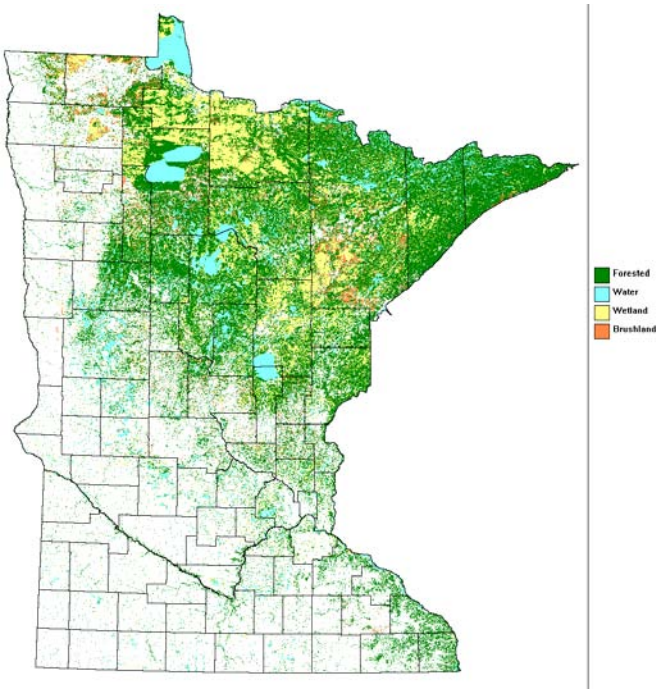
2004 Minnesota Forest Health Highlights

The Forest Resources of Minnesota

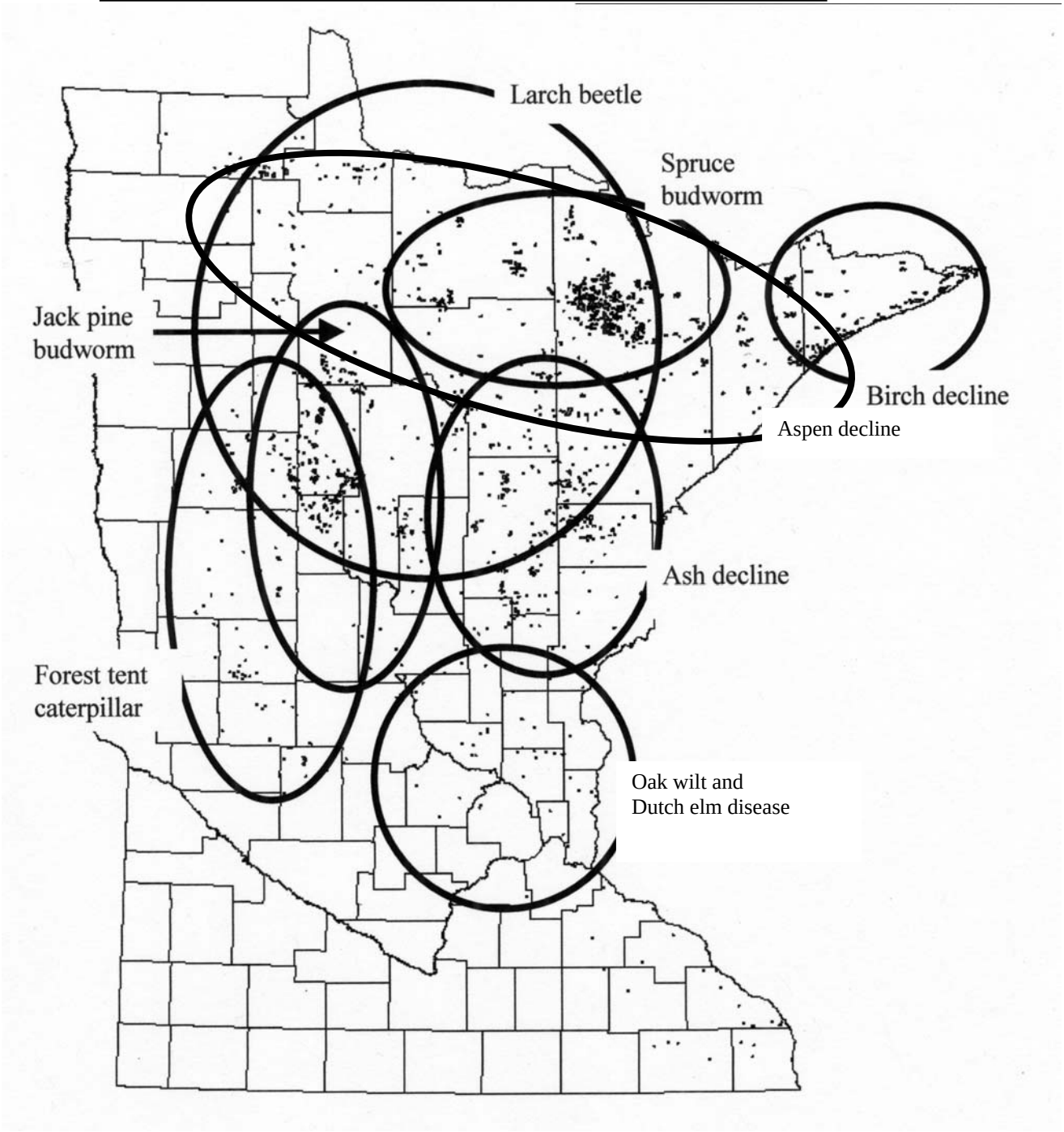
In Minnesota there are approximately 16.3 million acres of forest land, of which 14.9 million acres are classified as "timberland" or lands capable of producing timber. Forest type acreage can be found in the table below. (Source of data is the Minnesota 2001Eastwide Database provided by the USFS-NCFES.) A geographical depiction of forest land location can be seen on the map. 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.



Area of timberland by forest type	
Forest type	**Acres** in thousands
Jack pine	418.7
Red pine	381.7
White pine	70.7
Balsam fir	421.8
White spruce	86.6
Black spruce	1375.5
Cedar	565.8
Tamarack	648.2
Other softwoods	3.9
Oak	1252.0
Elm-ash-cottonwood	1218.0
Maple-basswood	1758.9
Aspen	5143.4
Birch	1078.6
Balm of Gilead	457.3
Non-stocked lands	101.3
Total	**14,982.4**

Two major industries depend on Minnesota's forest lands: forest industry and tourism. The forest industry is Minnesota's second largest manufacturing industry employing more than 55,000 people. The value of the 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 1 spring or summer trip in Minnesota rated "observing natural scenery" as the most important activity of their trip.

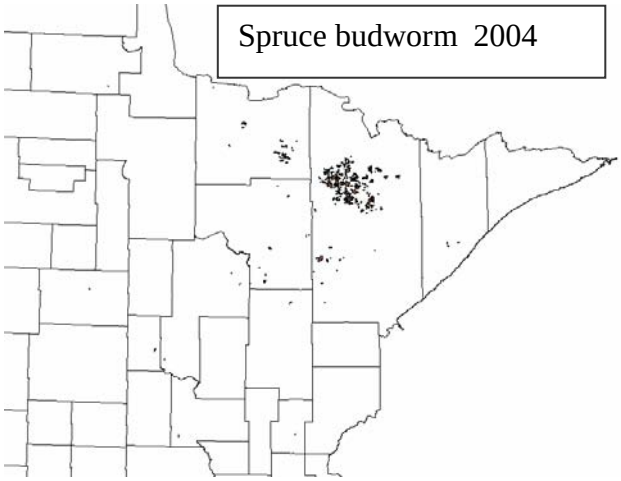
Results of Aerial Survey 2004
Cooperative effort between USFS and DNR



Pest Detection Survey Results * FFY04	
Causal Agent	**Acres**
Spruce budworm	83,200
Jack pine budworm	47,700
Aspen mortality (due to FTC)	27,500
Ash decline	27,000
Aspen decline (due to FTC)	22,900
Forest tent caterpillar	10,500
Larch beetle	10,000
Larch casebearer	6,700
Flooding damage	4,000
Birch mortality (due to FTC)	3,200
Oak wilt	3,000
Red pine mortality	600
Wind damage	500
Two-lined chestnut borer	250
Birch decline (due to FTC)	200
Wildfire damage	200
Dutch elm disease (not in Twin Cities)	160
Herbicide damage	60

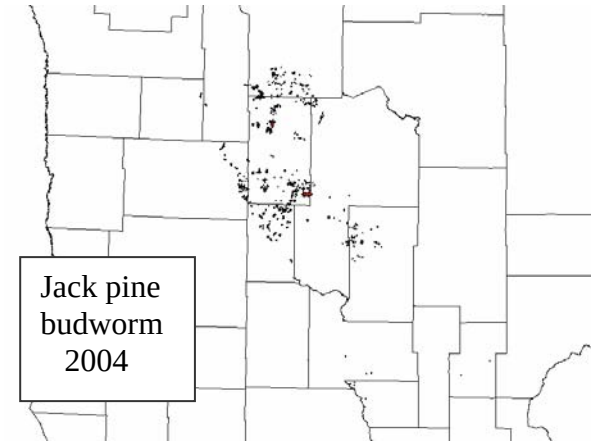
Spruce budworm expands 4-fold

For the last fifty years, spruce budworm has been active somewhere in Minnesota. Currently, the main population center is in northern St. Louis County. Between 2003 and 2004, the number of defoliated acres has risen four-fold to 83,000 acres leading to the speculation that the population is on the rise again.



