slightly optimistic, but it does show that additional tamarack volume is available.

Tamarack Health Assessment Report

Prepared by Central Office and regional staff, this document covers all the important aspects of the tamarack cover type in Minnesota, including the impact and trend of eastern larch beetle mortality. It can be found in its entirety at [Tamarack assessment.]

Executive Summary

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



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

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

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

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

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

Background

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

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

Key Findings

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

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

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

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

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

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

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

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

Recommendations

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

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

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

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

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

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

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

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

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

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

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

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

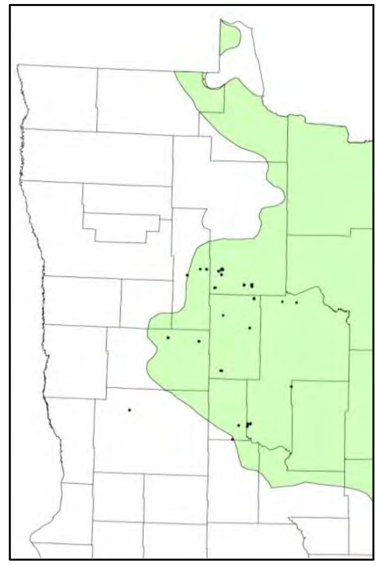
9. Encourage and support cooperative efforts with other land management agencies and research institutions to develop a comprehensive knowledge of the management approaches for this species and to ensure scientific studies on this species are relevant to the DNR and the current issues facing the resource.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

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

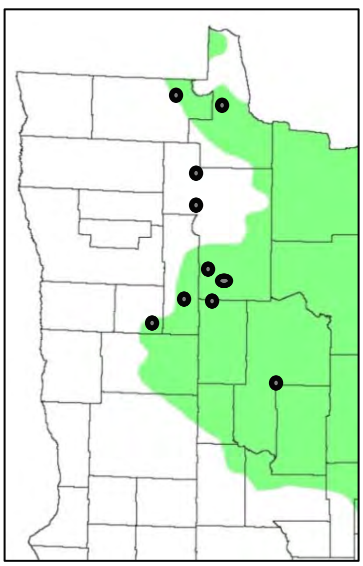
Tip blight and branch flagging in red pine plantations field study

During the spring of 2013, a small number of red pine plantations in the northwestern counties exhibited unusual symptoms in their crowns: scattered tip blight and branch flagging in otherwise green crowns (see photo below). Rarely-occurring symptomatic red pines were found in both ground and aerial surveys (see maps below).

Branch flagging in 60-year-old red pine, Beltrami Co.



Locations of symptomatic red pine plantations, 2013 aerial survey



Locations of symptomatic red pine plantations, 2013 ground survey

Most often, less than fifty trees in a plantation were symptomatic and they were usually clustered in a group. Symptomatic pines ranged in size from established saplings (15 ft) to over-mature trees and all had cones on affected branches. Symptomatic trees were only observed on very droughty sites, especially on gravelly ridges or former jack pine sites and in plantations outside the natural range of red pine.

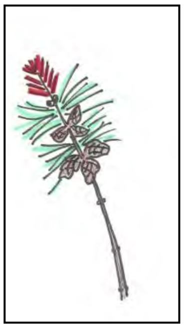
Four plantations were followed during the summer for symptom development and the presence of insects and pathogens (diagram on following page).

- In mid-June, the terminal twigs on sampled branches were dead. The remaining needles were green. *Pityophthorus* twig beetles were found in the first whorl of needles. *Diplodia* infections were commonly found in the second and third whorls of needles (in 55 percent of the sampled branches) or *Diplodia* was absent.

- By late August, all the needles on sampled branches had turned red and were dead. Twig beetles were infesting whorls 2 and 3. *Diplodia* infections had spread down the branch and could be found from whorl 2 to whorl 6 (in 90 percent of all the sampled branches).
- Cones were also examined on collected branches. The incidence of cone infection by *Diplodia* spp. varied from site to site (zero to 94 percent) and by collection date (June, 4 percent; July 13 percent; August, 73 percent). The number of cones examined was fairly small so no conclusions should be drawn from them.

Symptom development and presence of twig beetles and *Diplodia* in samples

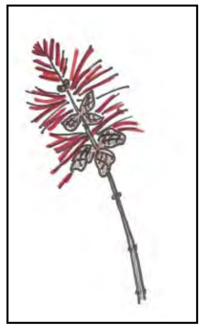
June 2013, tip blight



Twig beetles in whorls 1 and 2.

Diplodia infections either absent or present in whorls 2 and 3. Infections associated with presence of cones or cone scars.

August 2013, branch flagging



Twig beetles in whorls 2 and 3.

Diplodia infections present in whorls 2 through 6. Infections expanding downwards in branches.

Droughty weather has afflicted this area of the state for over a decade and was a predisposing factor for both *Pityophthorus* infestations and *Diplodia* infections. It is uncertain what will happen to these trees in the next few years. If the leader died, the tree may become suppressed. If drought continues, *Diplodia* is likely to kill more branches and even the crown of affected trees. If there is timely and abundant rainfall, symptomatic pines will likely recover. However, we do know that the *Diplodia* fruiting bodies will be present on cones and dead branches for the next few years and they could be a source of inoculum if droughty spells reoccur. We'll have to wait and see what happens to these pockets of trees in 2014.

Branch flagging in red pines. Clockwise from top left: Clearwater County, Beltrami County, Mahnomen County, Beltrami County

Storage Conditions Influence Cultural Detection of the Shoot Blight Pathogen *Diplodia pinea* From Asymptomatic Red Pine Nursery Seedlings

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Abstract

The pine shoot blight, canker, and collar rot pathogen *Diplodia pinea* can persist on or in asymptomatic red pine nursery seedlings, and it can proliferate after outplanting to cause disease and mortality. After lifting from nursery beds, seedlings are routinely kept in cold storage at nurseries.

During and after shipment to customers, however, seedlings may be stored without refrigeration. In each of 2 years, we assayed seedlings from a bareroot nursery before and after storage for presence of this pathogen. Each trial included a storage treatment in which seedlings were kept at room temperature for 1 week after cold storage. Results demonstrated the effectiveness of nursery cultural practices and protective fungicide applications, as well as cold storage, to reduce the frequency of association of the pathogen with asymptomatic seedlings. We recommend that seedlings be kept in cold storage, even at moderately cool temperatures, before, and especially after, delivery to customers.

Introduction

Red pine (*Pinus resinosa* Aiton) is the most planted tree in the North-Central region of the United States (Gilmore and Palik 2006), and most contemporary red pine stands are plantations of this single species (USDA Forest Service 2002). Seedlings are planted after clearcut harvests of mature plantations. Most of these seedlings are 2- or 3-year-old bareroot seedlings produced in State and Federal nurseries in Michigan, Wisconsin, and Minnesota.

