2013 Forest Health Highlights

Michigan Department of Natural Resources

Acknowledgments

Forest Health Highlights is a summary of the condition of Michigan's forests during 2013 and the work done to preserve and protect them by Forest Resources Division, Department of Natural Resources, www.michigan.gov/foresthealth.

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The Michigan Department of Natural Resources is committed to the conservation, protection, management, use and enjoyment of the state's natural and cultural resources for current and future generations.

For more information, visit www.michigan.gov/dnr.

Forest Resource Overview

Forestry was central to Michigan's early history, resulting in long-term effects of widespread logging and wildfires. Nearly all of the forest land in Michigan was cut or burned during European settlement. The bulk of the lumber boom and most of the fires occurred in the late 1800s and early 1900s. By 1920, the lumber boom had ended and secondary succession was in full swing with the recovery of the forests. Since then, these forests have been maturing.

Today, Michigan has more forest land than any other state in the Northeast or Midwest. The rich diversity of our urban and rural forests is being threatened, however, by exotic insects, plants and diseases finding their way into the state from around the world.

Invasive organisms like emerald ash borer, beech bark disease and oak wilt are affecting thousands of acres in Michigan and killing millions of trees. Without a plan of action, entire species of native trees are at risk of disappearing from our forests.

The solution to this growing crisis lies largely in public awareness. Understanding the role humans play in the accidental introduction of exotic pests into our forests is a vital first step in halting the problem.

The 2013 Michigan Forest Health Highlights publication is dedicated to getting the word out about the work the Department of Natural Resources and collaborative organizations are doing to protect our state's exceptional forest resource.

- Among the 50 states, Michigan ranks 22nd in land area and 10th in forest land area.
- Forest land accounts for 19.3 million acres or 53 percent of land in Michigan; 97 percent or 18.7 million acres is timberland.
- Sugar maple/beech/yellow birch is the predominant forest type (22 percent of timberland). Aspen (13 percent) is the second most abundant forest type. Northern white-cedar (7 percent) and red pine (5 percent) are the most abundant softwood forest types.
- Of Michigan's forest land, 62 percent (11.9 million acres) is owned by families, individuals, private corporations and other private groups. The remaining 38 percent (7.4 million acres) is managed by federal, state and local government agencies.
- Sixty-five percent of Forest Inventory and Analysis plots sampled for nonnative species had at least one identifiable nonnative species. Higher ratios of nonnative to total species were evident in the Lower Peninsula.

Michigan Department of Natural Resources
Forest Health Program

The Michigan Department of Natural Resources (DNR) Forest Health Program grew out of a 1970s collaboration between Michigan State University (MSU), the U.S. Department of Agriculture (USDA) Forest Service's Northeastern Area State & Private Forestry Unit, and the DNR's then-Forest Management Division. This interagency cooperation still drives the Forest Health Program today. The program's services are coordinated with both Michigan forestry schools, MSU Extension, Michigan Department of Agriculture and Rural Development, North Central Forest Experiment Station and the USDA Animal & Plant Health Inspection Service. Additionally, it includes strong cooperative ventures with other state forest health programs. The Northeastern Area State & Private Forestry program plays a strong coordinating role regionally and nationally.

Beginning in the early 1990s, Michigan's Forest Health Program became increasingly involved in multistate and national forest health issues. These efforts were, in part, a response to a new era of exotic forest pest challenges and ever-increasing demands and needs for quantifiable, high-quality information about the health of our forests.

In a 1997 effort to improve program utility and efficiency, a team structure was adopted to better serve the demands of national and statewide initiatives and of local programs across all forest ownerships in Michigan. Forest health activities were divided between two new programs: Forest Health Monitoring and Forest Health Management, coordinated statewide by two forest health specialists. These programs are supervised statewide by the Forest Health unit manager.

