Minnesota Forest Health Annual Report

2009

DNR-Forestry
Forest Health Unit

The Forest Resources of Minnesota

In Minnesota there are approximately 16.3 million acres of forested land, of which 14.9 million acres are classified as "timberland" or lands capable of producing timber. An additional 960,000 acres are not included in productive timberland due to their inclusion in the Boundary Waters Canoe Area Wilderness or other reserved land category. Forest land ownership is 46% private, 27% state, 14% county, 12% National Forest and 1% other federal ownership. (Source of data is the Minnesota 2001 Eastwide Database provided by the USFS-NCFES.)

Emerald ash borer was found in this St. Paul neighborhood in April of 2009.

Two major industries depend on Minnesota's forested lands: forest industry and tourism. Fforest industry is Minnesota's second largest manufacturing industry, employing more than 55,000 people. The value of forest products manufactured in Minnesota exceeds $7 billion and accounts for 16% of all manufacturing dollars generated in Minnesota. The tourism industry is Minnesota's second largest employer employing over 140,000 people and accounting for a payroll in excess of $3 billion. Gross receipts from tourism exceed $6 billion. Over 70% of people who took at least one spring or summer trip in Minnesota rated "observing natural scenery" as the most important activity of their trip.

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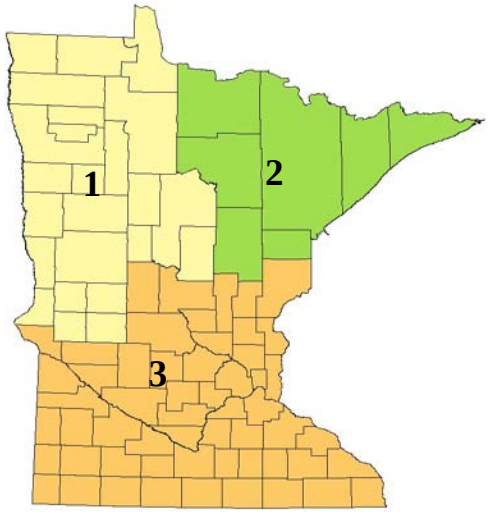

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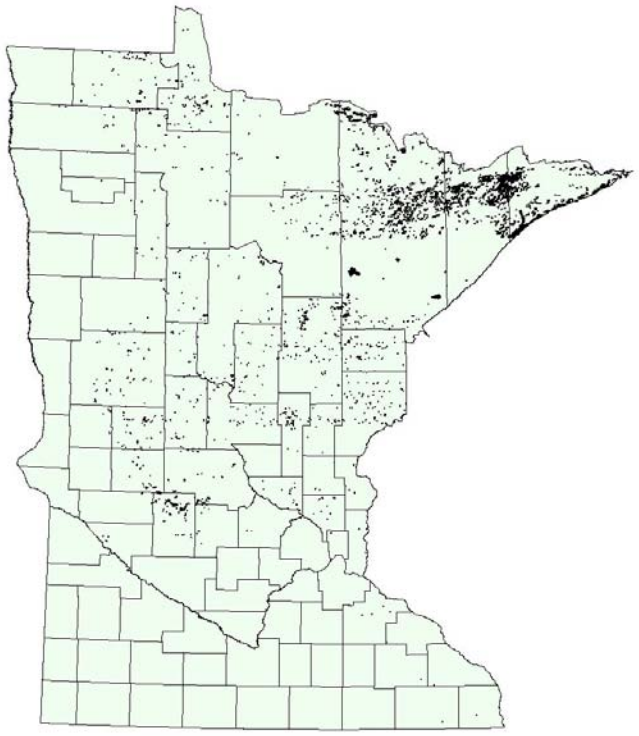
Aerial Survey Results – 2009

Since the early 1950's, aerial survey has been a valuable tool for monitoring the activities of forest insects and pathogens across the 16 million acres of forest land in Minnesota. For the past fourteen years, these surveys have been accomplished through the collaboration of DNR Forest Health and Resource Assessment Units and USFS, State and Private Forestry. The Forest Health staff plans the scope, timing and intensity of the surveys, trains Resource Assessment staff, provides ground-truthing, analysis and dissemination of survey data. Resource Assessment staff conducts the aerial sketch-mapping, digitizes the data and produces digital shape files. In addition to being used in Minnesota, the survey results are incorporated into the USFS's national database since our procedures and products comply with national standards.

Thanks to Mike Hoppus, Pat Churak and Larry Hoyt, Resource Assessment's sketch-mappers, who accomplished this year's aerial survey. Thanks also to Marc Roberts, USFS-S&PF, for mapping the federal lands, post-flight map rectification and for providing training in aerial detection.



Causal Agent	Number of Polygons	Acres
Ash Decline	520	21939
Aspen Decline	901	298974
Decline, Other Species	6	224
Bark Beetle	218	3658
Cattle	3	45
Dutch Elm Disease	723	568
Flooding	11	94
Forest Tent Caterpillar	369	30279
Larch Beetle	1882	19022
Larch Casebearer	139	25654
Large Aspen Tortrix	23	5790
Oak Wilt	2006	2597
Porcupine	1	1
Snow/Ice	3	363
Spruce Budworm	364	56861
Two-Lined Chestnut Borer	182	4970
Unknown	135	4896
Wildfire	4	65
Wind Damage	2	12
Winter Injury	21	24
Totals	**7494**	**475,991**

2009 Cheatsheet for Coding Damage Polygons in ArcView

File Names: Store successive shapefile versions as skm09v01.xxx, skm09v02.xxx, etc. in S:\sketchmp\dmg_polys_09

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

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

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

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

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

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

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

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

T, L	1	M, H	2

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

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

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

Bark beetles (BB)	11000	Dutch elm disease (DED)	24022
Larch beetle (LB)	11010	Fire (F)	30000
Large aspen tortrix (LAT)	12037	Porcupine damage	41006
Spruce budworm (SBW)	12038	Abiotic (A)	50000
Jack pine budworm (JPB)	12041	Flooding ~~(F~~, Fl)	50004
Larch casebearer (LCB)	12047	Snow/ice	50011
Forest tent caterpillar (FTC)	12096	Wind damage (WD)	50013
Two-lined chestnut borer (TLC)	15005	Winter injury (WI)	50014
Birch decline (BDb)	24005	Herbicide damage (HD)	70001
Decline (Dc)	24008	Unknown	90000
Oak Wilt (OW)	24021		

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.

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

What effect does doubling the intensity of aerial sketch mapping have in the detection and mapping of black ash decline in Minnesota?

By Mike Hoppus, DNR-Resource Assessment

Background: Mike Albers coordinates and administers an aerial survey of forest health for all forested portions of Minnesota during the summer months of each year. The survey protocols are based on U S Forest Service National Forest Health Monitoring Aerial Survey Standards, and the results are integrated into national maps of forest damage as reported annually through a cooperative effort between state and federal forestry agencies. Information contains polygonal delineations with attributes of cause, extent, severity and type of forest damages as observed from aircraft: see http://na.fs.fed.us/fhp/ta/av/index.shtm. Dave Heinzen, Forestry – Resource Assessment, manages the aerial sketch mapping program for most of the State and private forest land.

The purpose of an Aerial Detection Survey (ADS) is to:

- Detect new outbreaks or identify previously undetected outbreaks of forest pests
- Monitor existing outbreaks
- Provide timely information for management planning
- Provide information for forest health assessments and project plans

One insect of particular concern is the Emerald Ash Borer (EAB), *Agrilus planipennis* Fairmaire. It has the potential of causing widespread and heavy mortality in all species of ash trees. Minnesota has a large number of ash trees. According to recent ground based forest surveys: ash is present on about 3.8 million acres; ash trees are the majority of all live volume in stands estimated at 902,000 acres as well as composing at least 25 percent of the stand volume on 1,500,000 acres of forest land (USDA-Forest Service resource Bulletin NRS-12A 2007). EAB has now been detected in two areas of metropolitan Minneapolis-St Paul, MN and in areas nearby in Wisconsin. EAB is on the doorstep!

Minnesota's recent aerial surveys have detected large areas of Black Ash, *Fraxinus nigra,* that show signs of decline. Even though ground inspections have found the decline symptoms to be unrelated to EAB, the general appearance of the declining trees are nearly identical to the ash trees attacked by EAB. The aerial appearance is assumed to be identical as well.

Ash Decline Survey Test: The widespread black ash decline which has manifest itself in aerial surveys over large areas of Northern Minnesota presents two issues of concern: 1) EAB is reported to be predisposed to attack weak and unhealthy ash trees, and 2) the symptoms of "ash decline" and the early stages of ash mortality due to EAB are identical.

The creation of an accurate map of current black ash decline…prior to the possible infestation of EAB… is considered essential to effective monitoring and control of EAB movement into the natural forests of the state.

Question: **How much more black ash decline would be detected if: 1) The aerial survey flight line spacing was decreased from 6 miles apart to 3 miles apart; 2) A single observer in the plane was replaced by two observers, each looking out one side of the aircraft; and 3) Only a combined Host/Agent of black ash/ Decline was being mapped?**

Mike Albers asked the Resource Assessment Group of MN DNR Forestry to conduct an aerial survey of two 100K USGS Quads, Aitkin and Duluth, incorporating these three changes to the usual methodology.

1) The flight line spacing was decreased from 6 miles to 3 miles, reducing the farthest distance an observer has to look at a stand of trees from 3 nautical miles (nm) to about 1.5 nautical miles (nm).
2) Two observers replaced a single observer; each responsible for mapping from one side window of the airplane. The airplane was directed to fly at 1500 feet above the ground at a speed of 100 knots (115 mph). Both observers knew what ash decline looked like on the ground and both had observed known ash decline from the air. Both observers are relatively new to the aerial survey business…about two seasons of experience.
3) Usually, an aerial observer is responsible for detecting a multitude of host trees and associated pests or pathogens. In this case, the observers were to look for and map black ash decline only…eliminating distractions from the detection and locating of black ash.

Results: The two quads were flown on 11 & 12 August 2009. The sky was free of clouds but considerably hazy. However, in the opinion of both observers, the ability to adequately detect black ash decline was not impaired enough to discontinue the

survey. The "Test Survey" is compared with the normal survey conducted with 6 nm flight line spacing, one observer, looking out both sides of the aircraft and mapping all hosts and agents.

Test Survey vs Normal Survey of Black Ash Decline:

	Polygons	*Total Area*	*Ave. Area/polygon*	*Min. Size Detected*
3 nm/2 Obs:	**465**	**12,842 Ac**	**28 Ac**	**0.4 ac**
6 nm/1 Obs:	**85**	**5,834 Ac**	**69 Ac**	**3.4 Ac**

Cost Comparison:

	Flight Miles (Statute Miles)	*Days*	*$ Plane/Pilot/Obs.*
3 nm/2 Obs:	**1156 + 2X Transit Miles**	**2**	**$ 3443 + 2X Transit Cost**
6 nm/1 Obs:	**578 + Transit Miles**	**1**	**$ 1382 + Transit Cost**

Discussion: As expected, the more intense survey detected and mapped considerably more black ash decline stands (polygons) and the minimum size of a detectable stand was substantially smaller. Also expected was an increase in cost: about 2.5 times the cost in time and money.

More than twice as much area of black ash decline was detected in the intensified survey.

The intensified survey detected 5.5 times as many ash decline polygons, with an average stand size less than half that of the "normal" survey. This indicates that ash decline is more difficult to recognize from a distance, especially if the affected area is small. Compared to other aerial pest signatures, ash decline is more subtle in color contrast. Most of the affected trees still have considerable green vegetation in the crowns. Another indication that ash decline is difficult to see at a distance, is the obviously artificial distribution of the ash decline polygons. The linear distribution, parallel to the flight lines, is caused, in part, by the lack of ability to see under the plane; about a third of a mile swath is obscured from view. This striping of the polygon distribution is further caused by the lower probability of observing smaller polygons at a distance. As shown in the following graphs, there is big drop in both the number of ash stands observed and in total area of ash delineated when the distance out from the plane was 0.75 statute miles to 1.0 statute mile. This decreased inability to see and map ash stands continued out to 1.75 statute miles (the center between the flight lines). The average stand area per polygon of ash decline increased as the observer looked further out from the plane until the mean stand area was about a quarter mile square at a distance of 1.5 miles.

Another observation supporting the general difficulty in observing all stands of ash decline from aerial sketch mapping, is the fact that about half (40 polygons) observed in the normal manner were not detected by the intensified survey. Of those polygons that were observed by both methods, the average stand area was 25 percent greater than the stand area detected in the normal survey.

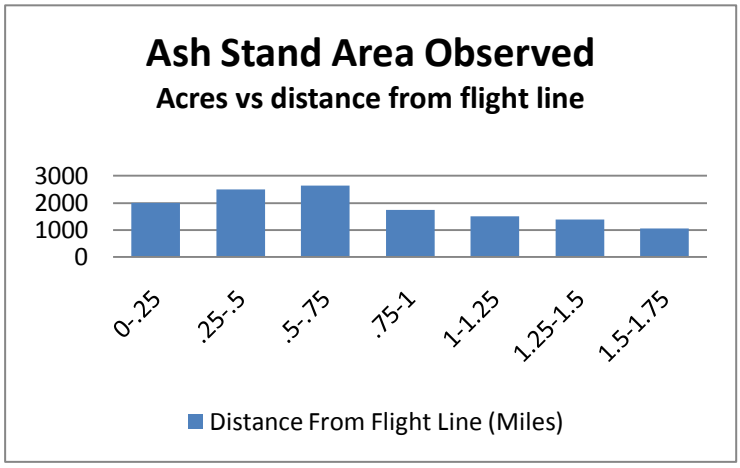
The summary lesson here is: "The intensified survey provided a much greater level of detection and spatial delineation, however, it is clear that even with the doubling of resources a significant number of ash decline stands escape discovery.

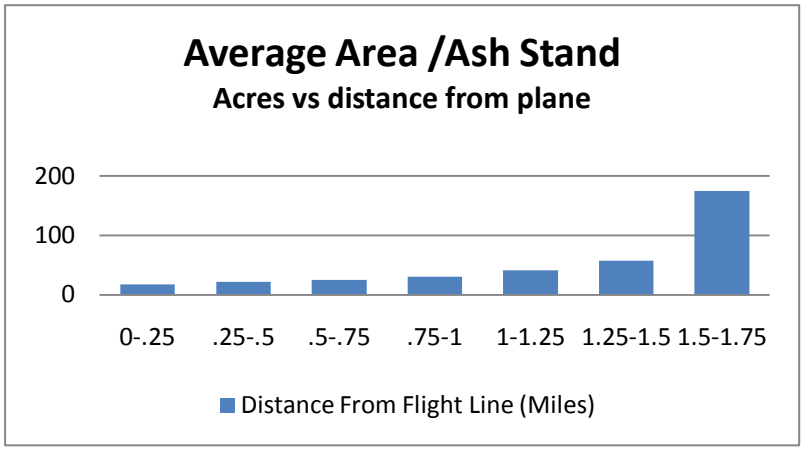
Cost Calculation: The additional costs of flying 3 nm flight line spacing compared with 6nm spacing is due to increased flight line miles, the increased cost of an additional observer, and the need for two transits to a two quad area. Cost comparison is based on flight line miles required to sketch map the area covered by two adjacent USGS 1:100,000 scale Quad maps.

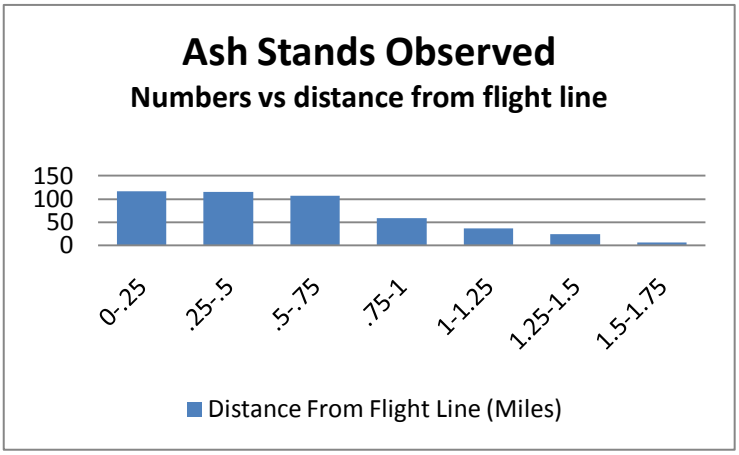
Flight mile distance doubles, of course, when increasing the flight line mile spacing by a factor of two. Additionally, since it takes about a day to fly a single Quad map using 3 mile spacing, an additional trip to the area is required to complete both Quads. So, at 3 mile spacing, more cost is incurred in getting to the sites. With consideration given to staying in motels, the transit cost would be less than twice as much...but the increase would vary.

The hourly cost for the plane and one observer is $275. The increased hourly cost for an addition observer is $67.50 or a total hourly cost of $ 342.50. When on site the plane travels at 115 miles per hour. So, for a single observer flying 6 mile spacing the

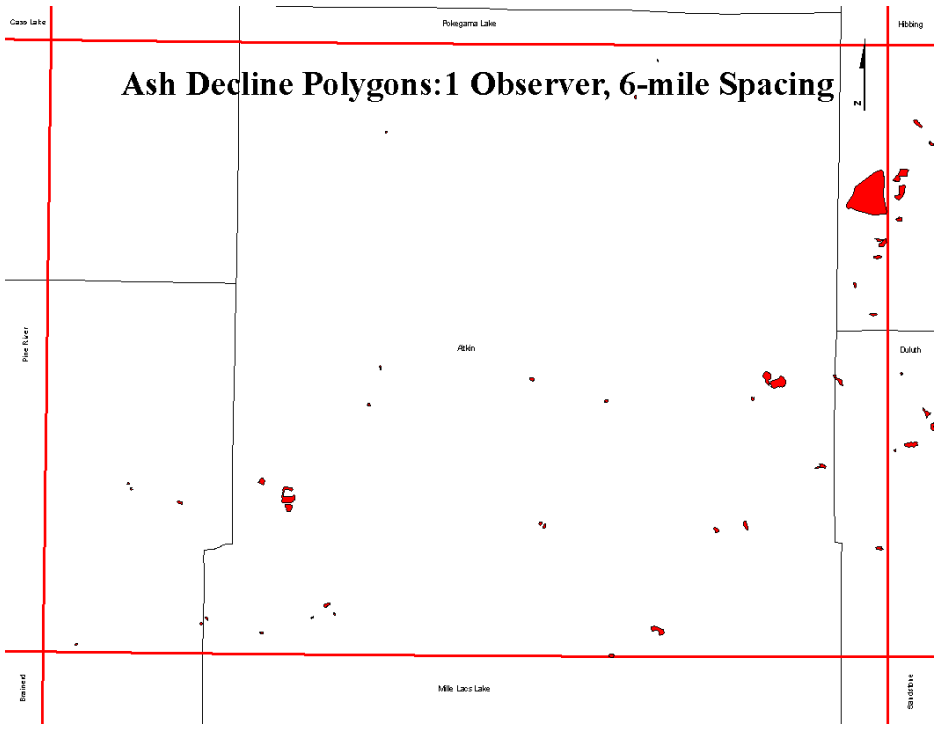
cost of completing two Quads is: 578 miles / 115mph* $275 = $1382. Two observers flying 3 mile spacing would cost: (578 * 2) miles / 115mph * $342.5 = $3443.

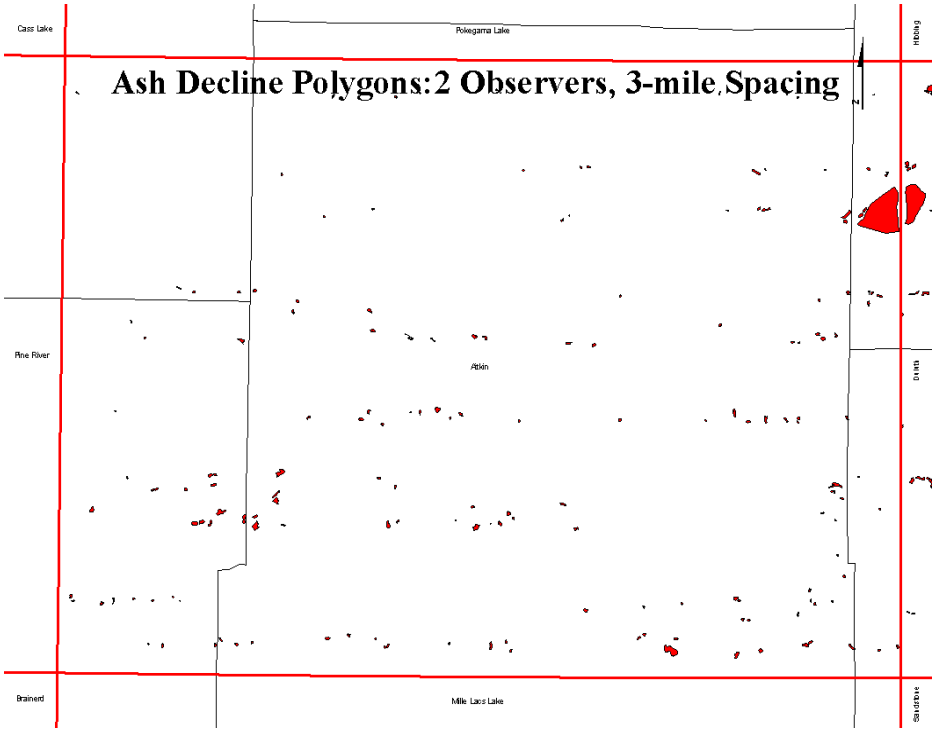




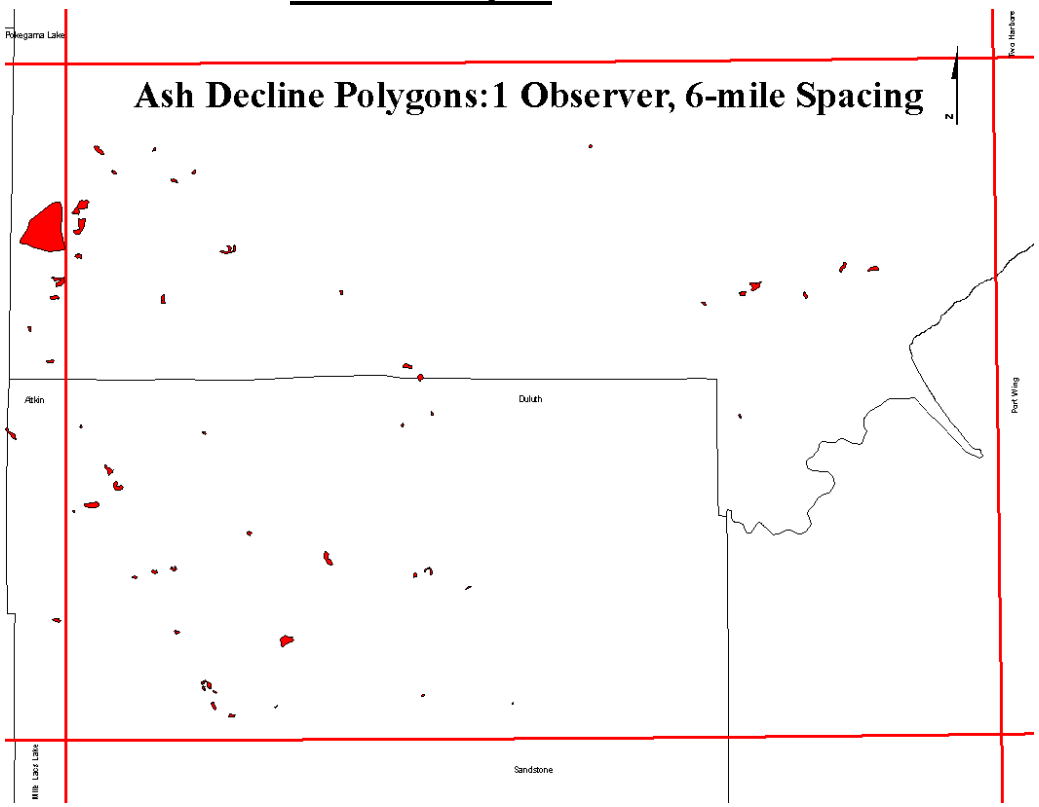


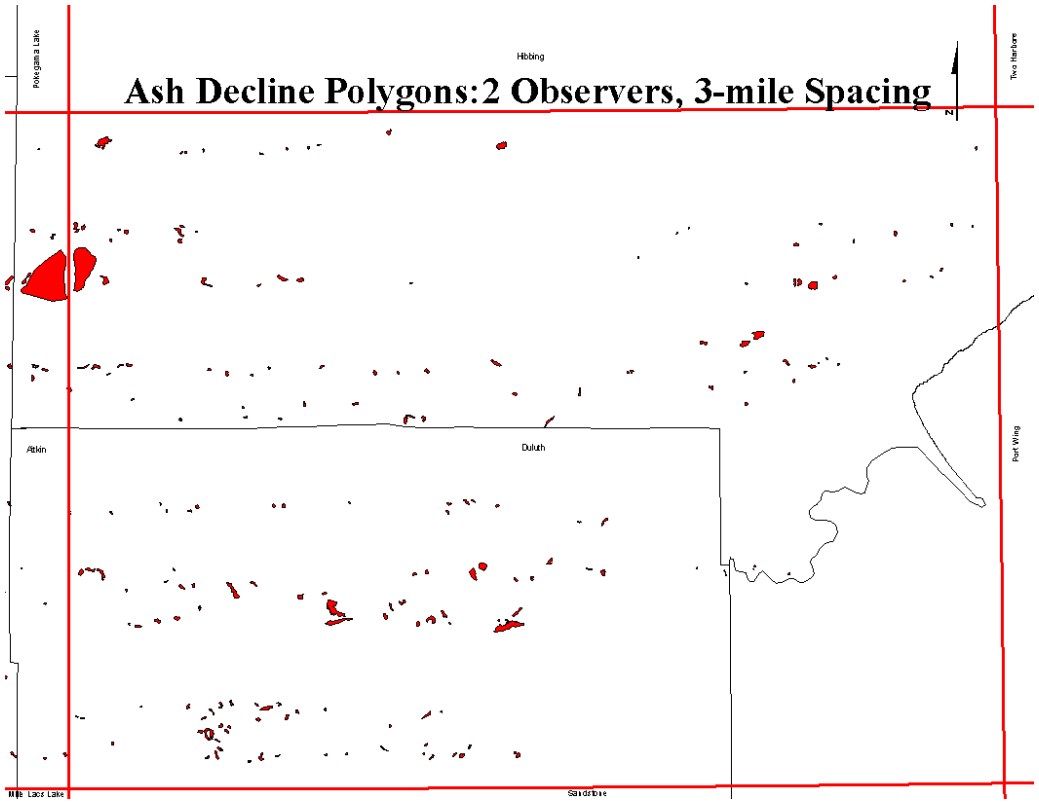
Aitkin 100K Quad





Duluth 100K Quad





Insects

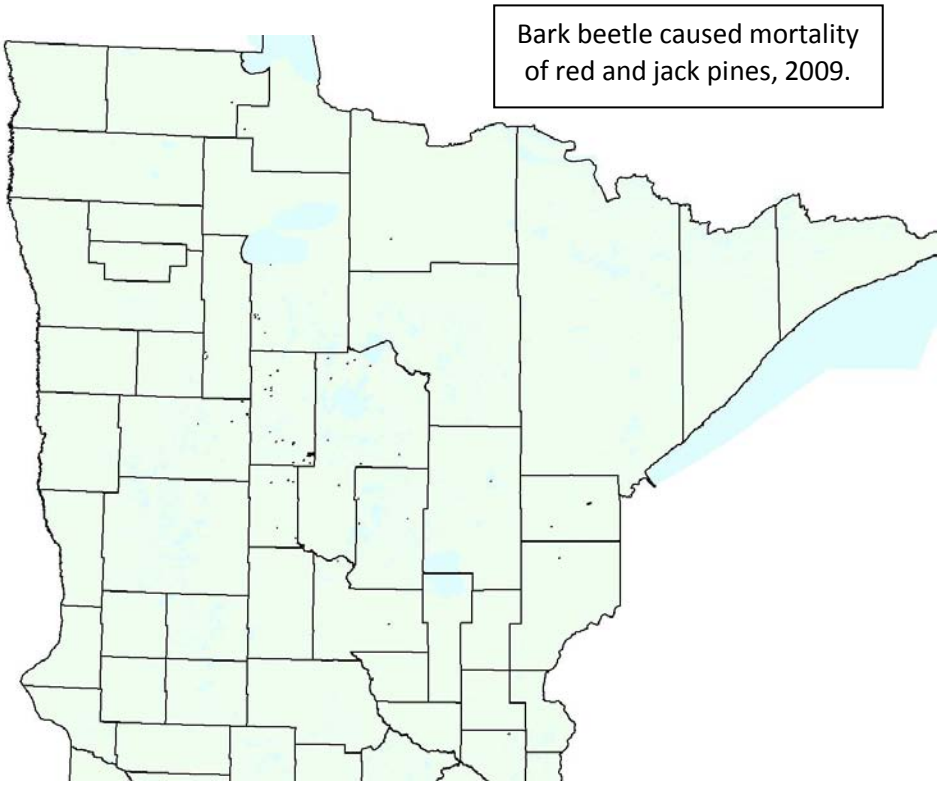
Bark beetles

Ips spp. and *Dendroctonus* spp.