Shoot blight, canker, and collar rot caused by *Diplodia pinea* (syn. *Sphaeropsis sapinea*) frequently damages red pine nursery seedlings. For example, Palmer and others (1986) reported a 42-percent disease incidence in 2-0 seedlings. In plots located in proximity to red pine windbreaks, which are a source of inoculum, the frequency of shoot blight can be even greater (Stanosz and others 2005). *D. pinea* survives in dead colonized needles, stems, and cones on which it bears asexual fruiting bodies (pycnidia) (figure 1) that release spores (conidia). Spores are disseminated by rain splash and are abundant during spring and early summer (Palmer and others 1988), when young shoots are most susceptible. The pathogen infects through stomata, directly through the surface of young stems, or through fresh wounds (Brookhouser and Peterson 1971, Chou 1976). Pycnidia with conidia can develop within a few weeks after infection on dead seedlings, killed organs of living seedlings, and shoots excised from top-pruned seedlings (Munck and Stanosz 2008, Palmer and others 1988), so that multiple cycles of disease within a single growing season are possible. The similar fungus *D. scrobiculata* also can damage red pines, but it has been less often associated with red pine nursery seedlings (Stanosz and others 2005). Red pine seedlings of all age classes may be rendered unmerchantable because of Diplodia shoot blight, canker, and collar rot, all of which lead to deformity or death (Palmer and Nicholls 1985). Infection of young seedlings during the first season of growth can result in rapid mortality, with retention of reddish to brown dead needles (figure 2). Colonization of elongating shoots on older seedlings can lead to shoot

Figure 1. Pycnidia of *Diplodia pinea* emerging from the base of a red pine needle. (Photo by Glen R. Stanosz

death before full needle elongation and result in curling or crooking of the stem (figure 3). Needles of diseased shoots often turn yellow, then red to brown, or gray. Cankers on seedling stems begin as discrete, purplish, resinous lesions that result from direct infection or pathogen growth into stems from diseased needles. Collar rot symptoms include relatively rapid desiccation of needles and seedling death (figure 4), with blackening of the lower stem and root collar inner bark, and with dark staining of the underlying wood (figure 5). Although obviously symptomatic seedlings can be discarded during sorting and grading before packing, shipments of bulk-lifted seedlings (those that are packed immediately after lifting without sorting or grading) may include blighted or dead seedlings that bear the pathogen.

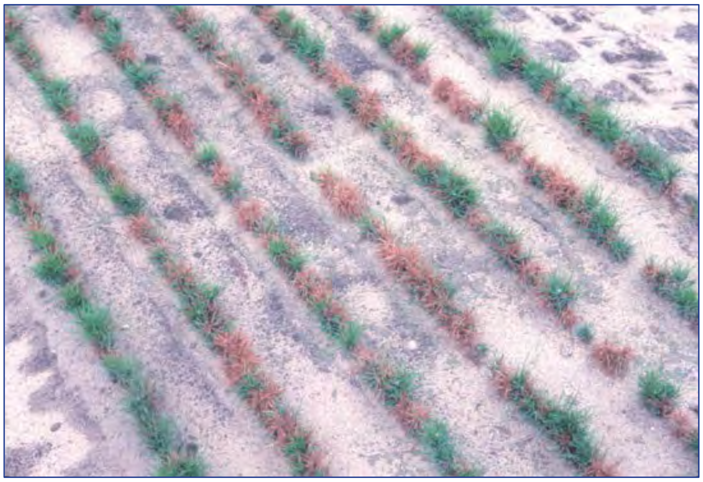

Figure 2. Dead red pine seedlings killed by *Diplodia pinea* in the first season of growth. (Photo by Glen R. Stanosz)

Figure 3. Distorted red pine shoot killed by *Diplodia pinea* during elongation. (Photo by Glen R. Stanosz)

Figure 4. Red pine seedling that was rapidly killed by Diplodia collar rot (inset) shortly after outplanting. (Photo by Glen R. Stanosz)

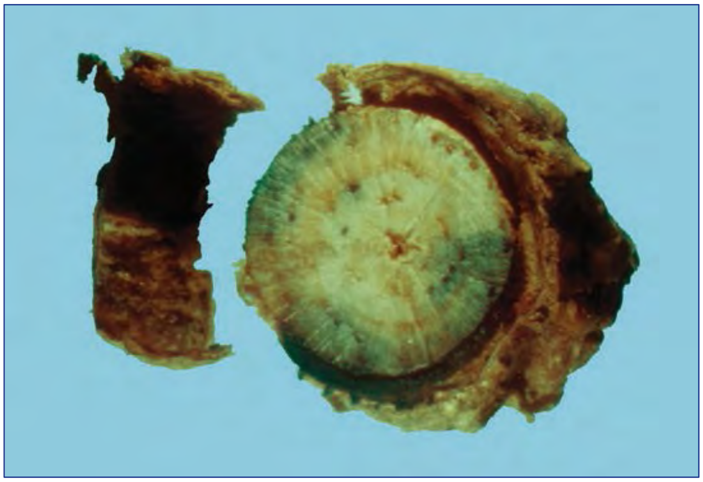

Figure 5. Darkly discolored inner bark tissues and stained wood of seedling killed by Diplodia collar rot. (Photo by Glen R. Stanosz)

Application of protectant chemicals to reduce losses caused by *D. pinea* has produced mixed results. Palmer and others (1986) reported that only 2.7 percent of 2-0 red pine seedlings were diseased when treated with benomyl during both growing seasons. In one nursery, however, Stanosz and others (2005) found that, in spite of benomyl application, the average disease incidence, based on visible symptoms, was 43 percent in plots of 2-0 seedlings in close proximity to a windbreak inoculum source. In addition, fungicide applications may not prevent persistence of *D. pinea* on or in seedlings in the absence of disease development. Stanosz and others (2005) culturally assayed surface-disinfested lower stem segments from healthy-appearing seedlings. The pathogen was detected on 63 percent (Wilson State Nursery, Wisconsin) and 88 percent (Badoura State Nursery, Minnesota) of asymptomatic seedlings in beds that were in close proximity to a windbreak inoculum source and in which symptomatic seedlings also were common. In addition, *D. pinea* can subsequently proliferate and kill previously asymptomatic seedlings under conditions that induce host stress (Stanosz and others 1997, Stanosz and others 2001). This ability of *D. pinea* to act as a latent pathogen may explain the frequent mortality associated with collar rot of recently outplanted red pine seedlings (Stanosz and Cummings Carlson 1996).

After dormant bareroot red pine seedlings are lifted and packed in early spring, they usually are stored until delivery to customers. For example, at the Minnesota Department of Natural Resources General Andrew Nursery, seedlings are placed in plastic bags and then into shipping cartons and maintained in a cold room at 3.3 to 4.4 °C (38 to 40 °F) for as long as 3 weeks. After seedlings are transferred to customers, however, conditions during transport and storage for days or even weeks until seedlings are planted are highly variable and often do not include cold storage.

Nurseries in which Diplodia shoot blight, canker, and collar rot have caused serious losses have implemented practices intended to reduce both the incidence of these diseases in nursery beds and the persistence of *D. pinea* on healthy-appearing seedlings. The influence of storage conditions on the activity of *D. pinea* on or in the asymptomatic seedlings, however, has not been explored. The objectives of this study were to (1) quantify the effectiveness of disease management practices on the persistence of *D. pinea* on or in asymptomatic red pine nursery seedlings and (2) determine the influence of storage, including a period of nonrefrigerated storage, on asymptomatic persistence of the pathogen on red pine nursery seedlings. Studies were conducted in each of 2 years, using cultural methods to detect the pathogen and molecular methods to confirm pathogen identity.