Jack pine budworm expands in western counties

In July, more than 43,000 acres of jack pine defoliation were mapped in the west central counties. See map. Then, the jack pines looked like they had been dipped in red paint as the effects of budworm feeding became apparent. But by now, the winds and rains have knocked off the red, clipped needles. Most jack pine stands in Hubbard, Wadena, Becker and Cass Counties suffered heavy, first year defoliation



prompting foresters to wonder what next year will bring. Fall egg mass studies will allow us to predict next year's defoliation potential, which should allow ample time to identify pre-salvage operations.
In Beltrami and some parts of northern Hubbard Counties, this was the second year of defoliation for most of the affected stands. The vast majority of these stands (15,000 acres) will not be defoliated in 2005, because male flowers necessary food for young caterpillars, won't be produced. State and county foresters have been salvaging dead and dying jack pine stands since this time last year.

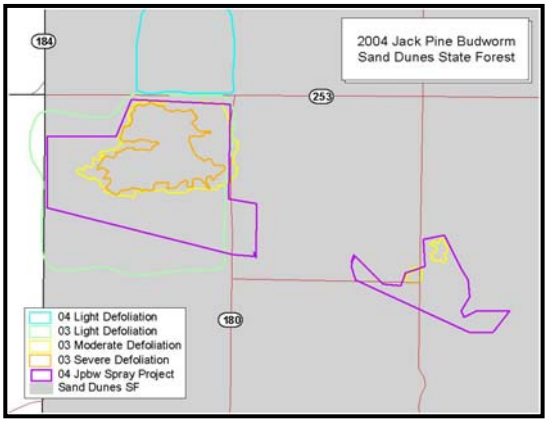
Typically, outbreaks only last two to three years in any stand or location. A collective sign of relief could almost be heard in Bemidji Area, but other nearby areas are gearing up for stand evaluation and timber sale preparation this winter. In these locations, both young and old stands suffered heavy to severe defoliation, leading to top kill. Fortunately, cool weather prevailed this summer preventing a bark beetle outbreak from developing in the defoliation-stressed trees.

Jack pine budworm in red pine

Due to an outbreak of jack pine budworm among red pine plantings in the Sand Dunes State Forest, 128 acres were treated this year with two applications of *Bacillus thuringiensis* kurstaki (Btk). While follow-up eggmass surveys have not yet been completed this fall, it is looking unlikely that additional treatments will be needed in 2005.

The outbreak was first discovered in July 2003. At that time, the damage had already been done and the adult moths were flying. In a 30Ac portion of the stand, the defoliation was severe enough to cause top kill of the trees. Because of the potential for a bark beetle infestation in the area, the area most severely damaged was cut the winter of '03-04. The rest of the stand was sprayed with Btk in June of 2004.
Spray boundaries were established based on an egg mass survey conducted in November, 2003 with the help of local forestry staff. Defoliation predictions are based on the average number of egg masses found on 15" branch samples (four branches per tree and four trees per plot). Of the 21 plots sampled, egg mass counts indicated 8 plots were at risk of minor defoliation, 7 were at risk of moderate defoliation, and 6 plots were at risk of severe defoliation. Because these sites had already been defoliated once, the concern was that a second defoliation would greatly increase top kill among the residual trees.

Larval surveys were conducted in May 2004 to determine winter survival rates and to monitor the potential spray schedule. Six shoots on each of five trees were surveyed on fifteen plots to determine the presence and location of actively feeding larvae. Based on the literature, selected shoots were evenly divided among those with pollen cones and those without. The number of shoots with actively feeding larvae determines the estimated population size, where a sample of 20 infested shoots out of 30 shoots sampled suggests severe defoliation is likely. Survey results this spring indicated 4 plots were likely to experience severe defoliation, while another 4 were likely to see light to moderate defoliation. Because the cone crop was large this year and almost no larvae were found on shoots without pollen cones, there was some later concern that selecting shoots without cones may have significantly under sampled the population.



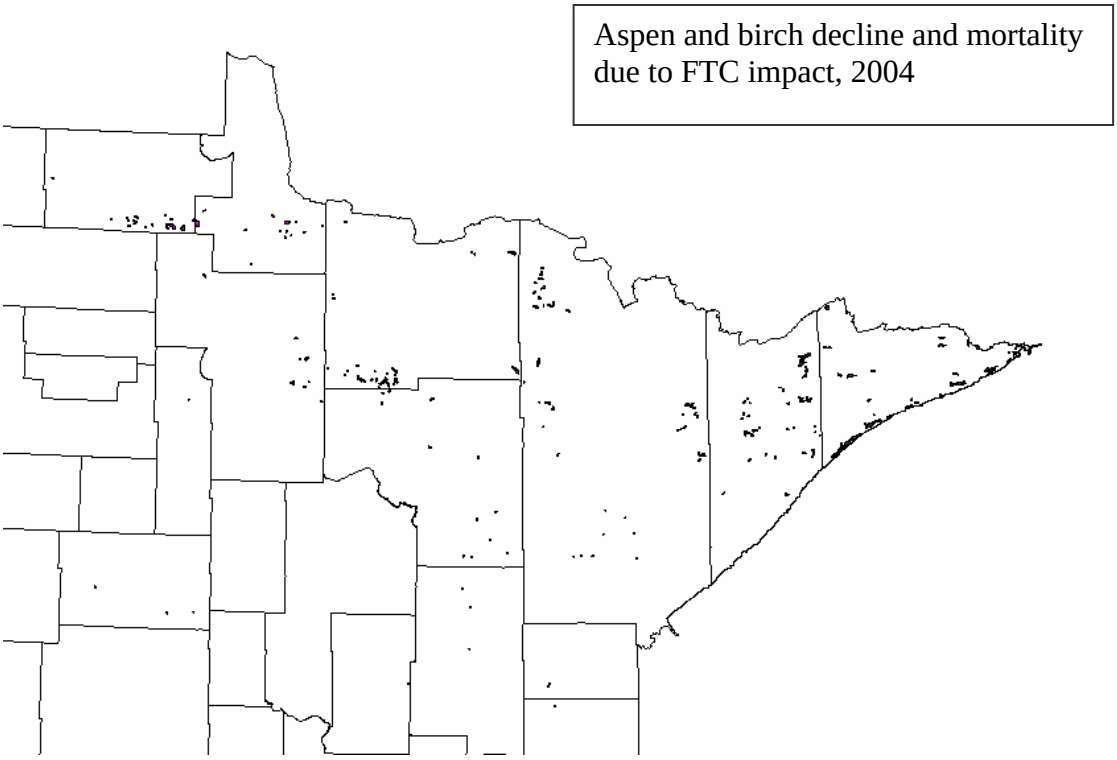
Informal larval surveys were also conducted through out the summer at a number of sites at up to 3 miles outside the proposed spray area. In all but one site, larvae were found, but in very small numbers.

Based on larval development, the first application would have ideally taken place the wk of June 7th. Because of heavy rains the first application was actually made on June 15 and the second application was made on June 2nd. Because of the delayed applications, light defoliation was noted across much of the spray area by the time the larvae stopped feeding.
However, the treatment was deemed a success based on informal larval surveys completely on June 29th following the final application.

However, due to larval dispersal prior to the Btk applications, the stand immediately to the north of the 2004 spray project (see map) saw light to moderate defoliation. Unlike the stand that was treated this year, there had been no shoot moth in the northern stand and it seemed to be less stressed by the previous drought. The stand also seemed to be handling the defoliation this year fairly well. By early fall, secondary growth had largely covered the previous damage so that it could not be seen from the air.