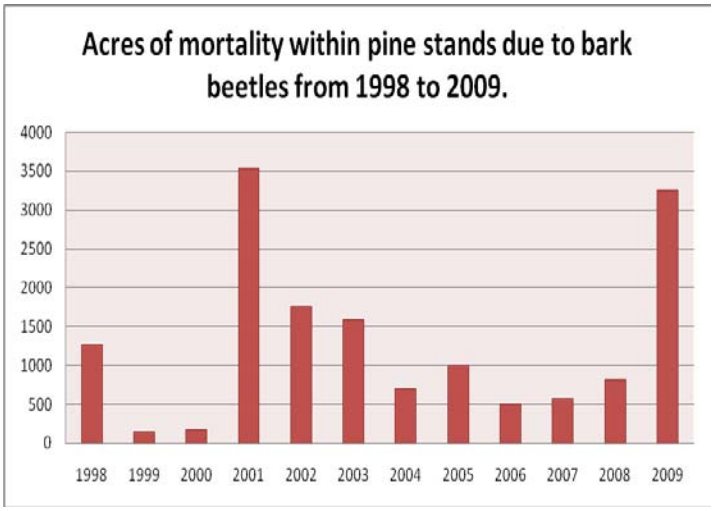
The serious and prolonged drought from the summer of 2006 to the fall of 2009 created stress conditions favorable for bark beetle build-up and damage. For the previous eleven years, bark beetles have averaged 1,093 acres of mortality per year and this year, mortality occurred on 3,657 acres. Similarly, bark beetles have infested an average of 43 stands per year, and this year, mortality was mapped in 218 stands. See charts below.

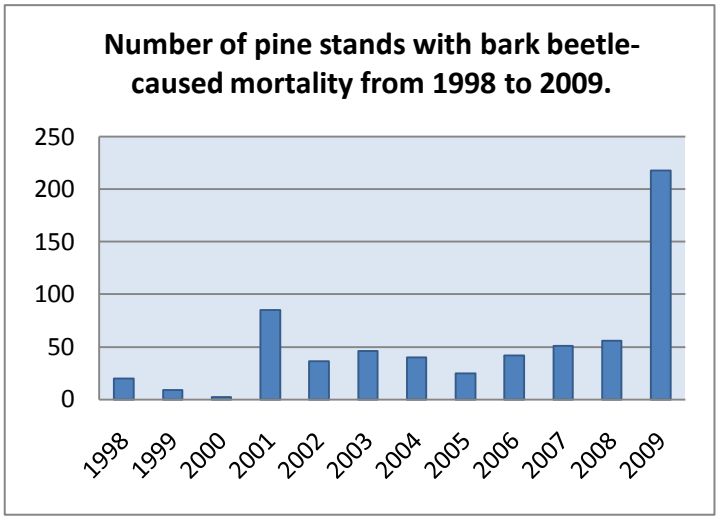
Due to the timing of aerial survey, not all bark beetle infestations are mapped, especially small or incipient infestations. These are detected and informally reported by field foresters and are not tallied here.

Ips pini galleries. Photo Mike Albers.



Bark beetle caused mortality of red and jack pines, 2009.





Eastern larch beetle

Dendroctonus simplex

Tamarack mortality caused by larch beetles. Both photos by Mike Albers.

An outbreak of larch beetle has been brewing for the past nine years. Significant levels of mortality have occurred on 92,600 acres of tamarack in Minnesota. This year, 19,000 acres of mortality were mapped. See next page. No consistent stress factor contributing to the current mortality has been found, however, the droughts and fluctuating water tables in 2002 - 2003 and 2006 - 2009 have undoubtedly been involved. Damage levels vary from scattered individual trees killed by the beetles to 80% of trees in stands being killed.

Because eastern larch beetles are currently so abundant and so widespread, attempts to control the beetles through management are unlikely to be successful in most situations. Salvage logging of stands with a lot of mortality is recommended to utilize the wood. Leaving 10 to 12 live tamarack per acre as seed trees on harvest areas is still recommended. These trees may be quickly attacked and killed by the beetle but hopefully some of them will produce seeds before they are killed. Leaving the seed trees is unlikely to cause any increased problems with larch beetle.

Larch trees sampled in following sites for LB over-wintering stages. Survey carried out 28-29 April 2009. Roger Hannigan.

1. NENE Sec. 1-T157- R34. Results 0 for 0.
2. NMNM Sec. 7-T161- r34. Results 0 for 0.
3. NESE Sec. 33- T160-R38. Adults 75 Dead, 0 Live. Larvae: 3 dead, 5 live. Pupae 5 dead. Plus 1 live clerid beetle and 4 live clerid larvae.

All these sites are Old-growth sites. Numerous other sites where accessible were checked.
Third site was at Hayes Lake S.P where on-going infestation has been taking place. Park Mgr. noticed that attacks have been fewer than in past years. I believe the population is waning.

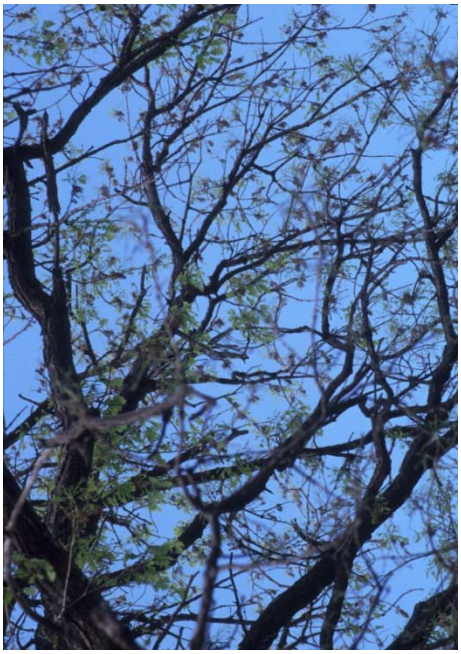
Larch beetle-caused mortality of tamarack in 2009

Forest tent caterpillar

Malacosoma disstria

FTC populations are building in east central Minnesota. The number of acres defoliated is climbing steadily with increases being found in the central counties. The number of additional sightings of individual caterpillars and small pockets of trace defoliation from the northern counties is also increasing. Taken together, these observations usually portend a north-wide outbreak in the near future.

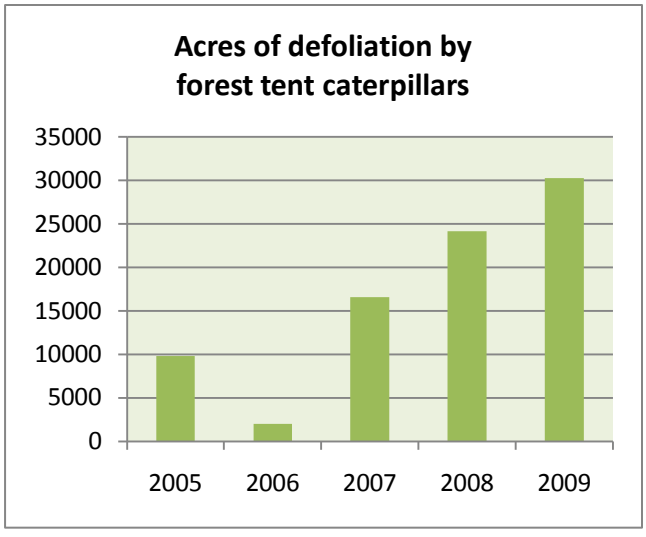
The Metro area is experiencing tree defoliation from two voracious defoliators this spring: forest tent caterpillar and fall cankerworm. Scattered pockets of moderate to severe defoliation of boxelder, basswood, oaks, elm and other species have been reported throughout the Twin Cites metro area. A very visible site is Swede Hollow which is the valley located between Metropolitan State University and downtown St. Paul. Approximately 50% of boxelder trees, the predominant species in Swede Hollow, have been almost completely defoliated by fall cankerworm. Basswood trees along the Mississippi River bluffs in the metro area are being defoliated by FTC; affected trees are 90 to 100% defoliated. The FTC are moving to oak and elm as they eat their way through the basswood.

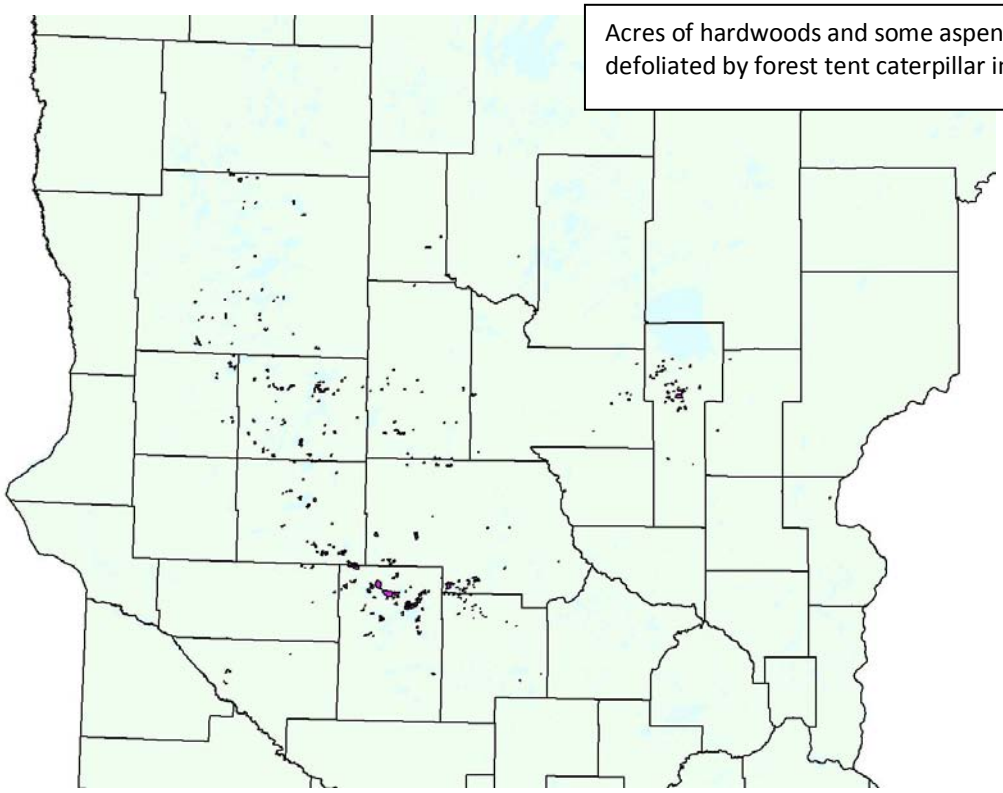


FTC defoliating an oak tree. Photo by Jana Albers.

In addition to the sites in the Twin Cities, populations of FTC can easily be found in central and west-central counties as far north as Hubbard County where they were defoliating basswoods and oaks. There are also sightings of individual caterpillars all across the northern counties on aspen, oak and basswood trees. Like many other insects, the cool spring delayed their development so that pupation is likely to be two weeks later than during the most recent outbreaks. In the southernmost locations, FTC were spinning down in mid-June and moved away from the trees they defoliated in order to seek nearby host trees. Moth flights occurred near July 4th this year and later in the more northerly locations.

There are several parasites which help keep these defoliators under control and even though there are high numbers in several areas of the state. Defoliation for one season seldom kills healthy trees and even though many trees in central Minnesota are experiencing drought stress which may add to overall mortality, most defoliated trees will survive.



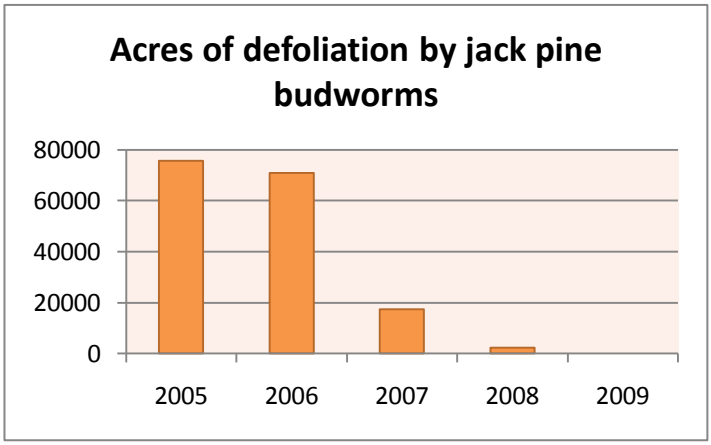


Acres of hardwoods and some aspen defoliated by forest tent caterpillar in 2009.

Jack pine budworm

Choristoneura pinus pinus

One of the bright spots of the summer was the realization that the jack pine budworm population had collapsed in Region 1. Egg mass surveys last year and early larval studies on June 8th this year predicted the collapse of the outbreak. See table.



In Region 2, jack pine budworms were still feeding in the pollen cone clusters on June 17th near Esquagama Lake in central St. Louis County. Most of the pollen had been shed and the clusters were crispy-dry. The larvae were only 3/16 to ¼ inch long. Larvae were more abundant than expected but significant defoliation did not occur.

No JPBW defoliation was observed this year during the aerial survey in either Region 1 or Region 2.

Jack pine budworm, Early larvae survey, June 8, 2009 in Beltrami County.

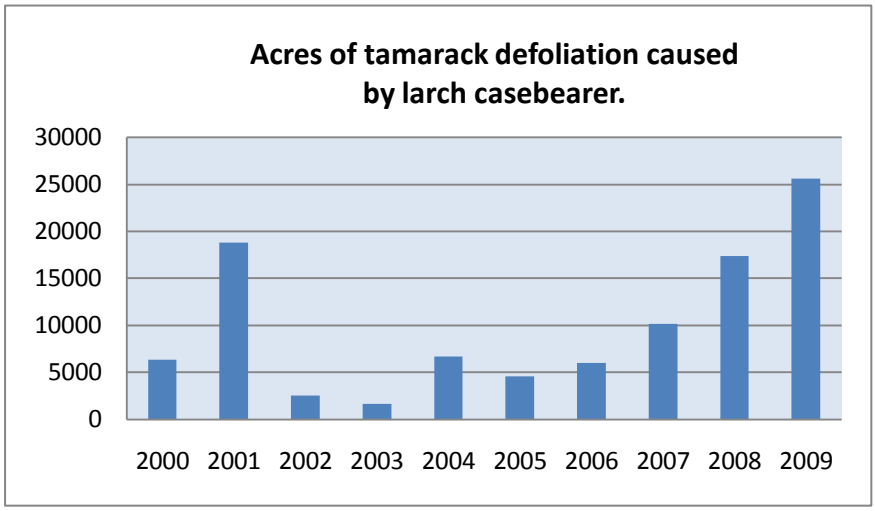
Location	*Township*	*Staminate shoots*	*Vegetative shoots*	*Comments*
NENE 22-148-35	Buzzle	0/12	0/12	Clean.
SESE 36-148-35	Buzzle	0/6	0/24	Clean.
SESE 23-147-34	Eckles	0/18	0/12	Spittlebug common.
NWNE 3-147-35	Lammers	0/24	0/6	Two shoots with webbing.
NWNE 4-147-35	Lammers	0/30	--	Shoots on remainder of branch with webbing. No defoliation evident.

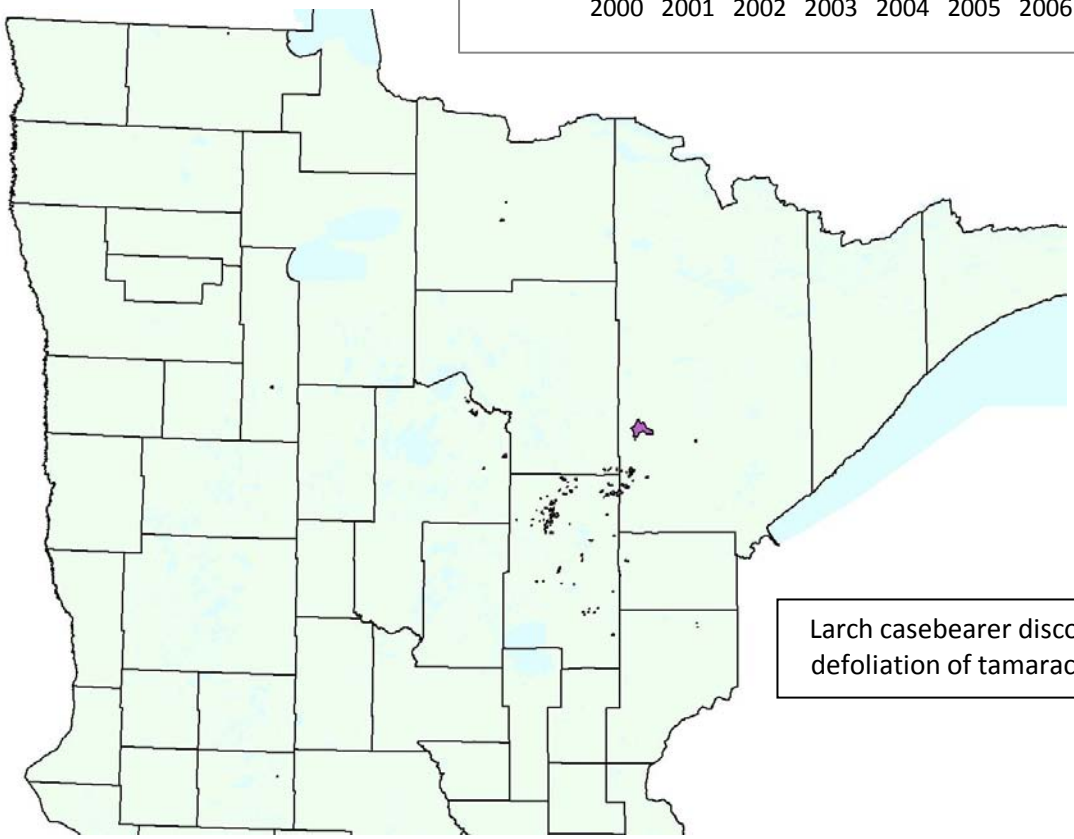
Larch casebearer

Coleophora laricella

A naturalized exotic insect, the larch casebearer, mines the needles of tamarack which causes them to dry out and turn a rusty- orange color by mid-summer. Unlike other states, we find that larch casebearer defoliation does not predispose trees to larch beetle attack. Larch casebearer attack has not been found to result in direct tamarack mortality in Minnesota, so far. The number of acres with discoloration/ defoliation has steadily increased since 2005 after it peaked most recently in 2001.

Typical discoloration caused by larch casebearer. Photo by Mike Albers





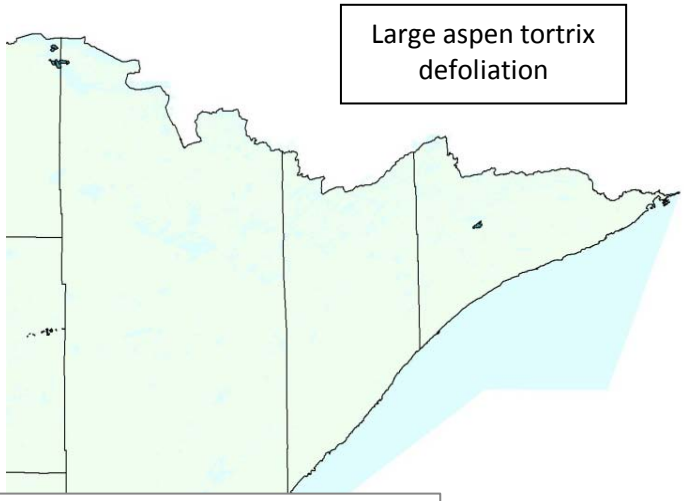
Larch casebearer discoloration/ defoliation of tamarack in 2009

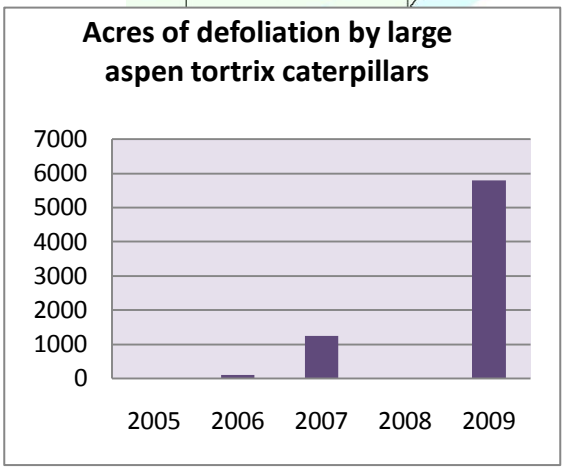
Large aspen tortrix

Choristoneura conflictana

With all the aspen dieback and decline occurring in the northeastern counties, it's a testimony to excellent sketch-mapping skills when pockets of large aspen tortrix defoliation are found. The acreage numbers indicate an increasing trend, but pockets of defoliation were only found in three main locations this year.

Defoliation and leaf-rolling by large aspen tortrix. Photo from Ives and Wong.



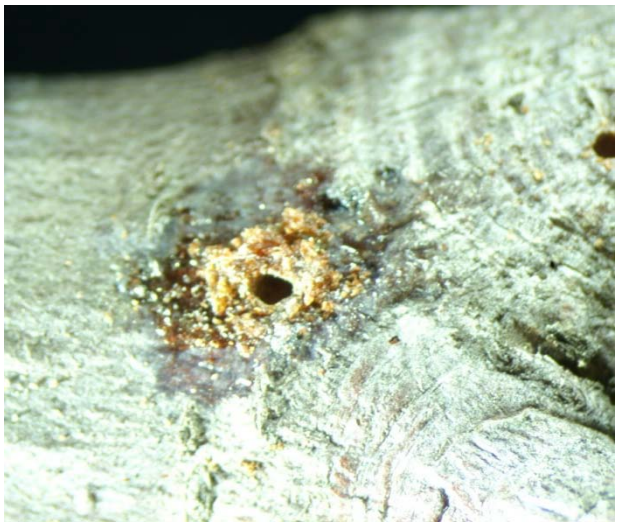


Pityogenes bark beetles on white pine

Pityogenes hopkinsi

White pines 2 to 8 feet tall being attacked by *Pityogenes* were fading and dying during the early summer. *Pityogenes* adults are approximately 2 mm long and create star shaped galleries under the bark on stems. Small piles of pitch and sawdust remain attached to the stem around the rims of their entrance holes. Main stem attacks appear to start near the soil-line but extend up to 3 to 4 feet on the larger trees. On July 1st, adults were present laying eggs, but a few larvae were also found.

The affected white pine trees were containerized seedlings planted over a period of years into very heavy clay soils with heavy sod competition. On the dying trees, the roots hadn't spread laterally out of the container plugs. Roots that did emerge from the plug grew straight down into the soil. The clay soil was dry and granular. The trees had been growing well the last couple of years and the taller trees put on up to 18 inches of height growth last year. More victims of droughty weather.

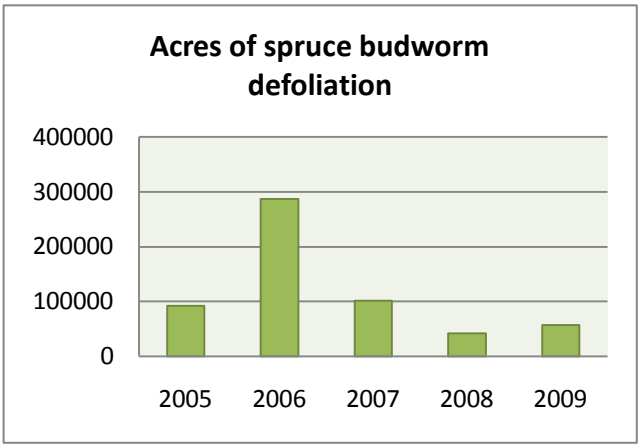


Pityogenes entrance hole into young white pine. Photo by Mike Albers.

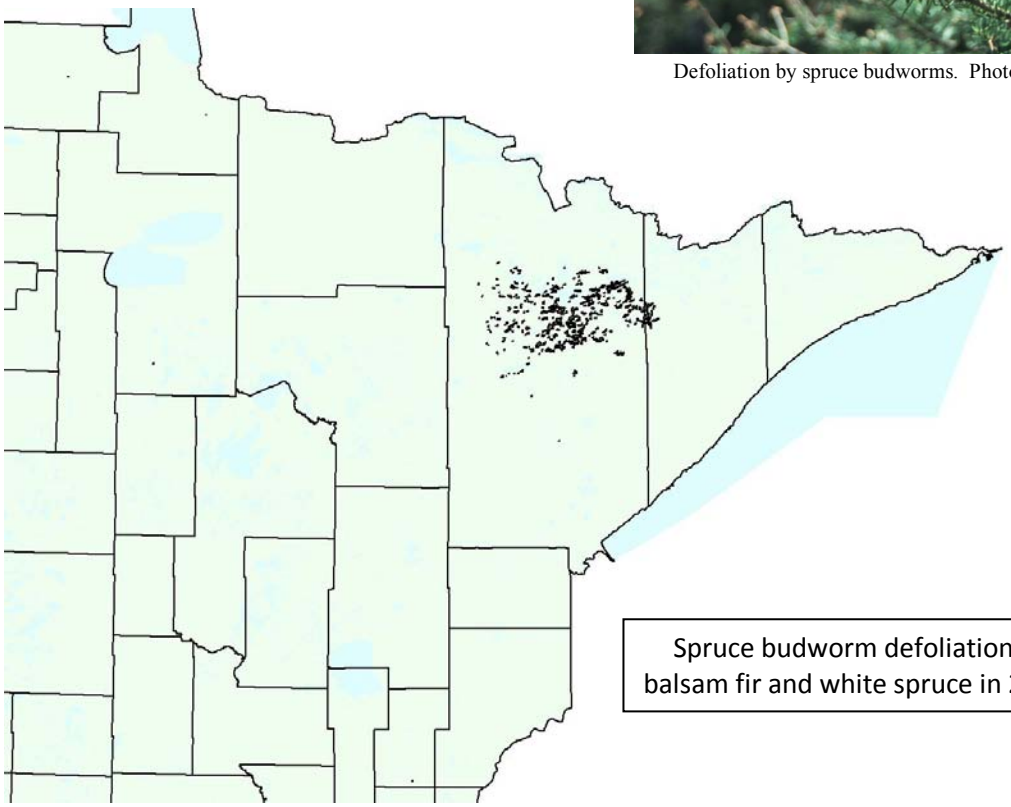
Spruce budworm

Choristoneura fumiferana

Since 1954, when annual aerial sketch-mapping began in Minnesota, spruce budworm populations have caused defoliation of balsam firs and white spruces every single year here. This year, 56,860 acres of defoliation were observed in 364 stands, primarily in the northeastern counties. In outbreak areas, budworm populations cause prolonged defoliation, sometimes for as long as ten years. Widespread fir and spruce mortality results, but, surprisingly, the host species are not locally eradicated. Instead, host trees are maintained at low densities as these mixed-wood stands mature. Surviving host trees serve as seed trees.



Defoliation by spruce budworms. Photos by Mike Albers

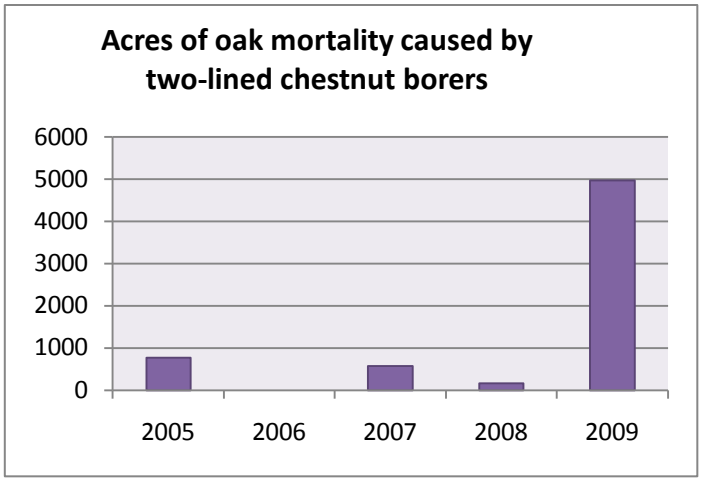


Spruce budworm defoliation of balsam fir and white spruce in 2009.