Methods

Experiments With Non-inoculated Seedlings

Experiment 1 was designed to compare the frequency of cultural detection of *D. pinea* among seedlings assayed

(1) upon receipt from the nursery (without extended storage),

(2) after storage for 3 weeks in a cold room, or (3) after storage for 3 weeks in a cold room and then 1 additional week at a room temperature. The third treatment was intended to simulate proper cold storage of seedlings after lifting, followed by storage at a warmer temperature during delivery or after receipt by a customer.

Asymptomatic, dormant red pine seedlings were lifted from two nursery beds in late April 2009 and 2010 from the Minnesota Department of Natural Resources General Andrews State Nursery, Willow River, MN (46.32° N., 92.84° W.). Seedlings from each nursery bed were packaged 10 per plastic bag (a replicate), with these bags placed within a larger plastic bag and corrugated cardboard box normally used for seedling shipment. The two boxes were shipped overnight to the laboratory at the University of Wisconsin-Madison, where five replicate bags of seedlings from each nursery bed were randomly assigned to each of the three treatments, and then replaced in the larger plastic bag in the shipping boxes.

Experiment 2 was conducted similarly in 2010 with five replicate bags of seedlings from each nursery bed assigned randomly to (1) storage for 4 weeks in a cold room or (2) storage for 3 weeks in a cold room, followed by 1 week at room temperature. Storage temperatures during each experiment were recorded hourly using Hobo data loggers (Onset Computer Corporation, Bourne, MA) placed among the bags of seedlings.

After storage, seedlings were culturally assayed using procedures similar to those previously developed to evaluate asymptomatic persistence of the pathogen on or in red pine seedlings (Stanosz and others 2005). A segment approximately 5 cm (2 in) long was cut from the lower stem/root collar of each seedling, needles were removed, and then surface-disinfested by 30 sec immersion in a 95-percent ethanol solution followed by two immersions for 2 min each in a solution of 1.05 percent NaClO plus two drops of Tween-80 per liter (8 drops per gallon) deionized water. Each segment was then placed on one side in an 84-mm-diameter (3.3-in-diameter) Petri dish containing tannic acid agar medium (Blodgett and others 2003) and twice-autoclaved red pine needles were placed on the other side (figure 6). The dishes were incubated 30 cm (12 in) beneath one cool white

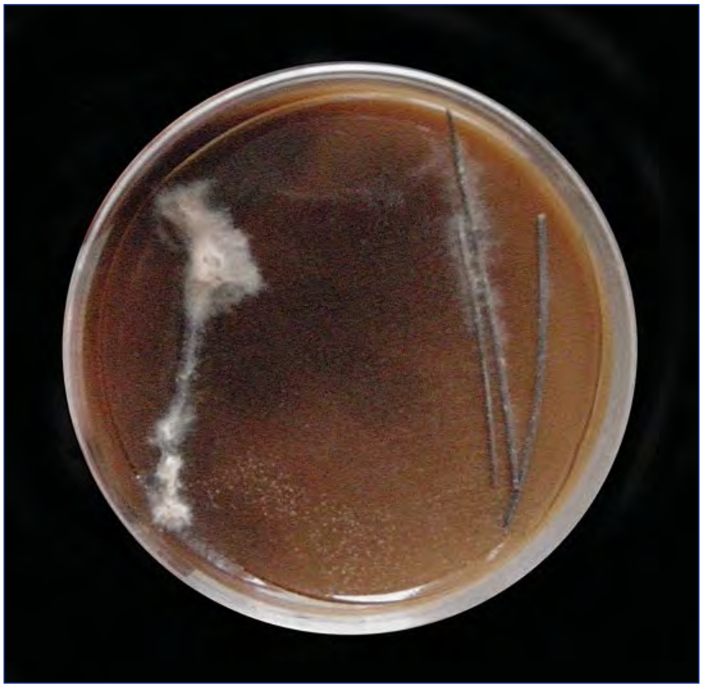

Figure 6. *Diplodia pinea* mycelium that has grown from a surface-disinfested red pine stem segment (left) to red pine needles (right) in a Petri dish containing tannic acid agar medium. (Photo by Glen R. Stanosz)

fluorescent light tube and one ultraviolet light tube for up to 6 weeks at approximately 24 °C (75 °F). Conidia from pycnidia produced on the needles were examined for characteristics consistent with those of *D. pinea* (Punithalingam and Waterston 1970).

To confirm the pathogen species, pycnidia from the Petri dishes were transferred to potato dextrose broth and incubated for approximately 1 week. After incubation, DNA from these subcultures was extracted using the procedures of Smith and Stanosz (1995). The fungus was then identified using specific mt SSU rDNA PCR primers that allow differentiation of *D. pinea* from the similar conifer pathogen *D. scrobiculata* and other related fungi (Smith and Stanosz 2006).

Experiments With Inoculated Seedlings

Because nursery disease management practices likely reduced *Diplodia* frequency on red pine seedlings, additional experiments were conducted to further evaluate storage effects on the pathogen's persistence and disease. Dormant seedlings from the same nursery were lifted from two nursery beds in late April 2009 (experiment 3) and 2010 (experiment 4), packaged 10 per plastic bag, and shipped to the laboratory as described previously for experiments 1 and 2. Conidial inoculum of *D. pinea* was applied to seedlings after receipt, however, to ensure presence of the pathogen with seedlings during storage treatments. Experiment 3 was conducted in 2009 with 10 bags (replicates) from each nursery bed assigned randomly to each of two treatments: (1) storage for 3 weeks in a cold room or (2) storage for 3 weeks in a cold room, followed by 1 additional week at room temperature. Experiment 4 was conducted in 2010 with 10 bags from each nursery bed assigned randomly to (1) storage for 4 weeks in a cold room or (2) storage for 3 weeks in a cold room, then 1 additional week at room temperature.

Conidial inoculum was obtained from twice-autoclaved red pine needles incubated for several weeks on colonies of *D. pinea* on water agar medium. Needles bearing pycnidia were crushed in sterile, deionized water. The resulting suspension was filtered through two layers of cheesecloth, and more water was added to adjust the concentration of conidia to 5 by 10^4 spores per millimeter. An atomizer was used to apply 1 ml of conidial suspension to seedlings in each replicate bag and then the bag was resealed. Germination of conidia in the inoculum suspensions was assessed by examination of 50 conidia per trial of experiments 3 and 4 after 4 hours incubation on water agar medium at 24 °C (75 °F) in the dark. For both experiments, germination exceeded 80 percent. After storage, seedlings were culturally assayed using procedures described above.

Experimental Design and Data Analysis

Because results were similar, data for seedlings from the two nursery beds were pooled into a single, completely randomized design for each experiment. Means of temperatures recorded hourly for each experiment were calculated, and maximum and minimum temperatures were determined. For each experiment, mean percentages of seedlings from which the pathogen was detected were calculated. Because the data lack normality, analyses were performed using a nonparametric method. Differences among storage treatments in each experiment were determined using the Kruskal-Wallis test of equality of medians using Minitab for Windows version 14 (Minitab Inc., State College, PA).