Prior to the 2003 outbreak, the entire area had been under severe drought stress. That plus additional damage by pine shoot moths contributed to the level of top kill seen in 2003 and the increased risk of pine bark beetle attack. With the heavier than normal rains in 2004, much of that stress was relieved. The rains combined with the increased vigor of the younger stands currently infested means that treatments are not likely to be necessary in 2005. A smaller scale egg mass survey is planned for later this fall to confirm that assumption.

Record breaking forest tent caterpillar outbreak collapses, yet leaves mortality in its wake



Aspen and birch decline and mortality due to FTC impact, 2004

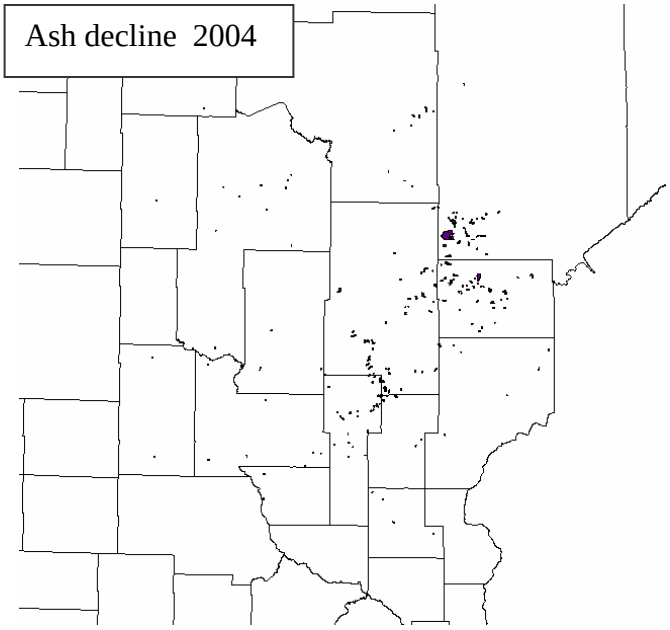
The forest tent caterpillar collapsed in 2004 over much of the state. Only 10,500 acres were tallied during the aerial survey. See map. At its peak in 2002, this outbreak saw the highest number of acres ever recorded (7,374,000 ac) for an FTC outbreak in Minnesota.

In its wake, this outbreak left thousands of acres of light mortality in both aspen and birch stands all across northeastern counties. See map. Host trees in these areas saw heavy defoliation for two or more years and experienced severe drought before, during and after the defoliation episodes.

Egg mass surveys for forest tent caterpillar indicated that heavy defoliation in 2004 could be expected in some locations especially across the Iron Range in St. Louis County from Nashwauk to Virginia. Up to 26 egg masses were found on small aspen trees in some locations. This is three times more that would be needed for complete

defoliation. Yet, in many of these locations larvae are absent or scarce. What happened? In some egg masses a high percentage of eggs did not hatch, likely due to a build up in the number of egg parasites. However, even when eggs hatched larvae are scarce. This is likely due to the cool spring. FTC egg masses were hatching from Grand Rapids to Ely on May 6th just as aspen leaves were beginning to emerge. However, May was a cold month with frosts occurring every week. Aspen leaves across the Iron Range have some evidence of frost damage. Average weekly temperatures in Hibbing were from 6.3 to 9.1 degrees below normal. It may have been too cold for newly hatched larvae to feed and they may have starved to death. Those that did make it to the pupal stage were likely attacked and killed by the abundant parasite, *Sarcophaga aldrichii*.

Ash decline crops up



The worst of it appears to be in a swath running through Mille Lacs County up through Aitkin, western Carlton and into southwestern St Louis County. But scattered amounts occur outside these areas as well. And while many stands look poor, there are often many stands of healthy and vigorous looking ash nearby. The first question that comes up is "Is it emerald ash borer". The simple answer is no, it is not emerald ash borer. There is no evidence that emerald ash borer is involved. Emerald ash borer has not been found in Minnesota or anyplace west of Lake Michigan. Of course that could change this afternoon and we have to be on the alert for it.

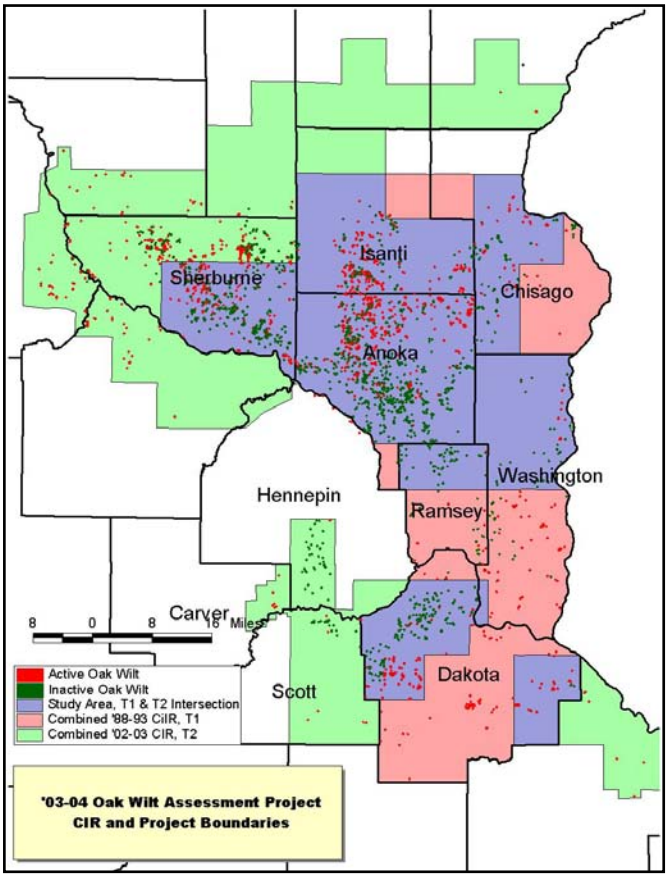
Right now the problem appears to be physiological and weather related. The weather the past couple of years has been enough to give anyone a bad attitude. We have had a winter with no snow cover resulting in deep frost and much colder than normal soil temperatures possibly causing some root damage. That along with drought, a late cold spring, and a cool summer made this summer feel like no summer.

Trees have been cut down in five or six different stands to try to determine cause. Eastern ash bark beetle was found on one tree and *Armillaria* on another, but so far, no insects or fungi have been found to be consistently associated with the declining trees. The trees produced a healthy set of buds last fall and look as if they just didn't break bud this spring. By mid-summer the cambium was brown and fermented in the branches and upper stem of the trees usually without evidence of any boring insects. Some trees were entirely dead. In many others, the entire crown appeared dead but most of these were producing epicormic branches on the trunk.

A similar episode of ash dieback and mortality occurred in the early 1990's. At that time we examined 37 stands of ash along a transect in eastern Aitkin County. You can read that report in your filed copy of the 1995 Forest Health Annual Report or in your copy of the Winter 1996 Forest Insect and Disease Newsletter. Just in case a couple of you have misplaced your copies here's a brief summary. No insect or diseases were consistently associated with the problem. The worst damage occurred in ash growing in closed depressions. Ash,growing in areas with a flow of water through the stand, were generally healthy. During wet years, water collects in these closed depressions and can't flow out. The ash roots grow very shallow in these waterlogged soils. It was felt that when drought hits, these ash trees are unable to draw water from lower in the soil profile and stress out, get a bad attitude and just quit.

Further investigations need to be done to better explain and understand the current problem and also to help answer questions about how to manage these stands and how to avoid or reduce these problems in the future.

2003-2004 Oak wilt assessment project



The program evaluation completed in 2002 raised a number of questions about the status of oak wilt in the state. Although a large number of communities have been aggressive in their management of oak wilt, the number of new infection pockets being discovered each year exceeds the number of infection pockets being treated each year. The result has been a gradual increase in the incidence of oak wilt across most of the original control zone and a dramatic increase in the incidence of oak wilt in Sherburne County - in spite of a model control program.