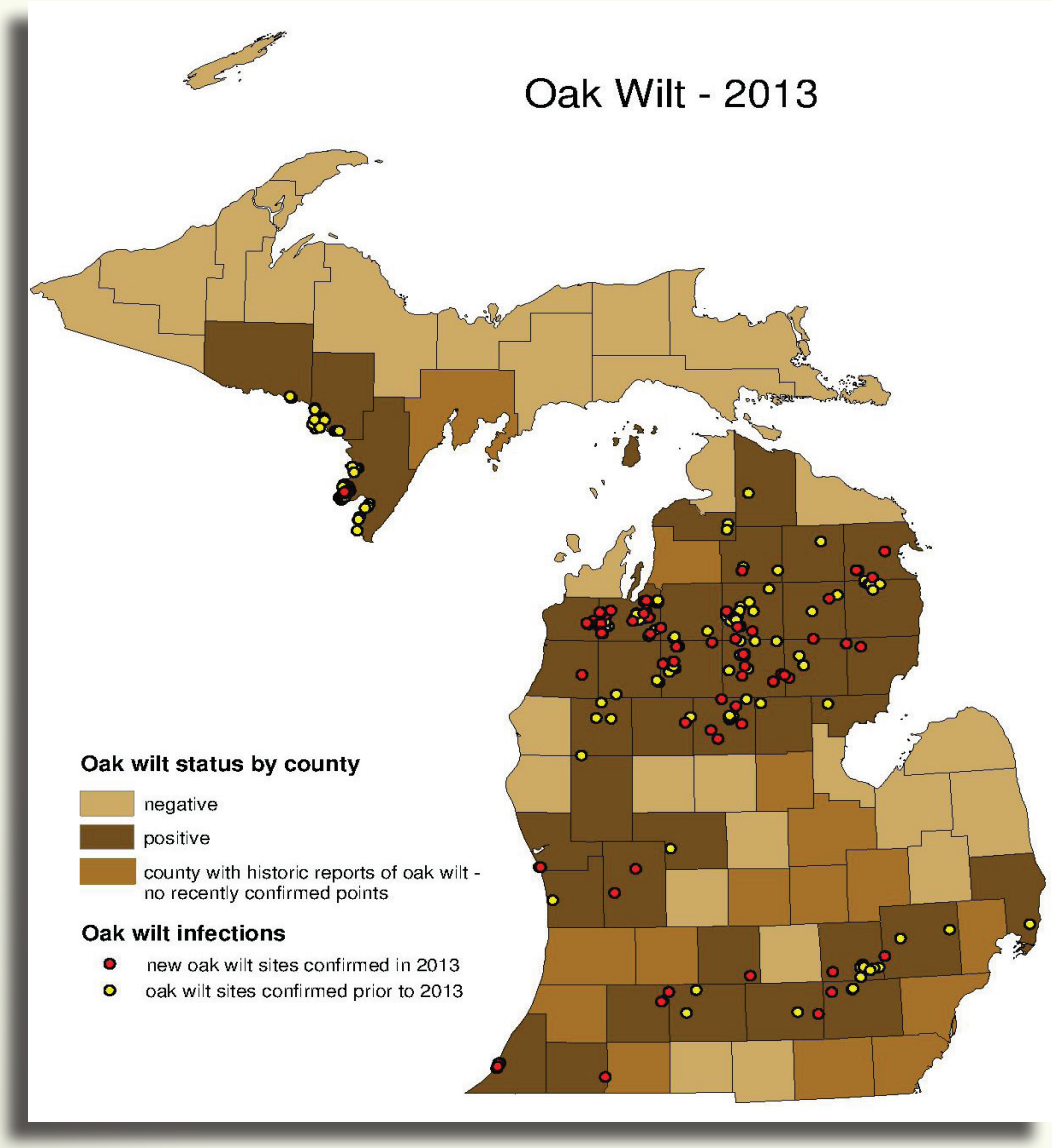
Oak Wilt in Michigan

Oak wilt is an aggressive disease that affects many species of oak (*Quercus* spp.). It is one of the most serious tree diseases in the eastern United States, killing thousands of oaks each year in forests, woodlots and home landscapes. Once introduced to an oak area, oak wilt spreads through root connections to adjacent oaks.

Oak wilt was first identified in 1944. The fungal pathogen that causes the disease, *Ceratocystis fagacearum,* is an exotic pathogen. Difficulty in isolating and identifying the fungus delayed recognition of the extent of its impact until the 1980s.

Oak species vary in their susceptibility to oak wilt. Species in the red oak group (leaves with pointed lobes) are the most susceptible. White oaks (leaves with rounded lobes) are the least susceptible.

