2014 Minnesota Forest Health Highlights

MNDNR

Prepared by MN DNR Forest Health Unit

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

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Table of Contents

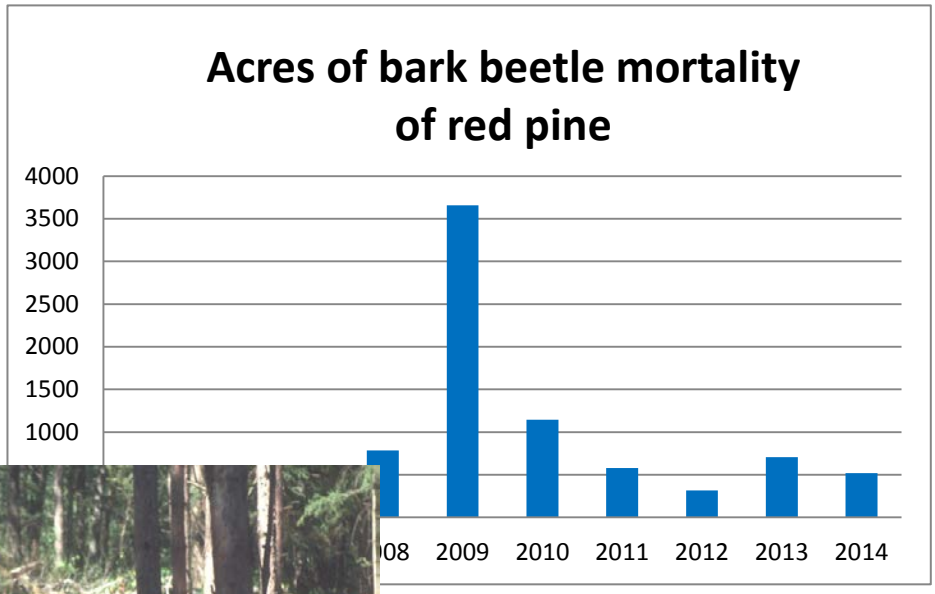
Bark beetles

Ips spp., *Dendroctonus valens*

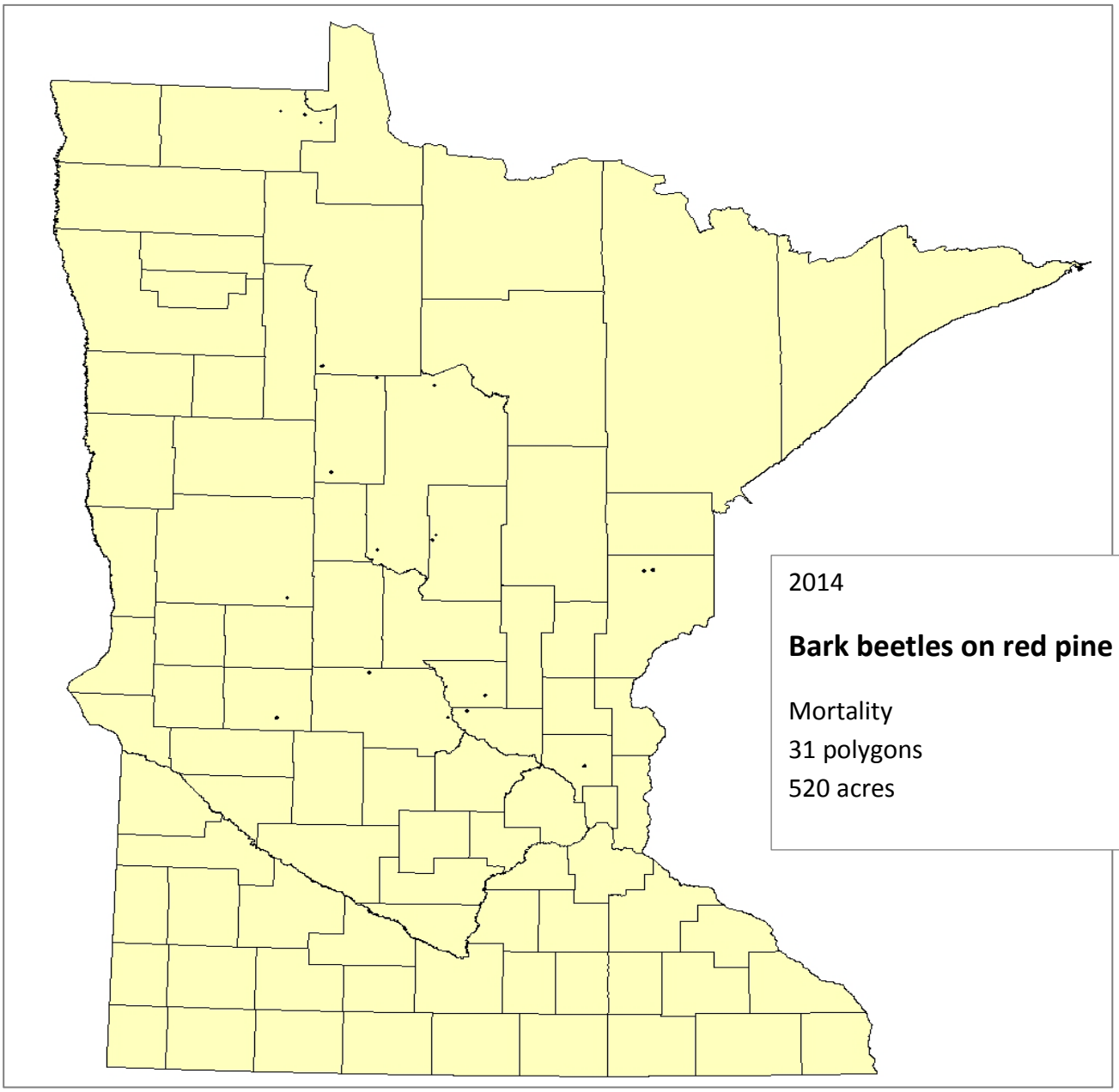
Hosts	Red pine and, rarely, jack and white pines
Setting	Rural forests
Counties	Roseau, Beltrami, Hubbard, Cass, Crow Wing, Ottertail, Pope, Stearns, Benton, Sherburne, Pine, and Anoka
Survey methods	Aerial detection
Acres affected	520 acres in 31 polygons
Damage type	Mortality

Narrative

Mortality decreased from 707 acres last year. Spring weather in 2014 was cool and rainy, discouraging bark beetle survival and subsequent pine mortality. See map on next page.



Fresh slash cut from February through July can attract adults and serve as brood material. The next generations attack the standing trees. DNR photo.


2014
Bark beetles on red pine
Mortality
31 polygons
520 acres

Eastern larch beetle

Dendroctonus simplex

Hosts	Tamarack
Setting	Rural forests
Survey methods	Aerial survey
Acres affected	42,305 acres on 1841 polygons
Damage type	Mortality

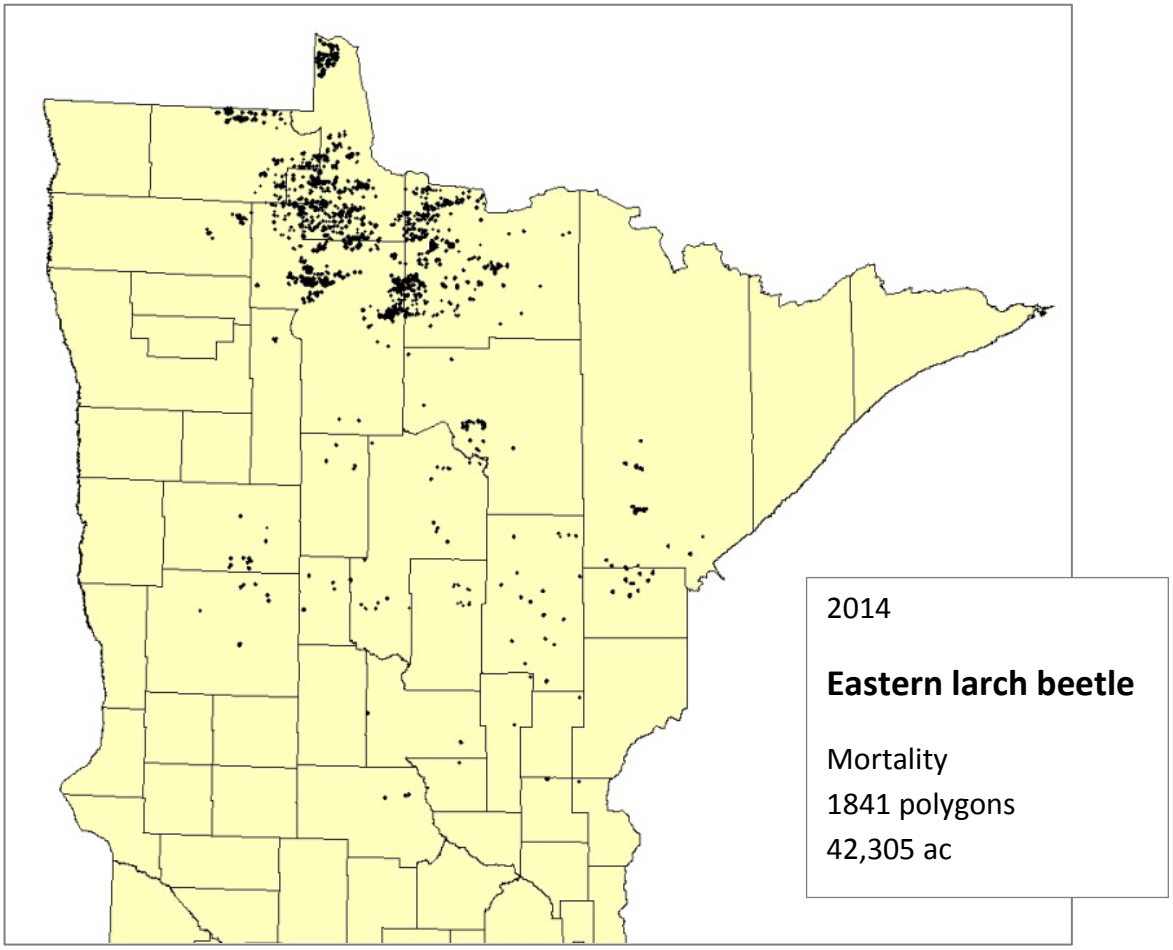
Larch beetle galleries under bark. DNR photo