Results and Discussion

Experiments With Non-inoculated Seedlings

Use of molecular methods confirmed *D. pinea* as the pathogen cultured from noninoculated seedlings in every case except one, when the similar pathogen *D. scrobiculata* was detected. The detection of *D. pinea* in this study is consistent with pre- valence of this pathogen with asymptomatic nursery seedlings at other nurseries, but contrasts with previous results for the General Andrews State Nursery. When surveyed in 2002, 7 of

10 seedlings from the General Andrews State Nursery for which molecular methods were used to confirm pathogen identity yielded *D. scrobiculata* (Stanosz and others 2005). Whether the current result indicates a shift in pathogen population in, or in the vicinity of, this nursery is unknown. These findings, however, underscore the importance of employing methods that allow for unambiguous identification of fungal pathogens.

Noninoculated seedlings were infrequently (0 to 7 percent) culturally positive with or without extended storage in both 2009 and 2010 (table 1). Detection of a *Diplodia* pathogen was rare in these 2 years compared with 2002, when seedlings from this nursery were similarly assayed. At that time, averages of 20 and 26 percent of asymptomatic seedlings from the two locations sampled tested positive for either pathogen, with as many as 40 percent of seedlings positive in one plot (Stanosz and others 2005). At other nurseries sampled that year in Minnesota and Wisconsin, as many as 88 percent of asymptomatic seedlings in proximity to windbreaks bore *D. pinea* or *D. scrobiculata*. The much lower frequency of detection in the current study can be attributed to efficacy of current disease management practices at the General Andrews State Nursery and the other affected nurseries. Removing red pine windbreaks, rouging affected seedlings, avoiding top pruning, and adopting a 2-year production cycle (instead of a 3-year cycle) reduce the exposure of seedlings to inoculum. Coupled with judicious application of fungicidal sprays, these measures have drastically reduced association of the pathogens with seedlings (Minnesota Department of Natural Resources 2009, Wisconsin Department of Natural Resources 2011).

Experiments With Inoculated Seedlings

Results differed significantly between storage treatments for seedlings to which inoculum had been added in 2009 ($p < 0.01$). The frequency of culturally positive inoculated seedlings was 6 percent when seedlings were cold stored (approximately 3.5 °C) for 3 weeks compared with 33 percent for seedlings that were stored for 1 additional week at room temperature (table 1). This difference demonstrates the potential for pathogen proliferation after removal of seedlings from cold storage. Detection, even after rigorous surface disinfestation, suggests that a pathogen is not merely persisting superficially, but that infection has occurred.

In 2010, temperature in cold storage was not as low as desired, averaging nearly 8 °C (14.4 °F) (table 1). The frequency of cultural detection was 12 percent for seedlings that were cold stored for 4 weeks and 21 percent for seedlings that were removed from the cold room and stored for a 4th week at room temperature ($p = 0.12$). Even though cold storage temperatures were higher than planned, a tendency still existed for more frequent pathogen detection after exposure to a warmer temperature for the final week.

Implications for Nurseries and Customers

Similar to the current study, previous research to examine the effect of temperature on growth of *D. pinea* and *D. scrobiculata* found that temperatures of 20 °C (68 °F), 25 °C (77 °F), and 30 °C (86 °F) were conducive to colony growth after 3 days on potato dextrose agar, whereas no discernable growth was observed for cultures at 5 °C (41 °F) or 10 °C

Table 1. Percentages of asymptomatic red pine seedlings from which cultural detection of *Diplodia pinea* or *D. scrobiculata* occurred.

	2009 (experiment 1)	2010 (experiment 2)	2009 (experiment 3)	2010 (experiment 4)
No storage	3	7	—	—
Stored 3 weeks at 3.5 ± 1.1 °C (38.3 ± 2.0 °F)	1	—	6	—
Stored 3 weeks at 3.5 ± 1.1 °C (38.3 ± 2.0 °F), followed by 1 week at 23.0 ± 1.1 °C (73.4 ± 2.0 °F)	1	—	33	—
Stored 4 weeks at 7.8 ± 1.0 °C (46.0 ± 1.8 °F)	—	0	—	12
Stored 3 weeks at 7.9 ± 0.5 °C (46.2 ± 0.9 °F), followed by 1 week at 24.8 ± 1.6 °C (76.6 ± 2.8 °F)	—	4	—	21
	p = 0.40[c]	p = 0.10	p < 0.01	p = 0.12

[a] Experiments 1 and 2: n = 10; 5 replicates from each of two nursery beds.
[b] Experiments 3 and 4, n = 20; 10 replicates from each of two nursery beds.
[c] Values of p for treatment differences using Kruskal-Wallis test of equality of medians.

(50 °F) (Palmer and others 1987). Temperatures of 0 °C to 2 °C (32 °F to 36 °F) are recommended as ideal cold storage temperatures for seedlings for up to 2 months (Landis and others 2010). Many nurseries now have facilities for storage of seedlings at these temperatures, although customers may not. Results of this study and others support the likely benefit of preplanting storage by customers at even moderately cool temperatures (≤ 10 °C [≤ 50 °F]).

In addition to the direct influence of temperature on fungal growth, lengthy cold storage durations or storage without refrigeration could affect seedling physiological condition (Landis and others 2010) and render seedlings susceptible to infection or disease development. For example, a controlled experiment with potted red pine seedlings demonstrated that moisture stress induces more severe Diplodia shoot blight symptoms (Blodgett and others 1997). As mentioned previously, stress can stimulate proliferation of *D. pinea* to kill previously asymptomatic seedlings (Stanosz and others 2001). Storage in sealed plastic bags lessens drying in storage and no visible indications of drying were apparent in the current study.

Conclusions

We infrequently cultured *Diplodia pinea* and *D. scrobiculata* from asymptomatic red pine seedlings grown in a nursery where practices included removal of inoculum sources, chemical protection, and other measures to reduce or eliminate presence of these pathogens. When we inoculated the seedlings with *D. pinea* immediately before storage, however, a period of storage without refrigeration led to more frequent cultural detection of this pathogen. Storage of seedlings at even moderately cool temperatures before, and especially after, delivery to customers is recommended.

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Surveys

Jack pine budworm: Early larval survey, June, 2013

County
Township
GPS Coordinates | #Larvae/30 Shoots *S = staminate cone* *V= vegetative shoot* | Est. Defoliation/ Pollen *Clean = no defoliation* | Notes

Beltrami County

Eckles Twp.
N 47 31.630 W 95 57.343 S- 0/20 V- 0/10 Clean Pollen Shedding Extensive drought mortality
N 47 53.388 W 94 59.561 S- 0/15 V- 0/15 Clean Pollen Shedding

Lammers Twp.
N 47 38.183 W 95 03.362 S- 0/24 V- 0/6 Clean Pollen Shedding
N 47 34.923 W 95 05.885 S- 0/18 V- 0/12 Clean Pollen Shedding
N 47 34.92 W 95 06.396 S 0/16 V- 0/14 Clean Pollen Shedding
N 47 35.042 W 95 07.525 S- 0/18 V- 0/12 Clean Pollen Shedding

Buzzle Twp.
N 47 35.254 W.95 08.350 S- 0/27 V- 0/3 Clean Pollen Shedding
N 47 36.938 W 95 09.638 S- 0/20 V- 0/10 Clean Pollen Shedding