The oak wilt fungus moves from tree to tree in two ways: transported underground through roots, or overland by sap beetles. New oak wilt areas are created when the fungus is carried by sap beetles from infected wood (e.g., a tree, log or firewood) to a fresh wound on a healthy oak. Trees killed by oak wilt produce spore pads the following year only. Sap beetles are attracted to these pads where they feed and pick up spores. They are also attracted to fresh wounds. Oak wilt is introduced to a wounded oak when visited by spore carrying sap beetles between April 15 and July 15. Most new oak wilt outbreaks can be traced to damage from pruning, construction, various human-caused tree-wounding activities, and damaging storms in areas with oak wilt or in areas where wood from



Oak Wilt in Michigan *continued*

infected trees has been moved.

Once an oak is infected, oak wilt moves to adjacent oaks through grafted roots. When roots of oaks of the same species come into contact, they often grow together, a process known as grafting. This allows neighboring oaks to exchange food and water, as well as infectious oak wilt spores.

Oak wilt is established widely in the southern Lower Peninsula with spotty distribution in the northern Lower and Upper peninsulas. It is found primarily on private lands. As the public moves northward into forested areas, the risk of spreading this disease grows. People often harvest dead oaks for firewood. This wood is often taken to camps or on camping trips where it serves as a source of inoculum to infect nearby oaks that are wounded in the spring or early summer.

Michigan's Oak Resource

The USDA Forest Service, Forest Inventory and Analysis reports a Michigan forest resource of 149 million oak trees greater than 5 inches in diameter in the oak wilt susceptible red oak group. There are 68 million red oaks with a diameter greater than 11 inches. This equates to a volume of 11.9 billion board feet growing on 3.9 million acres of Michigan forest land. Ownership of this oak forestland is 67 percent private, 22 percent state and local government, and 11 percent federal.

Detecting, Confirming and Reporting Oak Wilt

Knowing the number and distribution of oak wilt pockets is crucial to understanding the potential short-and long-term impacts of oak wilt on Michigan's oak resource. However, confirming oak wilt as

Pocket of dead red oak trees killed by oak wilt.

the cause of oak mortality is not always easy. Not all oak mortality is oak wilt-caused. Oak mortality and decline in the last decade is the result of drought, late-spring frosts, two-lined chestnut borer and a mature to over-mature northern pin oak resource. In addition, new infections started by movement of firewood are difficult to document. Most often, a newly killed tree is felled and cut into firewood. This firewood can serve as a source of new infections in this area, or if moved to areas near oaks. Removing the tree does not stop the disease. Neighboring oaks will start dying in a year or two. Generally, it isn't until more oaks start dying that people begin seeking answers as to the cause.

The Michigan DNR and Michigan State University, Department of Plant, Soil and Microbial Sciences have stepped up efforts in the last three years to detect and confirm oak wilt in Michigan. A grant from

Oak Wilt in Michigan *continued*

the USDA Forest Service has funded an effort to detect, confirm and record oak wilt occurrence. Once oak wilt is confirmed, data is entered into a national oak wilt database housed in Fort Collins, Colo., at the USDA Forest Service Forest Health Technology Enterprise Team facility. The oak wilt database is available to any state with oak wilt problems. As we populate this database, we can begin to understand the distribution and scale of the problem. It also provides operational guidance for prevention and suppression efforts.

If anyone suspects they have oak wilt, review the signs and symptoms of oak wilt by visiting, http://na.fs.fed.us/pubs/howtos/ht_oakwilt/identify_prevent_and_control_oak_wilt_print.pdf.

Managing Oak Wilt

Oak wilt can be removed from an infected oak resource. Oak wilt requires a living oak to survive. Thus, if infected trees are isolated by breaking root-grafts and all oaks within the area are removed, oak wilt is effectively removed. The only caveat is that trees that were killed the previous year will produce pressure pads, so they must be destroyed via burning, chipping, or cutting into lumber before the following April.

If oak wilt is detected the year it infects a new area via overland spread by sap beetles, removing the infected oak and its stump will remove the disease before spreading to adjacent oaks. If the stump remains in the ground the year following infection, many neighboring oaks will become infected.

Management recommendations include:

- Prevent wounding of oaks from April 15 to July 15. If pruning is necessary, or if wounded by accident, paint wounds with tree wound dressings or latex paints immediately to prevent transmission of oak wilt.
- Have a forest health professional confirm the presence of oak wilt. If confirmed, hire an experienced professional to isolate the oak wilt pocket by breaking root-grafts to a depth of 5 feet. This is done by using a vibratory plow or backhoe. Only after root-grafts are disrupted, remove all red oaks within the isolated area. Wood larger than two inches in diameter from oaks killed by oak wilt in the current year are debarked, chipped, sawn into lumber, burned and/or tightly tarped to the ground before the following April. If tarped, the tarps can be removed after July 15.