These increases led to several questions about statewide management strategies and the associated funding. The Forest Health Protection Branch of the USFS, State and Private Forestry provides the current oak wilt suppression funding. Their program targets areas at high risk of forest damage and as such are usually directed at areas with the highest pest incidence. But as seen with the gypsy moth program, not all areas are necessarily given equal consideration because of the likelihood of spread and the adjacent forest acreage at risk of damage. So for instance, the gypsy moth Slow-The-Spread program treats many more acres of forest than does the gypsy moth suppression program, even though the pest incidence is much lower. That is because, in the case of the gypsy moth, control measures have proven to be more cost effective when aimed at the leading edge of gypsy moth expansion or at high value forests under immediate threat of defoliation.

So what are the implications in oak wilt management? Should we target areas along the leading edge of expansion and abandon areas too heavily infested to manage? That might doom adjacent communities who are currently doing their best to limit disease incidence. Or should we continue to target areas with high pest incidence independent of where they occur? That tends to punish those communities that aggressively manage the disease and in the process lower its incidence. Or should we favor those demonstrating a long-term commitment to integrated urban forest management or those struggling to initiate a new program? Any approach we choose favors some communities over others.

Independent of the approach we choose, future federal funding is limited and dependent on demonstrable results. So it is imperative that the state defines where its priorities lie and define management goals accordingly. As such an assessment project was initiated in 2003 and is scheduled for completion this winter.

The hopes are that the assessment project will shed some light on where the incidence of oak wilt is changing and why. The results may help demonstrate which components of a community management program are most effective. The results may also highlight under what conditions disease management is most difficult. How these areas are distributed across the state's oak resource may help determine where we need to focus our efforts or perhaps where we need to redirect federal funds administered under the MN Releaf program.

Photography

Color infrared photography (CIR) was taken of various parts of the study area in 1988, 1989, 1993, 1997, 1999, 2002 & 2003. Photographs taken in 1988, 1989 and 1993 were combined to cover all of Anoka and Ramsey counties, and roughly half of Washington, Chisago, Isanti and Sherburne counties. This set of photos was used to represent time one (T1) in the assessment project. Photographs taken in 2002 and 2003 were combined to cover all of Anoka, Ramsey and Sherburne counties, as well as parts of Chisago, Isanti, Dakota, Hennepin, Scott and

Washington. This set of photos was used to represent time two (T2). The intersection of these two photo periods defined the project boundaries (see the CIR map). Photos taken in 1997 and 1999 were not used as part of this study.

Plot Selection and Design

The study area was divided into quarter sections, based roughly on the public land survey. The percent forest cover for each quarter section was determined based on the 1995 GAP data (1). A total of 600 plots were randomly selected from those quarter sections with greater than or equal to 15% forest cover. After exploring different thresholds of forest cover, 15% seemed to represent the best compromise between the labor needed to sample a large number of plots falling into agricultural areas if the threshold of forest cover was set too low, and potentially under sampling highly developed areas if the threshold of forest cover was set too high.

A regular grid of points was laid over the top of each quarter section plot, with an average of 64 points per plot. Each point represented roughly 1/10 acre. Both sets of photographs were rectified to the 2002 FSA photography. The office of DNR Forest Resource Assessment interpreted the photos covering each plot for both time periods. Land usage was defined as outlined below. Polygons representing each land use were visually determined. All points falling within a particular polygon were assigned to that land use category. For each point within a land use, the presence/absence of tree canopies and the presence/absence of oak wilt were recorded.

Field Checks

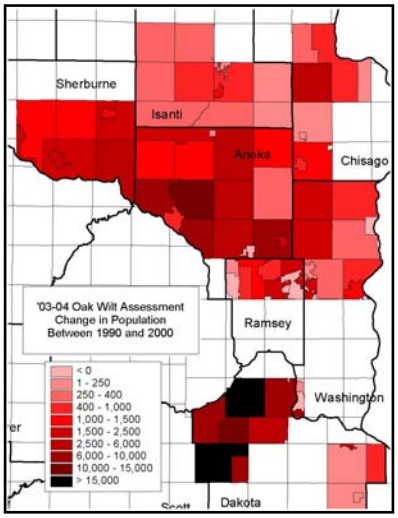
Five percent of the plots in each county were randomly selected to be field checked. Paper maps were created using the 2002 FSA photography as the base layer. County parcel data was laid over each plot and the landowner determined, where that data was available. Identified landowners were contacted for permission to access their land. Where landowners could not be identified, letters were sent to the current resident. All but one landowner contacted provided access to their property.

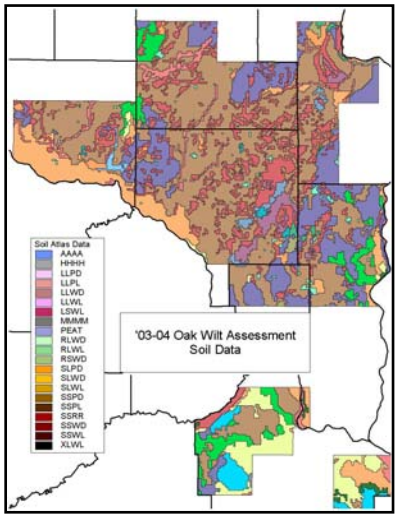
Field staff attempted to visit all points that appeared to have trees in the immediate vicinity. Points that were inaccessible were viewed with binoculars from the nearest possible location. Out of a total of (x) possibly treed points, (y) were visited and (z) were viewed from a distance. At each point tree cover was determined to be hardwood, conifer, mixed or none. Disease incidence was recorded as present, absent or unconfirmed, which meant dead oaks were present, but the cause of death could not be determined.

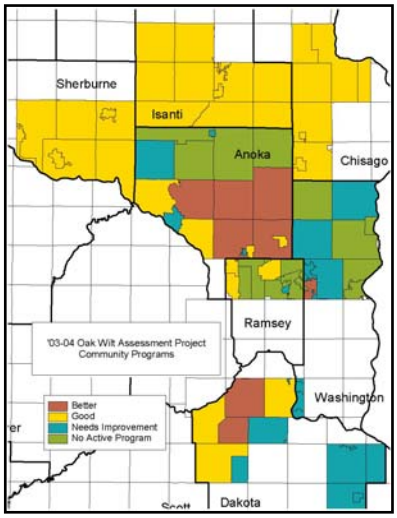
Independent Variables

Over the plot data, several GIS layers were overlaid. Soil type was based on the soil atlas (reference) where the four letter codes represent subsoil, topsoil, drainage and color in that order, where r = rock, s = sand, c = clay, l = loam, w = well drained, p = poorly drained, d = dark or unleached, l = light or leached. Change in human population, based on the difference between the 1990 and 2000 census was another data layer used along with the type of community oak wilt management program (see maps for all three data sets). The type of oak wilt management program was determined by a phone survey of all local units of government within the study area (xx total). The phone survey identified the field survey method(s) used, outreach and education activities, resident participation, management techniques, mapping and data collection, planning and long-term monitoring. Points were given or taken away from their total score based on components found in an “ideal program” as outlined by DNR and MN Releaf staff. Each local unit of government was then placed in one of four categories based on the sophistication of their program.

Spring storm events were not used as an independent variable because of a lack of data. Forest cover was not included because of the threshold used to define forest types in the statewide GAP data. The other reliable data set, MLCCS, does not yet cover the entire study area. Having that data layer would have made this analysis more robust because it combines land use with vegetative cover and describes percent imperviousness as well as the minor species commonly found in that cover type.







Analysis
The change in incidence of oak wilt will be calculated for each civil division on an area basis. Regression analysis will be performed by the USFS, NC Forest Exp. Sta. to determine the correlation, if any, between the change in disease incidence and the independent variables. At this point in time, all interpretation and fieldwork is complete. The final analysis will be completed and the final results presented in 2005.

Dutch elm disease

According to Minneapolis records, 2004 was the third worst year in history in the number of trees lost (over 8000 trees marked by mid August with the season yet incomplete). Only 1977 and 1978 saw more elm trees cut down - a total of 20,823 and 13,668 lost to Dutch elm disease (DED) during each of those years. So is Minneapolis an exception, or is DED truly on the rise? To help describe disease occurrence and community responses, a brief survey was conducted in central Minnesota. The survey points out that after several years of steadily increasing numbers of infected trees, 2004 saw a decided jump in the occurrence of DED.

The survey was sent to 194 communities in central Minnesota, including all incorporated cities and many townships. Of the 71 who responded (36.5%), 42 said they actively try to manage DED and reported the number of trees lost over the last 4 years. Excluding Minneapolis and St Paul, the respondents reported 18,013 trees cut down or marked for removal as of mid August. Several communities reported they were still marking an average of 20-30 trees per day, adding an estimated 1000 trees infected by the end of the 2004 season. This compares to a total of 9560 trees cut in 2003, an increase of almost 100% by the end of the 2004 season. In 2002 and 2001, 5674 and 4204 trees were cut down respectively, increases of 68% and 35% during those years. Clearly DED is on the rise!!!