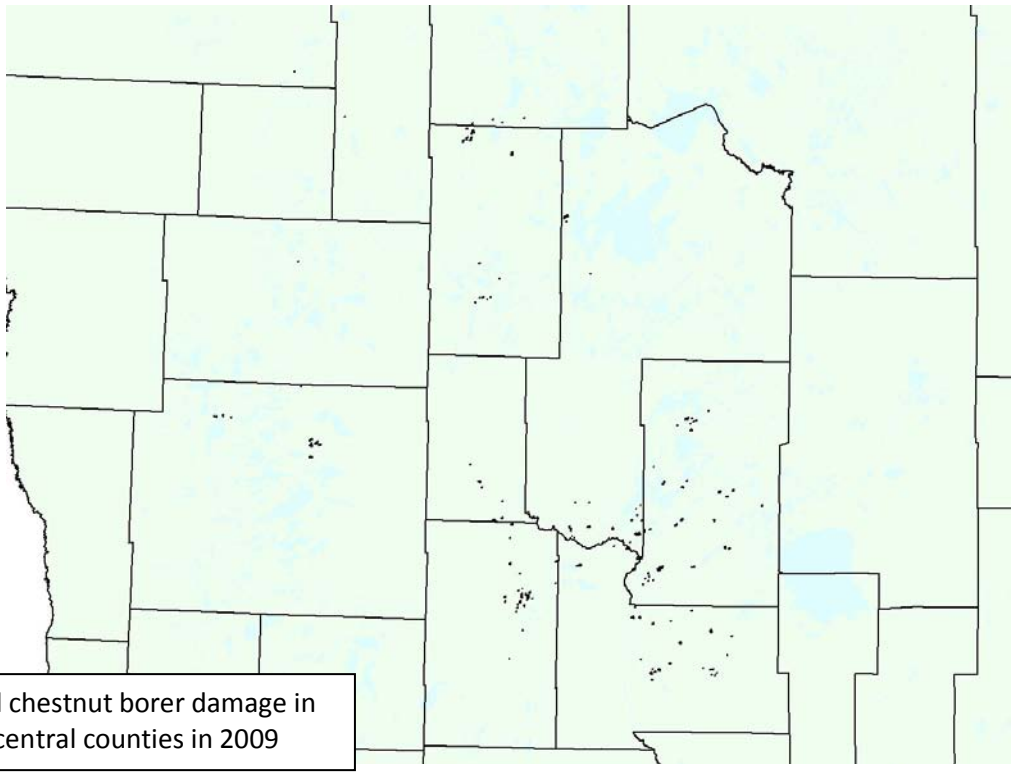
Two-lined chestnut borer

Agrilus bilineatus

Since aerial survey is flown in early to mid-summer, topkill and mortality due to two-lined chestnut borers (TLCB) is not detected by sketch-mapping until the following year. Widespread damage was noted during ground surveys last year and this year's aerial sketch mapping bore out those observations. In 2009, 4970 acres of oak forest had tree mortality. This outbreak is associated with four consecutive summers of severe drought and, in the vicinity of Brainerd, with three years of defoliation by linden loopers and fall cankerworms.



Mortality of red oaks by TLCB. Photos by Jana Albers.



Two-lined chestnut borer damage in north central counties in 2009

Diseases

Ash anthracnose

Gloeosporium aridum

In communities in northeastern Minnesota, green ash are shedding lots of green leaves. The shed leaves have symptoms of both ash anthracnose and ash plant bug. Ash anthracnose is caused by a fungus infection of the leaf. It is most severe during cool moist springs. Infections appear in the spring on expanding leaves as water-soaked spots that enlarge and coalesce becoming a greenish-brown. Leaflets may become distorted. During springs with prolonged wet weather the entire first flush of leaves may be affected. Severe defoliation for several years may lead to some twig dieback.

Ash anthracnose. Photo courtesy of Sinclair and Lyon.

Oak anthracnose

Discula quercina

Oak anthracnose is a common leaf disease caused by the fungus *Apiognomonia quercinia*. This year, bur oaks growing in the northwestern counties had very heavy anthracnose infections during the spring and early summer which caused heavy defoliation of the lower crowns.

Early spring infections of immature leaves cause necrotic (brown/dead), deformed margins on the leaf tissue as well as necrotic, irregularly shaped spots. These spots and lesions tend to form along the veins or be confined by them. Usually, a distinct margin develops between the dead and healthy leaf tissue. Heavily infected leaves may appear misshapen and curled. The heaviest infections tend to be located in the lower portion of the tree crowns where the humidity is highest and leaves remain moist and cool during the spring. Heavily infected leaves are shed in June; many have green, healthy tissues still present. As the weather conditions become drier in the summer months, infected trees produce new leaves that are generally free of disease symptoms.

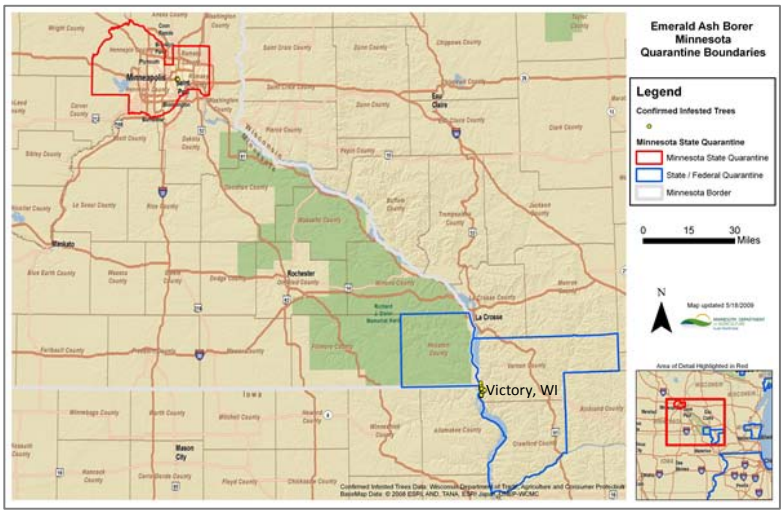
Early spring symptoms of oak anthracnose.
Photo by DNR-Forestry.

Invasives and Exotics

Emerald ash borer first found in Minnesota

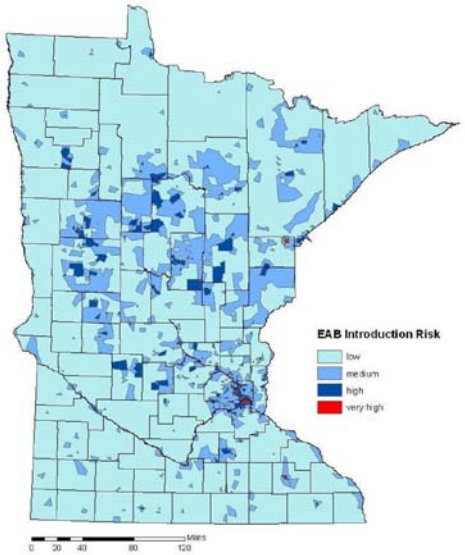
Agrilus planipennis

We knew it was coming. We just didn't know when. Many of us in state and federal agencies were hoping that a few more years would elapse before we had to engage our emerald ash borer (EAB) Preparedness and Response Plans.



EAB was found in Minnesota when our "backs were turned". Here's what happened. On April 6th, an EAB infestation was discovered in Victory, Wisconsin which is across the Mississippi River from southeast Minnesota in bluff country. See map on right. All attention turned to Houston County where EAB surveys were being conducted, traps and trap trees were being set up, quarantine regulations were being finalized, news releases were being created and inter-agency relationships were being forged.

Then, on May 13th, an EAB population was found in St. Paul, when we least expected it, but not where we least expected it. According to an EAB risk map produced by MDA in 2003, we knew that the Twin Cities area had a very high risk of introduction. See map. Visual searches were being conducted in this area where a tree care worker was doing some routine tree inspections. He noticed one of the symptoms of EAB in ash trees: a thinning crown. When he peeled back the bark with his knife, he saw characteristic S-shaped galleries, and contacted the Minnesota Department of Agriculture with his find.



The day after discovery, a quarantine was enacted in the Twin Cities' counties of Hennepin and Ramsey. See map. In an intensive, short-duration delimiting survey of the discovery area, 68 ash trees were found to be infested and were subsequently removed and chipped by the City of St. Paul and brought to St. Paul's District Energy for incineration. Twenty suspect trees were girdled near the infestation to attract some of the adult EAB in the area. The suspect trees were removed in the fall; some of these trees were found to be infested as well.

The Minnesota Department of Agriculture and agency partners deployed nearly 700 purple panel traps within a four-mile radius of the discovery, which captured only four EAB adults between the end of May and October. One of the adults was found in a trap ½-mile from the discovery site, and two were found on one trap one mile north of the site, on the St. Paul campus of the University of Minnesota.

Results from dendrochronological studies of EAB-infested trees indicate that the St. Paul infestation dates back to 2006, one of the quickest discoveries of an EAB infestation to date.

An Incident Command System was initiated to facilitate communication about EAB events, outreach, and planning, with unified command representatives from the Minnesota Department of Natural Resources (DNR), the Minnesota Department of Agriculture (MDA), and USDA APHIS Plant Protection and Quarantine.

The DNR has developed an EAB Preparedness Plan and is currently developing plans for ash utilization and black ash management. See article in Special Projects Section. Ash makes up 50 percent of the lowland hardwood forest cover type in Minnesota, and Minnesota has the third highest volume of ash in the US. Based on a survey in 2006, there are over 3 million ash trees that are publicly owned in municipalities across the state.

The DNR is continuing its efforts to limit introductions of exotic forest pests onto state-administered lands by enforcing recent firewood legislation. Over 900 businesses have been approved by DNR-Forestry to provide firewood to State Parks and the camping public. Since EAB was found inside MN and three counties are now quarantined, additional firewood restrictions were added in 2009. Hardwood firewood from quarantined counties cannot be moved to a non-quarantined county unless a compliance agreement is issued by the Dept. of Agriculture. Hardwood firewood from counties contiguous to a quarantined county can only be used on DNR-lands in contiguous counties. See Firewood Restrictions article in Special Projects Section.

Emerald ash borer: Play-by-play

By Michael Schommer, MDA, Communications

April 6, 2009

EAB infestation found within 1 mile of Minnesota's border

Emerald ash borer (EAB) is now known to be present just outside the Minnesota border in Vernon County, Wisconsin. This infestation became known in early April when a citizen in Victory, Wisconsin reported dying ash trees to Wisconsin officials. See map on next page. Since the initial discovery, infested trees have been confirmed two miles to the south of Victory, two miles to the north and 1.5 miles to the east. The original detection in Victory was approximately 1 mile south of the Minnesota border, the northernmost infested trees that have been discovered since are 0.1 mile from the Minnesota border.

The southeastern corner of Minnesota is comprised of the Upper Mississippi River Wildlife and Fish Refuge which is three miles wide at the Iowa border and composed of riverway, sloughs and forested islands. The nearest land accessible by foot is off of Hwy 26 which runs along the Minnesota "shore" to the west of the refuge. In the week following the detection of EAB in Victory, staff from Minnesota Departments of Agriculture (MDA) and Natural Resources, as well as from USDA APHIS Plant Protection and Quarantine conducted visual checks and sampled declining ash in the river valley west of Highway 26. No EAB were found through this work, though only heavily infested trees can typically be found through visual inspection. Considering that this area is three miles from the nearest known infested trees in Wisconsin, it likely that infested trees cannot yet be detected visually in this area. Additional surveys utilizing detection trees and purple traps will be implemented in the area (as well as elsewhere throughout the state) this summer. However, due to the proximity of the infestation in Wisconsin, an emergency state quarantine was declared on Houston County by the MDA on April 22 and was followed by a federal quarantine on April 28. There are two reasons for declaring the quarantine in advance of finding EAB in Houston County:
1) The lesson learned from EAB infestations elsewhere is that trees that can be recognized as infested are only the tip of the iceberg and that many additional trees over a wider area are also infested but cannot yet be recognized as such. Therefore we have to assume this infestation extends into Houston County.
2) EAB adults are known to be capable of flying up to 4-5 miles. While most adults seem to not move very far before infesting a tree, a portion of the population likely does fly some distance before infesting a tree. Houston County is well within the flight distance for EAB from known infested trees to enter Minnesota.

May 14, 2009

Minnesota officials find emerald ash borer infestation in St. Paul neighborhood

Plans underway to quarantine firewood and certain ash material for Ramsey and Hennepin counties

The Minnesota Department of Agriculture (MDA) today announced the discovery of an emerald ash borer infestation (EAB) in St. Paul just northeast of the intersection of Interstate 94 and Highway 280. This is the first detection of the destructive tree pest in Minnesota. The infestation was initially reported to MDA by Rainbow Tree Care Company on Wednesday. After receiving the report and conducting an initial inspection, MDA submitted larvae from the infested trees to the U.S. Department of Agriculture (USDA) for confirmation as EAB. USDA made that preliminary confirmation this morning.

In response to this finding, MDA plans to issue a quarantine prohibiting the movement of firewood, ash nursery stock, ash timber or any other article that could spread EAB in Ramsey and Hennepin counties. This quarantine is expected to be followed by a federal quarantine within days. MDA staff will now conduct a thorough survey of trees in the surrounding area to assess the extent of the infestation. Information from this survey will help determine the response strategy implemented by state and local officials. The Minnesota Department of Natural Resources (DNR) and the USDA Animal and Plant Health Inspection Service (APHIS) are working closely with MDA in the response.

EAB is an invasive beetle that attacks and kills ash trees. Its larvae kill ash trees by tunneling into the wood and feeding on the tree's nutrients. Since its accidental introduction into North America, EAB has killed millions of ash trees in 10 eastern states. With an estimated 900 million ash trees, Minnesota is a prime target for EAB. Earlier this year, MDA issued a quarantine for Houston County in response to an EAB infestation across the border in Wisconsin.

Officials urge Minnesotans to take steps to keep EAB from spreading:

- Don’t transport firewood, even within Minnesota. Don't bring firewood along on a camping trip. Buy the wood you need locally from an approved vendor. Don't bring extra wood home with you.
- Don’t buy or move firewood from outside your area. If someone comes to your door selling firewood, ask them about the source of the wood.

Watch for signs of infestation in your ash trees. If you suspect your ash tree could be infested by EAB, visit www.mda.state.mn.us/invasives/eab and use the "Do I Have Emerald Ash Borer?" checklist.

May 15, 2009

Quarantine implemented on firewood, ash products in Hennepin and Ramsey counties

MDA action designed to stop shipments of potentially infested products to other parts of state

Following yesterdays' discovery of emerald ash borer (EAB) in a St. Paul neighborhood, the Minnesota Department of Agriculture (MDA) today issued a state quarantine on firewood, ash trees, and ash tree products in Hennepin and Ramsey counties. The measure is designed to slow the spread of EAB, a highly destructive tree pest, to other parts of the state.
The quarantine prohibits the movement of the following items out of Ramsey and Hennepin counties:

- Firewood from hardwood (non-coniferous) species;
- Entire ash trees;
- Ash limbs and branches;
- Ash logs or untreated ash lumber with bark attached; and
- Uncomposted ash chips and uncomposted ash bark chips larger than 2 inches in diameter.

Last month, MDA issued a similar quarantine for Houston County, in Minnesota’s southeast corner, in response to an EAB infestation just across the Mississippi River in Wisconsin. MDA will work with nurseries and other impacted businesses in the coming days to explain the quarantine and help minimize business disruption.

"The number one way EAB moves to new areas is when people accidentally help it spread by moving infested firewood and other products," MDA Plant Protection Director Geir Friisoe said. "This quarantine will help slow the spread of the pest and give Minnesota the best chance to protect our 900 million ash trees." Even in counties not covered by these quarantines, officials urge all Minnesotans to follow common-sense steps to keep EAB from spreading:

- Don’t transport firewood. Don't bring firewood along on a camping trip, and buy it where you use it.
- Don’t buy or move firewood from outside your area for use in your home.

- Watch for signs of infestation in your ash trees. If you suspect an infestation, use the "Do I Have Emerald Ash Borer?" checklist on the MDA's EAB web page at http://www.mda.state.mn.us. You can also contact your local extension service office or a tree care company with a certified arborist on staff.

June 1, 2009
MDA survey finds 59 St. Paul trees infested with emerald ash borer
Next steps are to remove infested trees and closely monitor for any additional infestations

The Minnesota Department of Agriculture (MDA) reported today that a multi-agency survey found 59 trees infested with emerald ash borer in and around the St. Anthony Park neighborhood where the pest was first discovered in May. All 59 trees are within a half mile of

the first infestation site. Twenty-nine of the infested trees are on public property such as city parkland or rights of way. The remaining 30 are on private property. The City of St. Paul will begin removing the infested trees on public property this week. At the same time, city and state officials will contact affected property owners to coordinate the removal of infested trees on private property.

Given the limited number of infested trees, MDA and St. Paul officials believe the best approach in this case is to quickly remove all infested trees and carefully monitor nearby ash trees for possible signs of infestation. "Our goal is to make it as tough as possible for this pest to become a Minnesota resident," MDA Plant Protection Division Director Geir Friisoe said. "We know from other states how difficult it can be to eradicate emerald ash borer, but we are encouraged that infested trees have only been found within a half mile radius."

While removal of infested trees is the most visible part of the EAB battle, the monitoring effort is just as important. This monitoring takes several forms:

- MDA is placing purple cardboard traps in ash trees around the city. These mailbox-sized traps contain lures that attract adult ash borers in the immediate area. The insects land on the trap and become stuck to its sticky surface. Workers remove the traps in autumn to see if any borers have been caught.
- Workers will select unhealthy ash trees on public property for use as "trap trees." Injured trees are a strong attraction for borers in the immediate area. Bark along a section of the trunk will be removed and, ultimately, the trap tree will need to be removed.
- Homeowners are asked to join the effort by watching their trees for signs of infestation. These signs include dieback of leaves in the upper third of the tree's branches, heavy woodpecker activity, D-shaped exit holes in the bark, S-shaped tunnels under the bark or water shoots up the trunk. Homeowners who notice these signs should contact their city forester or a local tree care company with a certified arborist on staff. More details can be found on MDA's website at www.mda.state.mn.us.

MDA reminds homeowners that it is not necessary to remove healthy ash trees. Homeowners with questions about disposing of ash tree material should contact their city forester for guidance. Improper disposal of infested ash material could accelerate the spread of EAB.

Gypsy Moth State Summary Report: 2009

Prepared by Minnesota Department of Agriculture
Plant Protection Division, Gypsy Moth Unit

PROGRAM OVERVIEW

The gypsy moth detection program is a cooperative effort between state and federal agencies including the Minnesota Departments of Agriculture (MDA) and Natural Resources (DNR), the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS), and the U.S. Forest Service (USFS). The Gypsy Moth Program Advisory Committee (GMPAC) was formed in 1998, consisting of representatives from these cooperating agencies and the University of Minnesota. On a biannual basis, GMPAC meets to discuss issues related to gypsy moth management. It is this cooperative effort that has built a strong gypsy moth program in the state of Minnesota. A strategic plan was prepared by GMPAC members to describe the objectives and administrative structures necessary to manage the gypsy moth in Minnesota. The plan contains a mission statement, a framework for decision making, and outlines the strategies and mechanisms to implement the plan.

Since 2004, Minnesota has been a formal member of the Gypsy Moth Slow the Spread (STS) Foundation. The STS Action Area is moved annually based on trap catch data and to cover areas where moth populations are building. In 2009 portions of four counties (Houston, Winona, Lake and Cook) were included in the Action Area.

GENERAL SURVEY PROGRAM

The MDA has been the lead agency undertaking the annual gypsy moth detection survey since 1973. The trapping survey is the data source for determining where gypsy moth management strategies should be implemented. All gypsy moth collection data is routed through MDA for inclusion in annual reports.

Program Area
In 2009, MDA filled positions for 40 trapping routes and 7 lead workers to oversee field operations. Trappers were responsible for setting, checking, and removing gypsy moth traps during the field season. All trap data in Minnesota is collected and recorded using STS protocols. To gather comparable data, trapped areas beyond the STS Action Area do not follow the APHIS recommended trap density but rather use equivalent metric grids to achieve similar results. The entire state is not surveyed every year. Gypsy moth is moving into the state from the east, so trapping in the western portion of the state is typically done on a rotating basis from year to year. Minnesota's entire eastern border including the metro was trapped this season, along with an area extending west of the metro into the north central areas of Leech Lake and northeast to Ely and Crane Lake.

Much of the northern region of Minnesota remains a challenge to survey because of the lack of roads or road maintenance. As moth numbers rose in the northeast, trapping routes were designed to be hiked rather than driven. Although hiking field staff can only set about 40% of the traps that driving staff can, the extra attention to trapping on a pre-determined grid has enabled the program to gather more complete data on the existence of moth populations across the landscape. Tourism is a large part of the local economy in the north woods and along the North Shore of Lake Superior. Popular camping and outdoor recreation sites are still trapped heavily thanks to hike-in trappers.

High-risk sites
A determination of risk for the introduction and establishment of gypsy moth is based on human activity levels, preferred habitat for gypsy moth, and the advancing gypsy moth front heading west from the northeastern states. Wholesale nursery dealers and nursery growers that report stock sources from gypsy moth-quarantined areas or have a history of pest problems are considered high risk. Sawmills and pulp mills are regarded as high risk if it is known or likely that they have out-of-state sources and if they are within 100 miles of counties that trap fifty or more gypsy moths. State Parks, campgrounds, and other sites associated with the movement or sale of firewood and movement of humans and items from infested areas for tourism/recreation are also deemed high risk.

Compliance agreement sites are by nature high risk. Agreements for four mills and two nurseries in Minnesota were issued or re-issued jointly by state and federal officials this year.

Trapping Grid
The STS Action Area was trapped on at least a two-kilometer grid. Outside the STS area, standard grid densities ranged from 1.5K to 3K. Grid densities differ according to the risk of introduction: smaller grid sizes yield higher trap densities which

result in higher resolution of actual moth populations. Isolated traps with high moth numbers in 2008 were surveyed intensively in 2009 through site delimitation. This survey technique involves narrowing down a large area to find out if gypsy moth populations are persisting and if treatments should be administered. Each delimit site was trapped at a grid density varying between 250 and 1000 meters. There were 45 STS and 64 non-STS delimit sites designated in 2009. Urban areas (Twin Cities metro, St. Cloud and Rochester) outside of the STS Action Area are considered high-risk for gypsy moth introduction by human movement and were subsequently trapped on a 1.5-kilometer grid.

Nearly the entire North Shore was trapped at a higher density, between 0.5 and 1.0 kilometers, to increase accuracy and pinpoint recurring populations. In years past, most of the gypsy moth activity followed the shoreline and dropped significantly farther inland. Tourism and heavy recreational use by people living and vacationing in the northeast corner of the state (commonly referred to as the Arrowhead Region) puts the area at risk for artificial introductions of gypsy moth.

The standard trapping grid overlaid many high-risk sites. MDA supplemented the standard grid with random traps at places of interest to increase the chance of detection. Field staff had the liberty of setting the traps anywhere within the designated property but were instructed to space the traps out evenly to cover the entire site. Designated wholesale nursery dealers and nursery grower sites received 2-20 random traps depending on acreage in production. Designated sawmills and pulp mill sites received two random traps. Other high-risk sites also received variable random traps.

Asian Gypsy Moth

Trapping for the Asian strain of gypsy moth (AGM) continued in 2009. Traps from pathway sites (ports of entry, warehouses or sites that receive/store containers), and around sites where heterozygous strains were identified previously were sent to OTIS Laboratories for DNA analysis. This year, 45 AGM traps with 70 moths were sent in for analysis. No AGM have been identified in Minnesota at this time.

Research

Sharp increases in moth numbers along the North Shore since 2005 along with noticeable variations in moth size and an unusually long adult flight season led MDA to request further research into the biology and behavior of northerly populations.

- Meteorological data is being analyzed to determine if wind patterns are capable of carrying gypsy moth larvae or adults over Lake Superior from eastern infestations into Minnesota.
- Autotraps were hung along the shoreline to capture and record daily flight patterns as well as seasonal moth activity.
- A random sampling of moths will be processed for wing measurements for help in determining whether they are resident or immigrant populations. MDA submitted 2,736 traps with 13,794 moths this year for wing measurement studies, which started in Minnesota in 2007 and has since expanded to include other states for comparison. Preliminary results of this research indicate that approximately 20% of the males are immigrants from high density populations.
- A sentinel trap grid was established in Minnesota in 2008 on areas of the existing grid along the North Shore to monitor male moth flight patterns. Sentinel traps were set and checked frequently again in 2009.
- To address the question of how temperatures over time affect lure release rates from traps, MDA is participating in a regional lure release study to measure these differences.

These research projects are being coordinated through the USFS Field Station in Morgantown, WV.

Trapping Schedule

MDA's trapping area was divided into northern and southern regions, as the latitudinal climate range of the state creates a delayed moth emergence in the north. Southern trappers set traps between June 1 and July 3. With the northern gypsy moth emergence being delayed about three weeks, northern trappers set traps between June 8 and July 16. Traps remained in the field for six weeks in the south and 8-9 weeks in the north. Phenology models help determine when traps should be set and removed. Trap set should be completed just prior to moth flight and be removal should not occur until moth flight is over. The midseason trap check facilitates determinations of moth development and removal timing. It also helps with early detection and regulatory action at regulatory sites.

Southern trappers were finding moths during midseason trap check and were able to adhere to the set schedule. Trap removal in the south began on August 17 and was completed by September 3. The rotating survey area in north central Minnesota adhered to the original schedule because moth capture was low in that region, beginning trap removal on September 14. Trap removal in most of the northern region was extended to begin on September 21 to account for a later-than-predicted moth flight period. The majority of the moths that were caught in the north were found during trap removal, ending by October 22. By extending the season and recording the number of live moths, MDA is confident that the schedule was properly adjusted to cover the majority of the gypsy moth flight period.

Survey Results

A total of 23,639 gypsy moth traps were set in Minnesota this season, yielding 27,870 moths. MDA set 23,137 traps, capturing 27,858 moths. APHIS coordinated trap placement for 244 traps on several federal and tribal land sites and areas of high risk interest, including the Agassiz Wildlife Refuge, Pipestone National Monument and Red Lake Reservation, which were not included in MDA's program area. APHIS traps collected ten moths; seven in St. Louis County, two in Cass County, and one in Koochiching County. Minnesota County Agricultural Inspectors (CAI's) volunteered to set traps outside the MDA trapping area in Clearwater, Cottonwood, Koochiching, Lake of the Woods, Nobles, Otter Tail, Rice, and Todd counties. Out of the 200 traps CAI's set, one gypsy moth was trapped in Rice Co. and another was trapped in Koochiching Co. Positive traps will be followed up in 2010 as delimit sites according to GMPAC protocols. Three Rivers Park District, located in the Twin Cities metro area, set 58 traps and caught zero moths.

The number of gypsy moths trapped in Minnesota in 2009 increased by 127% since 2008 and by 673% since 2007. The moth numbers were much lower in the southern region of the state where the pressure of adjacent Wisconsin populations had subsided this year. A total of 254 moths were trapped in the southern region, accounting for less than 1% of the statewide 2009 total. Comparing this to the 2,481 moths that were trapped in the southern region in 2008 results in a 90% decrease in moths in that area from 2008-2009.

The majority of gypsy moths trapped in the northern region in 2009 were found in the northeast corner of the state, in the Arrowhead Region. This year ushered in a wave of moths to inland areas of the Arrowhead with previously low to moderate catches. Trapping in St. Louis, Lake and Cook counties brought in 27,579 moths. A total of 27,616 moths were trapped in the entire northern region of Minnesota, accounting for more than 99% of the statewide 2009 total. Comparing this to the 9,774 moths that were trapped in the northern region in 2008 results in a 183% increase in moths in that area from 2008-2009. MDA will be working closely with the land stewards within these areas to align management strategies with increased moth populations. Many of the isolated positive traps will be further delimited and treatments will be proposed for these areas in 2010.

APHIS funds were used to trap all national forest and tribal lands within MDA's standard trapping grid. There were 710 traps were placed on Reservation lands that captured 85 moths. Grand Portage, in the extreme northeast tip of Minnesota, was the only Reservation covered under STS Foundation funding in 2009. Results for federal and Reservation lands are listed in the summary table at the end of this report.

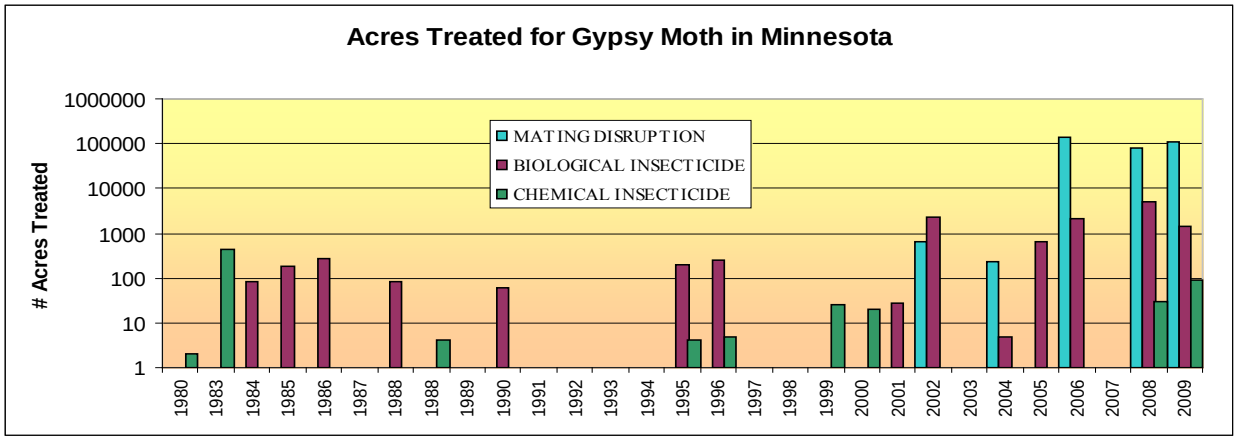
MDA staff set traps at 404 nurseries and 32 moths were recovered from nine sites. The substantial outreach campaign MDA has undertaken may have paid off as more nurseries are contacted and informed about proper sanitation of imported stock. MDA continues to work with the industry to minimize their risks of transporting gypsy moth into the state. Outside of the STS area, there was one nursery on the northwest side of the Twin Cities metro area that yielded a single moth at the midseason trap check. MDA and APHIS personnel followed inspection protocols, found no alternative life stages upon inspection, and all nursery stock certifications were in place.