Upper Peninsula

The USDA Forest Service has provided Oak Wilt Suppression funds to help remove oak wilt from the Upper Peninsula. The Michigan DNR and Michigan Technological University worked together in 2013 to:

- Remove oak wilt from the UP by detecting and treating all infection centers;
- Educate affected communities to prevent the reintroduction of oak wilt; and
- Demonstrate an approach that can be used for detecting and effectively treating oak wilt infection epicenters throughout Michigan.

This year's project focus was the Shakey Lakes Area of Menominee County. Thirty three oak wilt pockets totaling 116.5 acres were isolated by creating 36,160 feet of root-graft barriers with a vibratory plow. All red oaks within these pockets will be removed via timber sales before April 2014. All sites were reviewed and treatments approved by the USDA Fish and Wildlife Service,

Oak Wilt in Michigan *continued*

A Department of Natural Resources employee installs root graft barriers with a vibratory plow.

affected Native Tribes and the State Historic Preservation Office.

Michigan State University Extension continued to evaluate past oak wilt suppression efforts in 2013. Many treated areas in Menominee and Dickinson counties remain free of oak wilt. Although much has been achieved, untreated oak wilt pockets remain. Diligence will be needed if we are to succeed in removing this threat to the Upper Peninsula's oak resources.

Lower Peninsula

Michigan DNR, Parks and Recreation Division, treated oak wilt infection centers in two state parks and in four state recreation areas in the Lower Peninsula during October and November 2013. Approximately 10,000 feet of root graft barrier was created using a vibratory plow. All red oaks within the plow lines will be removed and chipped or otherwise processed before April 2014.

Forest Resource Division's Forest Health Program, participated by operating the vibratory plow to create several hundred feet of root graft barrier in the Huron National Forest to treat an oak wilt infection in the Sand Lake Campground, Oscoda County. Huron National Forest personnel will oversee the removal and treatment of all red oaks from within the root graft barriers before April 2014.

Oak wilt detection and confirmation efforts continue across all ownerships in Michigan's Lower Peninsula.

Spore-producing pressure pads on oak wilt-infected tree.

Insects & Diseases

Healthy and productive forests are comprised of a diversity of native tree, shrub and herbaceous plant species, as well as an even larger number of faunal species for which forests provide habitat. Forested ecosystems have continuously adapted and evolved over thousands of years, as insect, plant and animal species are naturally, intentionally or inadvertently introduced or extirpated from ecosystems. Prevention and mitigation of invasive plants, insects and disease introductions are important for the maintenance of healthy and productive forests.

From "Michigan Forest Resource Assessment & Strategy"
June 2010

Asian Longhorned Beetle

Since its discovery in Bethel, Ohio in 2011 – only four hours away from Michigan's southern boundary – officials continue their efforts to eradicate Asian longhorned beetle (ALB) before it can spread to adjacent forests and urban communities. Public education is a critical part of this effort, as movement of infested firewood is likely how ALB will eventually find its way into Michigan.

Once introduced, ALB is difficult to detect. This makes controlling ALB very difficult. The potential for accidental spread through movement of firewood or other wood products means the potential for new infestations is a serious concern. It is estimated that the infestation in Bethel was active for more than a dozen years before it was discovered. That's a dozen years where landowners and homeowners may have unknowingly moved ALB-infested wood to new areas of the country.

For a third-straight year, in cooperation with DNR Parks and Recreation Division staff and volunteers, the Forest Health Program conducted ALB surveys in 61 state parks and recreation areas. Surveys were targeted to high-risk locations with susceptible host species, including maple, elm, willow and birch. Campgrounds are of the greatest concern and pose the highest risk because ALB can easily be transported in firewood. Specifically, surveyors used zip code information to target campgrounds that were visited by residents of ALB-infested areas of the country. No ALB was detected during the 2013 survey.

Forest Health Program staff also inspected numerous sites to follow up on reports from concerned citizens whose descriptions of observations matched ALB symptoms. During the 2013 season, there was an increase in the number of suspect specimens being reported by the public to DNR offices across the state. In most cases these turned out to be the white-spotted pine sawyer beetle, a native insect and an ALB look-alike. The increase in these reports from the public is encouraging as it indicates increased awareness of the threat ALB poses to Michigan's forests.