Contributing Factors
Without the time and means for scientific study, community staff rely on observation and professional judgment to describe factors influencing the disease incidence in their area. While the responses varied, weather patterns and sanitation practices were most commonly cited as key factors in the current outbreak. One specifically said weather patterns were not involved and two specifically said the level of sanitation was not involved in the current outbreak. Other factors contributing to the outbreak that were commonly mentioned include insufficient staff and/or funds to manage local programs, lack of public awareness and/or interest in disease management, and an increase in the number of volunteer elms (mostly Siberian) in unmanaged areas. Two communities with active programs reported no increase in disease incidence.

Sanitation
The costs associated with disease management in native parks and woodlands make it impractical, so few communities address the large reservoir of beetle-infested wood these areas often contain. Sanitation of infected

ornamental trees (i.e. street, park and privately owned yard trees) may also be inadequate even in communities with active programs. Once city staff mark diseased trees, private landowners may not remove them. City ordinances may not contain the language necessary to enforce compliance. Or the program may not have the staffing necessary to follow through on compliance. For instance, seasonal staff may be laid off before private landowners have carried out ordered tree removals, so the trees are left standing until the following season. Another problem is the number of townships and/or communities without either an ordinance or the staff to carry out a disease management program. These areas can maintain large reservoirs of infested trees that can contribute to high rates of disease in the surrounding area. This can make it difficult for conscientious communities to stay on top on local enforcement.

Another factor contributing to the current incidence of disease is confusion about the need to manage Siberian elms. Siberian elms are more "resistant" to DED infection than American elms; so many communities tend to ignore them. Others confuse Siberian elms with Chinese elms, which rarely get DED, so attribute disease symptoms to some other problem. The end result is DED infected Siberian elms that are left standing to further contribute to the reservoir of beetle-infested wood. Because Siberian elms readily reseed themselves creating a large pool of volunteer trees, they can greatly increase the number of trees susceptible to infection, even though they are less susceptible than the remaining American elms.

Weather patterns

Three of the last four years have seen late season droughts that have stressed trees going into the winter. Three of the last four years have seen mild winter temperatures that may have increased the survival rate of over-wintering beetle populations. And two of the last four years have seen little if any snow cover. The winter of '02-03 in particular had a huge impact on tree health. Drought the previous summer left soils extremely dry and water levels dangerously low going into the winter. Prolonged cold spells and no snow cover drove frost lines far below normal. Many tree species; ash, hackberry, catalpa, honey locust and elm among them, showed signs of severe stress the following spring. The symptoms among elm included late leaf-out, small undersized leaves, sparse crowns, poor color, reduced growth and heavy seed crops. The results of a case study reported in 2003, showed 60% of the trees surveyed showed some signs of winter injury, while 9% showed signs of DED. At the time, the obvious question was how the current levels of stress were going to impact the future incidence of DED. This year, we found out. The incidence of DED in the area surveyed for winter injury in 2003 more than doubled in 2004.

Over-wintering beetle populations may be paying a large role in the current outbreak. Increasingly lax sanitation in many areas has increased the number of dead standing elm trees available as brood wood for the beetles. The mild winters have likely increased the survival rate. The combination has likely increased the population as a whole looking for suitable material for maturation feeding and reproduction. The large population of stressed elms seems to have met that need. The combination may well have led to the current outbreak.

2004 Gypsy moth statewide program summary

This summary was written by Kimberly Thielen Cremers, Gypsy Moth Program Coordinator for the MN Dept of Agriculture and it was further edited FH Staff.

General survey program

The Minnesota Department of Agriculture (MDA) was the lead agency during the 2004 gypsy moth detection survey program. Other cooperators included USDA, APHIS, PPQ; USDA, FS, MNDNR; and the Three Rivers Park District in the Twin Cities metro area. Staff in the cooperative program set 18,646 delta traps across the state, and 396 male moths were recovered. This was a 26 percent decrease from 2003, when 535 male moths were recovered.

In the fall of 2003, the STS action boundary moved into southeast Minnesota. This change did not have much impact on the management of gypsy moth in the state of Minnesota. What it does mean is that the gypsy moth front is nearing the Minnesota border and that the introduction pressure is likely to increase accordingly.

Overall, moth numbers were down substantially in the central and southeastern part of the state, making up only 107 of the total moths captured. The big surprise for the 2004 season was the record number of finds in Cook, Lake, and St. Louis County in northeast Minnesota (see map). These three counties had a total of 286 moths combined, with

Cook County alone at 198 moths. With the record low temperatures throughout the months of June, July, and August (frost in parts of northeastern MN in August), it was expected that traps in northern Minnesota would also show a substantial decrease in moth numbers. That did not end up being the case. It is expected that in 2005, the STS action boundary will be expanded to include Cook and Lake Counties in northeastern Minnesota. However, for the first time since the area was trapped on an annual 1 mile base grid beginning back in 2000, there was some correlation between positive finds and delimit sites (sites with past finds), which suggests isolated introductions (which are easier to control) rather than the possibility of low density resident populations suggested by widely scattered single moth catches.

Several grid densities were utilized across the state to be consistent with past trapping protocols yet allow for a smooth transition into STS protocols and data collection. The STS action area was trapped on a 2-kilometer grid with several areas of concern receiving a higher density of traps. Areas outside the STS action area that were considered high-risk for the introduction and establishment of gypsy moth received traps on a 1500 meter grid similar density to the one trap per square mile (1/1) density that had been used in the past. Areas are considered high risk for the introduction and establishment of gypsy moth due to human activity levels, preferred habitat for gypsy moth, and the advancing gypsy moth front from Wisconsin. Areas designated high-risk included the seven-county Twin Cities metro area extending north through the city of St. Cloud, counties bordering Wisconsin in southeastern Minnesota including Fillmore and Olmsted county, and two quads inland from the shoreline of Lake Superior including the entire city of Duluth.

The remainder of the state received traps at one trap per four square miles (1/4) or 3-kilometer grid on a four-year rotation, with approximately one-third of the state receiving traps annually. The entire central half of Minnesota was trapped in 2004 including the counties of Benton, southern portion of Cass, Chisago, Crow Wing, Dodge, Douglas, Isanti, Kandiyohi, Meeker, southern portion of Mille Lacs, Morrison, Mower, Otter Tail, Pine, Rice, Stearns, Steele, Todd, and Wadena. All Municipalities within these areas received a higher trapping density of 1500 meters. In addition to the standard trapping densities, areas which had positive moths in the past received intensive trapping or delimit trapping at densities of 250 meter, 16 traps per square mile, 500 meter, or 1 kilometer to determine if a potential population exits.

Additional traps were set at state parks, mills, and nurseries within the standard trapping grid. Thirty-nine of Minnesota's 69 state parks were within the standard trapping grid and received 1-2 additional traps. Twenty-eight moths were caught in the state parks.

Mill and nursery trapping

Mills and nurseries were trapped according to risk of gypsy moth introduction. Nurseries either reporting stock sources from gypsy moth-quarantined areas, who are wholesale dealers, or who have a history of pest problems are considered high/moderate-risk, and received between two and twelve traps this year. One hundred seventy nurseries are considered high/moderate-risk. Outside the standard grid, MDA nursery inspection staff trapped five high-risk nurseries and no moths were caught.