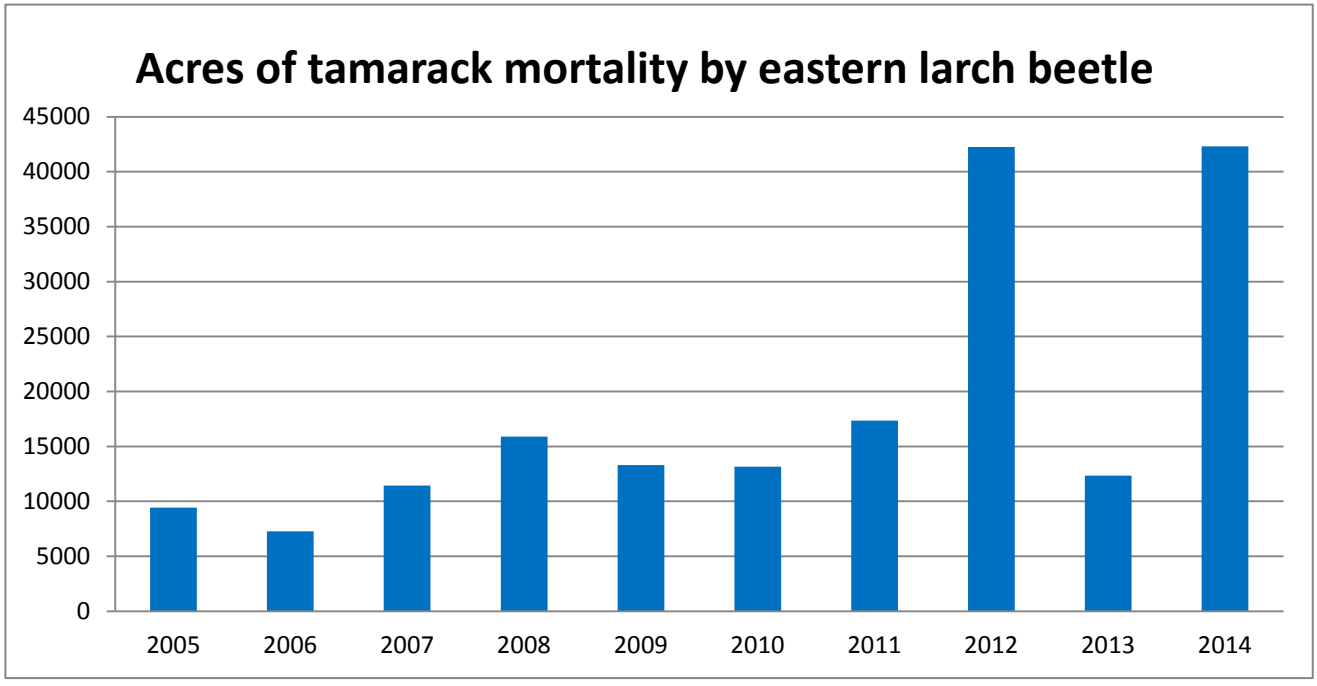
Narrative

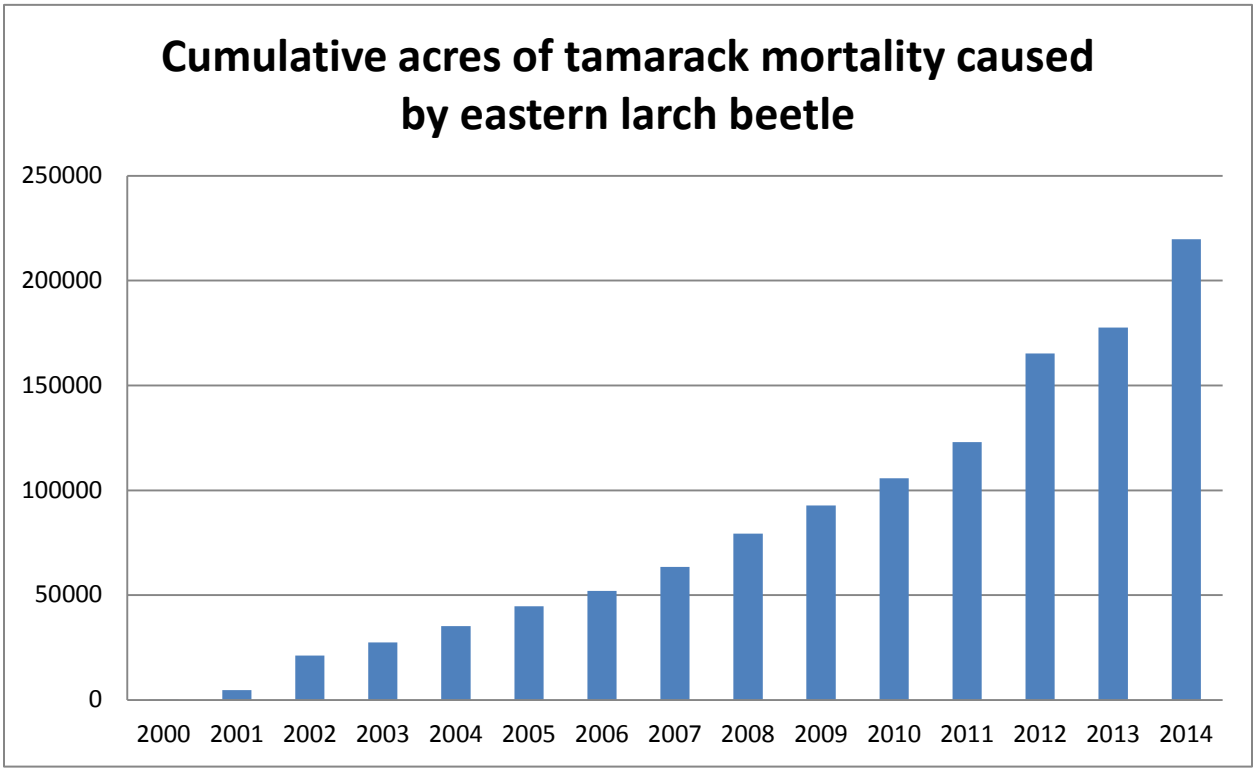
This is the fifteenth consecutive year of the first recorded outbreak of eastern larch beetle (ELB) in Minnesota. As of this year, 21.5 percent of the tamarack covertype on all ownerships has extensive to complete mortality due to larch beetle attack. See photo, map and charts on next page.

Fraser McKee and Brian Aukema, researchers at the University of Minnesota, Dept. of Entomology, have studied many aspects of insect biology and ecology of this outbreak. Here are some of their published findings:

- This outbreak has no known biotic predisposing factor such as extensive defoliation. Trends of recent climate warming, however, are suspected to be a contributing factor.
- Preliminary results show that within the current outbreak there is an increase in the rate of mortality following successive years of drought, with highest mortality occurring in areas with the most severe, prolonged drought.
- Probability of tamarack mortality from ELB was significantly negatively correlated to diameter, crown ratio, stand age, and stand basal area, and positively correlated to height.
- Researchers recorded development and emergence of brood adults:
    - Brood adults began emerging from natal trees in late summer and proceeded to successfully attack, colonize, and establish a new cohort that survived to adulthood in healthy tamaracks.
    - This finding indicates a shift in voltinism from one to two generations per year, not previously noted in the literature.
    - Multi-voltinism by the by the eastern larch beetle may be one mechanism by which the current outbreak in Minnesota is being sustained.
- Models indicated that tamarack mortality due to ELB increased when:
    - the first frost-free day occurred in late spring the previous year, and
    - the first day < 10 degrees C occurred in late spring of the current year.
- These patterns likely reflect synchronous emergence of beetles and attack of tamarack with frozen root systems.


2014
Eastern larch beetle
Mortality
1841 polygons
42,305 ac


Acres of tamarack mortality by eastern larch beetle
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014



Aerial view of recent (yellow) and old (grey) mortality of tamarack by larch beetle.
Photo by Fraser McKee, Univ of Minnesota

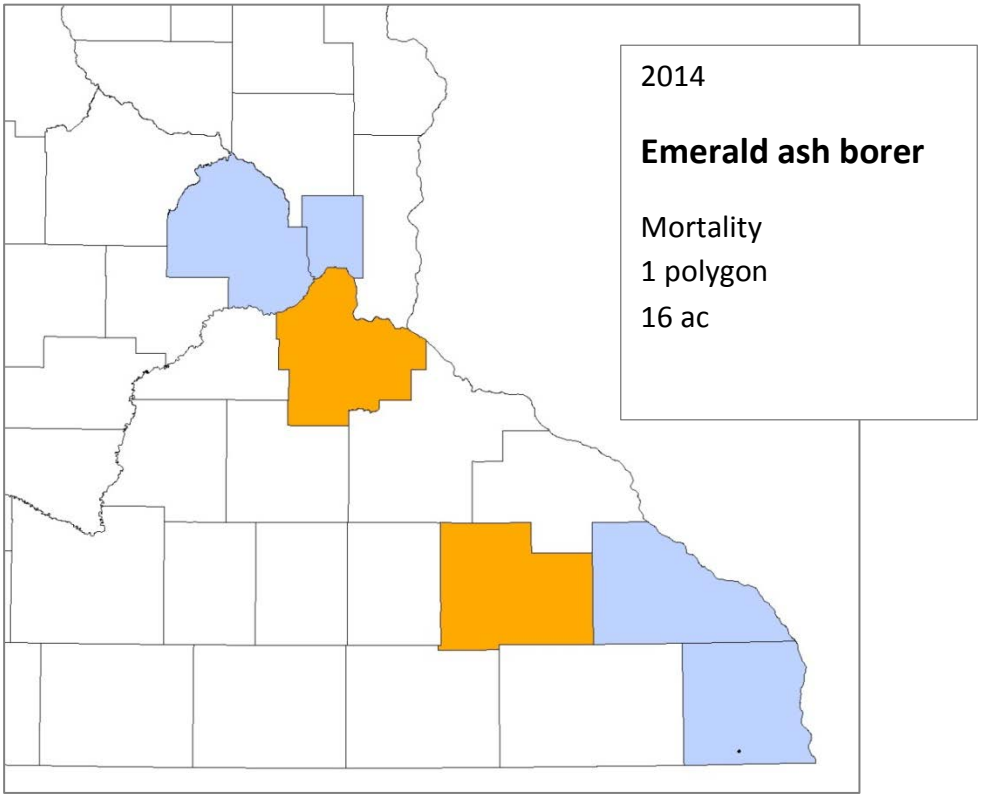
Emerald ash borer

Agrilus planipennis

Hosts	Ash species
Setting	Urban and rural forests
Counties	Olmsted, Hennepin, Ramsey, Winona, Houston
Survey methods	Ground survey and aerial survey
Acres affected	16 acres in Houston Co. mapped from the air
Damage type	Mortality

Narrative

Emerald ash borer (EAB) was discovered in two new counties (Olmsted and Dakota) in Minnesota during 2014, bringing the total number of known EAB-infested counties to six. The initial Olmsted County find south of Rochester was made in August after a report of declining ash trees. Shortly after that, another confirmation of EAB was made five miles to the north and just outside Rochester city limits. The initial find in Dakota County occurred in late December and was located across the Mississippi River from another infestation in Hennepin County. These finds resulted in emergency quarantines for EAB in Olmsted and Dakota counties by the Minnesota Department of Agriculture (MDA). After a comment period and public hearing, the emergency quarantines became part of the formal state quarantine for EAB in early January 2015 that already includes Hennepin, Houston, Ramsey, and Winona counties.



In addition to the discovery of EAB in a two new counties, there were also a number of new detections in counties already known to be infested – particularly

in the southeastern counties of Houston and Winona. In rural areas of eastern Winona County and throughout Houston County EAB has reached tree-killing levels, and rapid decline and death of ash trees not treated with insecticides can be expected. In the Twin Cities, the spread and increase of EAB has been much slower, and while new finds were made during 2014, EAB populations are generally not at tree-killing levels. This difference is likely due to the implementation of management strategies including systemic insecticides and targeted sanitation that are most practical in urban environments.

EAB has not been detected in Duluth yet, despite occurring just across the border in Superior, Wisconsin. MDA and others have worked to monitor Duluth for the presence of EAB using purple traps, visual survey and branch sampling with negative results to date. Sampling efforts in Duluth will continue; the only thing worse than finding EAB is not finding an active infestation with the potential to grow and spread to new areas.

Despite the new EAB detections in 2014, there is reason for optimism. Minnesota has done much better than other states in terms of EAB spread over time. The end of 2014 will mark six years since EAB was first confirmed in Minnesota. When we compare the progression of EAB in all infested states, the average number of counties infested after six years is 31 percent. Minnesota compares favorably with only six of 87 counties (6 percent) infested. Up-to-date results on where EAB is known to occur can always be found at the MDA website. If MDA has confirmed EAB in an area, the data should display on our interactive map within 24 hours.

There are likely a number of factors at play in the slower expansion of EAB in Minnesota. One factor that has received considerable attention is the impact of winter. Workers in Minnesota have studied the impacts of frigid temperatures on overwintering success of EAB larvae for several years; the “polar vortex” of 2013/2014 provided an opportunity to check experimental results against observations under natural conditions. Cold temperatures delivered as predicted, and in the Twin Cities larval mortality as high as 60-70 percent was recorded at some sites. Public concern about the need for continued management efforts against EAB grew due to media attention given to the topic. In response, a publication was drafted to place the potential impact of winter into context and offer some advice on how to incorporate it into a management plan. See “Cold snap is no snow day for emerald ash borer.”

A key component of EAB management in Minnesota cities has been the use of monitoring data to inform management activities. With support from the USDA EAB Parasitoid Rearing Facility in Brighton, Michigan, MDA, the University of Minnesota and Forest Service are halfway through a three-year project funded by the Environmental and Natural Resources Trust Fund to compare the efficacy of different techniques for monitoring EAB including:

- visual searching for EAB symptoms
- removing branches and dissecting to search for EAB life stages
- the use of purple traps to capture EAB adults

Preliminary results from one full year of sampling indicate that visual survey was the most economical technique and branch sampling the most sensitive. All survey techniques were useful in discovering the presence of EAB in areas prior to significant canopy decline, i.e., trees past insecticide rescue treatments. We will see how these trends stay the same or change during the remaining two years of the project.

Management options in rural areas are more limited than in urban areas because tools like insecticides and targeted sanitation are less practical. However, these areas do provide opportunities to introduce biological control agents for EAB such as the parasitic wasps *Tetrastichus planipennisi* and *Oobius agrili*. Again, with the support of the Environmental and Natural Resources Trust Fund, MDA along with partners has worked to introduce and monitor the establishment of these natural enemies of EAB in infested areas, particularly in Winona and Houston Counties. Although it will take a number of years to determine what impact these organisms are having on EAB populations, a promising development was the recovery of adult *T. planipennisi* in Great River Bluffs State Park during 2014, indicating not only that they were establishing in the area but also that they survived polar vortex winter temperatures.

Although two additional Minnesota counties are now quarantined for EAB, there are a number of positive developments in the ongoing work against EAB. Establishment of biological control agents, new information on the efficacy of monitoring for EAB, documentation of the impact of cold temperatures on EAB, and evidence that EAB has spread more slowly in Minnesota than elsewhere in the U.S. are all cause for optimism. In 2015, work in Minnesota will continue to slow the spread and impact of EAB as the EAB problem likely has many years left in which it will play out.

Forest tent caterpillar (FTC)