JonesTwp.
N 47 26.634 W 95 06.634 S- 0/6 V- 0/24 Spittlebug Pollen Shedding
Spittlebug common. Had to re-establish new plot due to storm damage in 2012.
N 47 25.573 W 95 06.141 S- 0/15 V- 0/15 Clean Pollen Shedding

Hubbard County June 12, 2013

Hendrickson Twp.
N 47 12.928 W 94 47.839 S- 0/18 V- 0/12 Clean Pollen Shedding
New Location due to 2012 burn. HWYS 64 & 200 Jct

White Oak Twp.
N 46 56.061 W 94 43.142 S- 0/21 V- 0/9 Clean Pollen Shedding

Badoura Twp.
N 46 51.749 W 94 43.429 S- 0/21 V- 0/9 Clean Shedding
N. 46 51.744 W. 94 42.029 S- 0/16 V- 0/14 Clean Shedding
N. 46 49.130 W. 94 45.938 S- 0/24 V- 0/6 Clean Shedding

Lake George Twp.
N. 47 13.172 W. 95 00.640 S-0/24 V- 0/6 Clean Shedding
N. 47 12.589 W. 94 59.314 S- 0/6 V- 0/24 Clean Shedding
Plantation

Schoolcraft Twp.
N. 47 14.213 W. 94 59.961 S- 0/21 V- 0/9 Clean Shedding

Cass County - Northwestern

Ansel Twp.

N. 46 46.776 W. 94 42.134	S- 0/18	V- 0/12	Clean	Shedding

Wadena County - Northern

Huntersville Twp.

N. 46 48.255 W. 94 49.806	S- 0/18	V- 0/12	Clean	Pollen Shedding
N. 46 47.670 W. 94 51.034	S- 0/12	V- 0/18		Pollen Shedding

Becker County - Eastern

Green Valley Twp.

N. 46 51.320 W. 95 12.301	S- 0/15	V- 0/15	Pollen Shedding
N. 46 50.700 W. 95 13.293	S- 0/12	V- 0/18	Pollen Shedding

Osage Twp.

N. 46 58 681 W. 95 15.248	S- 0/14	V- 0/16	Pollen Shedding

Two Inlets Twp.

N. 47 02.525 W. 95 11.901	S- 0/24	V- 0/6	Pollen Shedding

NOTE: No sign of needle loss or consumption was evident on any sampling or the remaining part of branches not inspected. However, considerable shoot and branch mortality was observed on samples taken in Eckles, Lammers, Buzzle, and Jones townships in Beltrami County.

Walnut Twig Beetle Survey

During the summer of 2013, the Minnesota Department of Natural Resources conducted a survey for the non-native walnut twig beetle (*Pityophthorus juglandis*), the beetle that carries the fungus causing thousand cankers disease of walnut (TCD). Minnesota has approximately six million black walnut trees at risk. While Minnesota has an exterior quarantine that prohibits bringing any black walnut (except processed lumber or wood products) originating in areas known to have TCD into Minnesota, monitoring black walnut for any symptoms is an important part of preventing the spread of TCD.

We placed 27 funnel traps baited with a walnut twig beetle pheromone in black walnut trees in nine southern Minnesota locations. Locations included a private landowner in Cannon Falls, Frontenac State Park, Richard J. Dorer Memorial Hardwood State Forest, Carley State Park, Great River Bluffs State Park, a private landowner in Brownsville, and Beaver Creek State Park. Traps were installed in mid-July and monitored approximately every two weeks until early October.

We found no walnut twig beetles in the samples, nor did we find any native beetles in the genus *Pityophthorus*. We did not observe any declining black walnuts, the first indicator of TCD. For more information on symptoms of TCD and what to do if you suspect it, please see the Minnesota Department of Agriculture website.

Forest Tent Caterpillar: Egg mass survey, winter 2012-2013

Location	Average egg masses /tree	Predicted defoliation in 2013
Aitkin Co. S5-T51N-R23W	1	very light
St Louis Co. S16-T61N- R16W	6	heavy
Aitkin Co. S17-T53N-R22W	0	none
Itasca Co. S27-T55N-R26W	less than 1	very light
Itasca Co. S4-T54N-R26W	0	none
Itasca Co. S34-T54N-R23W	0	none
Aitkin Co. S3-T47N-R26W	0	none
Itasca Co. S21-T55N-R26W	10	heavy
St Louis Co. S19-T50N-R15W	3	light

News Releases

DNR urges homeowners to resist pruning or removing conifers with red needles until late spring

April 16, 2013
Conifers growing in Minnesota have had a long, hard winter with plenty of opportunities for winter injury, according to the Department of Natural Resources (DNR). By now, many of us may have noticed conifers full of brown and red needles, especially along highways. Folks may also have noticed the conifers in their yards, or along buildings and driveways, are turning red or brown.

In spite of their appearance, folks should resist the urge to prune or remove the discolored trees. Chances are good that the trees are alive and healthy beneath their mask of red needles. Buds were well protected during the winter and will grow once spring arrives, explained Jana Albers, DNR forest health specialist.

The most evident damage, caused by de-icing salts, occurred on white pines growing along highways. This salty water settles on the pines and is absorbed into individual needles, killing them back starting at the tips. Other damage to conifers can be caused by winter drying, or needle dehydration. "Throughout the winter, each passing car sends up clouds of salty water," said Albers. "Winter injury is also caused by strong, dry winds, many days of bright sunshine and low relative humidity that dry the needles."

Some trees or groups of trees seem to get winter injury every year. It is likely that the trees are stressed due to poor site conditions. For example, some clumps of roadside red pines show winter injury symptoms every year because they are growing offsite, either in soils that are too wet or in soils that restrict rooting depth. This stress predisposes the trees to needle desiccation and ultimately to repeated winter injury.

Native tree populations are adapted to their locality. Moving seeds or seedlings 100 miles north or south of their site of origin can result in damage due to winter injury. Exotic species, such as Austrian or Scots pine, should be planted in climatic zones similar to their site of origin in Europe.

Prevention techniques

- When selecting trees to plant, choose species that are adapted to your local growing conditions.
- Avoid planting white and red pines, balsam fir and white spruce within 150 feet of a highway to prevent salt damage.
- Avoid planting yew and arbor vitae on south or southwest sides of buildings or in sunny and windy locations.
- Erect temporary barriers around conifers susceptible to winter burn. They can be made of plywood, burlap, tar paper or plastics. Recycle your Christmas boughs and tree by propping them up on susceptible conifers. They will act as a barrier and also hold snow for more natural insulation and protection.
- Just after the snow melts and prior to bud break, rinse de-icing salts off both conifers and hardwoods.
- Reduce or eliminate the use of de-icing salts.
- Replace trees that have severe winter injury year after year. They are not in the right location and will only decline due to needle and twig loss over a period of many years.
- Keep conifers properly watered throughout the growing season and fall. Decrease the watering slightly in September to encourage hardening off, and then water thoroughly in October until freeze-up. Watering only in late October does not help reduce winter injury.

Uptick in conifer mortality is drought-related

August 8, 2013
We've all noticed it, here and there, a few more mature conifers than usual have died in the last couple of years. Is this related to our recent droughts? Yes, definitely. Eight of the past 11 years have been very dry during the summer and fall, plunging many forested areas of the state into severe drought.