MDA trapped 121 mill sites in 2009, yielding 23 positive traps with a total of 43 moths at nine sites. Catches at these STS mills were not investigated for regulatory concerns because the numbers of moths caught there simply reflect the overall high moth population in the larger landscape.

Thirteen of Minnesota's 80 State Parks were covered by the standard grid this year and had an additional 1-2 random traps placed at each. No moths were caught in the 25 traps that were placed at State Parks in 2009. Looking at other regulatory sites, there were 16 other campgrounds, one firewood dealer, and three randomly trapped sites that had positive trap catches.

GENERAL TREATMENT PROGRAM

Since 1980 the MDA has coordinated and overseen the treatment of more than 328,000 acres to delay, prevent or mitigate the adverse impacts directly or indirectly associated with gypsy moth infestation on our state's natural resources, citizens and industries. As the gypsy moth front moves closer to Minnesota, treatment acreage is expected to increase to meet the statewide objective of decreasing spread rates from the historic 13 miles per year to less than 3 miles per year.



STS and Eradication

This year 108,532 acres were treated within the STS Action Area along with 685 acres in two metro eradication sites. An organic formulation of *Btk* was used in the eradication blocks as well as in two STS blocks near Lutsen and Tofte in Cook County. The majority of treatments used mating disruption products designed to interfere with the adult male's method of locating a female to mate with. Two distinct products, SPLAT GM in the southeast and Disrupt II in the northeast, were used to achieve the goal.

Over 37,000 acres between four sites were treated with SPLAT GM in Houston and Winona counties in late June. Around 70,000 acres between five sites in Cook and Lake Counties were treated with Disrupt II in mid-July. Outreach to affected communities improved this year and plans are underway to further increase communication opportunities for next year.

Two environmental assessments (EA) were prepared for the treatment projects. One was prepared by APHIS for the eradication sites because funding was obtained through that agency. The other EA was prepared by the USFS to address STS-funded treatments on the Grand Portage Reservation, the Superior National Forest, state properties, and private lands.

2009 Gypsy Moth Treatments (Non-Regulatory)

Site Name	Acres	Product	Application Rate/Acre	Applicator	Application Equipment	Date of Application	Cost/ acre	Project
Richfield	303	Foray 48B	24 CLU x 2	Scott's Helicopter Service	Rotary	5/23/2009	$34.93	Eradication
Minnetonka	385	Foray 48B	24 CLU x 2	Scott's Helicopter Service	Rotary	5/22/2009	$34.93	Eradication
Alfred Ck.	374	Foray 48B	24 CLU x 2	Airborne Custom Spraying (subcontractor)	Fixed Wing	6/15/2009	$34.93	STS
Carlton Ck.	343	Foray 48B	24 CLU x 2	Airborne Custom Spraying (subcontractor)	Fixed Wing	6/15/2009	$34.93	STS
Oak Ridge	13916	SPLAT	6g	Dynamic Aviation	Fixed Wing	6/29/2009	$6.93	STS
Hart Tnshp	1730	SPLAT	6g	Dynamic Aviation	Fixed Wing	6/29/2009	$6.93	STS
Kings Bluff	16124	SPLAT	6g	Dynamic Aviation	Fixed Wing	6/29/2009	$6.93	STS
Winona	5259	SPLAT	6g	Dynamic Aviation	Fixed Wing	6/29/2009	$6.93	STS
Castle Danger	45882	Disrupt II	6g	Al's Aerial Spraying	Fixed Wing	7/14/2009	$7.41	STS
Spruce Ck.	1023	Disrupt II	6g	Al's Aerial Spraying	Fixed Wing	7/14/2009	$7.41	STS
Hovland	13232	Disrupt II	6g	Al's Aerial Spraying	Fixed Wing	7/14/2009	$7.41	STS
Split Rock Pt.	9555	Disrupt II	15g	Al's Aerial Spraying	Fixed Wing	7/14/2009	$14.28	STS
Onion R.	1094	Disrupt II	15g	Al's Aerial Spraying	Fixed Wing	7/14/2009	$14.28	STS

Regulatory Treatments: (89 acres)

Two nurseries in Minnesota conducted eradication treatments after life stages were discovered there last summer and the stock was subsequently quarantined. Both nurseries were required to treat the stock and surrounding environs this spring using their own funds. Dimilin was aerially applied at both sites on May 25 and again on June 1, covering 88 acres. Both nurseries were released from their compliance agreements and delimit traps were placed around each site. Both sites remain gypsy moth free after the 2009 trapping season. A trace-forward from Nursery 2 is described in the Alternate Life Stage Surveys section.

2009 Gypsy Moth Treatments (Regulatory)

Site Name	Acres	Product	Application Rate/Acre	Application Equipment	Date of 1st Application	Date of 2nd Application	Cost/Acre	Project
Nursery 1	26	Dimilin	2 oz.	Aerial-Helicopter	5/25/2009	6/1/2009	unknown	Eradication
Nursery 2	62	Dimilin	2 oz.	Aerial-Helicopter	5/25/2009	6/1/2009	unknown	Eradication

Treatment Monitoring
Four sites were treated with Btk this year, which allows for same-year monitoring. Following up on treatments this year, both sites were delimited and after analysis by the STS Decision Algorithm (DA), were determined to have been successful. The two sites in Lutsen and Tofte were similarly treated and monitored. The DA declared them successfully eradicated; however, the surrounding populations of moths are still quite high. All of the five mating disruption blocks in 2008 were evaluated this year and all are considered successful.

Alternate Life Stage Surveys
An egg mass search was conducted in Hopkins, a suburb of Minneapolis, at a site where potentially infested nursery stock was planted. No alternate life stages were found but a delimitation of the area is planned for 2010. Two egg masses near Finland and Schroeder were recovered by seasonal trappers. A trapper also found alternate life stages inside a trap near Two Harbors. Searches around these sites yielded no additional finds but the areas are proposed for treatment in 2010. No life stages were found at either northeastern regulatory sites or in areas with extremely high trap captures after an inspection by MDA personnel.

OUTREACH

Outreach for 2009 treatments included press releases, several media interviews, public open houses, meetings with local government officials and direct mailings to affected residents. A brochure with general gypsy moth information was given to landowners, business owners and interested parties throughout the trapping season this year. Survey staff also handed out two specialized brochures aimed at the nursery and mill industries to explain ways to protect their operations from the gypsy moth. Presentations about gypsy moth were given at County Agricultural Inspector meetings, compliance agreement training sessions, community groups and national meetings.

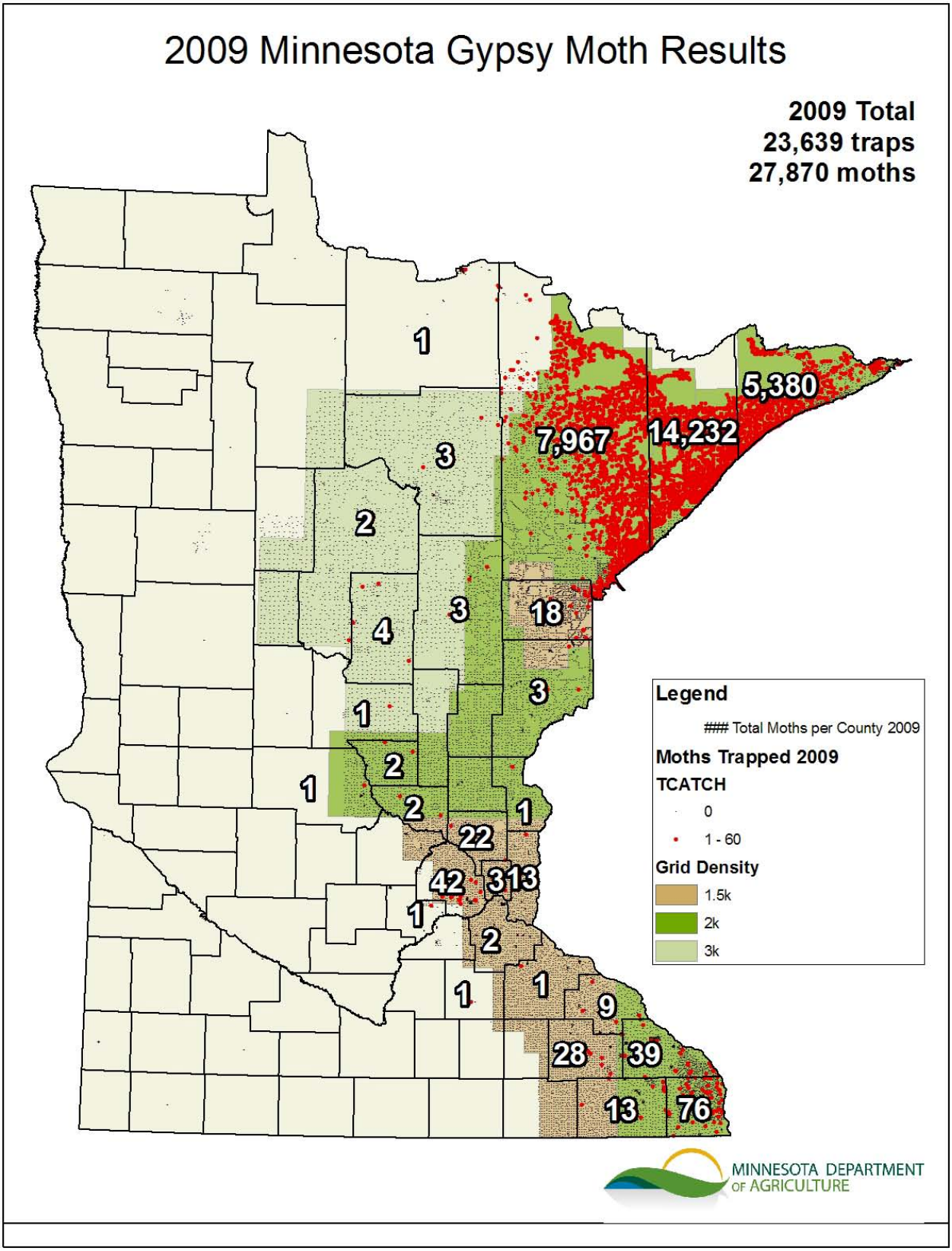
PROGRAM PLANS FOR 2010

• Preparations are in development to survey the eastern border of the state, concentrating on northern counties that showed higher gypsy moth activity in 2009 as well as rotating through southern areas.
• STS survey and treatment areas are being identified to track and treat isolated gypsy moth populations before they have a chance to become established. Several areas along the north shore will get higher attention to address growing moth concerns in the region.
• Outreach to high-risk businesses, industry groups, and the general public will continue.

2009 SURVEY SUMMARY STATISTICS

Management Zones	Total Traps	% of Total Traps	Total Moths	% of Total Moths
Eradication Area	17537	74	6234	22
STS Action Area	6102	26	21636	78
TOTAL	**23639**	**100**	**27870**	**100**
Traps set by agency	**Traps Set**	**Positive Traps**	**Moth Count**	
MDA	23137	3898	27858	
APHIS	244	9	10	
County Agricultural Inspectors	200	2	2	
Three Rivers Park District	58	0	0	
TOTAL	**23639**	**3909**	**27870**	
Trap Type				
Standard	20679	3195	22821	
Delimit	2039	544	4158	
High Risk Sites	921	170	891	
TOTAL	**23639**	**3909**	**27870**	
High Risk Sites	*Note that these figures are spatial and may duplicate trap and moth counts. These numbers are not to be incorporated into totals.*			
Nursery	404	10	30	
Mill	121	23	36	
State Park	25	0	0	
Campground	62	19	119	
Firewood Dealer	7	1	1	
Reactive	122	100	577	
Random	180	17	128	
TOTAL	**921**	**170**	**891**	
Urban Areas	*Not all urban areas listed; figures include all types of traps set within the urban boundaries.*			
Duluth	510	160	393	
Twin Cities Metro Area *	2935	42	83	
Rochester	199	6	13	
St. Cloud	19	1	1	
Winona	53	0	0	
Reservations				
Fond Du Lac	233	0	0	
Grand Portage	182	43	84	
Vermillion (Boise Forte)	3	1	1	
Leech Lake	289	0	0	
Mille Lacs	2	0	0	
Prairie Island	1	0	0	
TOTAL	**710**	**44**	**85**	
Federal Lands				
Superior National Forest	2647	2036	18137	
Chippewa National Forest	547	1	1	
TOTAL	**3194**	**2037**	**18138**	

** Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington Counties*


2009 Minnesota Gypsy Moth Results
2009 Total
23,639 traps
27,870 moths
1
3
2
4
3
1
2
1
2
1
22
42
3
13
1
2
1
1
9
28
39
13
76
5,380
7,967
14,232
18
3
Legend
Total Moths per County 2009
Moths Trapped 2009
TCATCH
0
1 - 60
Grid Density
1.5k
2k
3k
MINNESOTA DEPARTMENT
OF AGRICULTURE

Counties Trapped, Moths Caught

County	# Traps Set	# Moths	% of Total	1-year % change
Aitkin	768	3	0%	300%
Anoka	508	22	0%	100%
Benton	278	2	0%	100%
Carlton	1450	18	0%	-98%
Carver	86	1	0%	-97%
Cass	581	2	0%	-33%
Chisago	314	1	0%	100%
Cook	**1318**	**5380**	**19%**	**73%**
Crow Wing	374	4	0%	400%
Dakota	782	2	0%	-86%
Fillmore	848	13	0%	-93%
Goodhue	906	1	0%	-98%
Hennepin	722	42	0%	-80%
Houston	978	76	0%	-94%
Itasca	751	3	0%	50%
Koochiching	118	1	0%	0%
Lake	**1471**	**14232**	**51%**	**384%**
Morrison	245	1	0%	100%
Olmsted	841	28	0%	-81%
Pine	1106	3	0%	-99%
Ramsey	213	3	0%	50%
Rice	139	1	0%	0%
Saint Louis	**3661**	**7967**	**29%**	**340%**
Sherburne	334	2	0%	100%
Stearns	214	1	0%	100%
Wabasha	589	9	0%	-94%
Washington	519	13	0%	-32%
Winona	883	39	0%	-96%
TOTAL:	**20,997**	**27,870**		

Counties Trapped, No Moths

County	# Traps Set		County	# Traps Set
Becker	15		Mille Lacs	300
Beltrami	125		Mower	413
Big Stone	1		Nobles	25
Clearwater	25		Otter Tail	25
Cottonwood	25		Pipestone	8
Dodge	241		Redwood	10
Hubbard	168		Scott	105
Isanti	313		Steele	22
Kanabec	303		Todd	25
Lac Qui Parle	3		Wadena	149
Lake of the Woods	31		Wright	281
Marshall	24		Yellow Medicine	5
			TOTAL:	**2,642**

Status & implications of gypsy moths in Minnesota: November 2009

- Moth catches have increased dramatically along the North Shore (NS) since 2006.
- Moth catches in SE Minnesota peaked in 2008 and declined in 2009.
- Alternate life stages (2 eggmasses) were found along the North Shore for the 1st time this yr (near Finland)
- Pattern of moth flight along the North Shore (two peaks about 1 mo apart) suggests a mixture of resident and non-resident male moths, ie: males blown in from other states.
- Based on wing-span measurements, non-resident males come from two
- different populations, likely the UP of MN and the Apostle Islands of WI.
- Implications of the mixture of resident and non-resident moths
  - Normally, small isolated populations tend to die out because mating success is so low
  - Males blown into an area with scattered females increases chance of mating success, increasing chance of population survival and increase.
  - Blown-in males interfere with trapping data, so difficult to determine extent of resident population.
  - Certain mating disruption treatments also interfere with trapping data, so compound data interpretation.
- GMPAC has draft transition criteria describing process to decide quarantine & transfer of agency authorities (on county by county basis)
- MN GM Strategic Plan has been revised, but revisions have not yet been vetted or approved.
- Current conditions do not yet meet draft transition criteria.
  - While '09 trap catches >10 moths/trap, the area with high moth catches has not persisted more than 1 yr at a time.
  - Alternate life stages are too rare to determine extent or size of population.
  - Treatments have been successful so far in reducing local population numbers.
  - MDA & USFS are still advocating slow-the-spread treatments (not suppression).
  - Risk of spread out of the North Shore area is still too low to warrant quarantine.
- Recent pattern of catches mimics pattern seen in WI, as moths blew in from MI and then contributed to a rapid build-up of population numbers. Quarantines and/or a shift in management strategies may occur in as soon as 2 yrs, although weather conditions may delay the process.

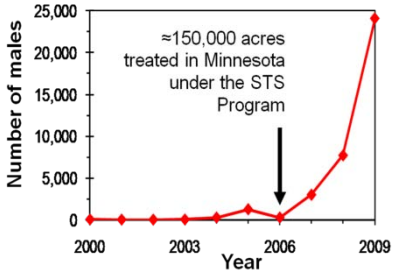


Figure 2. Number of trapped male moths in St. Louis, Lake, and Cook counties, 2000-2009

From poster by Tobin, et al, October 2009:

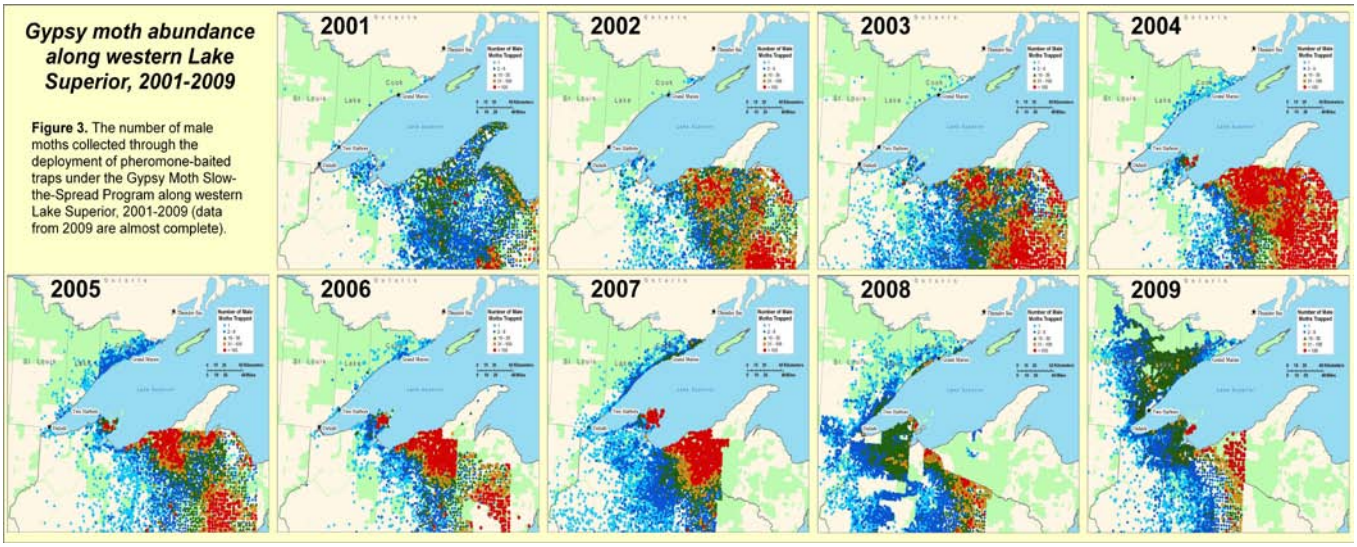
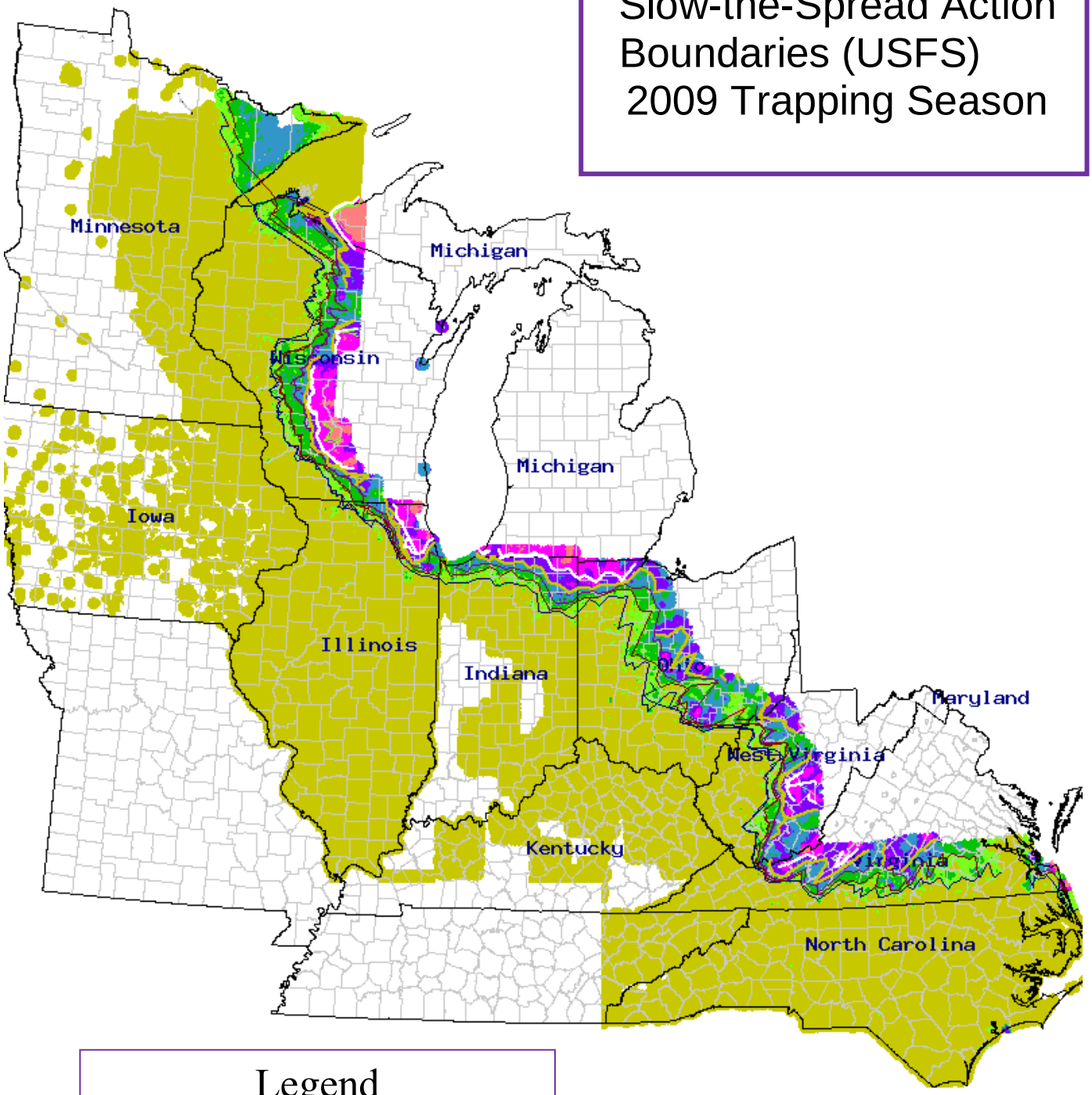


Figure 3. The number of male moths collected through the deployment of pheromone-baited traps under the Gypsy Moth Slow-the-Spread Program along western Lake Superior, 2001-2009 (data from 2009 are almost complete).

Slow-the-Spread Action Boundaries (USFS) 2009 Trapping Season



Legend

Moth counts in traps	Population boundaries
<1	1-moth line
1-3	3-moth line
3-10	10-moth line
10-30	30-moth line
30-100	100-moth line
100-300	300-moth line
≥300	

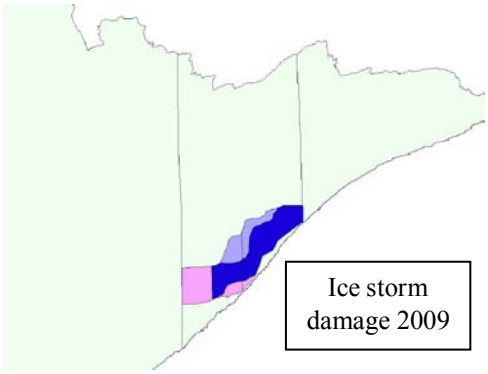
Abiotic Agents

Winter injury of Colorado blue spruces

Symptoms of this abiotic causal agent were ubiquitous this spring in the northern half of the state. Winter injury can take many forms including damage from cold temperatures, drought (yes, this happens even during winter) or a combination of both. The predominant symptoms were purple-brown needles on last year's twigs and bud death, especially of lateral buds. Needles and twigs that were below the snow-line were green and healthy. By early summer, the living buds broke and had "greened-up" the appearance of the trees. Winter-killed needles continued to fall off all season, leaving twigs quite bare behind this year's new shoots.

Ice storm damage along the North Shore

On March 16, 2009, Lake and Cook Counties suffered an ice storm that became a federally-listed disaster. The worst damage was in Lake County but did extend up to the Hovland area in Cook County. Damage in Cook County was spotty. All stands in the ice storm area received some damage but much of it was to trees scattered throughout the stands. State-administered lands did not receive enough damage to warrant salvage timber sales and most of the damage and cleanup was limited to roads, structures and other facilities.



The worst ice damage was on Lake County Forestry lands, primarily in the 15-to-35 year old aspen cover types. Aspen trees under 25 years of age tended to bend while aspen trees over 25 years tended to suffer crown breakage while maintaining a vertical stem. Approximately 5000 acres were determined to be severely damaged. To date 2500 acres of those have been salvage logged primarily for biomass using conventional logging equipment. Many aspen stands not intended for salvage will have lower stocking than normal and will likely have concerns about future decay.


BIRDSHOT RD
Paul Sundberg


Mike Hoppus


Mike Hoppus

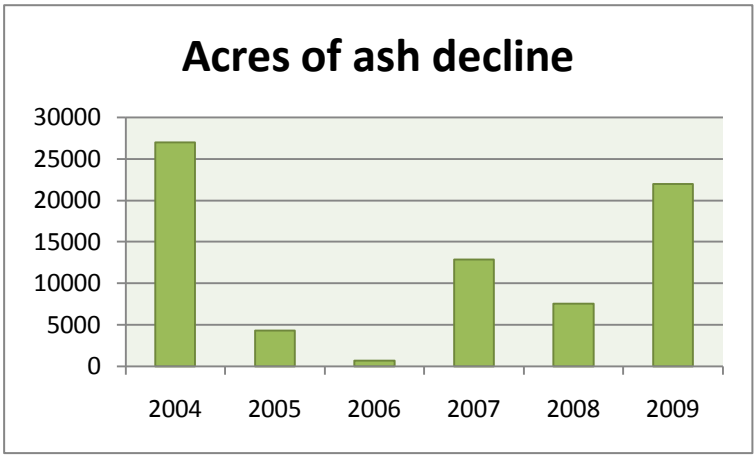

Paul Sundberg

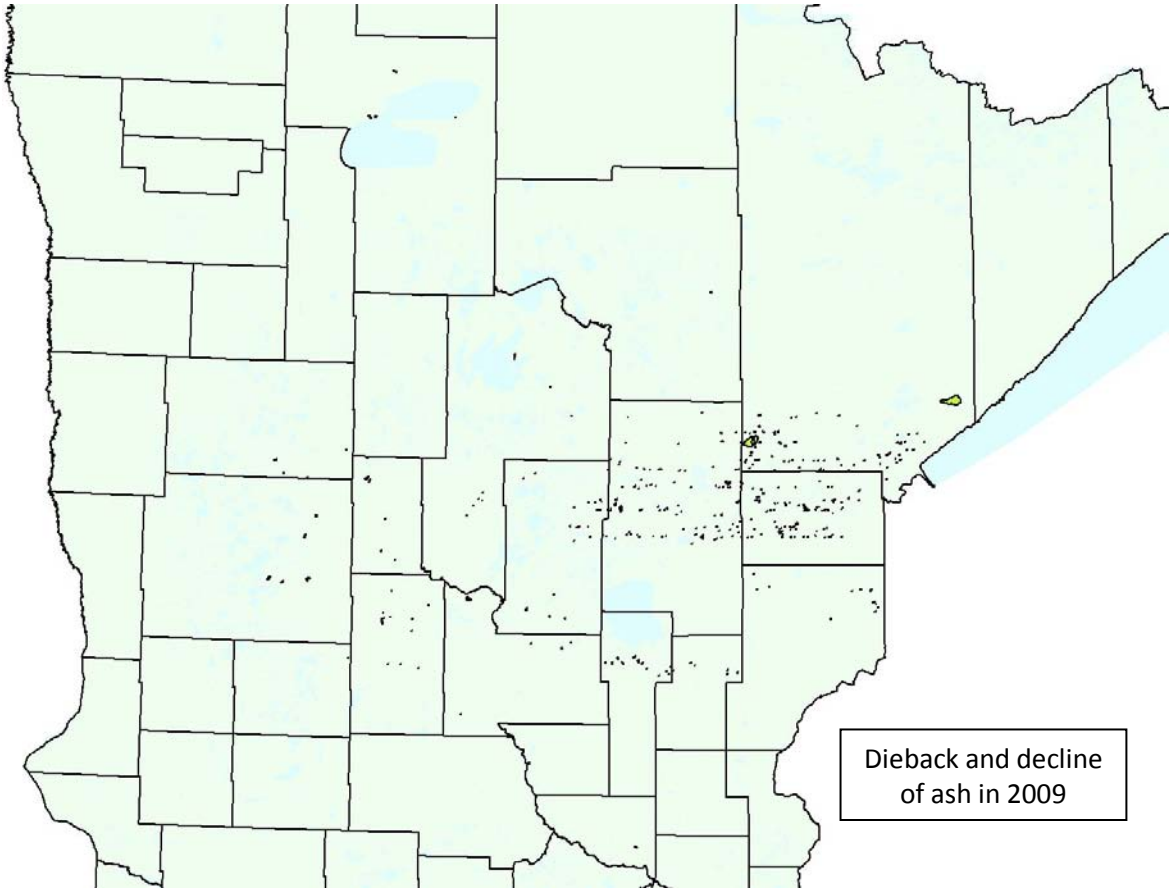

Mike Hoppus

Ash decline

Fluctuating water tables during the last few years is thought to be playing the major role in ash decline in Wet Forest Native Plant Communities. There are a number of other factors involved with some variation from site to site. Ash decline was observed on 21,940 acres this summer, a three-fold increase compared to last year's acreage. The incidence of ash decline has been elevated since 2004.