Beech Bark Disease

Since discovery of beech bark disease (BBD) in Michigan in 2000, BBD has spread widely through Michigan's forests. This disease is initiated by a scale insect that attaches to the tree and feeds on sap. Damage from this feeding allows one of two *Neonectria* fungi to invade the tree. The fungus inhibits the flow of sap through infested portions of the tree, causing a general decline in tree health and eventually killing the entire tree. Controlling the natural spread of the disease is not feasible because both the scale and fungus are moved by the wind. Scales are also moved by birds, bears and other animals feeding on beech nuts in the fall.

An infested tree is "painted" white by the tiny scale insects. A scale-infested tree may still have a healthy appearing canopy although its main stem is weakened by the fungus. These trees are subject to breakage known as beech snap. The main stem of the tree breaks or snaps in half somewhere below the canopy. All such "hazard trees" are removed from state parks and campgrounds.

According to the latest USDA Forest Service Forest Inventory and Analysis (FIA) data for the period 2008-2012, there are 31.7 million American beech trees greater than 5 inches in diameter and 2.5 million standing dead beech in the same size category. FIA estimates annual beech mortality in this time period of 6.15 million cubic feet of growing stock beech and 23.4 million board feet of sawtimber beech. To date, 74 percent of this loss is in the eastern Upper Peninsula. Michigan's American beech resource is under attack as newly infested areas are being reported in the Lower Peninsula every year.

Resistant American Beech Project

Since 2002, the Michigan Department of Natural Resources has been working with Dr. Jennifer Koch at the Northern Research Station (NRS) of the USDA Forest Service to select and breed American beech trees for resistance to beech bark disease (BBD). Beech trees that are resistant to BBD are resistant to the beech scale. Cuttings from potentially resistant beech are sent to the NRS where they are grown and tested for scale resistance. Techniques to propagate resistant trees through grafting have been developed, and genetic tests of full- and half-sibling families have demonstrated that BBD resistance is heritable and we can breed

Beech Bark Disease *continued*

Researchers study a beech tree killed by beech bark disease.

resistant beech. These genetic studies indicated that when both parents are resistant, approximately 50 percent of the progeny can be expected to be resistant.

Project efforts are now focused on identifying, selecting and propagating resistant beech for establishing seed orchards. These orchards will provide seed to generate resistant seedlings for restoration plantings so that healthy American beech trees will persist in Michigan forests. Planting of the first resistant American beech seed orchard began in 2011 at the DNR's Tree Improvement Center (TIC).

The root stock used for grafting to date is from southern Ohio. Forest health specialists believe that this has resulted in poor performance and survival in Michigan. Beech seed from northern Michigan has been collected, and Michigan State University is germinating the seed to produce root stock for grafting Michigan-destined resistant seedlings. In the meantime, the TIC seed orchard site has been provided with irrigation and is enclosed.

Resistant Michigan beech will be used with the existing Ohio rootstock to establish a seed orchard at Purdue University's Hardwood Tree Improvement and Restoration Center. Seed from Purdue's seed orchard will be available for Michigan's American beech restoration efforts.

So far, five different beech bark disease-resistant parent combinations have produced an average of 52 percent resistant progeny. Subsets of seedlings from these families were out-planted in November of 2011 in the Upper Peninsula in an area heavily impacted by BBD. These trees are within an exclosure and will be monitored annually for growth characteristics and continued scale resistance.

Emerald Ash Borer

The DNR is involved in many projects to prepare Michigan's unaffected urban and rural forests for the inevitable arrival of the emerald ash borer (EAB). These projects will address the loss of ash trees and provide for restoration of affected forests and neighborhoods.

Funding from the Great Lakes Restoration Initiative and the USDA Forest Service Pest and Disease Loan Fund were used by Michigan Technological University (MTU) in cooperation with the Michigan Department of Natural Resources to inventory 9,146 acres of potentially high-value ash stands.

Ash stands on state forest land in the western Upper Peninsula and the northern Lower Peninsula were intensively inventoried over the last two years. In the process, MTU developed a protocol for evaluating a stand's need for immediate treatment ranking them into general categories of "treat immediately," "treat next year" and "treat in the next three years."

MTU also trained the DNR's Forest Resources Division (FRD) foresters in using this evaluation protocol. FRD foresters then surveyed an additional 24,946 acres. Additionally, they reviewed 126,825 acres using staff knowledge and data from completed inventories. In total, 160,917 acres were evaluated.