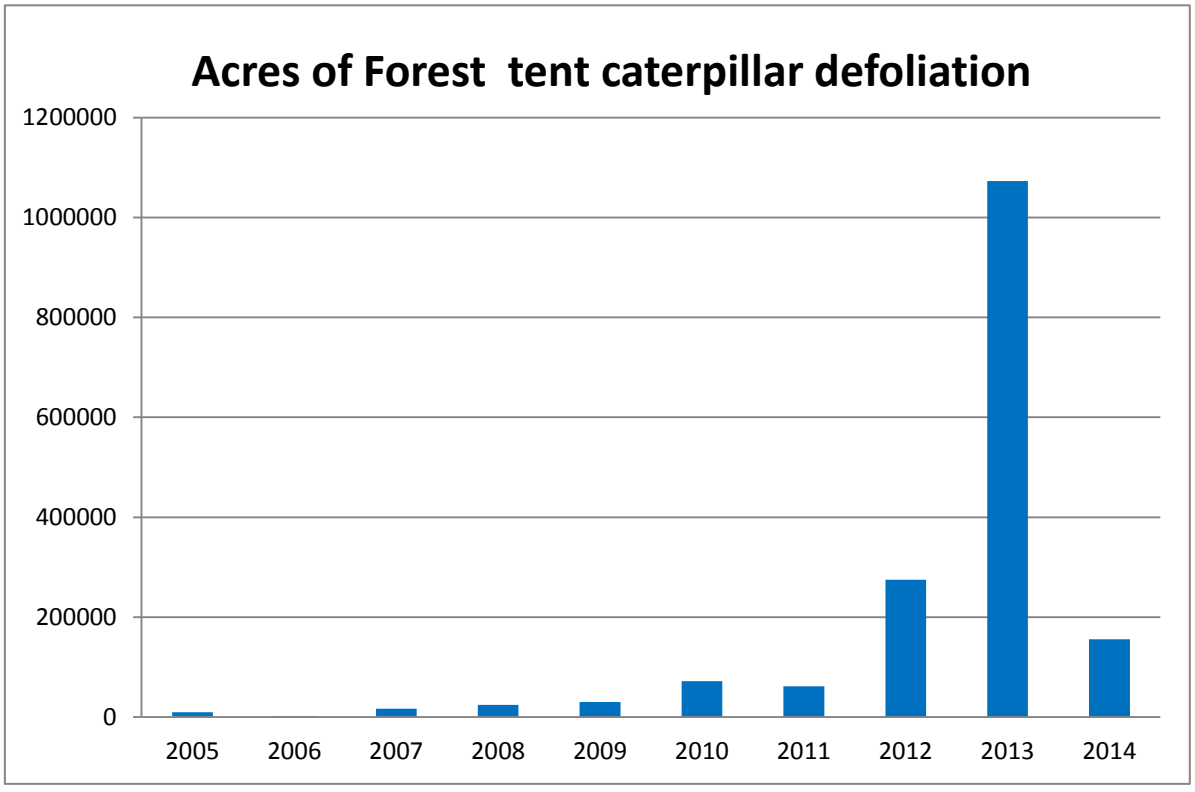
Malacosoma disstria

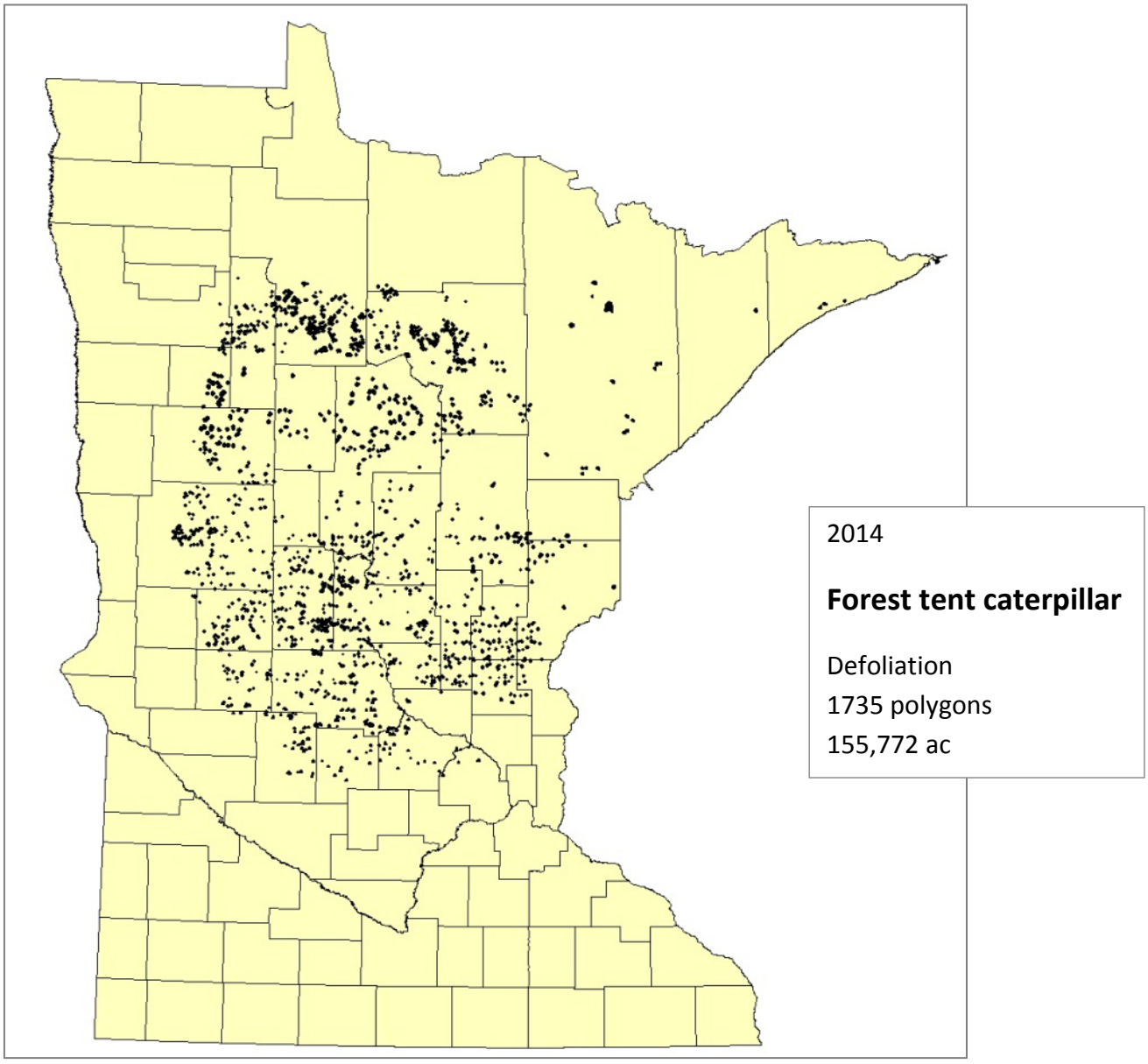
Parasitized FTC pupa inside the cocoon; see dark brown spot on pupa. DNR photo.

Hosts	Aspen, oak, basswood, birch, willow, tamarack, and other hardwoods
Setting	Rural forests
Counties	Beltrami, Cass, Crow Wing, Wadena, Hubbard, Becker, Ottertail, Mahnomen, Pennington, Clearwater, Grant, Douglas, Pope, Cook, Lake, St. Louis, Itasca, Aitkin, Carlton, Todd, Morrison, Mille Lacs, Kanabec, Pine, Stearns, Benton, Sherburne, Isanti, Chisago, Swift, Kandiyohi, Meeker, Wright
Survey methods	Aerial and ground survey
Acres affected	155,772 acres on 1735 polygons
Damage type	Defoliation was predominantly “very light” (less than 25 percent of canopy impacted).

Narrative

We were expecting the FTC outbreak to peak at two to four million acres of defoliation this year based on past outbreak patterns, but sketch-mappers only mapped 156,000 acres. We surmised that FTC populations crashed during larval or pupal development in 2013, as very few egg masses were found during ground survey in preparation for 2014 defoliation predictions.




2014
Forest tent caterpillar
Defoliation
1735 polygons
155,772 ac

Gypsy moth

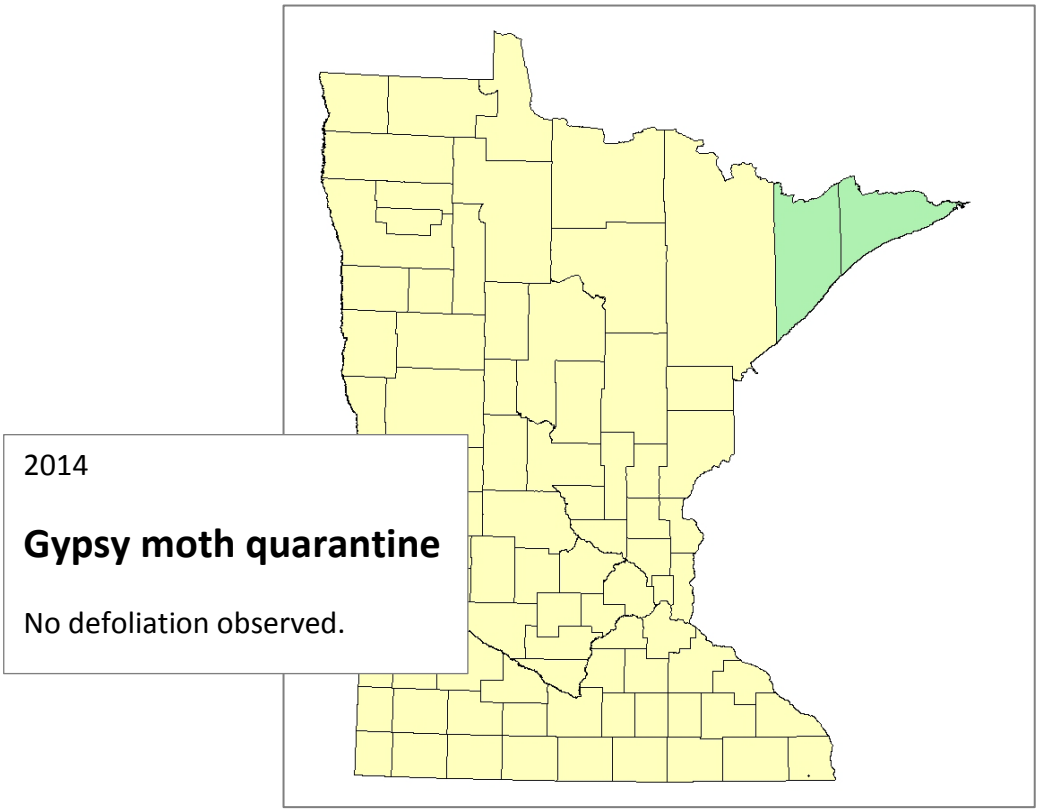
Lymantria dispar

Hosts	Oak, aspen and other hardwoods
Setting	Rural and urban forests
Counties	Cook and Lake
Survey methods	Ground male moth trapping and ground survey
Acres affected	None
Damage type	No defoliation observed

Narrative

The Minnesota Department of Agriculture instituted the first gypsy moth quarantine on July 1, 2014 in Lake and Cook Counties, based on last year's trap catches, life stages found, and population estimates. Trapping in 2013 produced over 70,000 male moths, nearly three times that of the year with the next highest total. Based on the number of moth catches, alternate life stages found and the recommendations of GMSEC and national STS program leaders, Cook and Lake Counties were quarantined as of July 2014.

Traps in 2014 caught just over 500 moths. A combination of the extremely cold winter and the wet spring is believed to be the cause of the sharp drop in numbers. No treatments are planned for the North Shore in 2015. One Btk treatment is planned for Oak Grove in the metro area where egg masses were found.



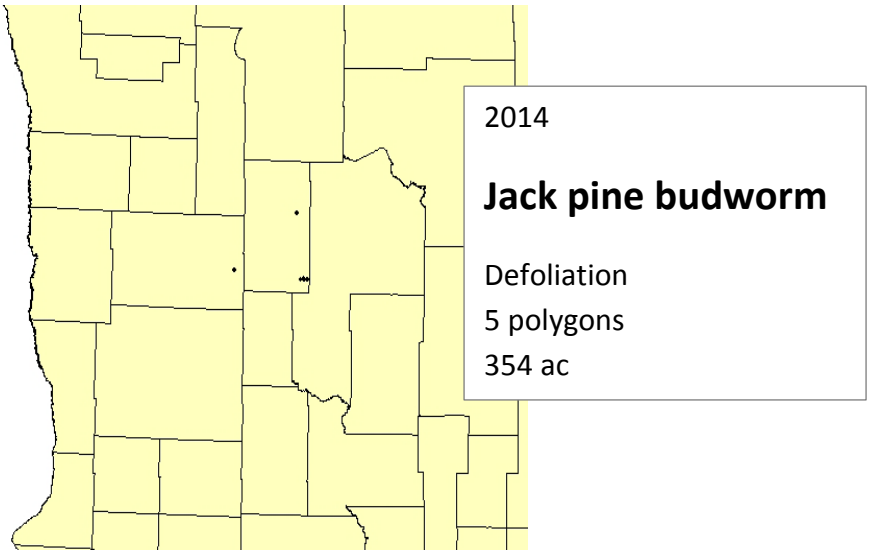
Jack pine budworm

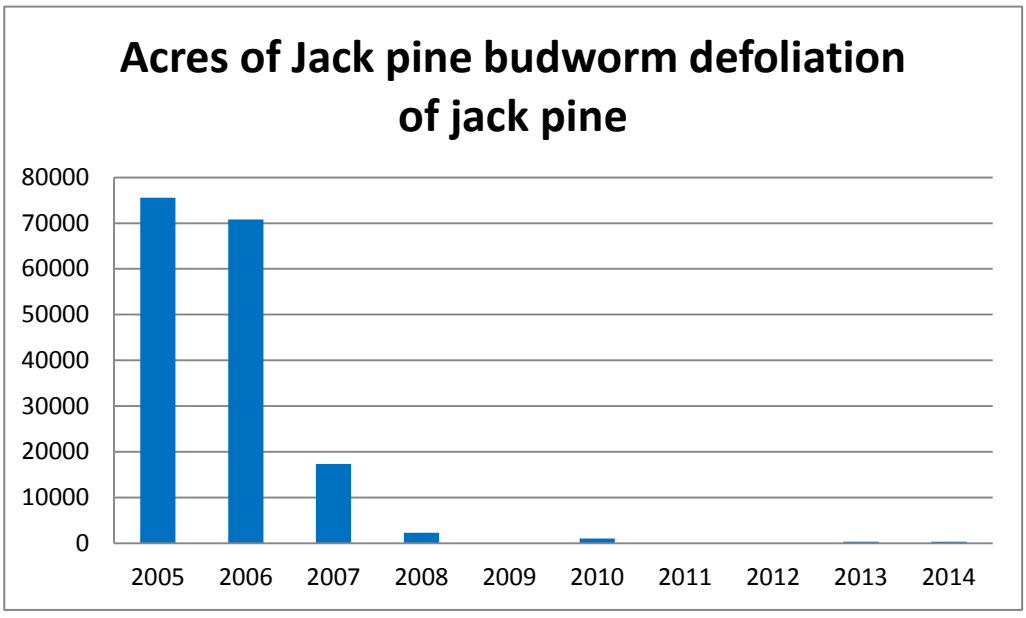
Choristoneura pinus pinus

Hosts	Jack and red pine
Setting	Rural forests
Counties	Hubbard and Ottertail
Survey methods	Aerial survey
Acres affected	354 acres on five polygons
Damage type	Defoliation

Narrative

We have had very little defoliation caused by jack pine budworm since 2007. This year there were 20 more acres than last year, but two more locations were mapped. This population is expected to build over the next few years, primarily in jack pine.