The Aitkin and Duluth quads appear to have an abundance of decline polygons. This is because these quads were flown on 3-mile flight lines instead of the usual 6-mile lines and with two observers instead of the usual one observer. Additionally, all ash decline was mapped, not just new occurrences of ash decline. See Aerial Survey Section. Without this special survey in the two quads, the statewide acreage (on the normal 6 mile flight lines) for ash decline would have been 15,473 acres.





Aspen decline

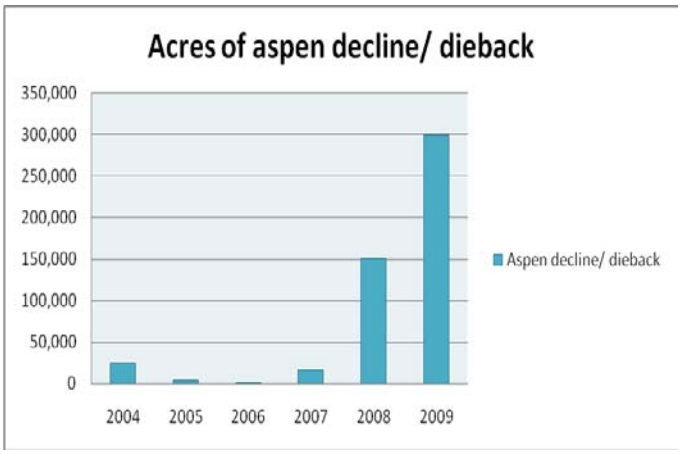
For the past several years, aerial survey crews have detected thousands of acres of defoliation, discoloration, dieback and mortality of aspen. Again this year, defoliation and dieback were mapped. See table, chart and map below.

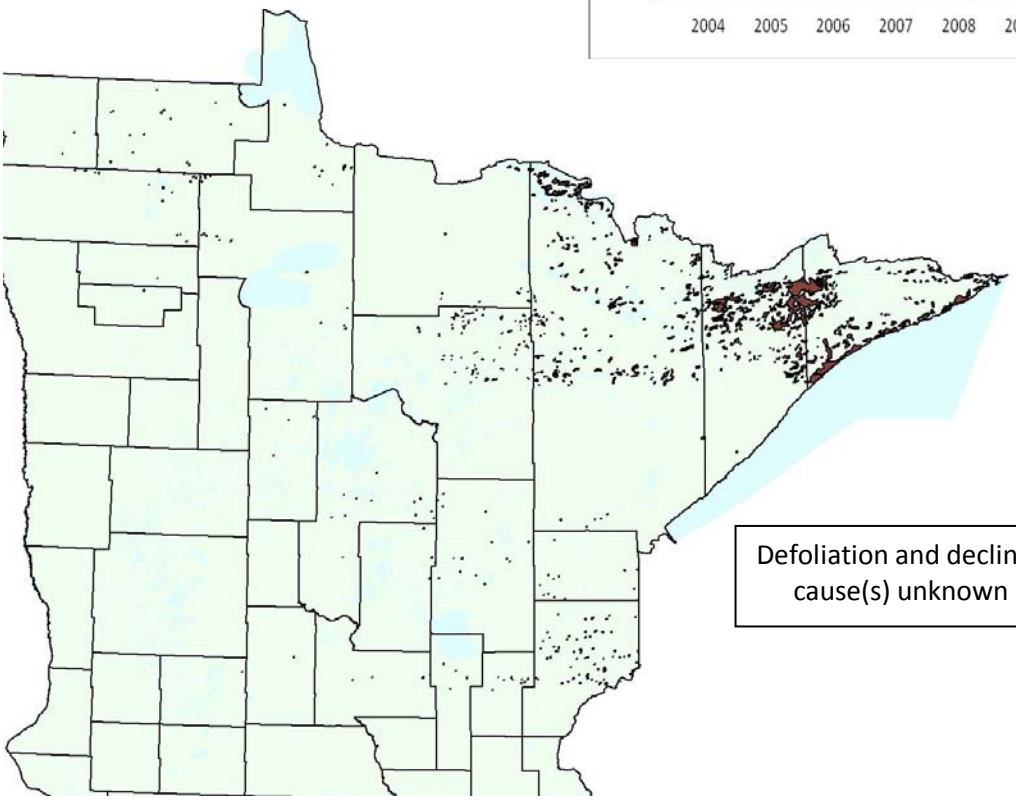
Dieback is the most common symptom but tree mortality has also occurred. Mortality can vary from scattered trees throughout a stand to patches of 30 to 40 dead trees scattered through stands. Trees with dieback also exhibited small off color (yellowish) foliage in the live parts of the crown. In 2008, serpentine galleries were abundant under the bark on dead trees as well as on trees with extensive crown dieback. *Agrilus*- like larvae were common in serpentine galleries in recently dead trees and in trees with extensive dieback. Poplar borer, *Saperda calcarata,* populations appear to have increased in some locations but are much less common than the *Agrilus*. So far *Armillaria* has not been found in the root collar area of examined trees.

Most of the dieback was mapped in the northern tier of counties, especially in St Louis, Lake and Cook Counties. Severe droughts occurred in these counties in 2002 and 2003, and from 2006 through 2009. Much of the aspen in these areas also experienced two to three years of heavy forest tent caterpillar defoliation in 2001-2003. It is likely the dead and dying aspen were stressed trees being attacked by secondary pests. There is also a concentration of aspen dieback in Pine County which, of course, didn't experience severe FTC defoliation earlier in the decade.

Acres of aspen damage by symptom, causal agent(s) unknown. 2004 to 2009

	Defoliation	*Mortality*	*Discol-oration*	*Dieback*
2004	14,570	27730	0	24,356
2005	407,606	658	423	4,381
2006	2,217	635	0	1,309
2007	73,284	613	0	16,666
2008	5,598	85	570	151,022
2009	5789	0	0	299,089





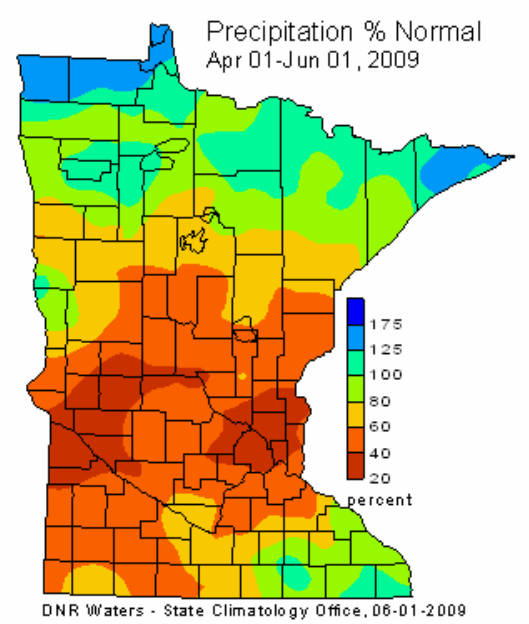
Defoliation and decline of aspen, cause(s) unknown in 2009.

Weather Summary

Snapshots of growing season weather in 2009

Prepared by the Minnesota Climatology Working Group

What happened in May

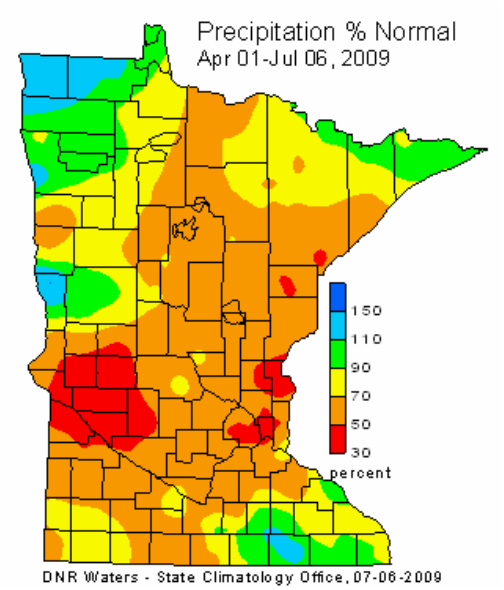


- May 2009 was a dry month across nearly all of Minnesota. Most Minnesota locales reported May precipitation totals that fell short of the historical average by one and one-half inch to two and one-half inches. This perpetuated a dry spell of weather that began in early April. There were two exceptions to the dry May pattern; far northwestern Minnesota received above-average precipitation, and May precipitation totals in far southeastern Minnesota were near historical averages.
- Monthly mean temperatures for May 2009 were below historical averages in west central Minnesota as well as most of the northern one-half of the state. May temperatures elsewhere in Minnesota were close to the long-term mean. Extreme temperature values for May ranged from a high of 100 degrees in Milan (Chippewa County) on the 19th, to a low of 20 degrees in Embarrass (St. Louis County) on the 21st. Numerous high temperature records were broken on May 19 and 20 when temperatures soared into the 90's in many locations. The hot temperatures were accompanied by very strong winds, gusting to 40 mph or more. The hot, dry, windy conditions led to numerous reports of blowing soil. The conditions were also favorable for very high evaporation rates. An evaporation pan located at the University of Minnesota Climate Observatory in St. Paul reported 0.63 inches of evaporation, the third highest daily value in history.
- The National Weather Service reported that on May 20, the Red River at Fargo-Moorhead dropped below flood stage. The river had remained above flood stage for 61 consecutive days, the longest duration flood of all-time at that observation point. For most of the Red River basin, dry weather in April and May caused rivers to return to within the confines of their banks. However, heavy rain in late May in far northwestern Minnesota led to moderate flooding in Kittson and Roseau counties.
- The U. S. Drought Monitor, released on May 26, placed areas of east central and southeastern Minnesota counties in the *Moderate Drought* and *Severe Drought* categories. Large portions of the remainder of the southern two-thirds of Minnesota are considered to be *Abnormally Dry*. The drought designations are the result of two spells of dry weather, one short-term and one longer-term. The shorter-term dryness has persisted since early April and impacts much of the southern two-thirds of the state. The long-term dry spell commenced in mid-June 2008 and has persisted in east central and southeast Minnesota, producing 12-month precipitation deficits of eight or more inches.

What happened in June

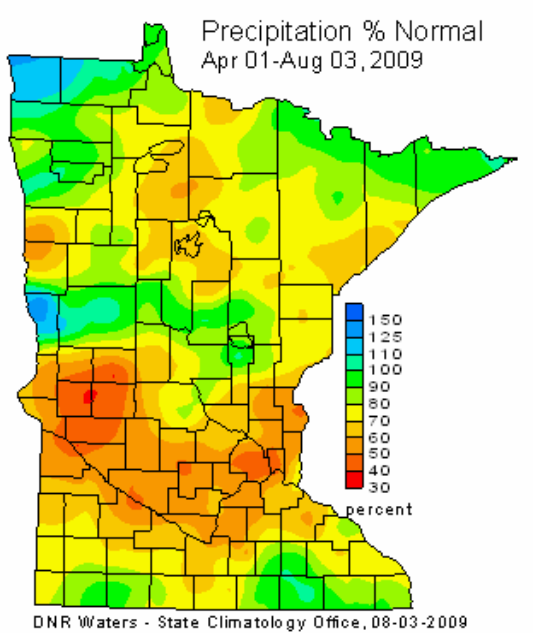
- With a few notable exceptions, June was a seasonally dry month across nearly all of Minnesota. Many Minnesota locales reported June precipitation totals that fell short of the historical average by one to two inches. By contrast, some counties in the already-saturated Red River basin of northwestern Minnesota reported near to above-average rainfall for the month. Isolated areas of south central and southeastern Minnesota also received above-average June rain. The overall dryness in Minnesota extended a rainfall shortfall that began in early April and continues to the present.
- Minnesota's heaviest rainfall event of the month occurred on June 16 when over six inches of rain fell on northern Wilkin County, leading to basement and road flooding. Heavy rain also fell June 26 and 27 in northwestern Minnesota. More than two inches of rain was reported in Polk, Red Lake, Pennington, Marshall, Kittson, and Roseau counties during the episode.

- Monthly mean temperatures for June were one to three degrees below the historical average statewide. The first half of June was very cool, with many days falling short of average by ten or more degrees. The cool early-June weather was offset somewhat by above-average temperatures during the third week of the month. Extreme temperature values for June ranged from highs in the mid-90's in many southern Minnesota locations on the 23rd, to a low of just 23 degrees in Embarrass (St. Louis County) on the 3rd. Across Minnesota many temperature records were set on June 5, 6, and 7 for coldest maximum or coldest minimum daily temperature.
- The U. S. Drought Monitor, released on June 30, placed areas of east central and southeastern Minnesota counties in the *Moderate Drought* and *Severe Drought* categories. Large portions of the rest of Minnesota are considered to be *Abnormally Dry*. The drought designations are the result of two spells of dry weather, one short-term and one longer-term. The shorter-term dryness has persisted since early April and impacts much of the state. The long-term dry spell commenced in mid-June 2008 and has persisted in east central and southeast Minnesota, producing 13-month precipitation deficits of eight or more inches.



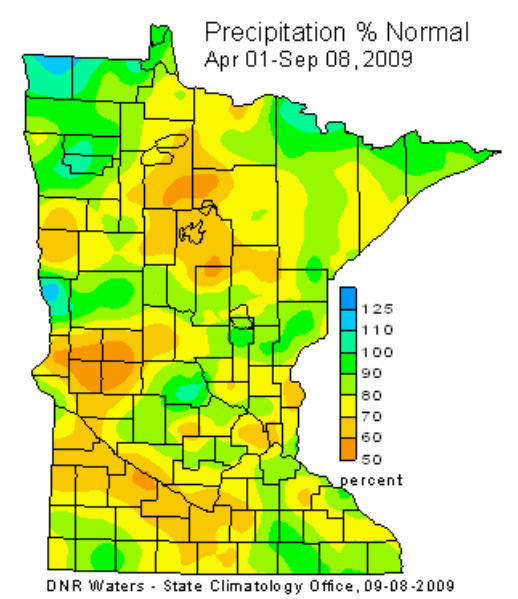
What happened in July

- With a few exceptions, July was a dry month across nearly all of Minnesota. Many Minnesota locales reported July precipitation totals that fell short of the historical average by one to three inches. However, some central and east central Minnesota counties, along a line that extends from roughly Brainerd to Moose Lake, received near to above-average rainfall. The overall dryness in Minnesota extended a rainfall shortfall that began in early April and continues to the present.
- The most significant widespread rainfall event of the month occurred on July 14 when more than two inches of rain fell along a 30 to 50 mile-wide band that stretched from Breckenridge to Brainerd to Cloquet. More than four inches of rain was reported in portions of Cass, Crow Wing, and Aitkin counties. Localized flooding was reported in communities such as Staples and Aitkin. Heavy downpours were also reported at Sauk Rapids on July 14 (3.11 inches) and Lakefield on July 9-10 (3.53 inches).
- July 2009 was the third coolest July in Minnesota's historical climate record. Mean monthly temperatures for the month finished three to seven degrees below the historical average statewide. Nearly all Minnesota reporting locations failed to reach 90 degrees during the month of July, a very rare occurrence. Extreme temperature values for July ranged from a high of 90 degrees at Wild River State Park (Chisago County) on the 10th, to a low of 31 degrees in Brimson (St. Louis County) on the 13th. Between July 12 and July 19, many temperature records were set for coldest maximum or coldest minimum daily temperature across the state. The seasonally cool temperatures prolonged a trend that began in northern Minnesota in May and throughout the state in June. The cooler-than-normal temperatures reduced evaporation and transpiration rates, partially counterbalancing the precipitation deficits and keeping drought conditions from worsening at a more rapid pace.



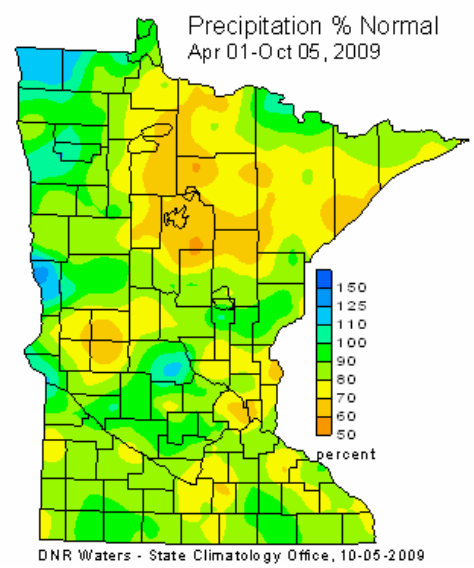
- The U. S. Drought Monitor, released on July 30, placed areas of west central, central, east central and southeastern Minnesota counties in the *Moderate Drought* and *Severe Drought* categories. Large portions of the rest of Minnesota are considered to be *Abnormally Dry*. The drought designations are the result of two spells of dry weather, one short-term and one longer-term. The shorter-term dryness has persisted since early April and impacts much of the state. The long-term dry spell commenced in mid-June 2008 and has persisted in east central and southeast Minnesota, producing 14-month precipitation deficits of eight or more inches.

What happened in August:



- Rainfall totals varied widely across Minnesota. Monthly rainfall totals in central and east central Minnesota topped historical averages by two or more inches and brought welcome relief to drought-affected areas. In some locations, August rainfall totals were near, or above, all-time records for the month. Conversely, August rainfall totals fell short of historical averages across much of north central Minnesota and along the southern tier of Minnesota counties. Monthly rainfall deficits in these areas amplified a dry situation that began early in the growing season.
- Two significant rainfall events in August were responsible for the bulk of the welcome precipitation that fell on central and east central Minnesota. On August 7, a sequence of thunderstorms dropped four or more inches of rain along a band that extended from west of Willmar to the southern suburbs of the Twin Cities. The largest 24-hour total reported was 6.20 inches at Chaska. On August 19, a 50-mile wide area extending from the northern Twin Cities suburbs to north of Duluth received two to five inches of rain. Some of the heaviest rain fell on drought-stricken counties such as Anoka, Kanabec, Chisago, Pine, and Carlton.
- Monthly mean temperatures were cool, averaging two to four degrees below the historical average. Many Minnesota reporting locations failed to reach 90 degrees during the month of August. The seasonally cool temperatures maintained a trend of below-normal conditions that persisted throughout the summer. Extreme temperature values for August ranged from a high of 96 degrees at Moorhead and Marshall on the 12th, to a low of 27 degrees in Embarrass (St. Louis County) on the 31st. Many low temperature records were set in northern Minnesota during the mornings of the August 30 and 31. As was the case throughout the summer, cooler-than-normal temperatures reduced evaporation and transpiration rates, and partially counterbalanced the precipitation deficits.
- The U. S. Drought Monitor, released on September 10, placed areas of east central Minnesota in the *Severe Drought* category. Portions of north central, west central, east central, and southeastern Minnesota were designated as experiencing *Moderate Drought*. Large portions of the rest of Minnesota were considered to be *Abnormally Dry*. The drought designations are the result of two spells of dry weather, one during this year's growing season, and one longer-term. The shorter-term dryness began in April 2009 and persisted through September over nearly all of Minnesota. April through August precipitation totals in many locations fell short of the historical average by more than five inches. The longer-term dry spell commenced in mid-June 2008 and most profoundly affects east central Minnesota. In this area, 15-month precipitation deficits of ten or more inches have led to a significant impact on hydrology.

What happened in September:



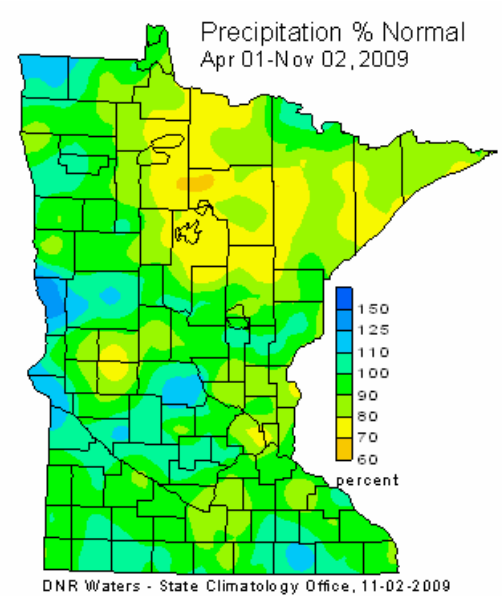
- Rainfall was very light across much of Minnesota. Monthly rainfall totals fell short of historical September averages by one to three inches in the eastern two-thirds of the state. Some east central and southeastern Minnesota communities received no measureable rainfall during the first three weeks of the month. Rainfall deficits, along with very warm September temperatures, amplified the drought situation in many locations..
- Although this product is intended to summarize September 2009 climate conditions, a notable turn of events during the first week of October must be mentioned. Over three inches of rain has fallen thus far in October across much of the southern two-thirds of Minnesota. The heavy rains have substantially eased many concerns regarding soil moisture deficits that would have impacted agricultural, horticultural, and forestry interests in spring 2010.
- Monthly mean temperatures for September were very warm, averaging four to eight degrees above the historical average. It was Minnesota's fifth warmest September on record, even though the month ended with record-setting cold days. The warm

September temperatures contrasted with the seasonally cool temperatures that persisted through the summer. Extreme temperature values for September ranged from a high of 88 degrees at Marshall on the 18th, to a low of 20 degrees in Embarrass (St. Louis County) on the 30th. Many low temperature records were set in northern Minnesota during the morning of September 30. Interestingly enough, no high temperature records were set during September in spite of the persistently warm weather during the first three weeks of the month.

- The U. S. Drought Monitor, released on October 1, placed areas of east central Minnesota in the *Severe* and *Extreme* categories. An area of north central Minnesota, centered on the Mississippi headwaters region, was also depicted as experiencing *Severe* drought. Elsewhere across the state, many counties were described as *Abnormally Dry* or undergoing *Moderate* drought. The drought designations are the result of two spells of dry weather, one during this year's growing season, and one longer-term. The shorter-term dryness began in April 2009 and persisted through September over nearly all of Minnesota. April through September precipitation totals in many locations fell short of the historical average by more than four inches. The longer-term dry spell commenced in mid-June 2008 and most profoundly affects east central Minnesota. In this area, 16-month precipitation deficits of ten or more inches have led to a significant impact on hydrology. The U.S. Drought Monitor product to be released on October 8 will reflect the impacts of the heavy early-October rains. Large-scale categorical changes can be expected.

What happened in October:

- October precipitation was very heavy across most of Minnesota. Monthly precipitation totals in the southern two-thirds of the state ranged from five to eight inches, topping historical October averages by three to five inches. For some communities, October total precipitation was three times the normal and set an all-time October record. On a statewide basis, October 2009 will rank among the wettest five Octobers ever.
- Snowfall was observed on many days, and in many places, across Minnesota in October. New October monthly snowfall records were set at Waskish (12 inches), Rochester (7.9 inches), Brimson (6.1 inches), and Grand Meadow (6.0 inches).
- Monthly mean temperatures for October were very cold, averaging four to seven degrees below historical averages across Minnesota. October 2009 ranks among the coldest Octobers of the modern record. The month featured persistently cold and cloudy weather. During the second week of the month, many daily records were set for coldest maximum temperature. Maximum temperatures greater than 60 degrees were infrequent. Extreme temperature values for October ranged from a high of 71 degrees at Preston on the 19th, to a low of 11 degrees in Brimson (St. Louis County) on the 13th.
- Although October 2009 was extraordinarily wet in many Minnesota counties, the U. S. Drought Monitor released on October 29, continues to reflect long-term precipitation deficits. A small area of east central Minnesota remains in the *Moderate* drought category due to lingering precipitation shortfalls that extend back to early-summer 2008. An area of north central Minnesota, centered on the Mississippi headwaters region, was also depicted as experiencing *Moderate* drought. This is the result of a very dry 2009 growing season. By late October, 12% of Minnesota's landscape was placed in the *Moderate* or *Severe* drought categories. This compares with 30% of Minnesota's total area in *Moderate*, *Severe*, or *Extreme* drought in late September. The early-November release of the Drought Monitor will incorporate last week's rain and snow, and the total area depicted in drought designations will decrease further.



What happened in November:

- November precipitation was quite light across most of Minnesota. Monthly precipitation totals fell short of historical averages by one-half inch to one and one-half inches in most locales. November snowfall totals were very small or nonexistent. For some communities, November 2009 ranked among the least snowiest November on record.
- In contrast to a very cold October, monthly mean temperatures for November were quite mild. November mean temperatures across Minnesota ranged from nine to twelve degrees above historical averages, making November 2009 the third warmest November in history on a statewide basis. The statewide October 2009 mean monthly temperature was only 1.5 degrees warmer than the statewide November 2009 mean monthly temperature, whereas

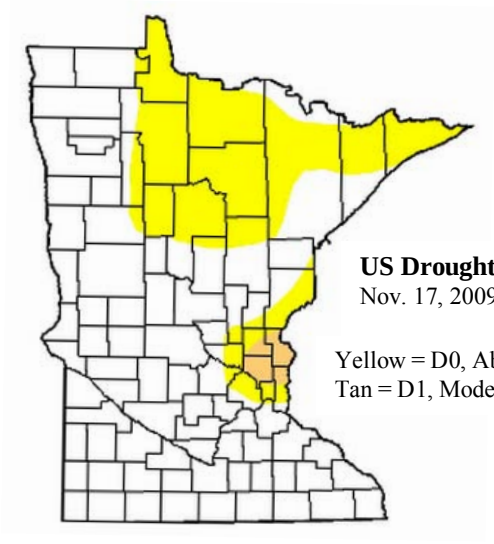
the long-term normals are separated by 15 degrees. Numerous warmest daily minimum temperature records were set during the month. Extreme temperature values for November ranged from a high of 72 degrees at Canby (Yellow Medicine County) on the 6th, to a low of 9 degrees in Embarrass (St. Louis County) on the 21st and 22nd.

- The U. S. Drought Monitor, released on December 3, reflects long-term precipitation deficits in a few Minnesota counties. A small area of east central Minnesota remains in the *Moderate* drought category due to lingering precipitation shortfalls that extend back to early-summer 2008. Portions of north central and northeast Minnesota are categorized as *Abnormally Dry*, as that area rebounds from a very dry 2009 growing season. Most of Minnesota is without drought designation.

Prolonged dry spells and droughts

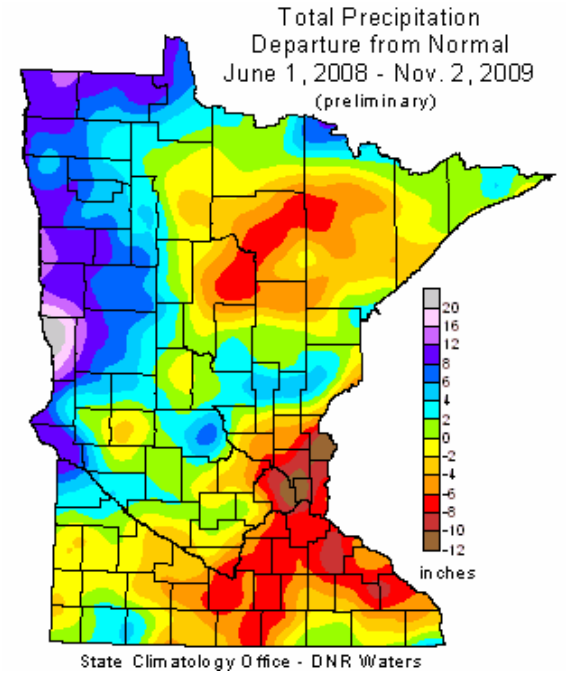
Prepared by the Minnesota Climatology Working Group

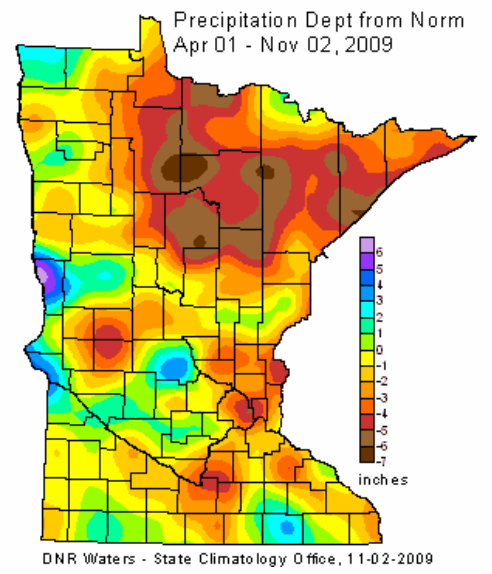
Minnesota's drought conditions at the end of 2009 are the result of two spells of dry weather. Growing season precipitation totals were well short of historical averages across much of Minnesota. Although October rains improved the situation greatly in many locales, some Minnesota counties continue to be categorized as Abnormally Dry or in a Moderate Drought.