Michigan's Ash Resource

According to the latest USDA Forest Service Forest Inventory and Analysis (FIA) data for the period 2008-2012, there are 162.8 million ash trees greater than 5 inches in diameter, and 17.9 million standing dead ash in the same size category. This number does not include ash on non-forest lands, such as urban environments. FIA estimates annual ash mortality in forested environments of 49.3 million cubic feet annually, and 142.9 million board feet of ash sawtimber per year.

Surveys and Quarantines

No new Michigan counties were added to the EAB quarantine in 2013. The Michigan Department of Agriculture and Rural Development (MDARD), in cooperation with the USDA Animal and Plant Health Inspection Service, continue to survey uninfested counties in the western Upper Peninsula. They deploy purple traps baited with an aromatic lure called manuka oil. Traps are placed around high-risk areas such as

Purple trap used to monitor for emerald ash borer.

Emerald Ash Borer *continued*

campgrounds and sawmills and along travel pathways. There were no detections in the uninfested, non-quarantined counties of the western Upper Peninsula.

EAB quarantine requirements for regulated articles moved entirely within Michigan are unchanged. For movement of regulated articles across state lines, relevant changes to the federal EAB quarantine include:

- A federal certificate or limited permit is no longer needed to ship articles regulated by the EAB quarantine out of Michigan's Lower Peninsula into or through Ohio or Indiana. However, if the final destination of the articles is outside of the contiguous federal quarantine boundaries or into the protected area of Illinois or Indiana, a federal certificate or limited permit is still required.

- A federal certificate or limited permit is no longer needed to move articles regulated by the EAB quarantine into Michigan's Lower Peninsula from areas inside of the contiguous federal quarantine boundaries.

- Regulated articles, including all hardwood firewood, are not to be moved without a compliance agreement, from:
    - The Lower Peninsula to the Upper Peninsula;
    - Quarantined areas of the eastern Upper Peninsula to unquarantined counties: and
    - The central and western Upper Peninsula.

There is still a general advisory against moving any firewood due to associated accidental introduction or spread of potentially devastating forest pests such as EAB, Asian longhorned beetle, oak wilt and others. People are encouraged to purchase firewood as close to where they will use it as possible and should not take any unused firewood home with them or move it to another camping location.

An ash tree heavily infested with emerald ash borer.

Remember: Burn it where you buy it!

For more information about EAB, visit www.emeraldashborer.info or visit the MDARD website at www.michigan.gov/mdard.

Eastern Larch Beetle

Eastern larch beetle (ELB), *Dendroctonus simplex*, impacted stands of tamarack (*Larix laricina*) in the south-central areas of Michigan's Upper Peninsula in 2013. Most of the tamarack trees in impacted stands were killed. The level of impact tends to progress from some tree mortality in small pockets along stand edges, to mortality of tamarack throughout the stand within a year.

ELB initially became an epidemic in Michigan as tamarack was stressed by two consecutive years of defoliation by the larch casebearer (*Coleophora laricel*la) in 2001 and 2002.

The repeated droughts of the past decade and associated stresses have contributed to continued ELB activity. This epidemic continued even with return to more normal rainfall during the last two years. Both Minnesota and Wisconsin have reported high tamarack mortality; especially in mature to overmature stands. ELB can also impact younger stands. Once ELB populations build to epidemic levels, it generally only collapses after most of the vulnerable tamarack has been heavily impacted. Mature to overmature tamarack trees, and tamarack stressed by drought, flooding or lowering of the water table, are most vulnerable to ELB-induced tree mortality.

Pockets of mortality caused by eastern larch beetle.

Forest Decline and Drought

Forest decline refers to a gradual loss of tree growth and vigor. Declining trees have lower energy reserves resulting in off-color leaves, early leaf drop, poor growth and/or dieback of twigs and branches. During this time of stress, trees are more vulnerable to insects and diseases that can only attack weakened trees (e.g., secondary pests).

Declining trees are further compromised by added factors including drought, poor site quality, advanced tree age and defoliation from late spring frosts. These added stressors can further reduce tree growth and increase the likelihood that the tree will die.

Drought years have contributed greatly to many of Michigan's forest declines and to the buildup of secondary pests such as the forest tent caterpillar, gypsy moth, spruce budworm, *Armillaria*, two-lined chestnut borer, hickory wilt and jack pine budworm. In the past decade we have reported declines of aspen, hickory, maple, oak, spruce and white pine in Michigan.