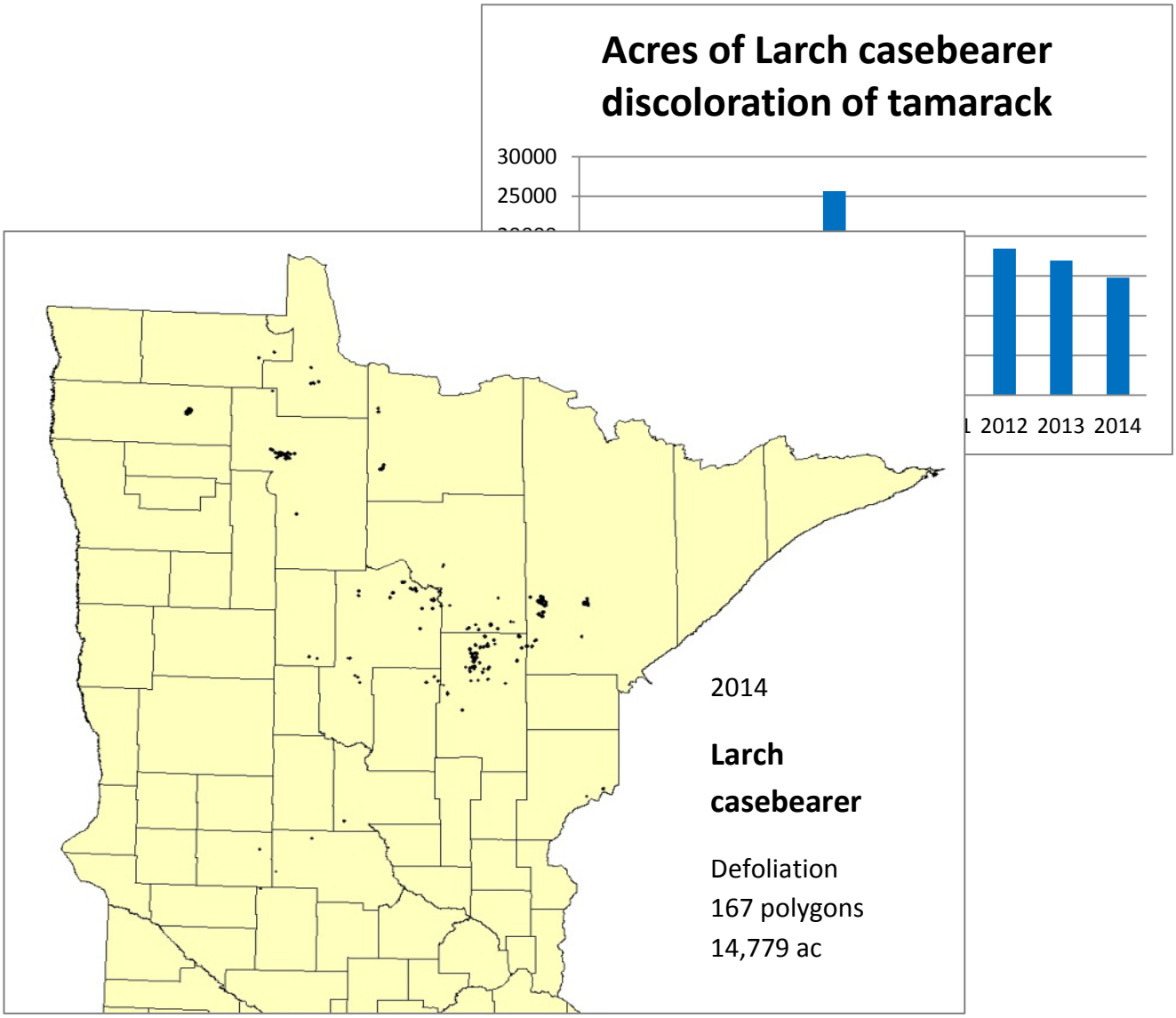
Larch casebearer

Coleophora laricella

Hosts	Tamarack
Setting	Rural forests
Counties	Roseau, Beltrami, Cass, Crow Wing, Hubbard, Becker, Lake of the Woods, Marshall, Clearwater, Pope, Koochiching, St. Louis, Itasca, Aitkin, Pine, Morrison, Stearns, Kandiyohi
Survey methods	Aerial survey
Acres affected	14,779 acres on 145 polygons
Damage type	Discoloration

Narrative

Casebearer feeding activity on tamarack foliage caused the needles to discolor. Acreage in 2014 was down 2000 acres compared to last year but there are 20 more stands with damage.



Large aspen tortrix

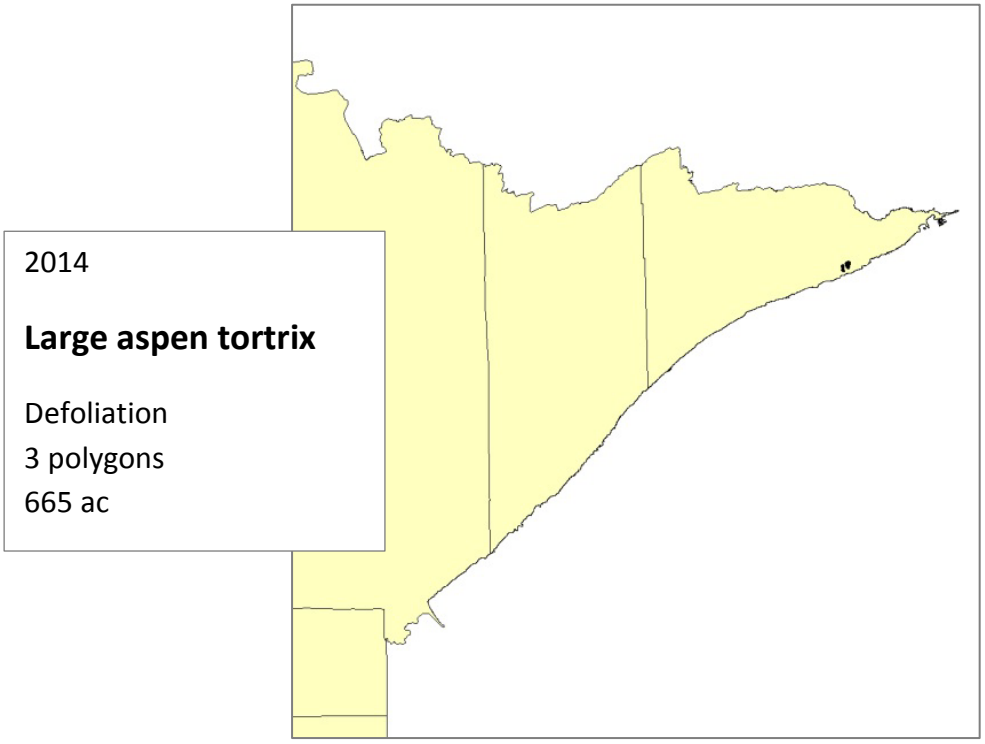
Choristoneura conflictana

Hosts	Aspen
Setting	Rural forests
Counties	Cook
Survey methods	Aerial and ground survey
Acres affected	2,552 acres on five polygons
Damage type	Defoliation

Narrative

Large aspen tortrix is an early season defoliator of trembling aspen. Small areas of defoliation were observed in Lake County in 2012 and 2013. In 2014, 665 acres of defoliation were mapped in Cook County.

Large outbreaks of large aspen tortrix have occurred in northeastern Minnesota in the past. One million acres were defoliated in 1969 in an outbreak that lasted from 1969 through 1972. The last recorded outbreak in NE Minnesota was in 1999 when 336,000 acres of defoliation were mapped primarily along the north shore of Lake Superior.



Spruce budworm

Choristoneura fumiferana

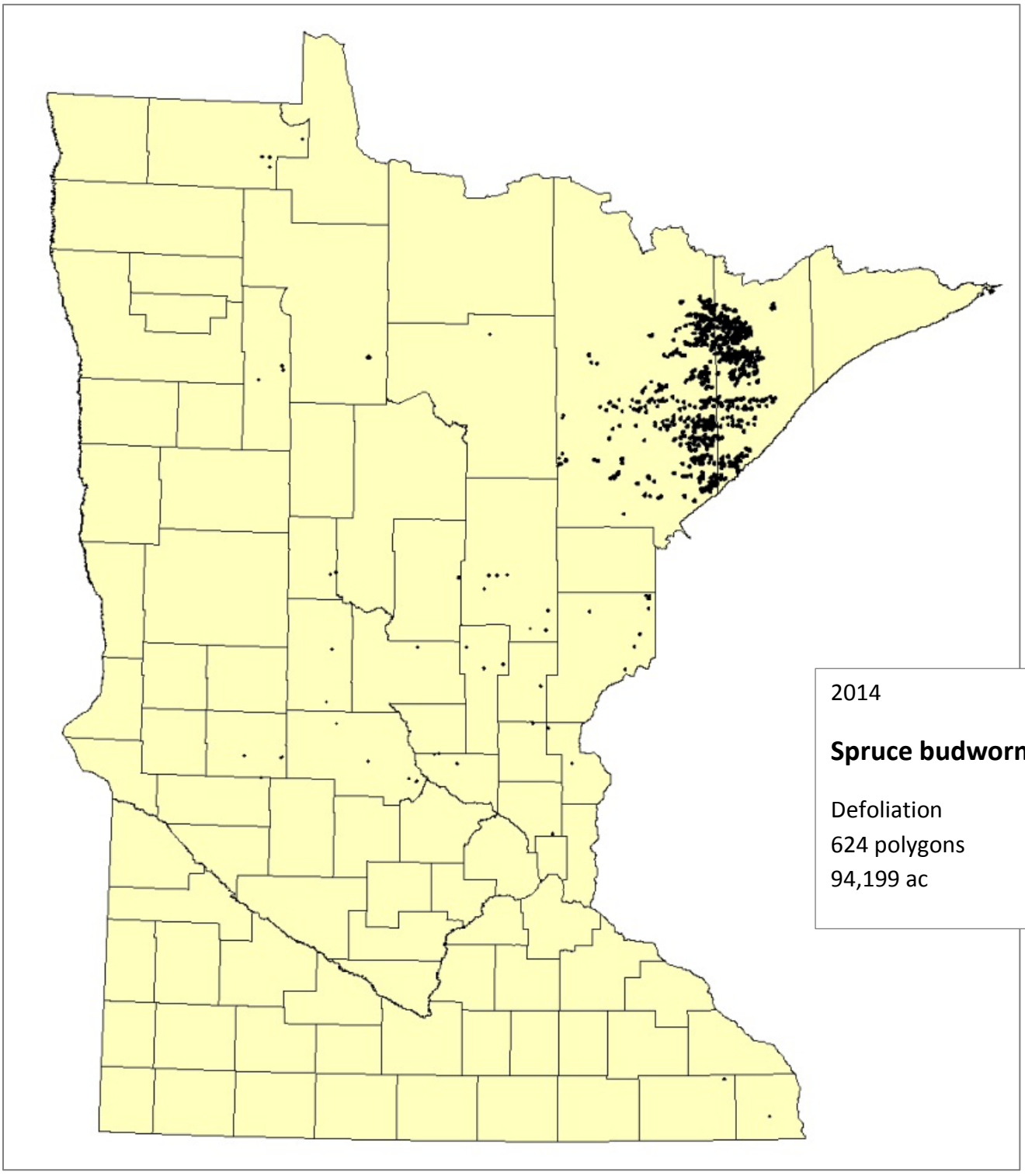
Hosts	Balsam fir and white spruce
Setting	Rural forests
Counties	Roseau, Beltrami, Clearwater, Hubbard, Becker, Wadena, Crow Wing, Pope, Lake, St. Louis, Itasca, Aitkin, Pine, Chisago, Isanti, Mille Lacs, Kanabec, Sherburne, Stearns, Todd, Swift
Survey methods	Aerial survey
Acres affected	94,199 acres on 624 polygons
Damage type	Defoliation. No mortality was mapped this year.

Narrative

A continuous population of spruce budworm has occurred in northeastern Minnesota since 1954. Acres of defoliation increased to 94,199 acres in 2014, up from 38,029 acres in 2013 (map on following page). There was a significant shift in the area defoliated to the east and south this year. We expect spruce budworm defoliation to occur in this location for many years, causing extensive mortality of balsam fir.

Small acreages of defoliation began near Two Harbors in Lake County and in extreme southeastern St. Louis County in 2010 and defoliation has increased since. Heavy defoliation occurred this year in Cloquet Valley State Forest. The last outbreak in this state forest occurred from 1974 through 1986. Defoliation also occurred this year in Finland State Forest. The last outbreak there occurred from 1969 through 1986. It has been roughly 28 years since these areas last experienced defoliation by spruce budworm.

Spruce budworm defoliation and mortality was centered around Lake Vermillion in northern St. Louis County from 2002 through 2013, and although no defoliation occurred around Lake Vermillion this year, balsam fir mortality continues.