US Drought Monitor
Nov. 17, 2009

Yellow = D0, Abnormally dry
Tan = D1, Moderate drought





2008-2009 long-term dry spell:
In east central Minnesota, a long-term episode of dryness began in mid-June of 2008 and continued into Autumn 2009. Long-term precipitation deficits in this area range from eight to twelve inches. Affected counties are categorized as experiencing Moderate drought by the U.S. Drought Monitor .

2009 growing season dry spell:
In the drier areas of north central Minnesota, precipitation totals were roughly 75% of normal for the growing season, falling short of average by four or more inches.

Phenology 2009

Date	*Event/ Observation*	*Location*
4 May	Some aspen clones are breaking bud. Leatherwood in bloom. Grand Rapids.	Itasca Co.
28 May	Spruce budworms are 1/8 inch long on balsam fir. Marsh marigolds in full bloom. Tower.	St. Louis Co.
28 May	Crabapples and lilacs begin to bloom. Grand Rapids.	Itasca Co.
2 June	FTC are 1 to 1.25 inches long. South of Onamia.	Morrison Co.
2 June	Red maples are loaded with seeds. These trees look brown or tan and have very few green leaves.	Pine Co.
3 June	Low temperatures and killing frosts across the northeastern counties: in Embarrass = 23 degrees F ; in International Falls = 30 degrees.	St. Louis and Koochiching Cos.
6 June	Hard freeze in early morning that killed bur oak leaves in large area centered around Mentor and MacIntosh.	Polk Co.
7 June	Ash plant bug damage and ash anthracnose symptoms are heavy. Hibbing.	St. Louis Co.
17 June	Spruce budworms are 5/8 to ¾ inches long. Lots of balsam twig aphid found, too. Jnct #169 and #26.	St. Louis Co.
17 June	Jack pine budworms are 3/16 to ¼ inch long. Still inside the pollen clusters. Pollen has been shed and pollen clusters are crispy and brown. Budworms fairly common but not causing noticeable defoliation. Esquagama Lake.	St. Louis Co.
17 June	Larch casebearer damage is starting to be visible on tamarack. Along US#2.	St. Louis and Itasca Cos.
22 June	Heavy seed set on silver maples, red maples, willows and elms (Siberian) in Brainerd.	Crow Wing Co.
Mid-June	FTC are beginning to cocoon up. Near Alexandria.	Douglas Co.
Late June	Mountain ash sawfly larvae are 1 inch long and causing defoliation.	Cass Co.
30 June	Collected 17 FTC cocoons on north side of Gull Lake in basswoods and oaks. No noticeable defoliation.	Cass Co.
6 July	Mayflies covering roads. Using dump trucks to haul them away. 35 cubic yards were scraped off the roads and hauled. Near Soudan.	St. Louis Co.
20 July	Spruce budworm moth flight occurring. Tower.	St. Louis Co.
27 July	Spruce needle rust is heavy on blue spruce. Meadowlands.	St. Louis Co.
28 July	Very dry in Blackduck Area. Birch are shedding seed.	Beltrami Co.
Sept.	September temperatures were much warmer than usual.	North-wide
26 Oct.	Leaves on many trees were still green until the killing frosts in October. Leaves turned brown but remained attached until the last week in October. Grand Rapids.	Itasca Co.

Incidental Insects & Diseases

Species	*County*	*Notes*
Spruce gall midge *Mayetiola piceae*	Crow Wing	Affecting 3 to 4% of young white spruces in a plantation.
E. poplar buprestid *Descarpentriesina spp.*	Crow Wing	Native borer in poplars.
Plum pocket *Taphrina communis*	Lake of the Woods	
Spurge hawk-moth *Hyles euphorbiae*	Crow Wing	Caterpillars eating buttercups. Exotic introduced to control leafy spurge.
Hardwood platypus *Platypus compositus*	Crow Wing	Red oak firewood with multiple borer holes. One of the more aggressive ambrosia bark beetles.
Ugly nest caterpillars *Archips cerasivorana*	Lake of the Woods	On apple tree.
Pine bark adelgid *Pineus* spp.	Cass	On ornamental pines.
Crumbly aspen Unknown decay fungus.	Cass	Forester at Washburn Lake is reporting "crumbling" aspen trees. Finding dead aspen in pockets of 4 to 5 acres in mature stands. When these are salvaged, the stem crumbles as it is cut or it breaks apart as the stems are being dragged out of the stand.
Clearwing moth *Parathrene asilipennis*	Clearwater	Native wood borer found in ash firewood.
Yellow-headed spruce sawfly *Pikonema alaskensis*	Beltrami	Defoliating spruce plantations.
Cytospora canker *Leucocytospora kunzei*	Red Lake	
Mountain ash sawfly *Pristiophora geniculata*	Itasca	In ornamental mountain ashes.
Root collar weevil *Hylobius radicis*	Becker	In Scots pine.
Poplar vagabond aphid *Mordvilkoja vagabunda*	Crow Wing	

Special Projects: List

Assessment of latent *Diplodia* infections in nursery stock.

Changes in *Diplodia* latency levels as red pine seedlings grow and are outplanted.

Storage condition influences on cultural detection of the conifer shoot blight pathogen *Diplodia pinea* from red pine nursery seedlings.

Emerald Ash Borer Preparedness Plan for DNR.

First Detector Training program

EAB training for DNR staff statewide.

Firewood restriction law: Changes in 2009.

Firewood message on tail-gate wraps for DNR vehicles.

Eastern larch beetle: Impacts and research in the last ten years.

Survey method for assessing overwinter survival of larch beetle larvae

Hazard Tree Policy: Revisions of DNR Op Order #97.

Hickory decline and mortality project: 2009 Update

Invasive species management on DNR-administered lands.

Social marketing: Invasive species and Minnesotans.

Oak wilt suppression and site monitoring report.

White spruce thinning study and spruce budworm defoliation data.

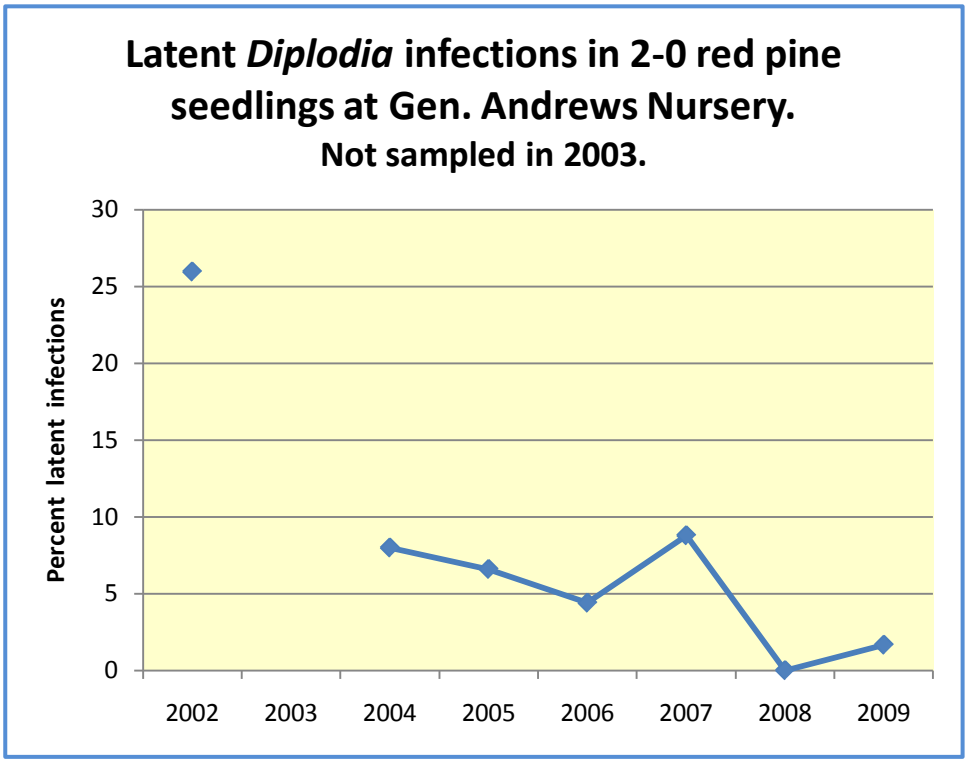
Assessment of latent *Diplodia* infections in nursery stock.

This year the *Diplodia* sampling pattern that has been done at our two state nurseries since 2002 was discontinued. Instead, two experiments were conducted to determine if the amount of latent infections are being amplified during warm temperature storage. See the "Storage conditions" report in Special Projects section for further information.

However, latency data from seedlings used as controls for these experiments can be used since they give the background levels of *Diplodia* latency in seedlings lifted from Field E-8. These levels do not reflect the overall latency levels at Gen. Andrews Nursery in 2009 since they only came from a single field and red pine seedlings were grown in several other fields.

Lifting seedlings at GASN. Photo by Jana Albers.

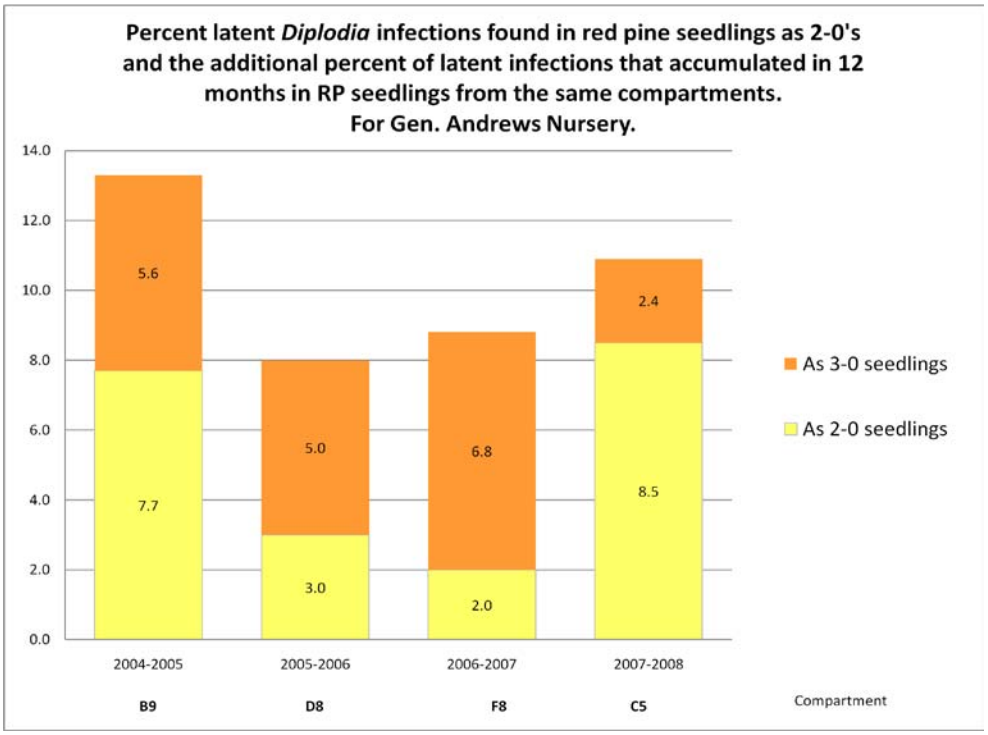
Gen. Andrews Nursery: 300 seedlings collected and assayed						
Field	**Beds sampled**	**Number of seedlings assayed**	**Seedling size and season of sowing**	**Location of positive seedlings**	**Total number of positive seedlings**	**Ave. percent latent infections**
E-8	12S	100	2-0 fall	12S	3	1.66
	12S	100	2-0 fall	12S	1	
	12S	100	2-0 fall	12S	1	



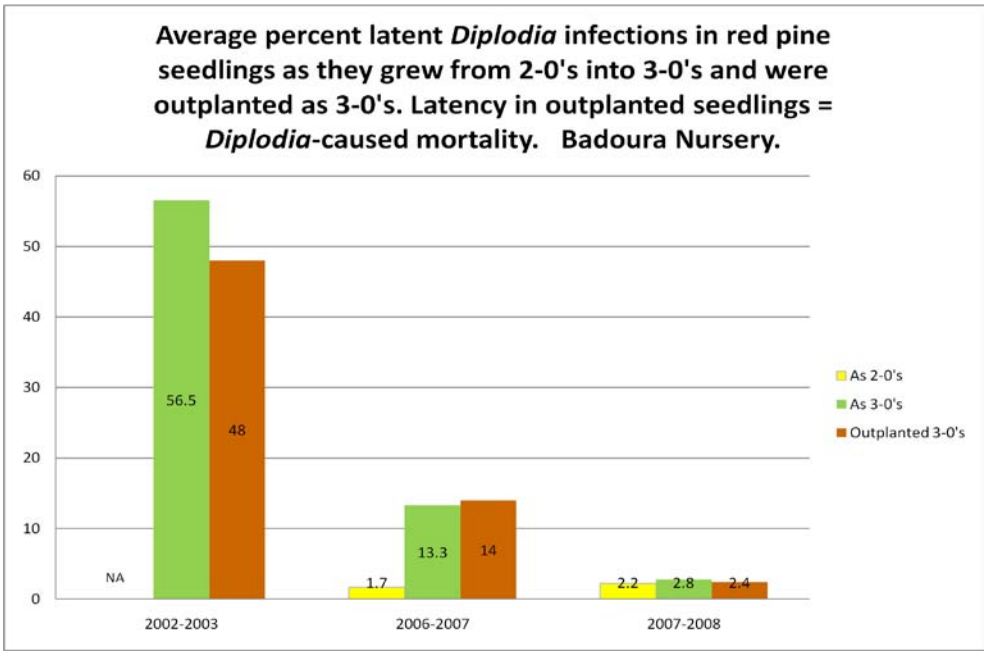
Changes in *Diplodia* latency levels as red pine seedlings grow and are outplanted

Most of the Diplodia studies that we've reported center around its effects on 2-0 red pine seedlings. We also have tracked its effects on 3-0 red pine seedlings at both nurseries and in new plantations.

At Gen. Andrews Nursery, we followed the accumulation of latent infections as seedlings grew from 2-0 to 3-0 age classes for seedlings growing in the same nursery compartment . In the 12 month period from 2-0 to 3-0, seedlings accumulated enough latent infections to exceed our 10% maximum guideline for latency two out of four years. See chart. These findings supports lifting seedlings as 2-0's and does not support allowing them to grow for another year , to 3-0 age class, since they can accumulate additional latent infections.



We have also followed seedlings from 2-0's to 3-0's to survival of the 3-0's after outplanting. Latency levels in the 2-0 and 3-0 seedlings were determined by lab assays of seedlings growing in the nursery. Latency levels in outplanted seedlings was determined by lab verification of *Diplodia* -caused mortality of seedlings from fixed radius plots. See chart. The mortality levels of outplanted seedlings were very similar to the level of latency found in the 3-0 seedlings. These data support the effectiveness of current shipping and storing practices because there was no significant amplification of the amount of latency between spring lifting and fall evaluations of the out-planted 3-0 seedlings.



Storage condition influences on cultural detection of the conifer shoot blight pathogen *Diplodia pinea* from red pine nursery seedlings

A project completed in collaboration with
Minnesota Department of Natural Resources, Division of Forestry

By Glen R. Stanosz, Ph. D., Professor
Departments of Plant Pathology and Forest and Wildlife Ecology
University of Wisconsin-Madison

Objective: To determine if storage conditions can influence frequency with which the shoot blight and collar rot pathogen *Diplodia pinea* can be detected (using a cultural assay) from asymptomatic red pine nursery seedlings.

Experiment A: This experiment was designed to provide information on the **potential** for *D. pinea* (if frequently present) to persist and/or proliferate in storage and subsequently threaten seedlings. Therefore inoculum was added in this experiment, to ensure initial presence of the pathogen.

Methods for experiment A. Four-hundred asymptomatic 2-0 seedlings from General Andrews Nursery were inoculated with conidia of *D. pinea* in this experiment. Seedlings were lifted from two beds on 24 April, with seedlings from each bed used in a separate trial. Seedlings were gathered into groups of 10 which were then placed into plastic bags. The 10-seedling bags were subsequently placed together into a large plastic bag and this large bag into a heavy cardboard shipping box (one box for each of the two trials). Seedlings were shipped to UW-Madison on 27 April where they arrived on 28 April and placed in a cold room at 3-4 degrees centigrade. On 4 May, ten 10-seedling bags (replicates) per trial were randomly assigned to each of two treatments:

"D+" or delayed control (inoculum added, stored for 3 weeks in cold room);
"DD+" or double-delayed control (inoculum added, stored for 3 weeks in cold room, then 1 additional week at room temperature of approximately 22-24 degrees centigrade).

Inoculum was added to each bag as approximately 1 ml of a suspension of 5×10^3 conidia per ml. Conidial germination tested on water agar was > 90%.

Seedlings were processed using procedures that have been used previously for cultural detection of *D. pinea* persisting on or in asymptomatic seedlings. Briefly, a segment approximately 5 cm long was removed from the lower stem/root collar region of the seedling, and stripped of needles. The segment was surface disinfested by immersions in alcohol and then bleach and placed on tannic agar in a Petri dish. Autoclaved red pine needles also are placed on the medium. Petri dishes are incubated at ambient laboratory temperatures, initially in the dark but later exposed to fluorescent light to stimulate production or pycnidia and conidia that form on the added needles or in the medium.

Results for experiment A. Because results for the two trials were similar, data were pooled. For all three treatments, *D. pinea* was detected very infrequently. Mean numbers of seedlings positive (out of 10 per bag) and total numbers of seedlings positive (out of 200) were as follows:
D+, 0.6 and 12; DD+, 3.3 and 66. The nature of the data precluded statistical comparison of means, but results for the treatments were compared using a Mann-Whitney analysis of medians for the number seedlings positive (out of 10 per bag). The results of this test supported difference of the medians (D+, 0.5; DD+3) at $p < 0.001$.

Experiment B: This experiment was designed to provide information on possible post-storage persistence of Diplodia shoot blight pathogens, as detected culturally from the lower stem/root collar region of red pine seedlings, produced **under the current disease management system**. A commitment to practices including windbreak removal and application of preventive fungicides has led to a relatively low ($\leq$2% in recent years) frequency of cultural detection of *Diplodia* species from surface-disinfested lower stem/root collar regions of seedlings, tested just after lifting. However, these fungi could be present superficially on lifted seedlings (recall that last year's project did detect *Diplodia* sp. conidia from water-washed, asymptomatic seedlings). Proliferation during storage could lead to a greater frequency of their persistence at time of planting.

Methods for experiment B. Three-hundred asymptomatic 2-0 red pine seedlings from the General Andrews Nursery, with no addition of inoculum, were used for this experiment. Seedlings were lifted from the same two beds as for experiment A above on 24 April, with seedlings from each bed used in a separate trial. Seedlings were gathered into groups of 10 which were then placed into plastic bags. The 10-seedling bags were subsequently placed together into a large plastic bag and this large bag

into a heavy cardboard shipping box (one box for each of the two trials). Seedlings were shipped to UW-Madison on 27 April where they arrived on 28 April and placed in a cold room at 3-4 degrees centigrade. On 4 May, five 10-seedling bags (replicates) per trial were randomly assigned to each of three treatments:

"C" or control (processed as described above with no further storage);
"DC" or delayed control (no inoculum added, stored for 3 weeks in cold room);
"DDC" or double-delayed control (no inoculum added, stored for 3 weeks in cold room, then 1 additional week at room temperature of approximately 22-24 degrees centigrade).

Seedlings were processed as described above for experiment A.

Results for experiment B. Because results for the two trials were similar, data were pooled. For all three treatments, *D. pinea* was detected very infrequently. Mean numbers of seedlings positive (out of 10 per bag) and total numbers of seedlings positive (out of 100) were as follows:
C, 0.3 and 3; DC, 0.1 and 1; DDC 0.1 and 1. These very low frequencies of detection do not allow any statistical comparisons to be made.

Conclusions for both experiments and implications for management:

Results of experiment A. strongly support the conclusion that storage conditions can influence the frequency with which *D. pinea,* if initially present, can persist on or in asymptomatic seedlings. Seedlings maintained in cold storage, still had relatively low frequencies of cultural detection of the pathogen. Seedlings with additional storage at a warmer temperature, however, were more than five times as likely to yield the pathogen. This is important because *D. pinea* has been demonstrated to be able to subsequently proliferate and kill seedlings on or in which it persists asymptomatically at the time of planting. **The results indicate the efficiency of suppression of asymptomatic persistence during proper cold storage, and the increased risk if seedlings are exposed to warmer temperatures (if the pathogen is present) before planting.**

Results of experiment B. strongly support the effectiveness of measures now employed in nursery practice to reduce the frequency of association of *D. pinea* with nursery seedlings. Even with removal from cold storage and an additional week of incubation at warmer temperatures, *D. pinea* was rarely (though more frequently that without the warm period) detected using the methods employed in this study. **Hopefully this will not be interpreted at justification for less than optimal storage and handling of planting stock.** *Diplodia pinea* continues to be present and sometimes abundant in forests in the areas of nurseries. In addition, recall the result of last year's project in which asymptomatic red pine seedlings were washed with water to determine the frequency of *Diplodia* conidia on seedlings. These were found with high frequency and sometimes in high numbers. **Therefore, continued practices to minimize association of the pathogen with seedlings, and maintain cold-storage conditions are recommended.**

DNR EMERALD ASH BORER PREPAREDNESS PLAN June 2009

Emerald ash borers (EAB) kill ash trees. EAB is one of the most significant exotic forest pests threatening Minnesota because it has the potential to cause extensive tree mortality among all types of forest resources where ash occurs, affecting local economies, plant communities, dependent wildlife and water quality. A comprehensive and consistent effort within the Minnesota Department of Natural Resources (DNR) is needed to develop and implement actions that help protect and sustain our forest resources.
Forest Health staff members were asked to explore and recommend strategies for long-term forest sustainability. This document is the result of those discussions. As outlined in this document, staff members (1) composed a set of desired future conditions for our forest resources, staff and partners well into the future, (2) identified measures of success for a comprehensive DNR effort, and (3) created an action plan for the DNR. Strategies to achieve each of the desired future conditions are recommended.

The desired future conditions are:

1. All DNR divisions and partner agencies are working closely together to define and implement EAB management and education strategies.
2. DNR divisions and disciplines understand their roles and responsibilities, are adequately trained, capable of meeting the needs, and are fulfilling key strategies.
3. Pathways for EAB introduction and dissemination are interrupted and/or minimized.
4. Stakeholders and the public are well-informed and actively engaged in EAB management activities.
5. Minnesota communities are prepared, with management and utilization strategies in place to help ensure community forests are resilient and EAB impacts are minimized.
6. Survey and monitoring protocols and data describing Minnesota's ash resource and EAB populations support planning and management decisions, and effectively track natural resource changes overtime.
7. Forest resources and diversity are sustained, while EAB population numbers and spread are minimized.
8. Scientific information needed for informed decision-making is available.
9. Landowners are informed, prepared and engaged in restoring affected forests.
10. Funding is sufficient to support all aspects of EAB planning, education and management as outlined in this plan.

The plan identifies specific actions to be taken by all DNR disciplines during the next five years, from 2009 –2014 (see pages 11& 12). The actions are needed to begin or continue the work necessary to prepare our forest resources and dependent economies for the potential impacts related to ash mortality, and to prepare the DNR to respond in a timely and effective manner once EAB becomes established in the state. Extensive eradication strategies will not be undertaken by the DNR. However, national management strategies being developed to slow ash mortality will be reviewed and applied to Minnesota where appropriate. DNR staff and cooperators will be informed and enabled to put these actions into place.

Background
EAB was first discovered in the Detroit, Michigan area in 2002, but is believed to have been introduced in wood packing material carried in ships or airplanes from China in the early 1990's. Since its discovery in 2002 until 2007, EAB has spread to Illinois, Indiana, Maryland, Ohio, Pennsylvania, West Virginia and Ontario and Quebec in Canada; in 2008 it was discovered in Missouri, Virginia and Wisconsin. In May 2009, it was discovered in Kentucky and in St Paul, Minnesota. While the beetle moves slowly on its own, numerous outlying populations have been established through accidental transport in firewood, nursery stock and unprocessed logs. Regulatory agencies have established quarantines and enforced fines to help prevent ash moving out of each of the states where it occurs.

EAB has proved capable of killing ash trees of every species in North America, and has already killed five percent of the total ash resource in Michigan, and nearly 100% of those in the core infestation (>40 million trees). Minnesota has the third largest acreage and volume of ash in the nation: 933 million ash trees one-inch dbh or larger on forestland (80 percent black ash, 19 percent green ash and one percent white ash), of which 191.5 million ash have a dbh of five-inch or greater (2007 FIA data). As demonstrated by the DNR (2006) rapid assessment of urban ash and elm, ash trees were the main tree planted after elms were lost to Dutch elm disease, and approximately 2.9 million ash trees are growing in Minnesota communities. In several Minnesota communities, as much as 60 percent of the street trees are ash.

Research has not discovered any resistance to EAB among native ash species, and Minnesota could lose much of this resource if EAB becomes established.

EAB is quite likely to be in other Minnesota sites not yet discovered. However, we cannot effectively predict when or where else it will be found. Campgrounds and urban areas are thought to be at highest risk of EAB introduction due to accidental transport. To address related issues, two parallel plans were previously developed that relate to and support the DNR plan.

The first was the Minnesota Department of Agriculture (MDA) EAB Response Plan. This plan outlines the steps through which MDA and partners would monitor, detect and respond to new discoveries of EAB in Minnesota. The second plan, the Minnesota EAB Readiness Plan, outlines four broad objectives to address a range of EAB related issues. These include:

Objective A: Delay the introduction and establishment of EAB in Minnesota
Objective B: Identify and prepare appropriate outreach, education and training
Objective C: Provide the basis for long-term forest sustainability
Objective D: Ensure financial and political support

The DNR Preparedness Plan provides the details for Objective C, for which the DNR has lead responsibilities, and outlines the specific roles and responsibilities of DNR staff members involved in the other objectives of the Minnesota Readiness Plan and in MDA Responses Plan activities. The three plans combined provide a comprehensive approach to EAB management.

As per state statute, MDA is the lead state agency responsible for detection, response and regulation of invasive forest pests and articles capable of transporting these pests. The DNR is the lead state agency responsible for forest protection, management and sustainability. However, both agencies work closely together, along with their state and federal partners, to address all aspects of invasive forest pest management.

The DNR Forest Health team identified the following ten desired future conditions as critical to Minnesota's long-term forest sustainability.

Desired future condition #1

All DNR divisions and partner agencies are working closely together to define and implement EAB management and education strategies.

PREMISE
State agencies, federal agencies, the University of Minnesota and other groups are working independently as well as collectively in planning for EAB. With the host of agencies involved, it is imperative that agencies understand their respective roles and that they approach the management of EAB with a cooperative attitude. It is also important that all pertinent DNR divisions be working cooperatively toward accepted EAB management objectives.

MEASURES

- An approved and implemented DNR EAB preparedness plan is in place.
- DNR staff members are playing key roles in statewide EAB Incident Command System structures to provide expertise and to help coordinate collaborative activities.
- DNR staff members are participating in all planning and management discussions related to EAB.
- A DNR EAB liaison for interagency communication is identified.
- Representatives from all partner agencies are trained to recognize EAB and EAB symptoms.

STRATEGIES

- Develop a DNR EAB coordinating group that ensures collaboration, development of discipline guidelines and effective communication among and within disciplines, and explores and identifies management strategies for areas of concern.
- Identify a DNR position as "EAB Liaison" to serve as a leader in planning, integration and implementation of the DNR Preparedness Plan.
- Develop and enhance opportunities to collaborate with state and federal agencies interested and involved in EAB detection, prevention and outreach (including common EAB messages). Explore revenue sources and approaches to ensure EAB preventative efforts are adequately funded.
- Identify and develop partnerships with additional stakeholders and community groups in order to seek their input and support.

Desired future condition #2

DNR divisions and disciplines understand their roles and responsibilities; are adequately trained, and capable of meeting the demand.

PREMISE
The recent finds in St Paul, Minnesota and western Wisconsin highlight the critical need to ensure that all DNR disciplines have a clear understanding of 1) EAB biology, management options, and potential impacts and 2) their responsibilities in implementing management strategies and their role in collaborative efforts. It is also important that all disciplines are communicating effectively with one another and are engaging their stakeholders.

MEASURES

- DNR staff members are trained to recognize EAB and EAB symptoms
- DNR staff members are actively participating in all phases of EAB-related planning, education and management.
- DNR staff members are able to effectively respond to new EAB finds within 24 hours of the notice of an infestation or threat with minimal discipline disruption. See Objective A of Minnesota EAB Readiness Plan.

STRATEGIES

- Review the existing Operational Order on Invasive Species for relevance to EAB and modify as needed to articulate DNR's goals, and identify the roles for each discipline.
- Develop and implement an internal education plan, including staff training for each component of EAB management
- Regularly monitor staff needs, evaluate EAB training success and identify needed modifications to address changes in attitudes and understanding over time.

Desired future condition #3

Pathways for EAB introduction and dissemination are interrupted and/or minimized.