We continue to see declines in these tree types, especially in areas impacted by drought. Southern areas of the western Upper Peninsula, and much of the Lower Peninsula experienced drought conditions again in 2012. In 2013, Michigan returned to close to normal rainfall. Although many areas are reporting differing levels of recovery, it takes years for trees to rebuild energy reserves and corresponding defenses to pest attacks. Some of the hardest hit areas have seen significant tree mortality from secondary pests. Hardest hit are mature to overmature, relatively short-lived trees growing in light, sandy soils or on lowlands exposed to significant water table fluctuations.

Examples of such stands include:

- Northern pin oak on sandy soils attacked by the two-lined chestnut borer (*Agrilus bilineatus*);
- Paper birch attacked by the bronze birch borer (*Agrilus anxius*);
- Eastern larch (tamarack) attacked by the eastern larch beetle (*Dendroctonus simplex*); and
- Aspen attacked by bronze poplar borer (*Agrilus liragus*) and *Armillaria* root rot.

Hardwood Defoliators

Leaf-feeding caterpillars and other defoliating insects took a bit of a break in 2013, as the large-scale defoliation evident in recent years was absent. Locally, large aspen tortrix and gypsy moth caused scattered heavy defoliation in many parts of the state.

Large aspen tortrix (*Choristoneura conflictana*)

The larvae of this small moth feed on the leaves of aspen trees, webbing the flat surfaces together to form a shelter from predators. Locally heavy defoliation was observed in scattered areas across the northern Lower Peninsula and in the Upper Peninsula.

The tiny larvae begin feeding in the early spring on aspen buds, causing small holes to appear as the leaves expand. As larvae grow and feeding continues until mid-June, the foliage of affected trees becomes thin and yellow. Outbreaks can last 2 to 3 years before subsiding.

Because this insect is native to Michigan's forests, over 20 species of parasitic insects have adapted to attack the eggs, larvae and pupae of the large aspen tortrix.

Predaceous insects – ants, wasps and large ground beetles – search out and feed on the larvae. Fungi and virus diseases kill large numbers of larvae, particularly in years like this one, with cool, wet spring weather. Several species of birds, including chickadees, vireos and woodpeckers, consume larvae when populations are high.

Populations of the tortrix in 2014 are expected to be similar, with scattered, heavy defoliation occurring again in many areas. Fortunately, with the increased precipitation this past growing season, trees are expected to recover from the defoliation without serious long-term effects.

Aspen tortrix larva and webbing.

Hardwood Defoliators

Gypsy moth (*Lymantria dispar*)

An exotic insect introduced into Michigan in the early 1950s, gypsy moth caused extensive defoliation across the northern Lower Peninsula in the late 1980s and early 1990s. During its heyday, gypsy moth defoliation approached 1 million acres over the course of a summer.

While not native to our forests, gypsy moth has become "naturalized" in recent years as many native insect parasites and predators have learned to use gypsy moth larvae as a food source.

A single gypsy moth egg mass can contain hundreds of eggs.

In addition, two pathogens – one a virus, one a fungus – can be quite lethal to gypsy moth populations in years when cool, wet spring weather allows these organisms to flourish.

As a result, while gypsy moth continues to periodically outbreak in oak and aspen forests, these outbreaks tend to be more localized, and their natural enemies decrease the number of years that outbreaks persist.

In 2013, caterpillar activity in the north central Lower Peninsula – including the Lewiston area – caused significant defoliation in some areas. Isolated pockets of defoliation also occurred in the southeastern area of the Lower Peninsula.

Full-grown gypsy moth larvae defoliating a young tree.

Extensive mortality of large caterpillars caused by fungal and viral pathogens was noted in many of these areas, which is expected to help keep populations low in 2014.

Hickory Wilt

Decline and death of bitternut hickory, *Carya cordiformis*, was reported in Michigan for the first time in 2010. This problem has since been named hickory wilt. Hickory wilt has been reported in several northeastern states and Wisconsin for the past eight years. The affected areas in Michigan are along the Menominee River in Menominee and Dickinson counties in the Upper Peninsula, adjacent to affected areas in Wisconsin. This is the northern-most range for bitternut hickory, and thus there are only a few scattered small stands in the Upper Peninsula.