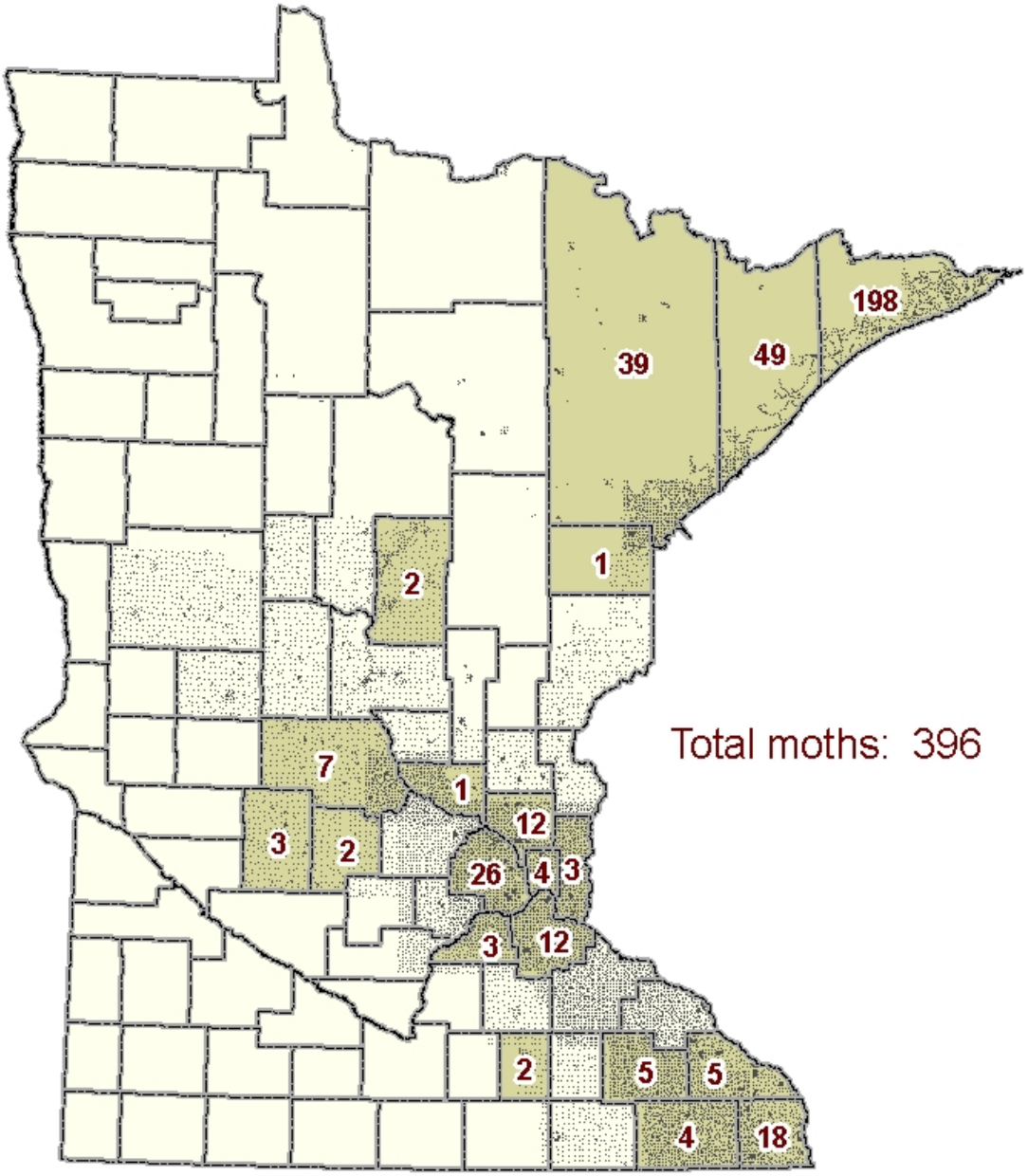
High-risk mills throughout the standard trapping grid received two random traps. Mills are considered high-risk if it is known or likely that they have out-of-state sources or if they are within 60 miles of Wisconsin counties trapping fifty or more moths. There are 63 high-risk mills throughout Minnesota.

Mills that are high-volume pulp or veneer or have greater than 500 MBF annually are considered to be at moderate risk. Moderate-risk mills received two traps if they were in the 1/4 trapping grid. There are 80 moderate-risk mills throughout Minnesota.

Three mills are under federal Compliance Agreements for gypsy moth. A Compliance Agreement is designed to decrease the risk of gypsy moth establishment and allows mills to transport logs from gypsy moth-quarantined areas for milling or pulpwood. Mills under compliance are trapped on a 250-meter grid. One hundred seventy five traps were set at compliance mills. No gypsy moths were captured at these sites.

Trapping for Asian gypsy moth was conducted at the northern Minnesota seaports of Duluth (MDA). Any moths collected at the seaport or in St. Louis, Lake, and Cook Counties are sent to OTIS Laboratories for Asian gypsy moth DNA analysis. No Asian gypsy moths have been identified at this time.

2004 Minnesota Gypsy Moth Survey
Results by County



MINNESOTA DEPARTMENT OF AGRICULTURE

USDA, FS trapping
The USDA, FS provided funding to MDA to trap all other National Forest land and Bureau of Indian Affairs land within MDA's standard trapping grid. Since 2002, a seasonal trapper conducted "hike-in" trapping along a predetermined 1/1 grid, 1500 meter in 2004 (as opposed to using available roads) for all of the Grand Portage Reservation in Cook County. One hundred seventeen traps were set on the Grand Portage Reservation, and 22 moths were caught in 19 traps. Ten traps were set on the Fond du Lac Reservation, and no moths were trapped. Nine hundred seventy nine traps were set in Superior National Forest, and 219 moths were caught in 153 traps.

Egg mass surveys
Only one site, north of Tower and one mile south of the Boundary Waters Canoe Area (BWCA) Wilderness boundary in northern St. Louis County, warranted an egg mass survey. The survey was conducted on October 26, 2004 and two egg masses were found at the site. There is a combination of forested landownership between Superior National Forest, St. Louis County, and the City of Tower. This site is being proposed for treatment with Btk in 2005.

General treatment program
In 2004, Minnesota conducted gypsy moth eradications at six separate locations across the state. Four of the six locations were regulatory sites (nursery operations) that had received quarantine breach material during the 2003 season. All four nursery operations were under state/federal compliance agreements, which required spring treatments in 2004. The other two sites were funded by state and federal cost share dollars.

Dimilin Treatments:
All four nursery operations conducted two applications of Dimilin, spaced 7-14 days apart. The first application was conducted on April 16, 2004 and the final application was conducted on May 8, 2004. The individual nurseries paid treatment expenses. After successful treatments were conducted the compliance agreements were removed. All four sites received intensive trapping during the 2004 trapping season and three of the four nurseries had positive gypsy moth finds. Site inspections were conducted and no alternate life stages were found. No further regulatory action has been taken at this time.

Btk Treatments:
One site in the Edina area within the Twin Cities metropolitan area received two applications of Btk, spaced 7-10 days apart. This was a rather small site of less than 5 acres in size. Both applications were conducted by ground utilizing a hydraulic mist blower. This site was part of the 2002 Lake Harriet treatment delimit site and had been delimit trapped for three years, with an increase in trap density from 16 traps per square mile in 2002 to 36 traps per square mile in 2003. Twenty-two moths were caught in seven traps at this site, the largest number of finds at a single site for the 2003 season. During the egg mass survey, more than a dozen egg masses were found on two large, isolated oak trees. A USDA-FS trained tree climber assisted in removing between 30-40 egg masses from these two oak trees.

After the treatments, the site received mass trapping at 3 traps per acre and two male moths were caught at the far northeastern corner. This site will again receive intensive trapping in 2005 to determine treatment success.

Pheromone Flake Treatment:
One site in southeast Minnesota totaling 225 acres was proposed for pheromone flakes. This site has had a history of low gypsy moth finds since 2002. Moth catches increased from eight moths in one standard detection trap (1 per sq mile) in 2002 to 14 moths in five delimit traps (36 traps/sq mile) in 2003, indicating the likelihood of a reproducing population. No egg masses were located during follow-up egg mass surveys (Fall of 2002 & 2003), although this is not unusual in forested areas with low gypsy moth populations. Pheromone flakes were the preferred treatment option at this site due to location, the history of finds at the site, and the forested component.