PREMISE

State and federal quarantines administered by USDA and MDA are useful tools in limiting the spread of EAB. Supporting those efforts and restricting the movement of EAB and woody materials potentially containing EAB into and within MN are critical steps in delaying and minimizing the spread and impacts of EAB. See Objective A, Minnesota EAB Readiness Plan.

MEASURES

Staff and partners are aware, engaged and actively supporting state regulatory efforts.
Timber and recreation industries have clear idea of EAB pathways and are taking steps to interrupt them.
Private campgrounds and resorts are regulating firewood used in their campgrounds.

STRATEGIES

- Explore and implement the infrastructure needed to support integrated early detection and rapid response efforts. Support and maintain active response and readiness teams.
- Work with timber, recreation and tree care industries to clearly convey their role in prevention and how they can comply with state and federal regulations.
- Work with private campgrounds, resorts, and other agencies to explore and implement the means to minimize the movement of unregulated firewood.
- Enforce firewood statute and Commissioner's Order to minimize the risk of EAB introductions and/or EAB becoming established on DNR lands.

Desired future condition #4

Stakeholders and the public are well-informed and actively engaged in EAB management activities.

PREMISE

Stakeholders and members of the public who are well-informed are more effective in identifying new infestations and in understanding and responding positively to management actions. They are also more willing to change behaviors that may contribute to the introduction and dissemination of EAB. See Objective B, Minnesota EAB Readiness Plan.

MEASURES

- A well-informed public that is:
- Able to recognize the signs and symptoms of an EAB infestation
- Familiar with EAB biology and life cycle
- Familiar with the range and occurrence of EAB in the US
- Familiar with the pathways of EAB introduction and spread
- Familiar with human behaviors capable of EAB dissemination
- Changing behaviors to mitigate EAB dissemination
- Familiar with management techniques
- An engaged public which is:
- Actively looking for infested trees
- Advocating with neighbors, local units of government and agencies to implement management, and moving toward management of their own trees
- Actively involved in local and regional planning efforts

STRATEGIES

- Assess audience and engage educators, public relations specialists, and social scientists to craft and deliver a public outreach campaign aimed at achieving the well-informed measures.
- Develop and utilize materials that will aid state park visitors and citizens in understanding more about invasive species in general and EAB in particular.
- Develop a single source of information either a web site or a telephone hotline for the general public to use to get EAB information and to report EAB finds or suspected discoveries.
- Identify and develop passionate individuals and stakeholder groups; provide more intensive training, recognition, and the tools to engage community government and non-governmental groups to monitor EAB in their community and to advocate for management and preventive actions.

Desired future condition #5

Minnesota communities are prepared, with management and utilization strategies in place to help ensure community forests are resilient and EAB impacts are minimized

PREMISE

Communities that are well-prepared for EAB can dramatically reduce impacts to tree and fiscal resources. DNR personnel have a responsibility to partner with and advise community leaders and land managers.

MEASURES

- Communities have their own preparedness plans.
- Ordinances are adopted or revised to effectively manage EAB.
- Communities have sustainable budgets to address EAB impacts.
- Ash inventories are complete and adequate to support management initiatives.
- Communities have staff or access to staff to adequately address issues.
- Communities have identified disposal options, necessary precautions and wood utilization opportunities.
- Private nurseries are aware of the threat and are actively seeking alternatives to growing and selling ash.

STRATEGIES

- With partners, develop tool box including risk assessment, planning guidelines, and sample ordinances.
- Work with communities to develop management, sanitation and utilization strategies.
- Work with private nurseries to explore alternatives to growing and planting ash.
- Encourage the development of infrastructure (staff and equipment) to respond to EAB.
- With partners, develop options and markets for community wood utilization.

Desired future condition #6

Survey and monitoring protocols, and data describing Minnesota's ash resource and EAB populations support planning, management decisions, and effectively track natural resource changes overtime.

PREMISE

Landowners and EAB program managers need information about the ash resource at risk (i.e., ash species distribution, size and condition), local topography, human occupancy and riparian corridors. This information can be used to select management tactics, decrease the natural spread and minimize the artificial spread of EAB. Tracking resource changes over time can help evaluate management success and identify possible future actions.

MEASURES

- Landowners, managers and program administrators are familiar with information on the ash resource, both rural and urban, including species, distribution, size, and condition.
- Survey methods are established and data obtained and in a format available to all agencies.
- Stand monitoring and inventory data are managed so they are in a format available to all agencies.

STRATEGIES

- Assess sources of existing data, identify gaps and determine the means to fill them.
- Encourage communities and local governments to formally inventory their ash resource on public and private lands so they know what is at risk, can take preventative actions where needed, provide data to the DNR for EAB management and monitoring activities and assess subsequent impacts over time.

- Develop and test an ash resource / EAB monitoring protocol that uses inventory and remote sensing data at the section, township, community and county-levels of scale. This would integrate the forest and community databases.
- Describe current ash resource conditions to establish baseline for future EAB impacts, and procedures to use after EAB arrives.

Desired future condition #7

Forest resources and diversity are sustained, while EAB population numbers and spread are minimized.

PREMISE

Developing EAB larvae are dependent on an abundance of ash phloem. As a result, the expansion and spread of EAB is strongly correlated to the volume of phloem within a stand. Reducing the volume of phloem by selective harvesting **prior** to the arrival of EAB can help slow the spread of EAB once it gets here and lessen the impact of associated tree mortality. Once EAB becomes established within an area, the use of a combination of treatments such as phloem reduction along the leading edge of infestation, clustered trap trees and sanitation behind the line, and chemical treatment of select high value and/or heritage trees can further limit the spread and future potential damage. How and to what extent the volume of phloem is reduced will vary with the type of site (urban versus rural), the native plant community involved and site-specific management objectives. And how these treatments are integrated with other management tactics will depend on site conditions and the status of EAB populations. The intent is to maintain diversity and ecosystem functions while limiting future potential damage and further spread of EAB. See Objective C, Minnesota EAB Readiness Plan.

MEASURES

- Native plant communities and ecosystem functions are maintained over-time.
- Large diameter ash trees have been removed along utility corridors.
- Ash stands are being thinned to promote vigor and reduce basal area. Where ash is a component of a stand, TSI practices consider EAB management options.
- As stands come up for harvest, ash trees are being selectively marked for harvest to reduce the volume of ash phloem (where consistent with stand objectives).
- The infrastructure needed for harvest and/or treatment efforts (i.e. chipping) is established and available.
- Non-industrial private forest (NIPF) landowners are aware of the threat and are actively managing their woodlands to limit the spread of EAB and promote forest sustainability.
- A temporary moratorium is in place on the production of ash in state nurseries, and the planting and seedling of ash on state lands.
- Ash seed collection and storage has continued to support native genotypes over the long term.

STRATEGIES

- With internal and, where appropriate, external partners, explore and identify management options for the range of sites containing ash.
- Develop guidelines for reducing the volume of ash phloem across the range of site types; with partners, begin to implement harvest guidelines where appropriate.
- Develop wood utilization plans for both pre-infestation and post-infestation phases of management.
- Establish a moratorium on the planting of ash on state lands and the production of ash seedlings in the state nurseries. Collect and maintain viable native ash seed to preserve genetic diversity.
- Evaluate landowner assistance programs and modify as needed to support EAB management objectives.
- Consider EAB management objectives during environmental review of proposed mining, development or other construction projects.

Desired future condition #8

Scientific research information needed for informed decision-making is available.

PREMISE

To effectively manage EAB and minimize its impact, it is critical to identify biological and social evidence to support informed decision-making about all aspects of EAB management, and that the information is made available on a timely basis.

MEASURES

- Managers, administrators and educators have ready access to the science needed to support planning and management decisions.
- Managers, administrators and educators are able to defend management decisions based on the available science.

- DNR is generally accepted as an authority on all aspects of EAB management.
- An expert is identified within DNR who stays current on the latest research.
- A protocol is developed for forested areas that assesses natural resource impacts and monitors EAB populations.

STRATEGIES

- Establish annual interagency scientific summit to exchange technical information and identify current needs.
- Review existing data and scientific evidence to determine applicability to Minnesota and explore sources of funding and/or partners where needed to fill information gaps.
- Conduct social research to support outreach efforts, measure education successes over time and guide adaptive communication/education plans to serve management goals.

Desired future condition #9

Landowners are informed, prepared and engaged in restoring affected forests.

PREMISE

EAB has been shown to cause significant tree mortality within all ash forest types. Because Minnesota's rural and urban ash resource is substantial, forest sustainability will be a key issue. As a result it is important to document the ecological role of ash in these ecosystems and support replacement and/or reconstruction of plant communities that fulfill that role in both rural forests and communities. See Objective C, Minnesota EAB Readiness Plan.

MEASURES

- Restoration practices applicable to Minnesota in both rural and urban settings have been tested and evaluated.
- The plant material needed to restore damaged forests is available.
- Planning and management guidelines are available for public and private land managers.
- State land managers are trained and prepared to restore damaged forests.

STRATEGIES

- Develop and test restoration guidelines for urban and rural lands.
- Apply and test restoration techniques.
- Develop sources for and provide (or facilitate the availability of) planting stock and seed needed for restoration efforts.
- Landowner assistance programs are evaluated and guidelines modified as needed to support restoration strategies.

Desired future condition #10

Funding is sufficient to support all aspects of EAB planning, education and management as outlined in this plan.

PREMISE

The availability of support funds, both state and federal continues to decline, even as the risk of damage increases. As a result, it is important to look for other sources of revenue. These could include competitive grant opportunities and or venues not current known, such as interest groups or stakeholders willing to support various aspects of the program. Exploring potential partnerships, collaborative efforts and alternative sources of funding can help meet program needs. See Objective D, Minnesota EAB Readiness Plan.

MEASURES

- Coordinated early detection and rapid responses are carried out in a timely fashion.
- Internal and external outreach and education efforts are effective in informing and engaging critical audiences.
- Management strategies are identified, tested and implemented as planned so the potential impacts are minimized.

STRATEGIES

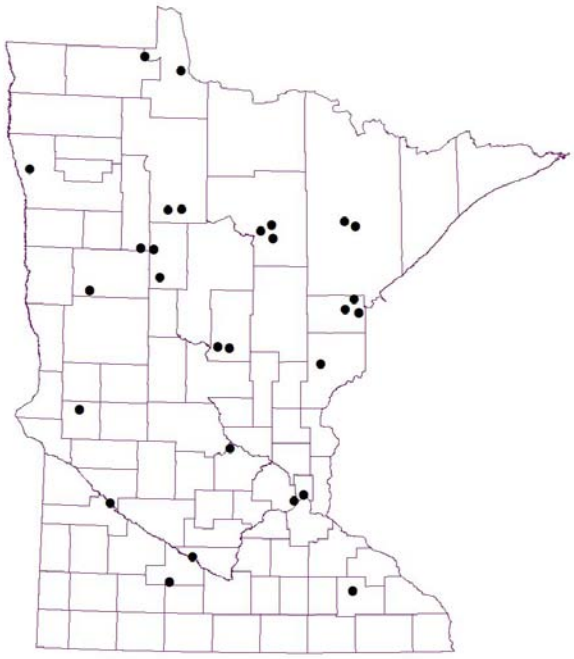
- Develop and submit proposals as needed through LCCMR.
- Develop and submit proposals through the USFS Redesign grant program and other federal venues.
- Explore other funding opportunities through key stakeholders (such as the utility companies and other special interest groups) and partners and develop proposals consistent with program needs and funding criteria.

First Detectors training

State and federal agencies have been proactive in developing strategies to minimize the impact of this insect when and where it is found in Minnesota. The University of Minnesota Extension Service, Minnesota Department of Agriculture, and the Minnesota Department of Natural Resources have trained nearly 180 volunteers to help protect Minnesota's forests and landscapes by serving as "EAB First Detectors."The role of an EAB First Detector is to serve as a public contact for EAB information and to help resolve reports of potential EAB infestations in Minnesota. Volunteers attended a one-day training session.

In March 2008, volunteers attended training sessions on EAB in Andover, Cloquet, Fergus Falls, Mankato, Marshall and Rochester. In 2009, five training sessions were held in Farmington (2), Crookston, Lamberton and Winona. This year they were called Forest Pest Detector trainings and included gypsy moth, Asian longhorned beetle and Sirex woodwasp information.

EAB training for DNR staff statewide



With the discovery of emerald ash borer in Minnesota, Minnesota Department of Natural Resources Deputy Commissioner Laurie Martinson directed the Forest Health Unit to provide EAB training to selected field and clerical staff from all units of the DNR. Training was delivered at various locations across Minnesota from June to December. See map. The following subjects were covered in each two-hour session: EAB biology, identification, expected impact, current situation in Minnesota, ash firewood identification, firewood restrictions, responding to questions from the public, state and federal quarantines, as well as DNR and Minnesota Department of Agriculture plans for response and management. More than 1,000 DNR staff attended the training.

Number of DNR Staff Trained, 2009	
Region 1	308
Region 2	363
Region3	357
Total	**1028**

Firewood restriction law and DNR policy: Changes in 2009

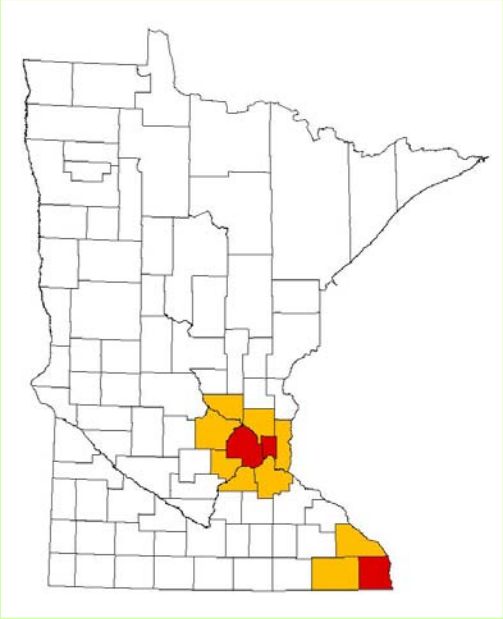
Written by DNR Communications and Outreach

The recent discovery of emerald ash borer (EAB) in a St. Paul neighborhood means that people should no longer pack firewood when making summer camping plans. Minnesota Department of Natural Resources (DNR) Commissioner Mark Holsten issued, on May 20, a revised Order dealing with use of firewood on state land. It will be published in the State Register from June 15-28, 2009. Under the new Order, only firewood purchased at a state park or from a DNR-approved vendor may be brought onto state land.

A list of approved firewood vendors is available online at http://www.dnr.state.mn.us/firewood_vendors/vendors/list.html. The receipt supplied by the approved vendor should be retained as proof of purchase. Unapproved firewood brought to a state-administered campground will be confiscated and the transporter is subject to a $100 fine. People camping on state

forest lands outside of a designated campground may gather dead wood on the ground for campfire use onsite. In state parks and designated campgrounds in state forests, people are prohibited from scavenging dead wood.

The new Order specifies that firewood originating from a quarantined county (red) in Minnesota will be approved only for use in that county. Firewood from counties contiguous to quarantined counties (yellow) in Minnesota will be approved only for use in those counties. See map. Currently, there is a quarantine on firewood, ash trees and ash products in Hennepin, Houston and Ramsey counties. To slow the spread of EAB, the quarantine prohibits the movement of the following items out of Hennepin, Houston and Ramsey counties:



- Firewood from hardwood (non-coniferous) species.
- Entire ash trees.
- Ash limbs and branches.
- Ash logs or untreated ash lumber with bark attached.
- Uncomposted ash chips and uncomposted ash bark chips greater than one inch in two of the three dimensions.

While EAB spreads slowly on its own, it can hitch a ride to new areas when people transport firewood or other wood products infested with the larvae. Officials urge Minnesotans to take these steps to keep EAB from spreading:

- Don't transport firewood, even within Minnesota.
- Don't bring firewood along on a camping trip.
- Buy the wood you need locally from an approved vendor.
- Don't bring extra wood home with you.
- Don't buy or move firewood that came from outside of Minnesota.

Since its accidental introduction into North America, EAB has killed millions of ash trees in 12 states and Ontario, Canada. With more than 900 million ash trees, Minnesota is a prime target for EAB.

Firewood message on tail-gate wraps

In collaboration with DNR C & O, the FHU developed tail-gate wraps (see below) which promote the message that the best firewood is local firewood. The wraps will be used on about 20 DNR pick-up trucks. Several other agencies in the Lake States have adopted the image and will print them up as posters and tail-gate wraps with their own state's logo.

Eastern larch beetle: Impacts and research in last ten years

An outbreak of eastern larch beetle, *Dendrotonus simplex,* was first observed in Minnesota in 2000. Since then, tamarack mortality due to eastern larch beetle has been mapped on 92,600 acres of forest land during aerial surveys conducted from 2000 through 2009. Minnesota has just over 1 million acres of tamarack covertype, so nearly 1/10th of the covertype has some mortality.

The eastern larch beetle is a bark beetle, native to North America that attacks tamarack. Historically, larch beetle was considered a secondary pest attacking stressed trees, but following large outbreaks in Canada and the US in the 1970's and 1980's, it is now increasingly viewed as a primary pest able to attack and kill relatively healthy trees. Additional information about eastern larch beetle can be found in Forest Insect and Disease Leaflet 175, Eastern Larch Beetle by Seybold, Albers and Katovich at http://na.fs.fed.us/pubs/.

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

Biology and detection surveys

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

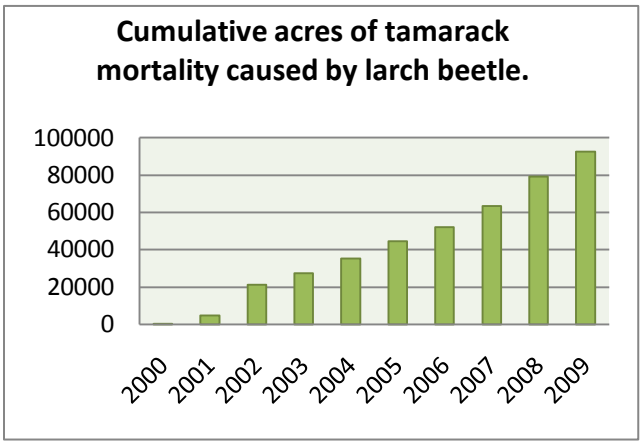
The first evidence of attack on a tree is holes in the trunk or branches. Resin flow can be very heavy and conspicuous, coating the surface of the bark during the summer. In late July or early August, foliage begins to yellow. Yellowing often starts on the bottom branches leaving the top of the tree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

Larch beetles and their damage. Photos by Mike Albers.

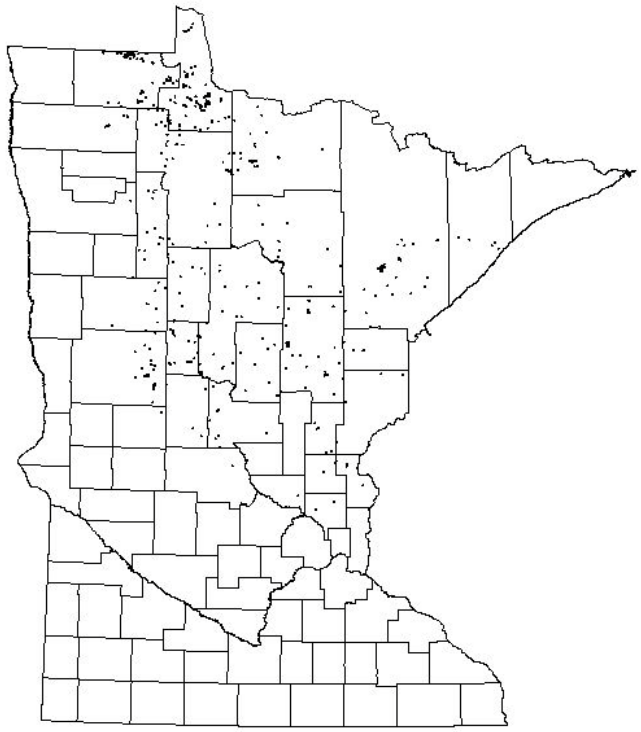
Often people don't notice larch beetle attacks until fall or winter when woodpeckers feed on the larvae, pupae and adults that overwintering under the bark of tamarack stems and larger branches. Foraging woodpeckers often remove all the bark leaving reddish purple inner bark or white sapwood exposed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

Mortality in Minnesota

In Minnesota, we have just under one million acres of tamarack covertype plus tamarack occurs as a component in other lowland as well as upland covertypes. We started seeing increased levels of mortality starting in 2000 and it has continued through this year. Areas of mortality have been mapped annually in our aerial survey. It is difficult to get a good picture of current year mortality but, as the acres accumulate, we get a better viewpoint in its cumulative mortality. Based on aerial survey, since mortality has occurred on 92,610 acres spread throughout the range of tamarack in MN. In some cases the mortality occurs in small scattered patches of trees but in other cases entire stands have been killed in two to three years. Most trees killed were 4" dbh and larger. Trees that were killed are 40 years and older. Mortality has occurred on lowland sites, upland sites, in pure stands of tamarack and in mixed stands.



Common stress factors such as defoliation, flooding, or drought, have not been found. We have experienced significant droughts in the past 10 years, which likely has caused moisture stress on some sites. The most significant moisture deficits have occurred during the growing season, April – Sept, in the last 6 to 7 years which may have helped keep the outbreak going in some locations. However, the outbreak started in 2000 and the years just prior to 2000 were years of above normal moisture during the growing seasons, so it appears as if drought is unlikely to have played a significant role in initiating the outbreak. Also with the broad range of sites, upland to lowland experiencing mortality, drought stress is unlikely to be a common stress factor.



Larch beetle caused mortality of tamarack from 2000- 2009.

In this past decade we have also experienced an unusual outbreak of larch casebearer and it has been suggested that larch casebearer defoliation has been stressing the tamarack leading to attack and mortality from eastern larch beetle. This does not appear to be the case in Minnesota. Less than 5 percent of the acres with mortality have also been defoliated by larch casebearer.

Eastern larch beetle appears to be attacking and killing healthy stands of trees with no obvious stress factor. However there has been no formal survey of stands to look at site and stand conditions and all the other factors that might related to larch beetle mortality.

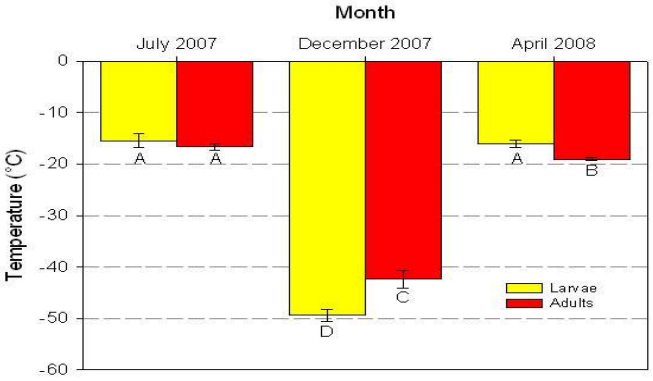
Pheromone studies

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

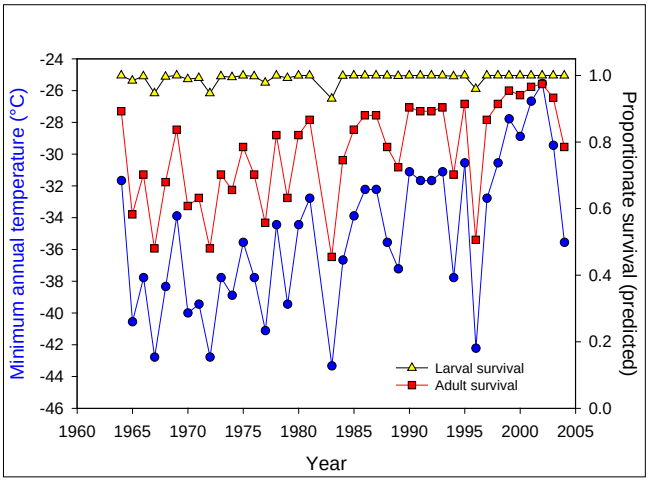
In the course of this study we also trapped Douglas-fir beetles, *Dendroctonus pseudotsugae*. Douglas-fir beetles were apparently being brought into a wood yard seven miles from one of our larch beetle trapping sites, hitching a ride on western larch logs from western Montana and eastern Idaho. They are not native to Minnesota. Fungi were isolated from adult beetles by Dr Andy Graves, (UC Davis formerly UMN, with assistance from Dr R. Blanchette, UMN and Dr T. Harrington, Iowa State) and identified. The identification of the isolated fungi based on DNA sequencing included these species; *Ophiostoma floccosum*, *Ophiostoma picea*, *Leptographium abietinum*, *Pesotum fragrans*, *Phlebiopsis gigantea* and the yeast *Pichia scolyti*. Most bark beetles vector one or more species of blue-stain fungi and it is thought they assist bark beetles in overcoming defenses of live trees. The role of blue-stain fungi, isolated from eastern larch beetles, has not been studied.

Overwintering behavior of eastern larch beetles

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



Supercooling temperatures of larch beetle larvae and adults. From Venette and Walter.



From -Proceedings Society of American foresters, 2008, Reno, Nevada

In Press- Forest Health Monitoring 2008, National Report

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

Venette and Walter also looked at winter temperatures and found that over the past 40 years, winters have become less severe. Low temperatures in Isle, MN have increased by approximately 0.25C per year from 1964 – 2004. Eastern larch beetle larvae are extremely cold-tolerant and so warming winter temperatures have had very little impact on their overwintering success. However, warming has had a substantial impact on adult overwintering success. They predicted that on average, adult survival has increased by 0.7% per year from 1964-2004. So in the mid-sixties adult overwinter survival was predicted to be about 60% while in the early 2000's adult overwinter survival was predicted to be about 85%. Venette and Walter concluded that recent

increases in tamarack mortality might be partially explained by warming winter temperatures that allow larger populations of adults eastern larch beetles to survive the winter. Larger overwintering populations of adult larch beetles could produce larger populations of offspring the following summer that may be able to overwhelm the defenses of tamarack trees and kill them.

Conclusion

The causes of the eastern larch beetle outbreak in Minnesota are not fully understood. Combinations of drought, stand, and site conditions likely contribute to the resulting mortality in individual stands. Warmer winters resulting in greater overwintering success by eastern larch beetle adults may also play a role.

References

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

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

Survey method for assessing overwinter survival of larch beetle larvae

How to determine larval survival. Mike Albers 4/23/2009

1. Find some tamarack trees that were attacked last summer. The example here would be trees attacked in the summer of 2008. The woodpeckers have been feeding on these trees overwinter and the trees show up pretty well because of the reddish brown color of the trunks where the woodpeckers have removed the outer bark. Trees that were attacked in 2007 and earlier either look brown or gray. You will only find larvae in trees that were attacked in 2008.
2. Only collect larvae 3 feet or more above the soil line so you **only collect larvae that overwintered above the snow line**. Larvae that were below the snow line were not subjected to the cold temperatures.
3. Collect larvae from 2 or more trees if possible. I try to get close to 100 larvae per collection site. If you can't get that many, just get as many as you can to have a good sample.
4. Peel bark off the tree trying not to damage the larvae. Be careful when collecting the larvae so you don't damage them. Some of the larvae are pretty small and some of the dead ones have started to change color. Collect them in something with a wide mouth to make it easier to catch the larvae. You will need something to flick the larvae out of the tree or off the bark. I usually use an empty film canister for collection. A lot of larvae fall out as you peel the bark off this time of year. You might want to try bringing a shoe box or something so when you peel chunks of bark off if a lot of larvae stick to the back of the bark. You could just put the bark pieces in the shoe box and collect the larvae later.
5. Bring the larvae back indoors. Examine under a dissecting scope and count live and dead larvae. A larva is live if it moves and dead if it doesn't move. If a larva isn't moving I usually prod it a time or two to see if it responds and moves. Sometimes they just lay still until you poke them.
    a. When it is cold outside the larvae don't move and I count the larvae everyday for up to a week taking out the ones that move each time and just looking at the ones that didn't move the next time. Sometimes you need to prod the larvae with a forceps or something to get them to move.
    b. During late spring and early summer, the larvae are pretty active and I have only been looking at the larvae and counting them once after I get back in the office. I think the temperatures have warmed up enough and you probably only have to look at them one time and count them.
6. Record a GPS location or record the County, section, township and range. Record total number of larvae, number of dead larvae and number of live larvae. Also determine and record the % live and % dead.

Revision of DNR's Hazard Tree Policy

This year, a revision of the DNR's Hazard Tree Policy, Operational Order # 97, was undertaken by the Department so that it would more aptly reflect current responsibilities and practices. See below. One of the two largest changes was moving responsibilities from the Division of Forestry to two other units, namely the Division of Parks & Trails and the Bureau of Management Resources. The second significant change was to update its technical reference to Chapter 3 of the federal publication, "Urban Tree Risk Management: A Community Guide to Program Design and Implementation. The revision has not been signed into policy yet.

DRAFT OPERATIONAL ORDER # 97

SUBJECT: Hazard Tree Risk Management on Recreational and Administrative Sites

CONTACT: Division of Parks and Trails (phone) and Bureau of Management Resources (phone)

DATE:

SUPERSEDES: Operational Order #97 Dated March 1, 1992

I. PURPOSE

The Department of Natural Resources (DNR) provides a wide variety of recreational opportunities on the forested lands it administers. It is the DNR's goal to maintain a reasonably safe recreational environment for visitors and employees. Forest and shade tree communities are living systems under constant change and the introduction of recreation or construction activities can induce or intensify detrimental changes in the trees. Additionally, there are significant unknown or undetectable interactions occurring naturally within biological systems that may result in structural defects within trees.