2014
Spruce budworm
Defoliation
624 polygons
94,199 ac

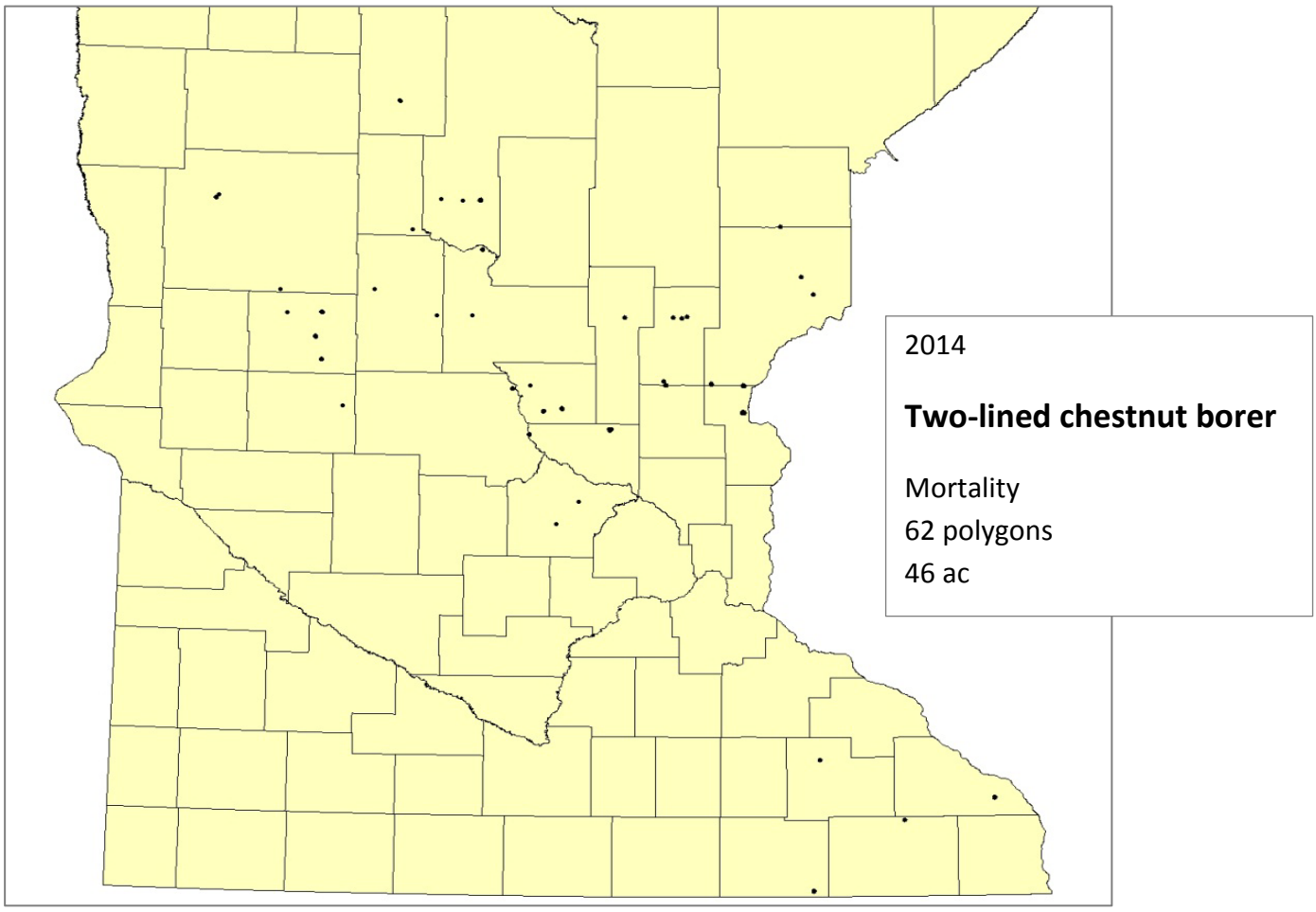
Two-lined chestnut borer

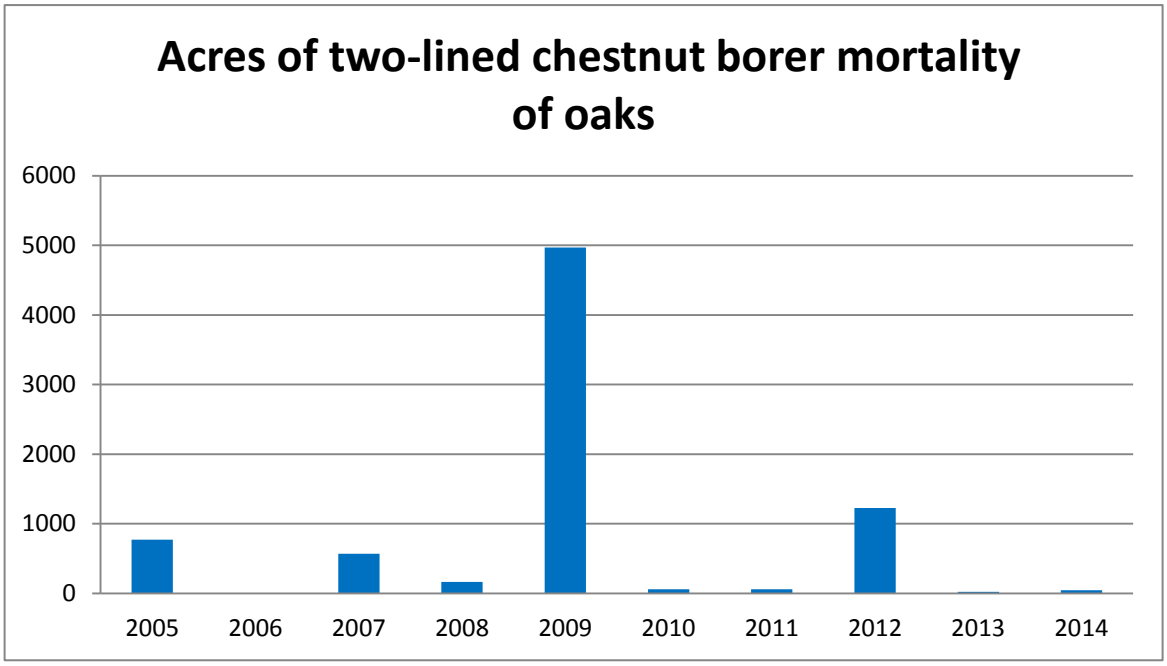
Agrilus bilineatus

Hosts	Oaks
Setting	Rural forests
Counties	Hubbard, Becker, Cass, Ottertail, Douglas, Pope, Carlton, Todd, Morrison, Mille Lacs, Kanabec, Pine, Benton, Isanti, Chisago, Benton, Wright, Stearns, Olmsted, Winona, Mower, Fillmore, Houston.
Survey methods	Aerial survey
Acres affected	46 acres on 62 polygons.
Damage type	Mortality

Narrative

Two-lined chestnut borers attack and kill oaks stressed by drought, defoliation or root damage. Compared to last year, both the acreage of mortality and the number of polygons doubled and the number of affected counties more than doubled.





TLCB attacks in upper crown and resulting partial mortality. DNR photo.

TLCB-killed red oak during a drought. DNR photo.

Bur oak blight

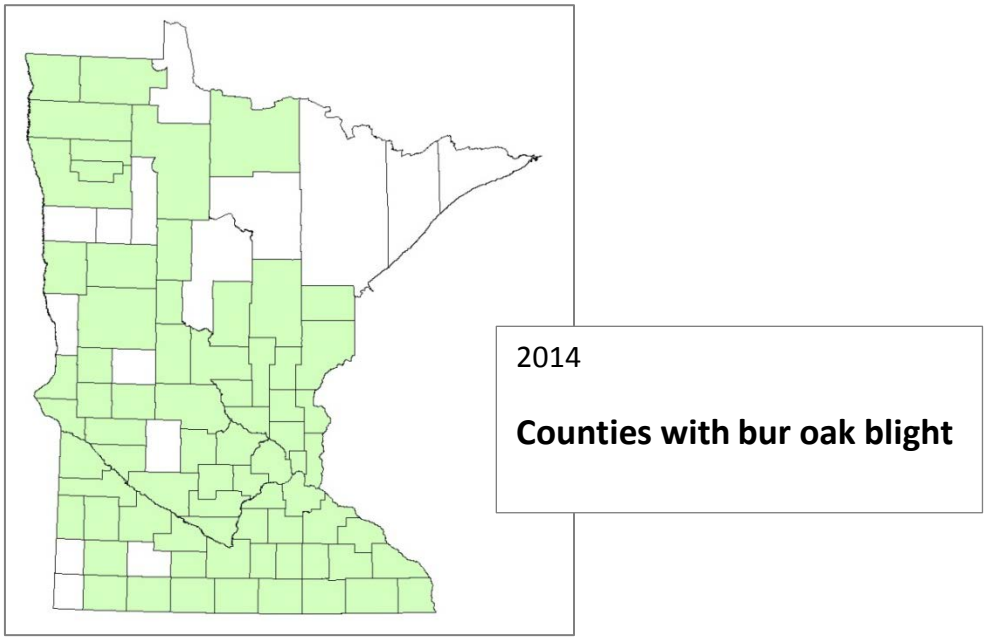
Tubakia iowensis

Bur oak blight. DNR photo. [1]

Hosts	Bur oak
Setting	Rural and urban forests
Counties	*New county records*: Dodge, Benton, Todd, Wadena, Yellow Medicine, Lincoln, Lyon, Murray, Nobles, Jackson, Watonwan, Martin, Chippewa, Pine, Traverse, Stevens, Grant, Carlton, Swift, Clay, Red Lake, Kittson, Roseau, Aitkin, Crow Wing, Koochiching. *Previously determined*: Beltrami, Ottertail, Marshall, Pennington, Pope, Morrison, Mille Lacs, Stearns, Sherburne, Isanti, Chisago, Wright, Hennepin, Anoka, Ramsey, Washington, McLeod, Carver, Dakota, Sibley, Olmsted, Mower, Lac Qui Parle.
Survey methods	Ground surveys to ascertain presence of pathogen
Acres affected	Unknown
Damage type	Leaf discoloration and defoliation; twig dieback

Narrative

Bur oak blight (BOB) was commonly seen in Minnesota again in 2014. Twenty-six new counties were added in 2014 to the above list of counties known to have BOB. Conditions in April and May during leaf emergence were wetter than the 30-year average over much of bur oak's range in Minnesota, which has been the case each spring since 2011. These moist conditions favor leaf infection by the fungal pathogen that causes BOB, so the occurrence of BOB was expected. Areas of central Minnesota had noticeably higher BOB incidence and severity than other parts of the state, such as southeastern Minnesota.



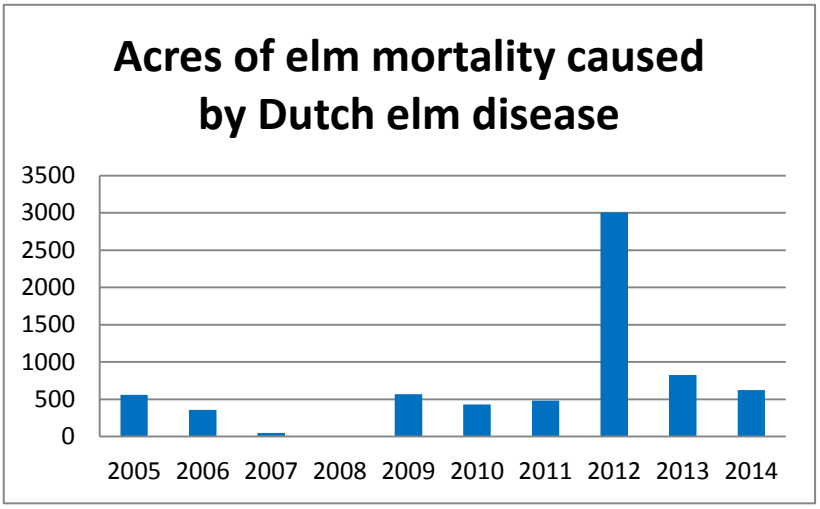
Dutch elm disease

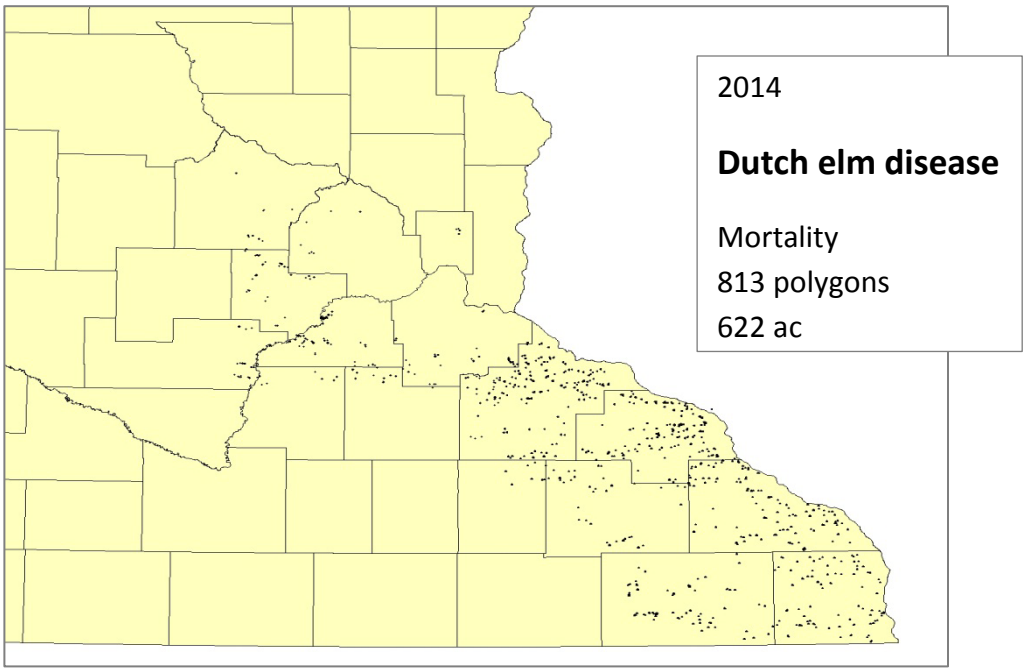
Ophiostoma ulmi

Hosts	American and red elms
Setting	Rural forests
Counties	Wright, Hennepin, Ramsey, Carver, Sibley, Scott, Dakota, Le Sueur, Rice, Goodhue, Wabasha, Dodge, Olmsted, Winona, Fillmore, Houston.
Survey methods	Aerial survey
Acres affected	622 acres in 813 polygons
Damage type	Discoloration and mortality

Narrative

Acreage observed in 2014 is down by 200 acres and the incidence is down by 26 percent compared to 2013.





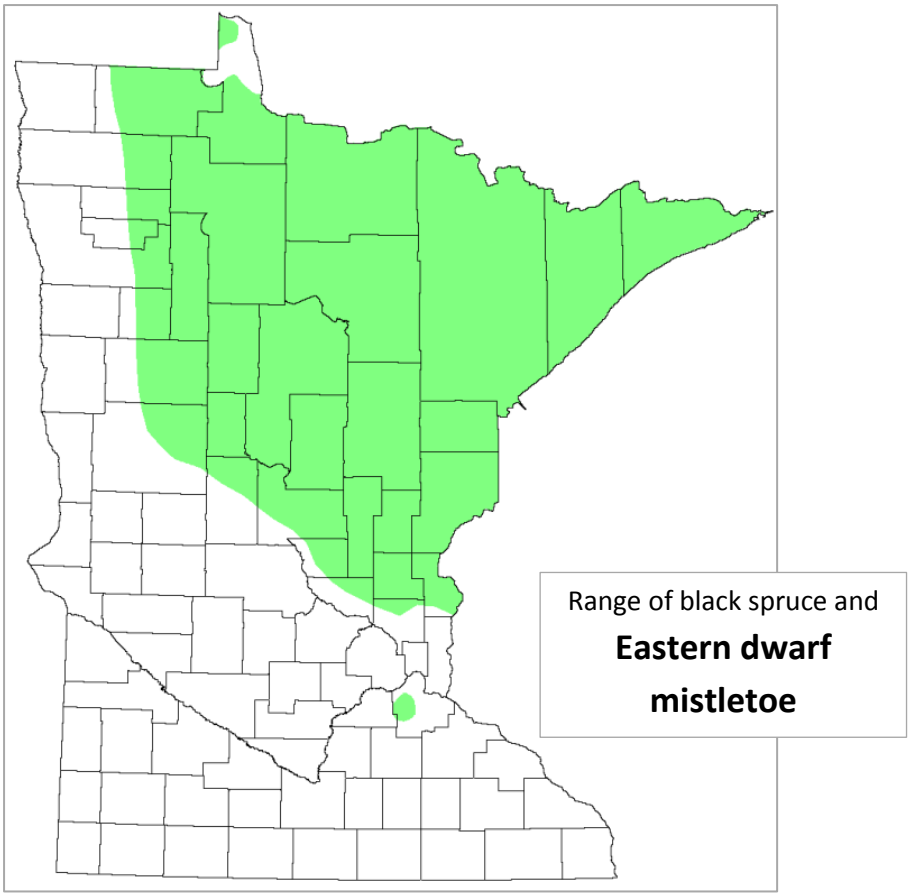
Eastern dwarf mistletoe

Arceuthobium pusillum

Hosts	Black spruce, rarely, white spruce and tamarack
Setting	Rural forests
Counties	Beltrami, Cass, Crow Wing, Wadena, Hubbard, Becker, Ottertail, Lake of the Woods, Roseau, Mahnomen, Marshall, Pennington, Red Lake, Clearwater. Cook, Lake, St. Louis, Itasca, Aitkin, Carlton, Todd, Morrison, Mille Lacs, Kanabec, Pine, Benton, Sherburne, Isanti, Chisago, Anoka, Dakota
Survey methods	Ground observations
Acres affected	Unknown. The literature suggests 11-55 percent of the cover type is infested.
Damage type	Mortality

Narrative

Eastern dwarf mistletoe is a native disease and is always fatal. The primary host is black spruce and there are approximately 1,551,000 acres of black spruce in the state. Losses are not spread equally over the forest. Infections occur in un-merchantable stands and along stand edges where it has been active for decades or centuries and in new infection centers that are roughly circular. Losses are estimated to be less than 2 percent of the cover type area each year.