Conifers growing along the edge of lakes, wetlands and ditches have been victims of fluctuating water tables over the past few years. When water is overly abundant, root systems are flooded for weeks and the root system loses its lowermost roots. Prolonged flooding prunes off the lower roots. Then, when water is scarce, these root systems don't extend down far enough to reach the low water table. With too much or too little water, tree health and vigor suffers as photosynthesis shuts down and reserved sugars and starches are used up. In a few droughty growing seasons, these trees, especially balsam firs and white and black spruces, die of starvation.

The situation is similar for red, white and jack pines except that root death due to fluctuating water tables is not involved. Photosynthesis was shut down for days and weeks during droughty growing seasons in the past decade. To make up for this, trees used up their reserved sugars and starches in order to remain alive. Critically, they couldn't resupply their reserves in the following years because these years were also droughty. Eventually, reserves were drawn down too far and they also died of starvation.

Now the good news. For most of Minnesota, the 2013 spring and early summer have been wonderful for tree growth and the restoration of sugar and starch reserves. We could definitely use a few more years just like this to completely resupply reserves and tree vigor.

For more information on forest health, contact Jana Albers, DNR forest health specialist, 218-327-4234, jana.albers@state.mn.us or visit the forest health website.

Spruce needle rust appearing in northern Minnesota

Aug. 11, 2013
Some homeowners in northern Minnesota have recently noticed their spruce trees turning tan, yellow, orange, and sometimes - pink. Quite often, the trees are infected with spruce needle rust fungus, which presents an aesthetic problem but seldom a tree health problem, according to the Minnesota Department of Natural Resources (DNR).

Two rust fungi, *Chrysomyxa ledi* and *Chrysomyxa ledicola*, can infect the current year needles of blue spruce trees, but can also be found on white and black spruce. Infected needles will turn yellow and be shed in the fall, but healthy buds on the ends of the branches will produce new needles the following year.

"Seeing your favorite ornamental trees turn a rusty color and appear to be dying can cause some concern for homeowners, but don't rush to cut them down," said Mike Albers, DNR forest health specialist. "The fungus only infects the current year's needles, and is not spread from tree to tree."

In some years, like this one, spruce needle rust is very common; but in most years it is difficult to find because it requires other plants and specific growing conditions to complete its life cycle.

In early summer, the rust fungus produces spores on the leaves of Labrador tea or leather leaf which grow in the acidic conditions in peatlands, bogs and swamps. If the wind blows these spores onto current year spruce needles, and if the weather is wet and cool, the spruce needles can become infected. Rust fungus produced by the infected tree can re-infect and overwinter on the sturdy, alternate host plants, but that cycle is generally interrupted by changing weather conditions. A widespread infection one year, can be undetectable the next.

Chemical control with a fungicide is usually not helpful and cannot cure the infected needles.

Recommendations for keeping your spruce trees healthy during a spruce needle rust infection include:

- Keep trees well watered if the weather turns dry, but avoid using sprinklers because they prolong the needle's exposure to water and can lead to additional needle and twig diseases.
- Keep weeds and grass mowed around small trees so winds can dry the needles better and prevent infection.
- Mulching around trees is recommended to help maintain soil moisture and keep weeds and grass away from trees. Mulching also keeps your lawn mower and weed whip away from your trees thereby reducing injury to the stem.

Phenology 2013

Date	Event	Location
4/ 21	30 inches of snow remaining in the woods	Itasca
4/ 28	20 inches of snow remaining with patches of open ground where sunlight can penetrate	Itasca
5/ 1	Snow cover mostly gone, few patches left in the woods. There are a few groups of paper birches with catkins on them. 20 percent of trembling aspen with male catkins in western part of the county.	Itasca
5/ 1	100 percent of trembling aspen with male catkins. Some grasses showing green. Winter browning of conifers is common in young white pines and some red pines along roadways.	Beltrami
5/ 1	80 percent of trembling aspen with male catkins in western part of county; only 50 percent in eastern part.	Cass
5/ 6	Spring peepers are noisy. Still some snow left where it was piled. Dark-colored ice on Lake Pokegama in Grand Rapids with 30 feet of open water to shoreline.	Itasca
6/ 6	Blooming: yellow rocket, hoary puccoon, chokecherry (peak bloom), marsh marigolds. Jack pine gall rust: aeciospores being shed. Jack pine pollen cones about peak and needles just emerging from bracts. Bigtooth aspen and bur oak leaves still expanding.	Cass and Crow Wing
6/ 6	Red pine pollen cones still covered by bracts. Jack pine cones still shedding pollen, past peak. Heard turkeys calling.	Hubbard
6/14	Scab and black canker symptoms are very abundant on planted willows along south shore of Lake Winnie and Cass Lake; also on old homestead sites. Lots of seeds on red maples, ripening now.	Cass
6/17	Forest tent caterpillars 1.75 to 2.0 inches long; in the wandering phase. Blue bead lily in peak bloom. Nodding trillium and lilacs blooming.	Itasca
6/19	Forest tent caterpillar defoliation is evident from the ground along Hwy 169 at Lake Pokegama.	Itasca
6/19	Noted pockets of leaf roller activity on aspen in northern Cass. Lilac blooms at end of peak. Jack pine pollen cones are orange and still attached.	Cass
6/19	Noted tip blight and branch flagging in mature red pines east of Park Rapids; made collection for lab analysis.	Hubbard
6/20	Active bark beetle pocket on private property	Clearwater
7/ 9	Blooming: baby's breath and wood betony	Cass
7/10	Blooming: oxeye daisy, black-eyed susans, chamomile, golden alexander. Goat's beard, seed heads are full.	Cass
7/16	Forest tent caterpillars are still in their pupae. Friendly flies are abundant.	Itasca
7/16	Cattails shedding pollen	Cass
7/17	Basswood in full bloom	Beltrami

Forest Pest First Detector

Now in its sixth 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.

Six workshops were held in locations around Minnesota, including Fort Snelling State Park in St. Paul, Maplelag Resort in Callaway, Little Falls Government Center, Lamberton Research and Outreach Center, Gustavus Adolphus College in St. Peter, and at the Shade Tree Short Course at Bethel University in Arden Hills. Training topics in 2013 included emerald ash borer, gypsy moth, brown marmorated stink bug, thousand cankers disease of walnut, Imprelis herbicide damage, 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, 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). This year the team trained 140 individuals.

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

North Central Forest Pest Workshop, September 23-26, 2013

This year's workshop in Frontenac, Minnesota was well-attended by nearly 80 people from Indiana, Maine, Michigan, Minnesota, Missouri, Ohio, West Virginia, Wisconsin, and Ontario, Canada, representing state departments of natural resources and agriculture; the US Forest Service, Northern Research Station, Forest Health Protection, and State and Private Forestry; the Chequamegon-Nicolet National Forest; Natural Resources Canada, the Ontario Ministry of Natural Resources, and the Canadian Food Inspection Agency; the Menominee Tribal Enterprises; and USDA APHIS. Four Minnesota DNR forest health staff, resource managers from Parks and Trails, as well as four foresters from around Minnesota were among the attendees. A special guest this year was Ralph Crawford, new Assistant Director of Forest Health Protection with the US Forest Service Northeastern Area in Newtown Square, Pennsylvania.