The purpose of this operational order is to establish and maintain a hazard tree risk management program that provides for reasonable public safety by detecting and correcting situations involving hazard trees in intensively-used recreation areas and on administrative sites where appropriate and feasible within the constraints of the DNR's budget. The DNR faces the challenge of preserving a forested environment for the enjoyment of visitors while providing for adequate public safety. As there are limits to our capability to detect, interpret and manage hazardous trees, there will be unpredictable tree failures. We cannot detect, correct or eliminate all of the hazardous trees.

II. POLICY

The DNR is authorized to provide sites for public recreation and to manage these sites for their natural resources. It is the DNR's policy to try to preserve the natural beauty of its recreation sites while providing for reasonable public and employee safety on intensively-used recreation sites and administrative sites by detecting and correcting situations involving hazard trees insofar as it is feasible within the constraints of the DNR's resources.

A hazard tree risk management program will accomplish this goal through timely inspections, maintenance and corrective actions. Use Chapter 3 in "Urban Tree Risk Management: A Community Guide to Program Design and Implementation" to guide program decisions and actions. This document standardizes procedures based on the DNR's previous practices.

> *Pokorny, Jill. 2003. Urban Tree Risk Management: A Community Guide to Program Design and Implementation. US Forest Service. NA-TP-03.03,* or, see http://www.na.fs.fed.us/spfo/pubs/uf/utrmm/index.htm).

This operational order covers trees with targets on intensively-used recreation sites and on administrative sites. It does *not* cover trees on dispersed-use recreation areas such as along trout streams, trails or forest roads, on forested lands used for dispersed recreation or in "wilderness-experience" areas.

III. DEFINITIONS

Hazard tree: any defective tree or tree part that, due to a visible or detectable defect, poses a high risk upon failure or fracture to cause injury to people or damage to property.

Target: people, automobiles, tents, boats, picnic tables, playground equipment, buildings, kiosks, trail heads, etc.

Intensively-used recreation areas: locations in parks and other recreation areas where people are invited to congregate or stop. Examples include day-use areas, campsites, picnic areas, swimming beaches, playgrounds, parking lots, buildings, facilities and public water accesses

Administrative sites: lands surrounding DNR buildings and facilities that are groomed or otherwise maintained for public and employee use.

IV. RESPONSIBILITIES

The Director of the Division of Parks and Trails is responsible for guiding program implementation on administrative and recreational lands under their jurisdiction.

On all other jurisdictions, the Director of Management Resources is responsible for guiding program implementation on administrative sites.

V. PROCEDURES

On an annual basis, evaluate and correct hazard trees on intensively-used recreation areas and administrative sites as is feasible within the constraints of the DNR's resources .

In cases of claims against the state, consult Operational Order #105, "Procedures for reporting and managing incidents of personal injury and/or property damage".

Hickory decline and mortality project: 2009 Update

The following is a brief summary of progress made in MN and in cooperation with the U. S. Forest Service and results from survey and research activities on hickory decline and mortality for 2009.

By Dr. Jennifer Juzwik, USFS-Northern Research Station, St. Paul

Hickory Decline Field Surveys

In previous years (2007 -2008) fungal isolates obtained from cankered stems of bitternut hickory trees were found to be *C. smalleyi* based on morphological characteristics and DNA sequences (ITS and tef gene regions). In 2009 isolates of *Fusarium* were identified as *F. solani*, though two types were found (black walnut canker and birch bark types) based on DNA sequences (tef gene region). Additionally *C. smalleyi*, *F. solani* and *Phomposis* sp. isolates were identified on stem cankers. The results were similar in sampling from other states with hickory decline (IN, MN, NY and OH).

The Role of *Ceratocystis smalleyi* in Hickory Decline

Pathogenicity studies; Koch's Postulates have demonstrated that *C. smalleyi* is the cause of diffuse cankers with reddish inner bark and sapwood on pole-timber size bitternut hickory. See Figure 1.

Association between hickory bark beetle attacks and bark/sapwood cankers. Frequency of hickory bark beetle (*Scolytus quadrispinosus*) attack, life stages present, egg niche and larval gallery presence, and occurrence of associated lesions or cankers were documented for three pole-timber size bitternut hickory exhibiting 55 to 70% crown decline symptoms. See Figure 2. Data were recorded for each variable for 1 m long stem sections from the tree base to tree top (stem diameter > 7 cm). Larval galleries were not found to coalesce. Hickory bark beetle attacks, ranging from aborted to full gallery establishment, numbered between 700 and 1400 per tree. Hundreds of stem lesions were found (commonly associated with the beetle attacks) and the margins of the lesions extended beyond any larval galleries present.

C. smalleyi – S. quadrispinosus relationship. Bark beetles emerged from stem sections obtained from declining bitternut hickory in late spring 2009. See Figure 3. Of 150 groups of beetles (3 per group) from May collected logs, *C. smalleyi* was found for only one based on serial dilution plating of aqueous suspensions resulting from vigorous agitation of beetles in 1.0 ml sterile distilled water. *F. solani* was found more frequently and *Penicillium*-like colonies were even more common. Bark beetles attacking stems of declining bitternut hickory were collected from three locations in late August and early September 2009 (Figure 3). Similar assays are being conducted with these specimens. They have been successful in obtaining *C. smalleyi* from the collected attacking beetles (2 of 19 from southeastern MN location; 12 of 14 from a location east of Wasau, WI).

Conclusions to Date

Of the three most commonly observed scenarios associated with hickory decline/dieback and mortality of hickory, the relatively rapid crown decline associated with *S. quadrispinosus* and diffuse stem cankers was most prevalent based on field surveys conducted in multiple states. Coalescing larval galleries is not what is killing the affected hickory. Rather, it appears that either the coalescing of hundreds of stem lesions or cankers associated with beetle attacks is the cause. Preliminary results show *C. smalleyi* and *F. solani* are causes of these cankers. Other, as yet undetected, fungi may be involved. Control of hickory bark beetle is the key to managing hickory decline. Survey data suggests that reducing density of bitternut hickory in a stand may greatly reduce tree decline and mortality during bark beetle outbreaks. Sanitation is also recommended, but is difficult for landowners to accomplish.

Future Work

Surveys and sampling will continue in 2010.

Figure 1. Elongate, diffuse cankers with reddish inner phloem and outer sapwood resulted from inoculation of bitternut hickory with *Ceratocystis smalleyi*. This evaluation was completed 14 months after inoculation.

Figure 2. Bark and sapwood lesions were commonly associated with hickory bark beetle attacks.

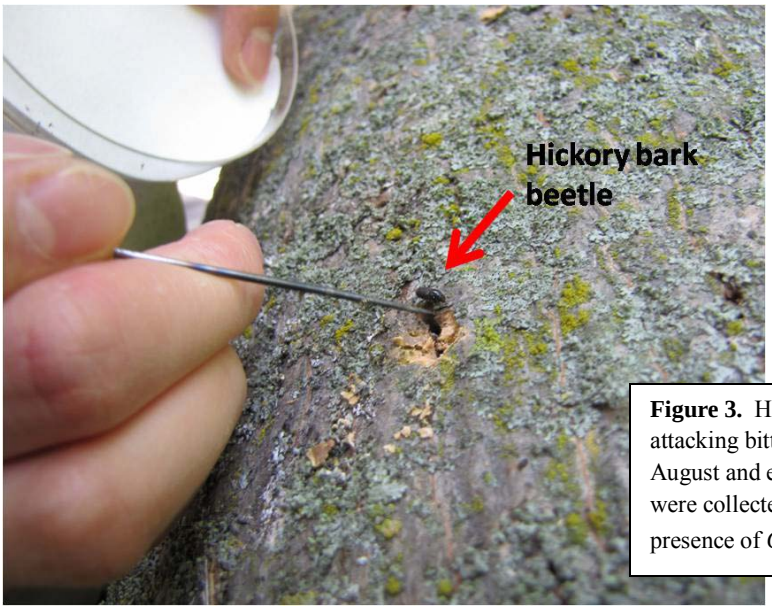


Figure 3. Hickory bark beetles attacking bitternut hickory in late August and early September 2009 were collected and assayed for presence of *Ceratocystis smalleyi*.

Invasive species management on DNR-administered lands

In May 2007, the Department of Natural Resources (DNR) adopted a new operational order regarding the management of invasive species on DNR administered lands. The intent was to provide a coordinated approach to invasive species management consistent with state and federal statutes. Research and case studies have shown that prevention and appropriate pest management is cost effective when compared to the losses associated with lost business revenue and/or resources impacted by invasive species. So the objective of the order was to minimize the risk of introducing invasive pests into areas where they didn't already occur and/or spreading existing infestations of invasive pests. While invasive species are fast becoming a major issue on all lands, public and private, the operational order does not apply to any but those lands administered by the DNR.

The operational order directed each division to develop a set of guidelines specific to their operations. The reason behind separate division guidelines was to provide the flexibility needed to address varying state mandates. For instance, the division of Forestry has been charged with the responsibility of producing an income on school trust lands (administered by the division) to support county school districts. That requires practices and contract specifications that may not be appropriate on a Scientific Natural Area (SNA). And likewise, protecting a critical habitat such as an SNA, requires a level of care that may not be feasible in a working forest. However, separate division guidelines do create the potential for discrepancies between the Divisions. So development of division guidelines was coordinated through an oversight committee where ideas and approaches were shared and in many cases borrowed to facilitate shared fieldwork. Within that context, Forestry division guidelines were completed this summer. Implementation began in August.

Implementation

Division of Forestry's "Guidelines for Invasive Species Management" were finished and approved in July 2008. Now that they are complete, attention can turn to developing the tools needed to effectively implement the guidelines. There are a number of tools needed that are not yet in place. These include among other things: equipment wash stations, species occurrence data, survey and monitoring protocols, reporting methods, management practices and priorities. Because many of the needed tools are not yet in place, division guidelines will be implemented slowly with an emphasis on outreach for the first year.

Division staff will be expected to begin to incorporate these guidelines into their day-to-day operations, much like they do practices meant to ensure their personal safety. That means identifying where the guidelines apply to their operations, what actions they need to take and what procedures and tools are needed to support those efforts. But this first year will be largely used as an education opportunity for both staff and program administrators. As a new endeavor, we are all learning what it takes to meet these objectives. And feedback on what doesn't work is as important as what does. This is especially true when working with contractors and vendors. Unless there is a regulatory issue, following division guidelines will be voluntary and will not be incorporated into contract specifications for some time.

Outreach Efforts

The most critical of the tools needed is the materials and means to reach out to and educate division staff and cooperators. Initial training was accomplished through three regional workshops hosted in August and September 2008. But more is needed. Audiences and their concerns need to be identified. Partnerships need to be explored. And materials and trainings are needed for key interest groups. One of the first efforts undertaken was to develop a brochure for loggers working on DNR administered lands. The brochure, Timber Operations on DNR Lands, Invasive Species Guidelines, released in November, outlines the voluntary actions being asked of loggers working on state administered land. Primarily the requests are to 1) arrive on any job site for the first time with clean equipment. Then on a regular basis, walk around any equipment being taken off site to knock off dirt clods and plant debris. A second effort undertaken with the Minnesota Logger Education Program (MLEP) involves developing curriculum for their annual logger certification training. The first presentation is scheduled for April 2009.

The US Forest Service funded a third larger project. The proposal includes two phases, 1) to develop an education plan and 2) to design an interagency web site on terrestrial invasive species. The education plan is meant to integrate outreach and education with social marketing techniques. The goal is to interrupt pathways by which invasive species spread across the landscape, focusing on those pathways associated with recreational activities. In 2008, an interagency core team was initiated to outline project goals, decision processes and time lines. A larger advisory committee was organized with their first meeting scheduled for January 2009. With a broad range of representatives, the committee brings to the project expertise and knowledge about recreation groups within the state and the social sciences needed to effectively reach them. Besides assisting the planning process, members of the advisory committee can pre-test ideas and help explore avenues of audience research. A focus group study and a baseline survey, scheduled later in 2009, will help more fully describe key audiences, their current

understanding of invasive species, their attitudes, motivations, values and concerns to help ensure an education plan capable of positively influencing public behavior.

Surveys and Occurrence Data
In part because there was no reporting mechanism in the past, there is little information available to describe where invasive species, particularly plants, occur on Forestry administered lands. So besides developing those mechanisms, beginning to fill in our understanding of where invasive species occur and where they might pose management issues will be one of the major tasks undertaken. To begin that process, a road-based survey was initiated summer, 2008. Using software developed by Ecological Resources, the survey includes all roads within state forest boundaries in the central and northern parts of the state. Completing that survey and a survey of all DNR managed gravel pits is scheduled for 2009.

Another project initiated in 2008 was a comparison of 5 different methods used to map the occurrence of buckthorn in order to evaluate their capability of detecting low levels of infestation. Interpreted photographs taken at three different resolutions are being compared to data obtained through aerial sketch mapping and ground surveys. The study results, expected spring 2009, will help guide detection efforts in other parts of the state. With grant funds provided through Ecological Resources, these surveys and several smaller projects will begin to give us the information needed to prioritize future survey and management efforts.

Reporting systems are being evaluated with plans to modify and adapt existing systems to manage invasive species data. A system of quality control is being added to the software used in our road-based survey. Utilizing handheld data recorders, the system provides a ready means to record and report populations of invasive plants. Two other reporting systems, SRM and FIM, used within the division to manage forest stand inventory data and management projects are being modified to include invasive species information. Overtime, the combination should provide the basis for future planning and management needs.

Management Practices and Priorities
While there is a lot of information out there about how to identify invasive species, the information about how to control them at an operational level is lacking. Often multiple plant species occur on a site and the management recommendations for one plant may actually favor another. And in some areas, invasive plants are so widespread and well established, that controlling them seems impossible. Trying to manage or even report each and every infestation isn't feasible. So where do we start?

While the population dynamics of some species may not be fully understood, in general, the highest priorities for both reporting and active management are as follows:

When a new infestation is discovered with the potential to cause long-term damage. Management is much more likely to succeed during the early stages of an infestation.
When small infestations occur outside the current range of that pest, or occur only in small isolated pockets away from larger well-established infestations. Again, management is much more likely to succeed when infestations are small and isolated.
When infestations are discovered that can be effectively managed during planned operations, such as during a timber harvest or site preparation.
Where state and county regulators require invasive species management due to the potential impact on adjacent farm and/or range lands.

Tackling large well-established infestations can consume large amounts of time and money. They also may not be effective in the long run because of the likelihood of repeated reintroductions from adjacent land. Rarely would such infestations be considered a high priority except in an area of exceptionally high value and/or visibility. Examples might include high use parks or historical sites or developed areas used for educational purposes.

Future plans
Because this first year of implementation is a learning process for all involved, our division guidelines will likely evolve over time. As we try various practices out and see what works and what doesn't, protocols will be developed and/or fine-tuned to support division needs. As outreach efforts progress and division cooperators become more familiar with the practices needed, contract specifications will be more and more common to protect the resources being managed. We will also begin to explore how best to pass this information onto private land owners and share it with our other partners.

In December 2007, the division of Forestry created a new position, the Invasive Species Program Coordinator, thus simultaneously establishing the Forestry Invasive Species Program. Sue Burks, previous Central Region Forest Health Specialist took the position. The next year or two of the new program will focus on implementing the division guidelines and establishing a long-term vision for invasive species management within the division.

What Makes Them Tick? Figuring out how to change citizens' behavior around invasive species issues

Ever hear the axiom, "foresters manage trees and people?" This unspoken understanding addresses what we all know intuitively – managing trees and any natural resources requires that we "manage" human behavior and decision-making—whether we want to or not. You may already be familiar with some of the tools we use to manage behavior: policies, laws, enforcement, guidelines, communication, education, and most recently, "social marketing. " Yet, because there are several tools, we must select the right tool for the job. Today, I'm sharing the following story to inspire you to think about how to best employ the tools we have.

Last year, the Terrestrial Invasive Species group realized it needed to reduce the spread and the number of accidental introductions of emerald ash borers and other invasive species into Minnesota. By nature, beetles, moths, and seeds don't move very fast, but with human help they can reach speeds of 55 miles per hour and faster. Knowing that bugs tend to ignore "no trespassing" signs, the Division of Forestry used a U.S. Forest Service grant to fund a contract with a marketing firm to 1) assess recreational user groups, and 2) figure out ways to influence people to make better decisions when they recreate outdoors.

The plan, in a nutshell
Purpose: Build an education plan to change public behavior to break or weaken the link between recreation and the spread of terrestrial invasive species.

Audience to Assess: Three user groups (motorized trail users, non-motorized trail users, and campers) across three regions (north, south, and central) in Minnesota.

Focus: How recreational activities affect the movement of soil and firewood, which are recognized as two of the primary carriers of terrestrial invasive species.

Once we defined the purpose, audience, and focus, we needed to select the right tools for the job. While policies and guidelines are already in place, it was time to tackle the challenge of changing the behavior of those three user groups. That's when we jumped into the field of "social marketing," which uses commercial marketing techniques to influence human behavior around environmental issues.

First step
We wanted qualitative information of peoples' opinions and motivations, so we held a series of small, localized focus groups. Our contractor wrote a 31-page report, preceded by an explanation that focus group study results are not statistically relevant. Here's just some of what we found out:

Current attitudes and behaviors
Most users can list several invasive species by name (mostly aquatic, fewer terrestrial).
Some users lump in nuisance species—like ticks—with invasive species.
Motorized trail users sampled seem to be more concerned, more aware of, and more actively controlling invasive species than non-motorized trail users.
Those unconcerned with invasive species made comments like: "As a mother of four kids, it's a 3 on a scale of 10." "Perhaps it (invasive species) is a natural process and the species we have now were once invasive."
Regarding restrictions on firewood, some wondered: "If the problem was real, why isn't there more enforcement?"
Others doubted the rationality of restricting firewood, prompting comments like: Why just in state parks? Since the emerald ash borer only kills ash, why can't I bring in oak? If I buy on-site, two days of campfires cost $60—that's higher than the cost to camp!
Two-thirds of users get their information on-site from kiosks, signage, and verbally from rangers. One-third gets it on-line. Users suggested more intrusive media such as television and billboards for those who don't seek information.
Users want to know why invasives need to be controlled, as in "why can't we bring in firewood," and "why can't we ride in the ditch?"
Some users don't think that their actions are causing invasives to spread, and doubt that changing their behavior would help control invasives anyway.

Comments about the DNR were largely favorable. The DNR was described as credible and believable, in part because it is non-political, non-controversial, and scientifically based in its decision-making. However, the DNR was also described as slow to act, bureaucratic, and not aggressive enough.

We were able to describe six desired beliefs. A user must believe ALL of them to change his or her behavior. The beliefs are:

1. The spread of invasive species has undesirable consequences.
2. It is plausible that I may be contributing to the spread of invasive species.
3. It is plausible that, if I limit or eliminate certain risky behaviors, the spread of invasive species may be prevented or delayed.
4. I wish to do my part to prevent or delay the spread of invasive species.
5. I know what to do.
6. I have the resources to do it.

What's next?

With this data, we can design the education plan and a survey that will consist of a random cross-section of Minnesota residents to quantify their current baseline knowledge, behaviors, and attitudes. Then we can mix our qualitative data from the focus groups with more statistically measureable quantitative data from the survey. This will give us a better understanding of what makes people "tick." Also, we can repeat the survey in the future and measure changes in knowledge, behaviors, and attitudes over time, as well as measure the success of the project.

Do you see an application for social marketing in your neck of the woods? We think this model could be used not only for managing invasive species, but also for managing private land (stewardship), urban and community forests, and for supporting public programs, which are any programs through which we interact with the public and/or private landowners.

Oak wilt suppression and site monitoring report

In 2009 DNR cooperators in 13 Minnesota communities collected efficacy data on 349 oak wilt treatment sites (21 miles of Root Graft Barrier (RGB) line) treated in both 2007 and 2008. Efficacy results range from 95 to 100%!

In 2008 the MN DNR Division of Forestry began intensively monitoring all of the 2007 treatment year, grant administered, oak wilt suppression projects (126 sites) within 13 Minnesota communities. The MN communities included Andover, North Oaks, Maplewood, Ham Lake, Lino Lakes, Shakopee, the Chicago County Soil and Water Conservation District, City of Columbus, Mahtomedi, Lake Elmo, Blaine, and Isanti County. This field work was done in cooperation with the USDA Forest Service (NA, State and Private Forestry) using their recommended field protocol.

Inspectors from the communities were trained and instructed to inspect all 2007 treatment sites using U. S. Forest Service field protocol. Infection centers were considered successfully treated if (1) there were no failures in the root graft barrier (RGB) line and (2) all potential spore-producing trees (PSPT's) were properly removed and disposed of.

In 2009 we completed the second year of monitoring of the 2007 treatment sites and began monitoring additional treatment sites installed in 2008. In the 2007 treatment sites 37,432 feet (or 7 miles) of RGB line was installed and 519 PSPT's trees were removed on time. In the fall of 2008 and with additional funds still available in the grants and with an existing extension of the grants for another year, an additional 182 treatment sites were installed.

The 2008 participating communities were Andover, Lino Lakes, City of Columbus, City of North Branch, Mahtomedi and Isanti County. This resulted in an additional 75, 829 feet (or 14 miles) of RGB line with an additional 640 PSPT's removed on time. The majority of this 2008 work took place in Isanti County and the City of Columbus (116 sites, Sam Klocksien cooperator) and city of North Branch (41 sites, Jason Rehm cooperator).

In 2008 the efficacy data for the 126, 2007 treatment sites was roughly 98% with only a few sites to follow-up on. In 2009 the efficacy data for these 126, 2007 treatment sites was 95% (12 failures/5 re-treatments). The final field checks for 30% of these 2007 treatment sites will be conducted in August –September, 2010.

In 2009 the efficacy data checks for the 182 treatment sites from 2008 treatment, was 98% (8 failures/5 re-treatments). The second year field checks for these 182, 2008 treatment sites will be conducted in August –September, 2010, with the final check in 2011.

In 2008 an additional grant was awarded to the City Of North Branch, Minnesota. In this grant the City of North Branch is under contract with the Chicago County Soil and water Conservation District to administer the suppression program. This is a pilot project will attempt to implement suppression activities on an estimated 200 active oak wilt infection centers within the city over a 5-year treatment period. In 2008, 41 sites were treated, 15,276 feet of RGB line was installed and 51 PSPT's were removed. In 2009 post treatment evaluations were conducted on the 41 sites. This was the first year of efficacy checks. In 2009 the efficacy data for these 41 sites is 100% (1 failure/1 retreatment). As of December 2009 an additional 39 sites were treated in 2009. An additional 19,225 feet (or 3.64 miles) of RGB line was installed. Efficacy checks will begin on these sites in 2010.

All site data is available in spread sheets by community.

The balance of the oak wilt cost share program to Minnesota communities is now over with the exception of the City of North Branch which will make their final treatments in 2010 and continue monitoring through 2012.

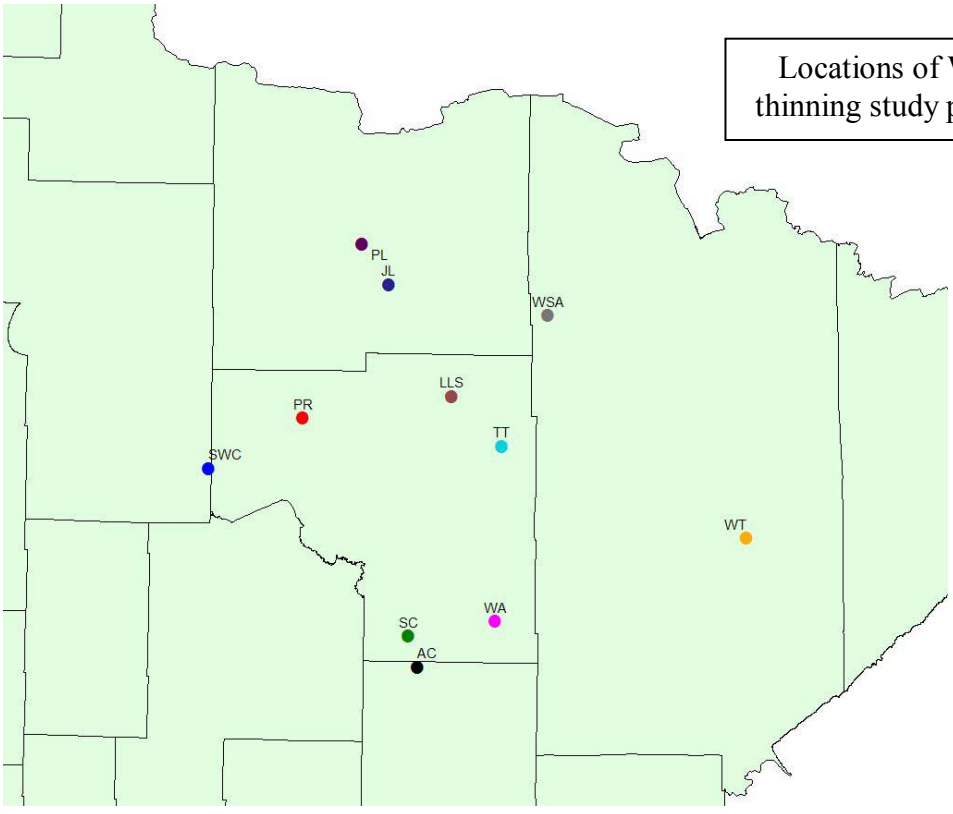
White spruce thinning study and spruce budworm defoliation data

This study was started in 1998 with a USFS Focus fund Grant, to study white spruce, spruce budworm and thinning. The project was started with Dr. Klaus Puettmann , U of MN as the principal investigator and Mike Saunders, his graduate student at U of MN.

There are 11 stands on State, Federal and Blandin Paper Company lands included in the study. See list and map below. Stands were thinned between 1998 and 2002. A portion of each stand was thinned and a portion left unthinned as a control. Each stand has 6 permanent plots established with rebar as the center points. All stands in the study are visited yearly to evaluate spruce budworm defoliation. Spruce budworm defoliation levels are shown in the following table. Resource Assessment crews collected tree measurements after harvest, 5 growing seasons after harvest and, in the winter of 2008 -2009, started the 10 year after harvest remeasurements.

Dr. Anthony D'Amato, University of Minnesota, agreed to take over as principal investigator. A graduate student of Dr. D'Amato analyzed the 5 year data as a research project for a MS degree. A manuscript is being written for publication in the Northern Journal of Applied Forestry.

Name of Site	Label	Date thinned
Aitkin Co	AC	11/1999
Johnson Landing	JL	2/2000
Larson Lake Salvage	LL	3/2000
Plantation Rd	PR	10/1998
Power Line	PL	2/2000
Sam Welch's Corner	SWC	7/1999
Smith Creek	SC	11/1999
Taconite Trail	TT	1/2001
Warba	WA	1/2002
White Spruce Alley	WSA	8/2002
White Township	WT	8/2002



Locations of WS thinning study plots.

White Spruce Thinning Project: Spruce Budworm Defoliation Ratings

	Plot	*Date thinned*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
Plantation Road PR	Thinned	Oct-98	L	L	O	O	O	O	O	L	O	O	*1
	Reserved		H	L	L	O	O	O	O	L	O	O	*1
Sam Welch Corner SWC	Thinned	Jul-99	L	L	O	O	O	O	O	O	O	O	O
	Reserved		L	L	L	O	O	O	O	L	O	O	O
Aitkin Co AC	Thinned	Nov-99	O*	O	O	O	O	L	M	L	L	L	O
	Reserved		O*	O	O	O	O	O	L	L	L	L	L
Smith Creek SC	Thinned	Nov-99	L	L	L	H	M	H	M	O	O	O	O
	Reserved		L	L	L	M	M	H	M	O	O	O	O
Johnson Landing JL	Thinned	Feb-00	M	L	O	O	O	O	O	O	O	O	O
	Reserved		M	M	L	O	O	O	O	O	O	O	O
Power Line PL	Thinned	Feb-00	L	L	O	O	O	O	O	L	O	O	O
	Reserved		L	L	O	O	O	O	O	L	O	O	O
Larson Lake Salvage LLS	Thinned	Mar-00		L	L	M	M	L	M	L	O	O	O
	Reserved			L	L	L	L	L	L	O	O	O	O
Taconite Trail TT	Thinned	Jan-01			O*	O*	O*	O	O	O	O	O	O
	Reserved				O*	O*	O*	O	O	O	O	O	O
Warba WA	Thinned	Jan-02				O*	O	O	O	O	O	O	O
	Reserved					O*	O	O	O	O	O	O	O
White Spruce Alley WSA	Thinned	Aug-02				O*	O	O	O	O	O	O	O
	Reserved					O*	L	O	O	L	O	O	O
White Township WT	Thinned	Aug-02				O*	O	O	O	O	L	O	O
	Reserved					O*	O	O	O	O	L	O	O

* = no defoliation rating done on the ground on this site, rating based on aerial survey data
*1 = no defoliation rating done this year because this site is more than 10 years since thinning
0 = no current needles missing
L = 1 to 33% defoliation of current year needles
M = 34 to 66% defoliation of current year needles
H = 67 to 100% defoliation of current year needles