Heterobasidion root disease

Heterobasidion irregulare

Hosts	Pine, balsam fir, eastern red cedar and other trees and shrubs
Setting	Pine plantations
Counties	Winona
Survey methods	Ground survey
Acres affected	1/10 acre in a red pine plantation
Damage type	Decreased canopy vigor and mortality

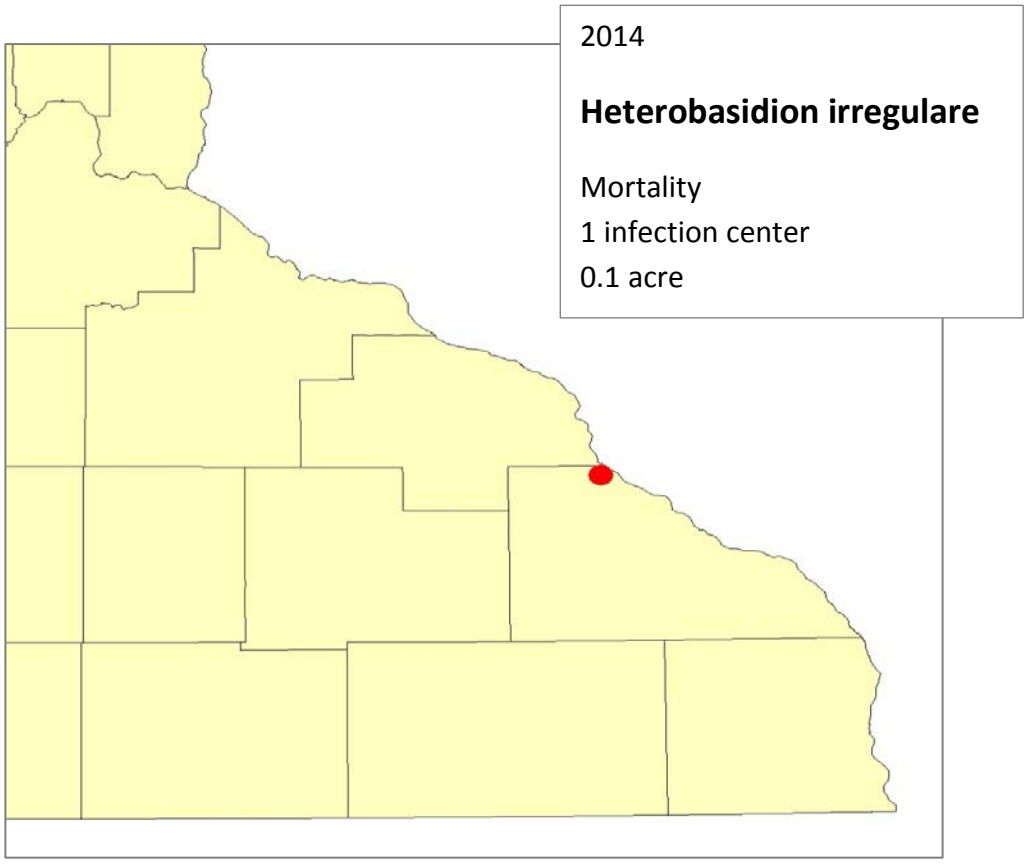
Narrative

Dr. Robert Blanchette, University of Minnesota Forest Pathologist, made the first confirmed discovery of Heterobasidion root disease (HRD) in Minnesota in mid-November 2014. Blanchette's lab isolated the fungus from a dead red pine root in northern Winona County on state land, two miles southwest of Minneiska. They confirmed the identity of the fungus through culturing, DNA sequencing, and fruiting body identification. The nearest known confirmed HRD site to this site is roughly 28 miles northeast in Trempealeau County, Wisconsin.

HRD has killed four neighboring pines at the Winona Co. site, and approximately 10 other adjacent red pines have crowns with reduced vigor. The infection likely occurred during the previous thinning in December 2003. Weather conditions during that month were unusually warm (highs commonly reached 40°F) with no snow cover. Such conditions make infection by Heterobasidion likely if spores are present. The spore source is unknown, but surveys in 2015 by DNR and University personnel will determine if other HRD infections occur in southeast Minnesota. Spores may have come from nearby infected trees, from the Trempealeau County location, or from contaminated logging equipment.

This is the third detection of Heterobasidion species in the state, but it is the first official confirmation of disease. Two Heterobasidion species conks (i.e. shelf fungi) were collected from conifers in Itasca State Park in 1970 and 1979. Their species identity has not been confirmed to date by DNA sequencing

Heterobasidion conks on old, cut stump. DNR photo.



First confirmed report of *Heterobasidion irregulare* in Minnesota

Oak wilt

Ceratocystis fagacearum

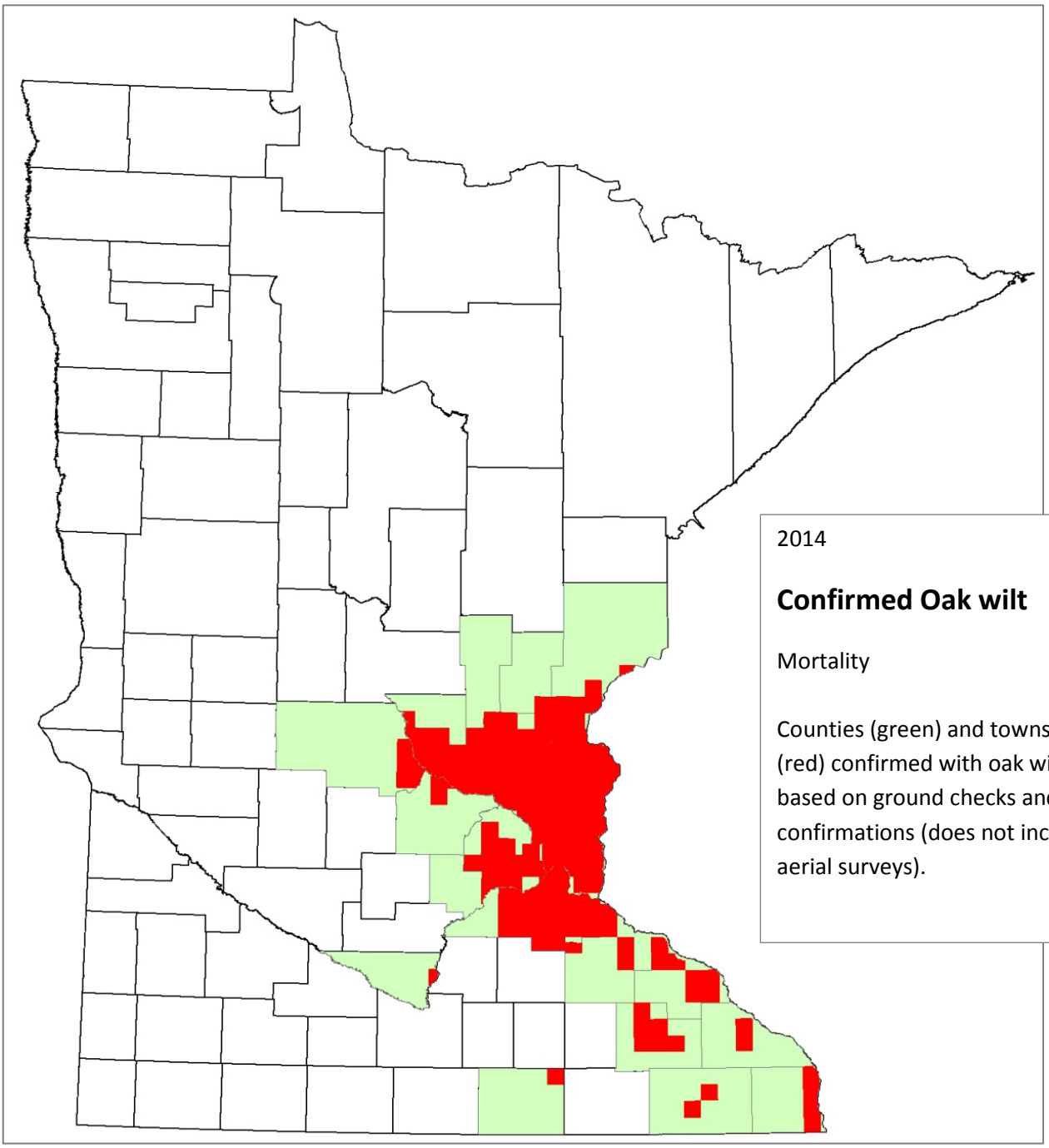
Hosts	Oaks
Setting	Rural and urban forests
Counties	Mille Lacs, Kanabec, Pine, Stearns, Benton, Sherburne, Isanti, Chisago, Wright, Hennepin, Anoka, Ramsey, Washington, Carver, Scott, Dakota, Goodhue, Wabasha, Olmsted, Winona, Houston, Fillmore, Freeborn, Nicollet
Survey methods	Ground surveys and University of Minnesota Plant Disease Diagnostic Lab results
Acres affected	Not determined
Damage type	Mortality

Narrative

Oak wilt symptoms were noticeably more abundant on bur oaks in 2014 than in previous years. DNR aerial surveyors identified over 1,900 oaks in Minnesota that showed active symptoms of oak wilt, comparable to previous years. Freeborn and Nicollet counties were confirmed to have oak wilt for the first known time by the University of Minnesota Plant Disease Diagnostic Clinic. Following is a list of counties where oak wilt is widespread and relatively abundant: Anoka, Chisago, Dakota, Hennepin, Isanti, Olmsted, Ramsey, Sherburne, and Washington.

The northernmost known oak wilt-infected area is in St. Croix State Park in Pine County. Oak wilt is a severe threat to surrounding forests there due to species composition and flat terrain. State park staff in 2014 attempted eradication of several oak wilt infection centers in their campground.

The DNR's forest health unit plans to improve early detection efforts of oak wilt at its northern geographical edge in 2015 with the use of high-resolution aerial photographs and ground investigations. In order to target the leading geographical edge of oak wilt, a finer resolution map of disease distribution was made in 2014. The red townships on the map below contain a confirmed oak wilt tree or pocket. These confirmations were made by DNR personnel or program partners from 1987 through 2006. Due to staff changes and shortages, no oak wilt locations were confirmed between 2007 and 2013. Starting in 2014, tracking and confirming oak wilt locations resumed by DNR regional forest health staff and the University of Minnesota Plant Disease Diagnostic Clinic.



2014

Confirmed Oak wilt

Mortality

Counties (green) and townships (red) confirmed with oak wilt based on ground checks and lab confirmations (does not include aerial surveys).

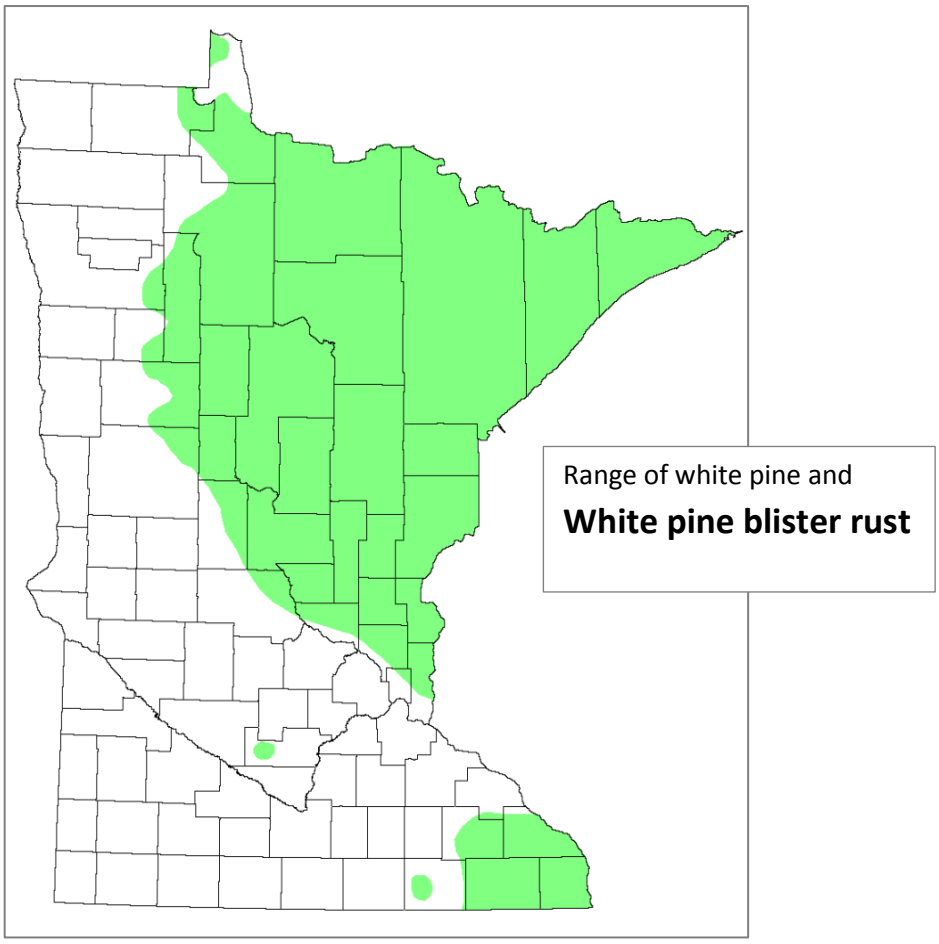
White pine blister rust

Cronartium ribicola

Hosts	White pine
Setting	Rural forests
Counties	Beltrami, Cass, Crow Wing, Wadena, Hubbard, Becker, Ottertail, Lake of the Woods, Roseau, Mahnomen, Marshall, Clearwater, Cook, Lake, St. Louis, Itasca, Aitkin, Carlton, Todd, Morrison, Mille Lacs, Kanabec, Pine, Stearns, Benton, Sherburne, Isanti, Chisago, Anoka, Ramsey, Washington, Sibley, Wabasha, Olmsted, Winona, Mower, Fillmore, Houston
Survey methods	Ground survey
Acres affected	Unknown
Damage type	Decline, dieback and mortality