Five presentations at the workshop focused on *Heterobasidion* root disease, or *Annosum*, underscoring its importance to the forestry industry in the North Central states. The biological control of *Heterobasidion* was also the topic of an informal after-dinner meeting, where a representative from the Finnish company Lallemand Plant Care was on-hand to talk about the potential of the biological stump treatment the company produces, ROTSTOP, which is based on the pathogen *Phlebiopsis gigantea*. Discussion revolved around the registration of this product in the US, since the current treatment for *Heterobasion*, borax, will likely be unavailable for FSC-certified lands. The product is registered in nine European and Scandinavian countries and is pending in two others, as well as Canada.

This year for the first time, a student presentation competition was instituted. Winning students, including a student from Minnesota, were offered a memento of the conference. Students represented the following universities: Maine, Michigan Tech, Minnesota, Missouri, and Wisconsin. Their presentation topics included emerald ash borer biological control, potential northern limits of the walnut twig beetle, suitability of the Great Lakes region for mountain pine beetle, and new research findings on eastern larch beetle, to name a few.

A highlight of the workshop every year is the all-day field trip to look at sites with forest pests or diseases and other forest health-related issues. This year was no exception. With lovely fall weather on our side and wonderful views of the river from the bluffs in Frontenac State Park as a backdrop, attendees learned about aspen decline, oak wilt, bur oak blight, Dutch elm disease, and various cankers; Oriental bittersweet and Japanese barberry were seen elsewhere in the area. One Canadian researcher gave a demonstration of ash branch sampling for emerald ash borer that will be employed by the Minnesota Department of Agriculture in Great River Bluffs State Park. Parks and Trails Area Resource Manager Shawn Fritcher described invasive plant management being conducted in the park and included a geological history of the region.

Feedback gathered at the workshop indicated that attendees very much enjoyed the scientific presentations, informal gatherings, opportunities to connect, and the workshop location. The workshop organizing committee was led by Val Cervenka and Linda Haugen (US Forest Service, S&PF) and included Mike and Jana Albers and Sue Burks (DNR), Brian Aukema (U of MN), Steve Katovich and Jenny Juzwik (S&PF), and Richard Wilson (Ontario Ministry of Natural Resources).

Training Accomplishments in the Northwest Region

Audience: Topic	***Attendees***
Forest Health team hosted the Annual North Central Forest Pest Workshop: Minnesota State Report	75
DNR and Chippewa National Forest Collaboration: Forest Health Workshop in Walker	95
U of MN College of Food, Agriculture, and Natural Resources: Dwarf mistletoe biology and management	105
Federal program review: University research projects using MN aerial survey data	20
Woodland Owners Conference, also broadcast as a webinar: Forest Health Update	50
Minnesota Forest Resource Council: Forest Health Update	10
Entry-level forester orientation: Forest Health Basics	22
Webinar for MyMinnesotaWoods: Forest Health Update	webinar
Women-to-Women Walk in the Woods: What is forest health?	11
Minnesota Forest Industry meeting: Forest Health Update	15
Green Valley Fire: Insects and management/ for legislators and agencies	20
Green Valley Fire: Insects and management/ for landowners	35
Informal sessions:	
Itasca State Park "Forestry Day": Insects and diseases booth	25
Northwest Region management team: Forest Health Update	15
Blackduck Area: Outdoor session on root diseases	3
Nimrod Field day: Green Valley fire/ insects	3
Blackduck Area: Indoor and outdoor sessions	12
Baudette Area: Field day	7
Big Falls Station: Field day	7
Wannaska Station: Field day	3
Kelliher Station: Field day	3
Bagley Station: Field day	5
Red Lake Band Ojibwe: Field day	10
Total	**551**

Training Accomplishments in the Northeast Region

Audience - Topic	***Attendees***
Deer River Forestry Wildlife Coordination MTG- I&D update	20
Chippewa National Forest I&D training Walker – Forest health (FH) update	90
SFEC Tamarack and black spruce management Workshop Cloquet – Pests of Tamarack	110
Region 2 Silviculture meeting –FH update and gypsy moth quarantine	15
Entry Level Professional Forestry Training – FHU work plan and FH update	18
Littlefork Area I&D training day – Field day	4
SAF field trip Wolf Ridge – I&D issues along north shore	40
Hibbing Area Silviculture tour –I&D issues in area (webinar)	11
North Central Forest Pest Workshop – aspen decline	75
Itasca County Woodland Owners Oak management tour – oak I&D	30
Tower Area Meeting – I&D update, GM & emerald ash borer	20
Itasca Community College Lecture – Invasive I&D	12
Minnesota Forestry Employee Association annual meeting - I&D update	50
Statewide Silviculture meeting – I&D update	50
Total	**545**

Training Accomplishments in the Central Region

Central Region Forest Health Specialist Ryan Blaedow resigned in July, 2013. He conducted several training sessions, including oak wilt training in St. Croix State Park, storm damage mitigation in Worthington

Forest Pest First Detector training in Lamberton, 10 attendees – Val Cervenka

Terrestrial Invasive Species Program

Susan Burks, Program Coordinator

PlayCleanGo: Stop Invasive Species in Your Tracks

PlayCleanGo is an outreach and education campaign developed by the state of Minnesota with help from the U.S. Forest Service to encourage outdoor recreation while protecting valuable natural resources. PlayCleanGo gives outdoor recreationists a clear call to action to be informed, attentive and accountable for stopping the spread of terrestrial invasive species, much like its national sister program Stop Aquatic Hitchhikers! Terrestrial invasive species can impact human health and native habitats as well as industries and societies that depend on our natural resources. While they can spread naturally on their own, long-distance spread of terrestrial invasive species is almost exclusively based on human activities. PlayCleanGo encourages individuals and organizations to work together to get the word out about harmful plants and animals.

The campaign is growing by leaps and bounds. Public and private partners alike find the clear, positive messaging effective at engaging outdoor recreationists. In fact, 42 different organizations (including two in Canada) have signed on as PlayCleanGo partners over the last two years.

The campaign's positive, fun, and accessible use of messaging and colors appeals to young and old alike and provides a flexible platform that can be adapted to any outdoor audience or partner organization (e.g., WorkCleanGo is used with DNR employees and vendors). PlayCleanGo works to stop the spread of terrestrial invasive species by changing behaviors associated with pathways of spread for terrestrial invasive species. By engaging folks in simple measures to prevent the spread of terrestrial invasive species, the campaign strives to create a new social norm and teach our kids the right thing to do: help prevent the spread of invasive plants and animals, and

- Arrive with clean gear
- Burn local or certified firewood
- Use local or weed-free hay
- Stay on designated trails
- Before leaving, remove mud, seeds and insect life stages (like gypsy moth eggmasses) from your gear

In June 2013, volunteers and partner organizations helped put on the first annual PlayCleanGo Day to coincide with National Get Outdoors Day, the second Saturday in June. Located at six state parks across the state, the event reached over 2000 park visitors in one day. In July 2013, PlayCleanGo launched an advertising campaign via social media, and by October 1 had produced nearly eight million visits! In 2014, PlayCleanGo Day will be June 14, so watch for the announcements and list of participating parks.