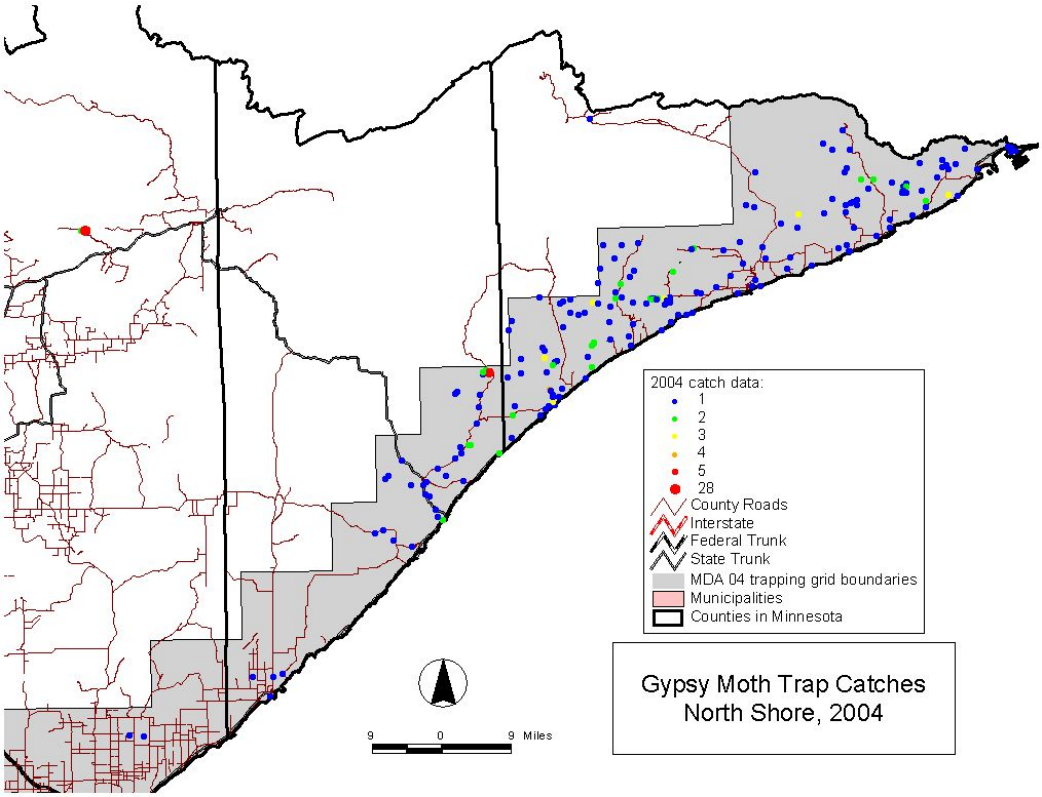
The pheromone flake treatment was conducted on June 28 and was completed without incident. The aircraft flew into Minnesota from an airport in Boscobel, Wisconsin. The site received 15.2 grams active ingredient (disparlure) per acre. A total of 85 grams of flakes were applied.

The site received follow-up traps in 2004 to ascertain that no male moths were caught in the pheromone traps (i.e., males are sufficiently confused by the amount of pheromone used that they are unable to locate the traps). No male

moths were caught in these traps. Intensive trapping will be conducted in the summer of 2005 and 2006 at a density of 250 meters. This monitoring will determine whether the project was successful and whether there is a need for further action.

Future Outlook

Although, moth catches along the North shore were correlated to some extent with existing delimit sites, the large number of catches across a wide-area is a concern. Typically, isolated introductions that later become established produce a pattern of moth catches that increase in number over time around a focal point. The intensity of the focal point among a background of relatively few, if any moth catches, makes locating isolated populations much easier. A more or less uniform distribution of moth catches over a wide-area provides few clue as to the origin of the population. That kind of pattern suggests either a low-density resident population across the landscape or a 'moth blow'. A moth blow occurs when weather patterns pick up a large number of moths and either move them or drop them into another area. While the occurrence of moth blows has been debated, there is considerable evidence to



defend the theory. For instance, early in the history of the Wisconsin infestation, trap data demonstrated two peaks in the timing of moth catches. These two peaks neatly corresponded to the timing of moth emergence in the few isolated populations within WI and to emergence in the larger MI infestation. Apparently, at least some of the WI moth catches were being blown in as adults from MI.

Along the North Shore, moth catches in 3 of the last 5 years were widely scattered across the landscape. The interim years saw few moth catches, so no clear pattern was evident (except around 1-2 delimit sites that were being closely monitored). The same pattern was seen in the early years of moth catches in Door County, WI. The question is whether the North Shore catches due to moth blow or a resident population. In Door County, even though moth blow was evident, there was also a resident population that dramatically increased in number in the mid 1990s. In that case, moth blow obscured the data, so the resident population wasn't evident until it had grown substantially. Could that be happening in the North Shore?

We don't know. The current data suggests moth blow is producing the pattern of moth catches seen along the North Shore. One piece of evidence to support that theory is the moth catch pattern in the Apostle Islands. This year, moth catches along Apostle Island shorelines were extremely high, while moth catches in the interior of the islands

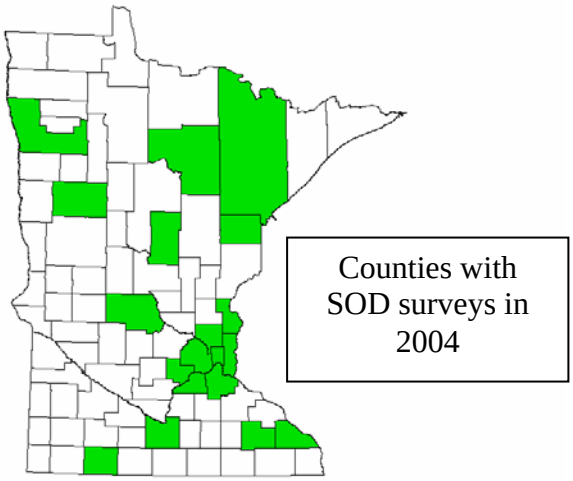
were quite low. If the moth catches were due to a resident population, you would expect to see uniform moth catches across the entire island and not just along the shore. Moths associated with the shoreline tend to suggest the moths were moving across the water and were trapped by the first trap they came to. Given the high numbers of moths building on the mainland, moth blow makes sense to explain the patterns seen. But the STS scientists are carefully studying the data. That attention is the best part of being included in the STS action zone, because few in Minnesota have the experimental expertise to decipher these complex patterns (a plug to encourage the UMN to fill their vacant staff position in forest entomology).

The end result is that as the Wisconsin infestation moves closer, we don't know which will become infested first (if they aren't already), SE Minnesota or the North shore. Both are predicted to become infested sometime around 2007 or 2008. However, even after permanent infestations move into the state, we are likely to see many years before gypsy moth defoliation becomes an issue. So instead of panicking just yet, we ought to take the time to review the management status of those lands under our care and prioritize those at need of attention prior to gypsy moth arrival.

Banded elm bark beetle found in Fridley

Banded elm bark beetle (BEBB) was first identified in Colorado last year. This year, Minnesota was among five states to find this exotic pest in residence. Pheromone traps were set out by MDA and APHIS in the Metro area and in several counties along the Iowa border. In June, three banded elm bark beetles were caught in Fridley, a northern suburb of Minneapolis. Interestingly, the three beetles were caught in three separate traps, each baited with different pheromones. Exotic insects and diseases all have the potential to alter our natural forest ecosystems and/ or damage ornamental vegetation. We'll have to wait to see what the effects of banded elm bark beetles are and where they become established.

Minnesota participates in a national SOD survey No *Phytophthora ramorum* was found



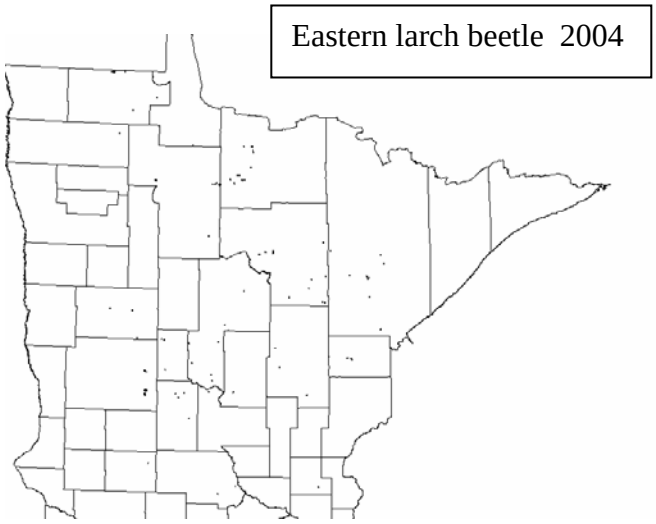
This summer, Minnesota participated in a national sudden oak death (SOD) survey. *Phytophthora ramorum* is a quarantined pathogen that may have been inadvertently introduced to other states outside of large regulated areas in California and Oregon on infected nursery stock in 2003 or 2004. Given this unfortunate probability, a national detection survey was designed and implemented this year. DNR Forestry participated by gathering samples and information on the possible presence and distribution of the pathogen within the state. Forestry crews, working out of the Resource Assessment office, were trained in data collection and were dispatched to 30 pre-selected sites in 18 counties. See map. The majority of these sites were forested areas adjacent to major nurseries that have the potential to import nursery stock from California nurseries. At each plot location, transects were run in four cardinal directions. Along those transects hundreds of suspect leaf disease samples were collected and later examined. Ultimately, 89 specimens made it to laboratory testing. They were sent to labs in Minnesota (MN. Dept. of Ag.), and Mississippi State University. Samples were sent to the lab at MSU as a quality control check. All samples were negative for the pathogen *Phytophthora ramorum*. Neither the disease nor the pathogen was found.