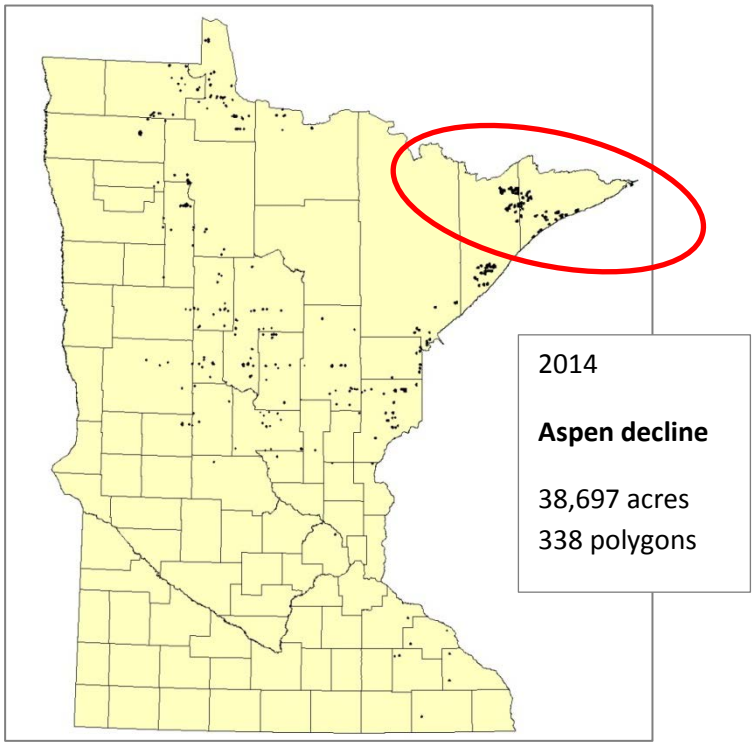
Narrative

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



Aspen decline

Hosts	Trembling and bigtooth aspen
Setting	Rural forests
Counties	Beltrami, Cass, Crow Wing, Wadena, Hubbard, Becker, Ottertail, Lake of the Woods, Roseau, Mahnomen, Marshall, Polk, Pennington, Clearwater, Douglas, Koochiching, Cook, Lake, St. Louis, Aitkin, Carlton, Todd, Morrison, Kanabec, Pine, Stearns, Benton, Mille Lacs, Kanabec, Chisago, Hennepin, Goodhue, Wabasha, Olmsted, Winona, Fillmore.
Survey methods	Aerial survey
Acres affected	38,697 ac on 338 polygons
Damage type	Crown decline, dieback, and mortality. Decline in aspen crowns is reversible with abundant rainfall. Decline ranges from small leaves and discoloration through dieback and top-kill to eventual mortality.
Narrative	We have mapped and studied aspen decline since 2004. Less aspen decline was mapped in 2014 than in the two previous years. Acreage mapped by the aerial survey peaked at just over 400,000 acres in 2005. The main area of concern is within the red oval on the map below. There are a number of reasons for the decrease in acreage in recent years. The first is that the area has received more precipitation. Surviving trees showing symptoms of decline such as small leaves, thin crowns, or off-color foliage are showing fewer symptoms with the return of better moisture conditions.

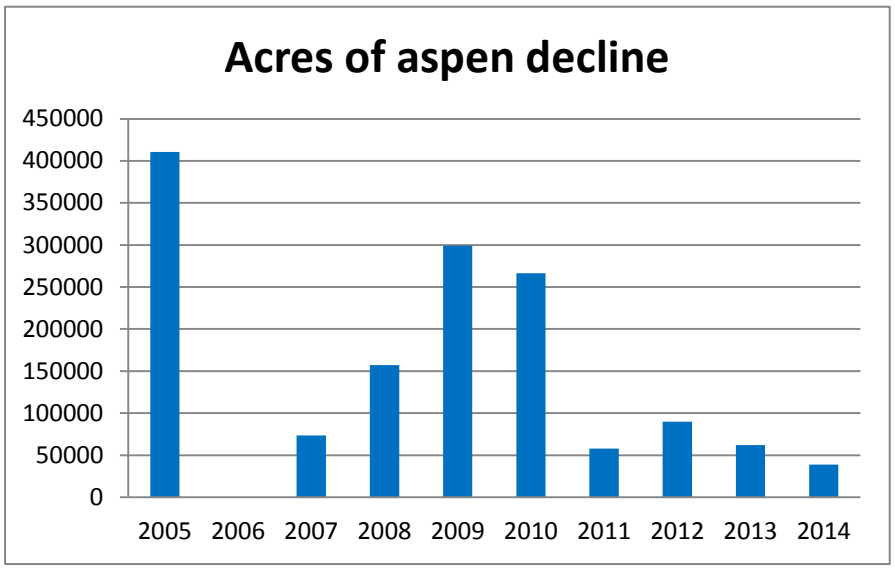


Aspen that has died due to decline fall down quickly after dying (see photos below). As a result, many of the dead trees are no longer standing and are not visible from the air. We now see many surviving trees as well as the understory and regeneration on the sites. Many of the stands no longer have obvious

symptoms of aspen decline. While we're mapping fewer acres, it does not change the amount of tree mortality and growth loss that has already occurred.

The causes of the decline are several. Trees in this portion of the state suffered three to four years of heavy forest tent caterpillar defoliation in the early 2000's. During the 2000's this area also experienced severe drought. This area is on the Canadian shield and many of the sites have very shallow soils over bedrock. Unless they receive a steady supply of moisture through the growing season, trees are stressed by drought very quickly. The stress of defoliation and drought combined made the trees susceptible to attack by bronze poplar borer and Armillaria root disease.

The polygons in the other parts of the state have been less studied and the reason for them being mapped is less clear. It is likely there are a number of different causes on the different polygons in different parts of the state. In some locations, aerial sketch-mappers indicated pockets of trees killed by hypoxylon canker, not aspen decline.



2008 photo of dead aspen on Otter Lake Road in Cook County. DNR photo.

Both photos taken in 2013. Same spot as in 2008 on Otter Lake Road, Cook County. DNR photo.

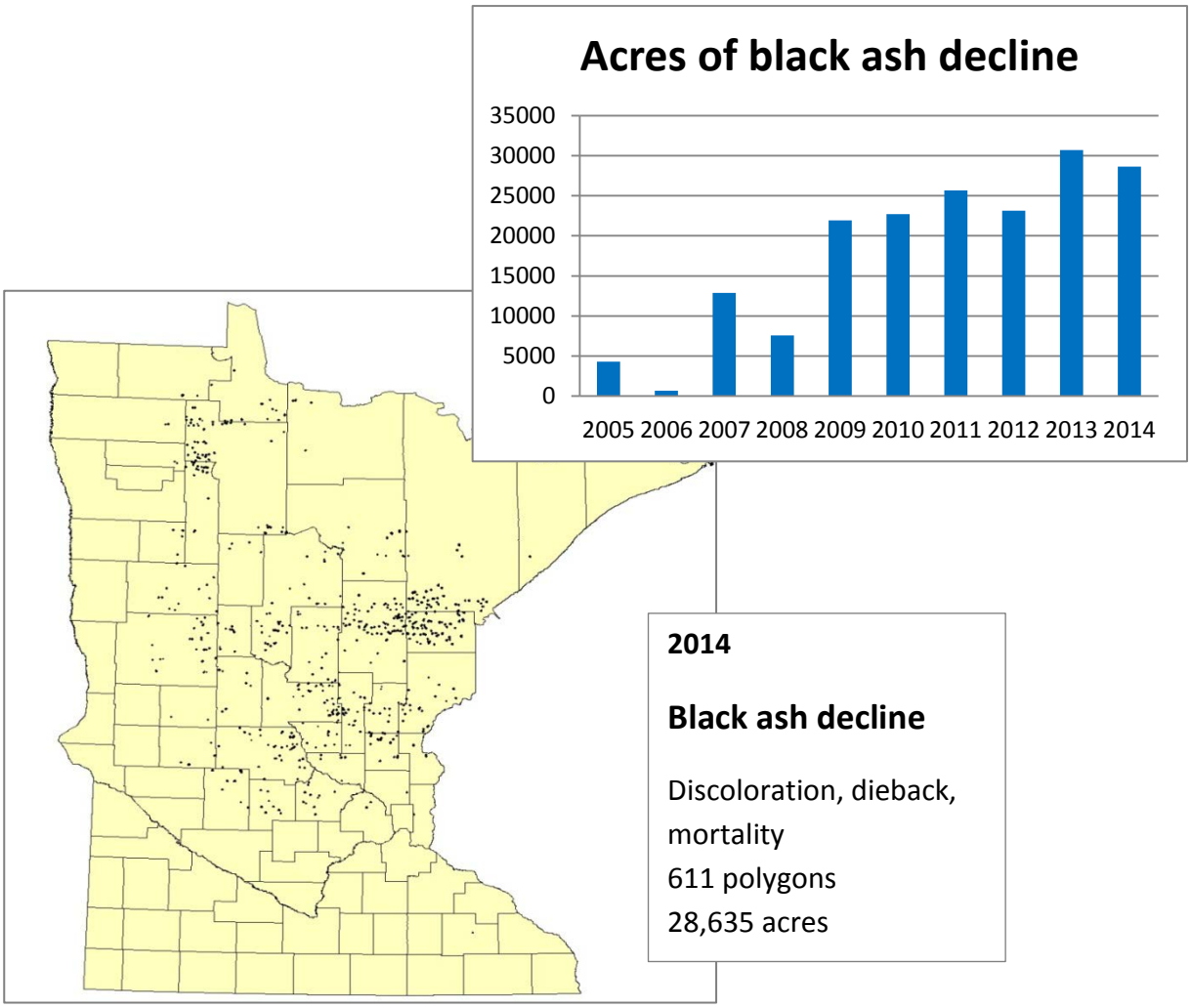
Black ash decline

Physiological problem

Hosts	Black ash
Setting	Rural forests
Counties	Beltrami, Cass, Crow Wing, Wadena, Hubbard, Becker, Ottertail, Lake of the Woods, Polk, Mahnomen, Marshall, Pennington, Clearwater, Douglas, Pope, Lake, St. Louis, Koochiching, Itasca, Aitkin, Carlton, Todd, Morrison, Mille Lacs, Kanabec, Pine, Stearns, Benton, Sherburne, Isanti, Chisago, Kandiyohi, Meeker, Wright, Hennepin, Anoka, Washington, Olmsted.
Survey methods	Aerial survey
Acres affected	28,635 acres on 611 polygons
Damage type	Decline in ash crowns is reversible with the return of favorable growing conditions on the site. Decline ranges from small leaves and discoloration through dieback and top kill to eventual mortality.

Narrative

Acreage decreased slightly, but number of sites decreased by over 100 compared to last year. The trend is stabilizing around 25,000 acres per year.