With the momentum created so far, the intention is to expand PlayCleanGo messaging across the country to reach and engage recreationists of all sorts in positive actions toward sustainable recreation and natural resource protection. Check out the PlayCleanGo website and social media pages. "Like" or "follow" PlayCleanGo and receive terrestrial invasive species news, information and tips on how to stop the spread of terrestrial invasive species. For more information on PlayCleanGo go to our website or contact Susan Burks.

Oriental Bittersweet Eradication

Though recently added to the Noxious Weed List in Minnesota, pockets of Oriental bittersweet have been growing in the state for at least 20 years. The largest infestation sites are located in Winona, Red Wing, Stillwater, and Elm Creek Park Reserve in Osseo, with scattered infestations throughout the Twin Cities Metro area. Survey and management of these areas are in the beginning stages, with plans to continue eradication of Oriental bittersweet throughout 2014. You can view Oriental bittersweet distribution in Minnesota through EddMapS.

To help eradicate Oriental bittersweet, interested people can become First Detectors. The Forest Pest First Detector program is produced cooperatively by the Minnesota Department of Agriculture (MDA), Minnesota Department of Natural Resources, and University of Minnesota Extension. Training workshops teach volunteers to identify insect and plant pests and how to report suspected pest sightings. First Detectors often provide the crucial early data needed to determine sites infested by noxious weeds so that eradication can proceed.

Landowners who identify a potential eradication target weed on their property can also report the sighting to EddMapS or contact Arrest the Pest at 888-545-6684 (voicemail) or Arrest.The.Pest@state.mn.us. We encourage landowners to take action by contacting MDA when they identify a noxious weed and learn the eradication procedure for the species identified.

Noxious and invasive weeds threaten our natural habitats and ecosystems, in addition to cultivated farmland and landscapes. The earlier we can detect, identify, and eradicate those species on the target invasive species list, the better the chance that we can contain and control destructive plant species.

2014 Changes to the Minnesota Noxious Weed List

Sue Burks, DNR Forestry Terrestrial Invasive Species Coordinator, standing in front of a Japanese knotweed infestation.

There have been a few changes to the Minnesota Department of Agriculture's (MDA) Noxious Weed List. These changes reflect the current understanding of the impacts, distribution, and control methods available for these species. You can find the full noxious weed list at MDA's website.

Key changes include:

- Musk thistle (*Carduus nutans*) has been removed from the Noxious Weed List. Control is no longer mandated by law. Please note that counties are free to add it to their county noxious weed list and some may choose to do so.
- Garlic mustard (*Alliaria petiolata*) has been moved from the Prohibited-Control list to the Restricted list. Control is no longer required by law, but movement of propagating parts is still not allowed.
- Japanese knotweed (*Polygonum cuspidatum*) and giant knotweed (*Polygonum sachalinense*) can only be sold if they carry a label advising people not to plant them within 100 feet of a water body or floodplain.
- Japanese barberry (*Berberus thunbergii*) will become a specially-regulated plant with the direction to phase out the seediest cultivars (these are listed in MDA's risk assessment). The phase-out will likely go into effect in 2015, as MDA works with the nursery industry on planning implementation during 2014.

Counties are also able to list additional noxious weeds that are specific to their county. You can look at county noxious weed lists to see if there are additional species for your county.

MDA also has a webpage with recommendations on removal and disposal on noxious weeds. Their two simple guidelines to follow when dealing with noxious weeds on an individual property are:

1. Kill, and when possible, do not remove weeds from an infested area
2. If removal of weed plant materials from an infested site is necessary, properly contain and transport the materials to an approved disposal site.

By controlling noxious weeds, landowners can reduce impacts to their own land and reduce spread to their neighbor's land.

Buckthorn Detection

Project Overview and Update, March 2014

In 2012, the Department of Natural Resources Division of Forestry received a grant from the U.S. Forest Service to map buckthorn across the leading edge of invasion in central Minnesota. Occurrence data suggested that south of Mille Lacs Lake, buckthorn was widespread with thickets of mature trees. North of that area, buckthorn seemed to be patchy at best with large areas of no reported infestations.

In order to take advantage of the early stages of buckthorn invasion, the state launched a large-scale buckthorn detection project. Utilizing the short window of opportunity between fall leaf drop among native tree species and fall color in buckthorn one to two weeks later, the Division of Forestry took standard color photography in stereo pairs over nearly 300,000 acres of state-managed land in 2012 and another 300,000 acres in 2013. The photos were interpreted and polygons (areas mapped in a geographic information system) of suspected buckthorn mapped and digitized. Stereo-paired photographs and ERSI shape files were distributed among field foresters and wildlife managers. A minimum of 5 percent of the 2012 polygons in each management unit were ground-checked during 2013, and the first set of control projects was launched in the fall of 2013.

Learning as we go, interpretations push the envelope to err on the side of inclusion rather than exclusion to avoid missing small infestations of buckthorn. While that approach detects more buckthorn, it also creates a number of false positives. The species that show up as false positives seem to vary somewhat across the state. In southern Minnesota where the detection methods were piloted, the false positives seemed to be either black locust or honeysuckle. That worked out well, since these are also invasive species we wanted to control. In Pine County, we began to see alder showing up in the false positives. As we moved west across central Minnesota, alder showed up on the wetter sites and understory conifer showed up on the drier sites.

In describing and mapping native plant communities, we developed a series of suitability tables to help land managers determine where desired crop tree species can be effectively managed. Using similar techniques, sites thought to be at risk of buckthorn invasion were identified. To help test the risk model used and perhaps give us a better idea of where buckthorn might occur, we broadened the range of the 2013 flights to include a number of other ecological subsections (i.e., subdivisions of sections of the state that are defined, using local climate, bedrock formations, and the distribution of trees, and other characteristics. Minnesota has 26 subsections). The hope, besides detecting and controlling more buckthorn, is to begin to describe associations between buckthorn occurrence and differences in land type. If successful, these associations may provide the basis for more efficient buckthorn detection and subsequent management, and allow the state to more effectively budget the cost of invasive species management.

This summer, the plan is to verify the presence or absence of buckthorn on all of the remaining polygons of suspected buckthorn and prioritize the control projects needed. That leaves this fall and winter for buckthorn removal and next summer for spot treatments to help clean up the highest priority sites. In the meantime, we'll assess buckthorn occurrence relative to land type to describe any potential correlations.

Invasive Plant Management

With a combination of state and federal funds, work on three other invasive plant projects took place in 2013. A grant from the US Forest Service allowed all state lands and selected private lands within the Kettle and St. Croix Scenic River ways to be inventoried and infestations treated. The inventory work was completed in 2010 and 2011. Management projects were carried out in 2012 and 2013. The results of that project will be covered in the next issue of the Forest Insects and Disease Newsletter.

With funding received from the Division of Ecological and Water Resources, two other projects were begun in 2013. In one project, St. Croix state forest land impacted by the 2012 blow-down event will be inventoried. Once mapped, infestations will be prioritized and treated as funding allows. In the other project, buckthorn in the Zumbro Bottoms area of the Richard J. Dorer Memorial Hardwood State Forest will be treated using cut-stump treatment methods. Both projects are scheduled to finish in 2014.