Two-lined chestnut borer

Oak mortality caused by drought stress and two-lined chestnut borer activity continued this year but at a much lower level than in the past two years. Weather seemed to be the driving force. Precipitation was higher than during the past two years but was still below normal in some locations. For example, for the period of April 1st to August 31st, Grand Rapids received only 60 to 70 % of normal precipitation. Temperatures were also below normal which reduced evaportranspiration, ultimately reducing the trees' moisture stress. The cool weather also slowed the development of the TLCB larvae.

E. larch beetle

Eastern larch beetle continues to kill tamarack. Last year 6,000 acres of tamarack mortality were reported and this year, about 10,000 acres were reported. Mortality in some of the most severely damaged stands where the beetle has been active for a number of years, seems to be declining. This indicates that additional stands have been attacked.



Sphaeropsis collar rot in state nursery seedlings

Until recently, the prevailing pathological dogma was that if there were no symptoms of *Sphaeropsis* in the nursery seedbeds, then there were no *Sphaeropsis* infections in the seedlings. That belief was turned upside down by the work of Glen Stanosz's lab at the University of Wisconsin. He and his co-workers found that there could be *Sphaeropsis* infections without any symptoms. In other words, *Sphaeropsis sapinea* is a "latent pathogen".

A latent pathogen has three attributes:

- The pathogen can persist in the host plant in the absence of symptoms.
  Sphaeropsis creates structures called "hyphal bundles" in needle stomates or in the bark surface without any disease reaction or symptoms being expressed.
- It has a prolonged period of inactivity that is induced by the host.
  As long as the seedling is vigorous, latent *Sphaeropsis* infections do not occur. Even after outplanting, latent infections in red pine seedlings can persist for as long as seven years.
- The pathogen can be released to cause disease symptoms as a result of a physiological change in the host.
  Sphaeropsis infections are released by internal water deficits in the red pine seedlings. In fact, the incidence and severity of symptoms are directly related to soil moisture deficits.

As it fate would have it, in the spring of 2002, Dr. Stanosz decided to sample all the Mid-western nurseries to document the incidence of latent *Sphaeropsis* infections in red pine seedlings. We were certain that Minnesota's nurseries would be fairly clean. See dogma above.

Was it fate, destiny or karma that set the dominoes tumbling?

- As usual, the Nursery rigorously culled out
  diseased and deformed seedlings during lifting

so that only “clean” and “green” seedlings were shipped.

- Northern Minnesota experienced a significant drought in 2002, especially during the planting season and early summer.
- By mid-July, losses in newly-established red pine plantations averaged an unprecedented 55 percent Only part was due to drought. Lab examinations showed that the remainder of these losses were due to *Sphaeropsis*.
- In late August, we learned that Badoura Nursery had 18 and 88 percent latent infections at the two sample locations.

The inescapable conclusion was that *Sphaeropsis* infections evident in our plantations came from our Nursery in the form of latent infections. Now, not only did we have *Sphaeropsis* in our Nursery, but we were also in the midst of a nasty epidemic.

Our best course of action was to eliminate the sources of the infection in the Nursery by removing the overstory red pines. (*Sphaeropsis* spores from infected windbreak red pines are spread in raindrops down onto the seedlings in the nursery beds.) In the winter of ‘02-03, Badoura Nursery removed 1250 cords of red pine windbreaks.

These removals would have an impact, but not immediately. Seedlings that were alive in 2002, prior to the removal of windbreaks, had already been exposed to *Sphaeropsis* and were likely infected. Nursery managers also reinstituted fungicide spray regimes and rogued seedbeds regularly among other actions.

In 2003, the first systematic survey of the entire 3-0 red pine crop was conducted to determine the levels of *Sphaeropsis* latency. Dr. Stanosz’s lab found that latent infections in the red pine fields averaged 40 to 71 percent. As a result, the entire crop of two million seedlings was rejected and destroyed.

This summer, we anticipated a drop in disease levels because this crop of seedlings had emerged after the windbreaks were removed. Another systematic survey of the 3-0 red pine crop was done and latency levels were determined by Dr. Stanosz’s lab. His news delighted us. There was less than 3 percent latent infections found in the nursery beds. These seedlings can be sold and planted next year. Good karma, at last.

Sphaeropsis survey across northern Minnesota

This federally-funded project will address critical gaps in understanding and managing the lethal, invasive pathogen, *Sphaeropsis sapinea,* on red and jack pine seedlings in plantations and in natural regeneration of multi-storied pine stands.

Current, unprecedented losses of pine seedlings in nurseries, young plantations and natural regeneration are attributed to this pathogen. We propose to develop a method that foresters can use to evaluate *Sphaeropsis* disease potential in overstory trees. Site specific information on the incidence and disease potential of 120 mature pine stands in 10 ecological subsections would be analyzed so that (1) a technique to evaluate disease potential is developed, (2) guidelines for natural and artificial regeneration of pines next to overstory pines are developed, and (3) a thematic map is created that shows the *Sphaeropsis* distribution, severity and fungal strain type across northern Minnesota.

Trends toward uneven-aged management of red pine (Ostry et al, 1998) and the paucity of natural jack pine regeneration (FH Report, 1999) have renewed concerns over the impact of *Sphaeropsis* on pine seedling vigor and survival. The presence of infected overstory red pines limits the success of both artificial and natural regeneration (Palmer, 1991). Since the early 1980’s, infected red pine seedlings and saplings have died or remained stagnant, the inoculum being derived from cone and shoot infections in nearby or overstory red pines. Under optimal conditions, such as in conifer nurseries, spores can be rain-splashed more than 1000 feet from the inoculum source (Palmer et al, 1988). Empirical evidence has shown that the impact of this disease is variable across northern Minnesota (FH Reports, 1976 to 2003), reflecting both differences in overstory infection and in epidemiological conditions on those sites. At present, we have no field method to evaluate the presence of *Sphaeropsis* in mature red pine stands, much less to evaluate their disease potential. By developing a method to evaluate *Sphaeropsis* at the stand level, foresters

could evaluate sites prior to planting and avoid losses by preventing the acquisition of lethal infections. More importantly, sites where inoculum levels are low would be well suited to natural regeneration and the development of multi-storied red pine stands.

Objective:
Since the early 1980's, red pine seedlings, saplings and pole-sized trees have exhibited shoot blight symptoms, the inoculum being derived from cone and shoot infections in nearby, overstory red pines. Natural regeneration of red pine in northeastern counties is scarce in large areas where it occurred historically due to mortality caused by *Sphaeropsis*. In northwestern counties, natural jack pine regeneration is poor or lacking, with *Sphaeropsis* likely as a contributing factor.

In the forest, the presence of infected overstory trees limits the success of both artificial and natural regeneration because seedlings and saplings can acquire the fungus from the overstory trees. At present we have no field method to evaluate the presence and severity of *Sphaeropsis* in overstory trees. We could reduce the risk of disease losses if the levels of infection could be predicted. Losses in red pine plantations could be reduced if foresters knew where to plant seedlings to avoid acquiring the disease. More importantly, natural regeneration would be more reliably predicted if we knew where disease potential in the overstory is very low or rare.

To reduce current losses in artificial regeneration and make predictions of natural regeneration more reliable, we propose the following:

1) to evaluate the ability of *Sphaeropsis* infections in overstory red pine trees to cause disease in understory seedlings and in nearby plantations by studying cone and seedling infections in stands with different ecological characteristics.
2) to evaluate the potential ability of *Sphaeropsis* infections in overstory jack pine trees to cause disease by studying cone infections in stands with different ecological characteristics.

All field work, except determining site ecological classifications and determining *Sphaeropsis* strains in collected cones, was accomplished during 2004. By the end of next year, we expect to produce a report that includes: 1) guidelines for natural and artificial regeneration of pines next to overstory pines, 2) a thematic map that show the *Sphaeropsis* distribution, severity and fungal strain type across northern Minnesota, and 3) a method that foresters can use to evaluate *Sphaeropsis* disease potential in overstory trees.