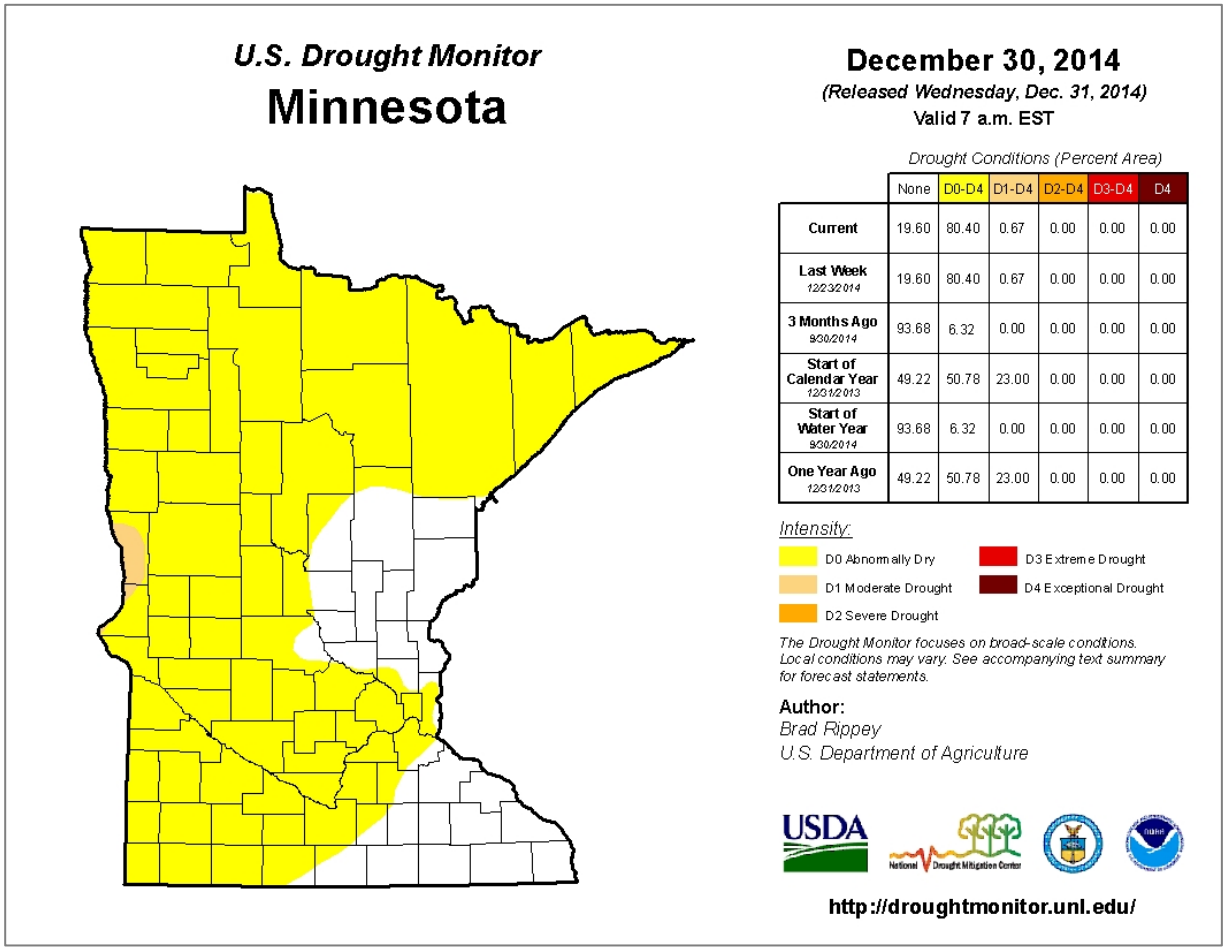


Drought

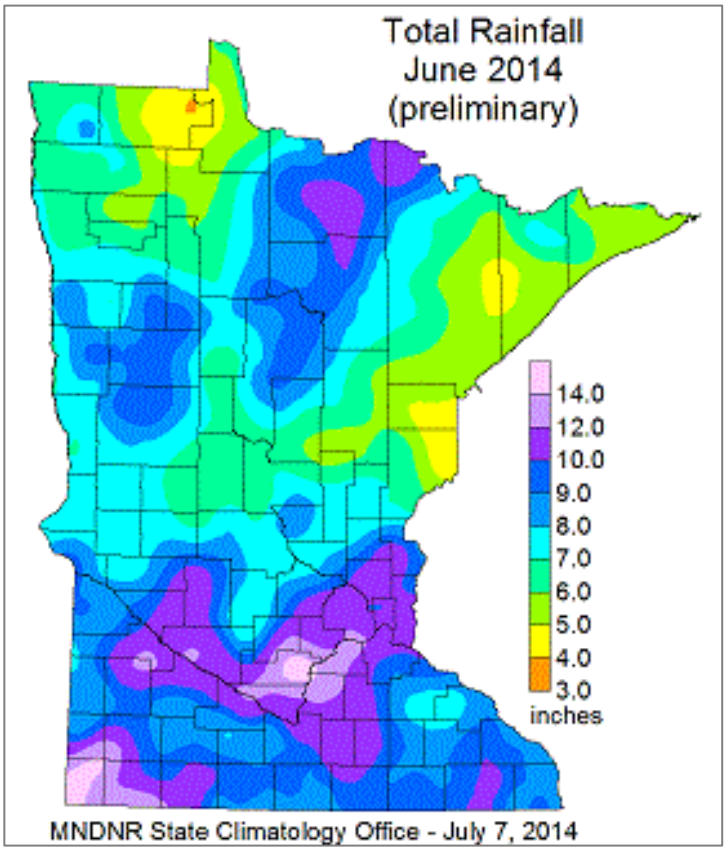
Hosts	All species
Setting	Rural and urban forests
Counties	Beltrami, Cass, Crow Wing, Wadena, Hubbard, Becker, Ottertail, Mahnomen, Pennington, Red Lake, Clearwater, Grant, Douglas, Stevens, Pope Cook, Lake, St. Louis, Itasca, Aitkin, Todd, Morrison, Stearns, Benton, Sherburne, Swift, Kandiyohi, Meeker, Wright, Hennepin, Anoka, Ramsey, Dodge, Washington, McLeod, Carver, Scott, Dakota, Le Sueur, Rice, Goodhue, Wabasha, Dodge, Olmsted, Winona, Fillmore, Houston
Survey methods	Ground survey
Acres affected	Statewide
Damage type	Decline, dieback and mortality

Narrative

A cool wet spring was again followed by a dry spell during the summer and fall months. The intensity of the drought in forested areas was much diminished compared to last year.



Record-Setting Rainfall in June 2014

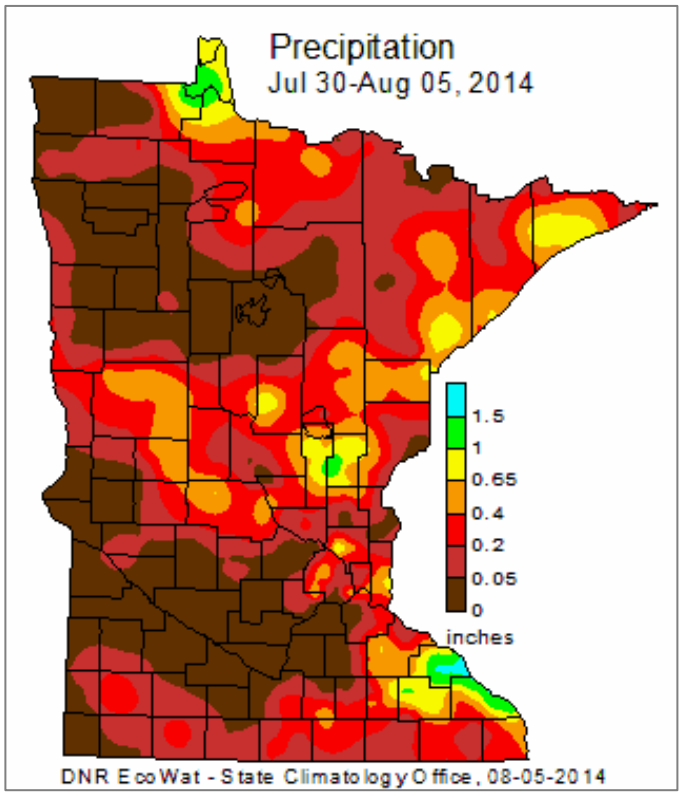


June 2014 was Minnesota's wettest June, and wettest month, of the modern record. The state-averaged monthly rainfall total for June 2014 in Minnesota was 8.03 inches, well over the previous record of 7.32 inches set in July 1897 and again in June 1914.

The state-averaged monthly rainfall record was established because of the broad geographic extent of heavy rainfall events. Individual station June monthly rainfall records were set from Luverne on the Iowa border to International Falls on the Canadian border. June rainfall totals across large sections of the state ranked above the 95th percentile (one year in twenty) when compared with the historical record. Some of these totals triple the historical rainfall average for the month of June.

The impacts of the heavy June rainfall were apparent: flooded farm fields and delayed fieldwork, flooded basements, mudslides and flooded roads leading to transportation disruptions, and negative consequences for outdoor activities including construction and outdoor recreation. The spillway connected to a dam at Blue Mounds State Park washed out on June 15 and drained Lower Mound Lake.

Late Summer 2014 Dry Spell



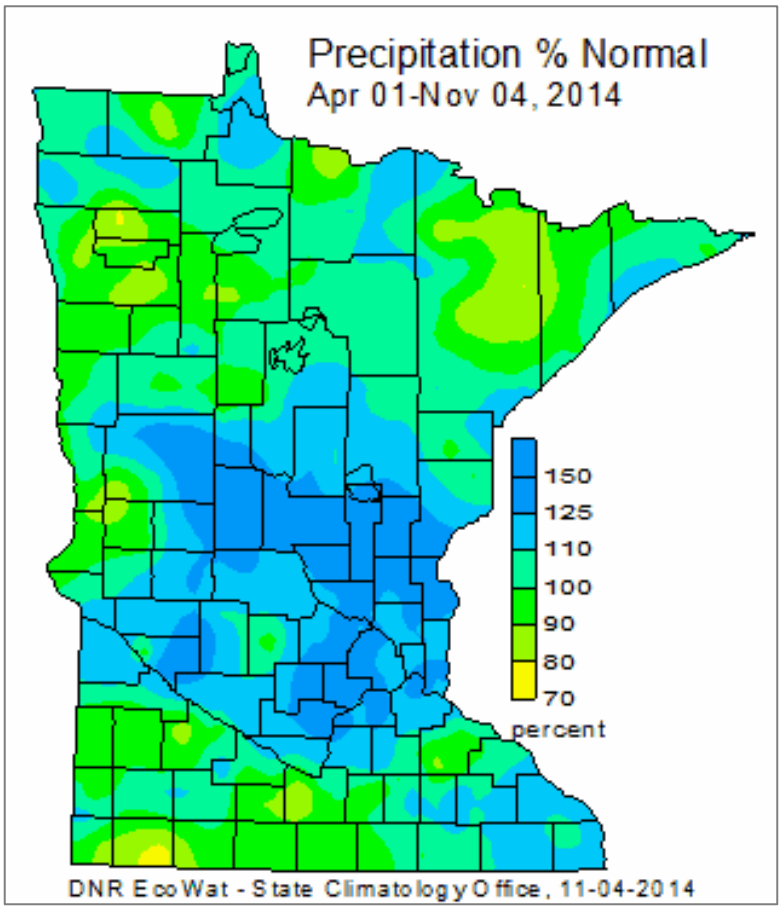
The summer of 2014 started with an extremely wet June. Then the last eight weeks were dry; in fact, from June 25 to August 26 most of central and southern Minnesota was from two to six inches short of normal.

As of August 28, the Drought Monitor shows that part of south central Minnesota and a small area of southeast Minnesota has been categorized as "Abnormally Dry." So why has the drought been slow to return to Minnesota? There are two main reasons. One is that this summer dry spell came on the heels of the wettest June on record for the state, and secondly it hasn't been too warm. The preliminary statewide average temperature departure for July 2014 was the same as the Twin Cities at 2.3 degrees below normal. August so far has had a pattern of near normal temperatures, with a lack of extreme heat. Through August 28th in the Twin Cities, there have only been two days of 90 degrees or more. By

August 28 in 2013, there were 15 days of 90° F or above. Putting this period in a historical context the total rainfall historical rank shows that parts of southwest and south central Minnesota have had one of the driest June 25 to August 26th periods on record.

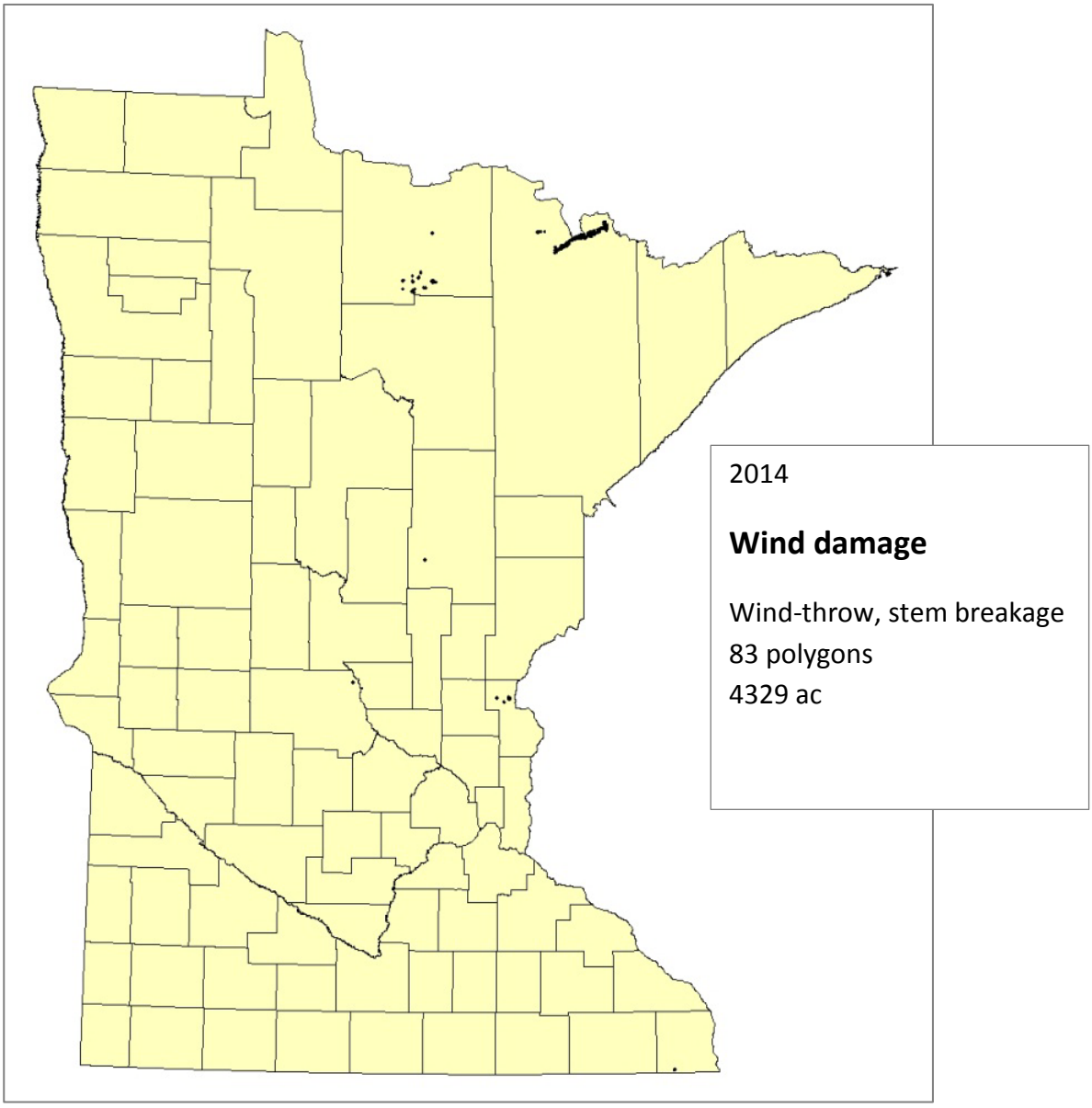
Percent of Normal Precipitation for the 2014 Growing Season

Despite a dry July-through-October period, seasonal precipitation totals since April 1 remain above historical averages nearly everywhere in Minnesota. For large portions of the state, season-to-date precipitation totals rank above the 75th percentile when compared with the historical database for the April-through-October time period. Below-normal rainfall during the late summer and autumn slowed the record-setting pace established earlier in the growing season.



Wind damage

Hosts	All species
Setting	Rural and urban forests
Counties	Koochiching, St. Louis, Aitkin, Stearns, Chisago, Houston.
Survey methods	Aerial survey
Acres affected	4329 acres on 83 polygons
Damage type	Wind-throw, uprooting and stem breakage
Narrative	Similar damage to standing timber compared to last year.



Invasive pests not known to be in Minnesota

Asian long-horned beetle

Beech bark disease

Dogwood anthracnose

Fusiform rust

Hemlock wooly adelgid

Laurel wilt disease

Mountain pine beetle

Sirex wood wasp

Sudden oak death

Thousand canker disease of walnut