The first symptom of hickory wilt is thinning crowns with small, yellow leaves. Decline and tree mortality follow within a year or two. Loss of hickory historically has occurred after extended periods of drought predisposed trees to outbreaks of the hickory bark beetle, *Scolytus quadrispinosus*. A newly described native fungus, *Ceratocystis smalleyii*, is now associated with bark beetle attacks. The fungus causes numerous bark cankers which impair the tree's ability to transport water and nutrients. Hickory wilt is caused by this fatal association of the bark beetle and fungus.

Hickory wilt has not been detected in the Lower Peninsula where most of Michigan's hickory grows.

Heterobasidion Root Disease

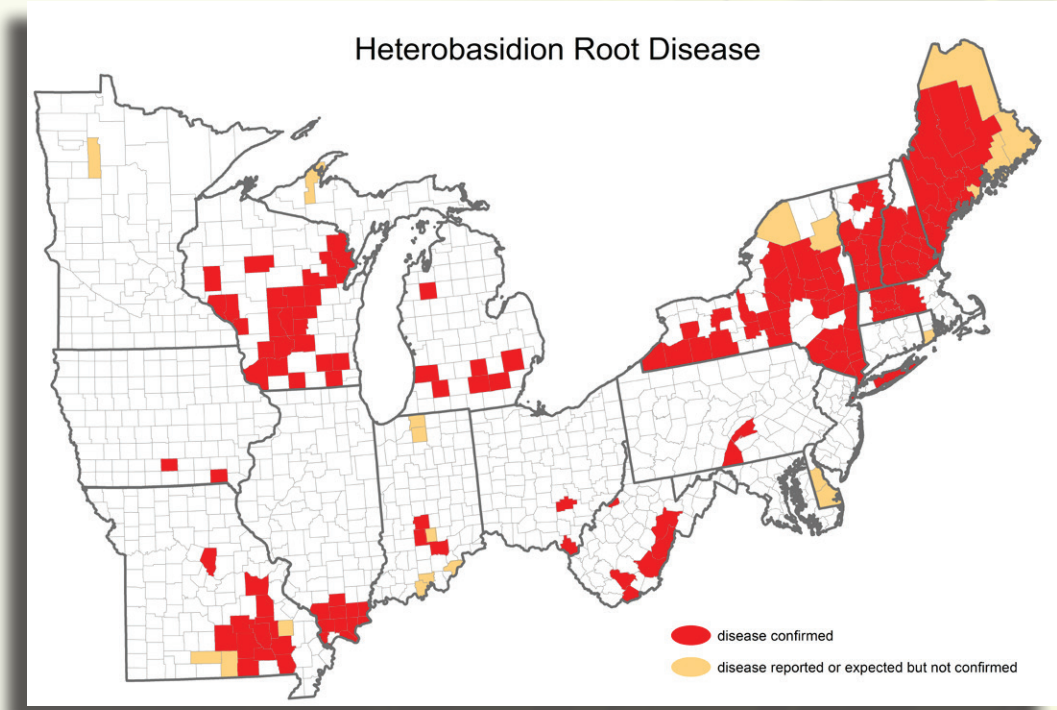
Heterobasidion *root disease mushrooms at base of a red pine.*

Unlike many forest insects and diseases that are attracted to stands stressed by lack of management, *Heterobasidion* root disease (HRD) is most commonly found in actively managed forest stands. In Michigan, red pine, jack pine and white pine are most susceptible. Fresh-cut stumps provide an ideal entry path for spores of HRD, which move through grafted roots to infect healthy trees. Infected trees suffer from thinned crowns, reduced height and trunk diameter, as well as shoot growth. Over time, circular pockets of dead and dying trees within a forest mark the progression of the disease. Caused by the fungus *Heterobasidion irregularae* (formerly *Heterobasidion annosum*), this disease is considered among the most destructive fungi in North American forests.

Using aerial survey detection, numerous sites with pockets of pine mortality in actively managed stands were observed. Three new infections of HRD were confirmed. Two of these are located in Allegan County, where no previous occurrences of HRD had been recorded, and one active infection of HRD was also confirmed in Oakland County.

With active HRD infections in Michigan, across much of Wisconsin and the Canadian province of Ontario, early identification and containment of HRD in Michigan remains a forest health priority.

To address this, the Michigan DNR's Forest Health Program, in cooperation with partners in Wisconsin and Minnesota, have applied for a National U.S. Forest Service Forest Health Monitoring, Evaluation and Monitoring grant. This grant will facilitate intensified efforts to delimit the distribution of HRD across Michigan over the next two years.



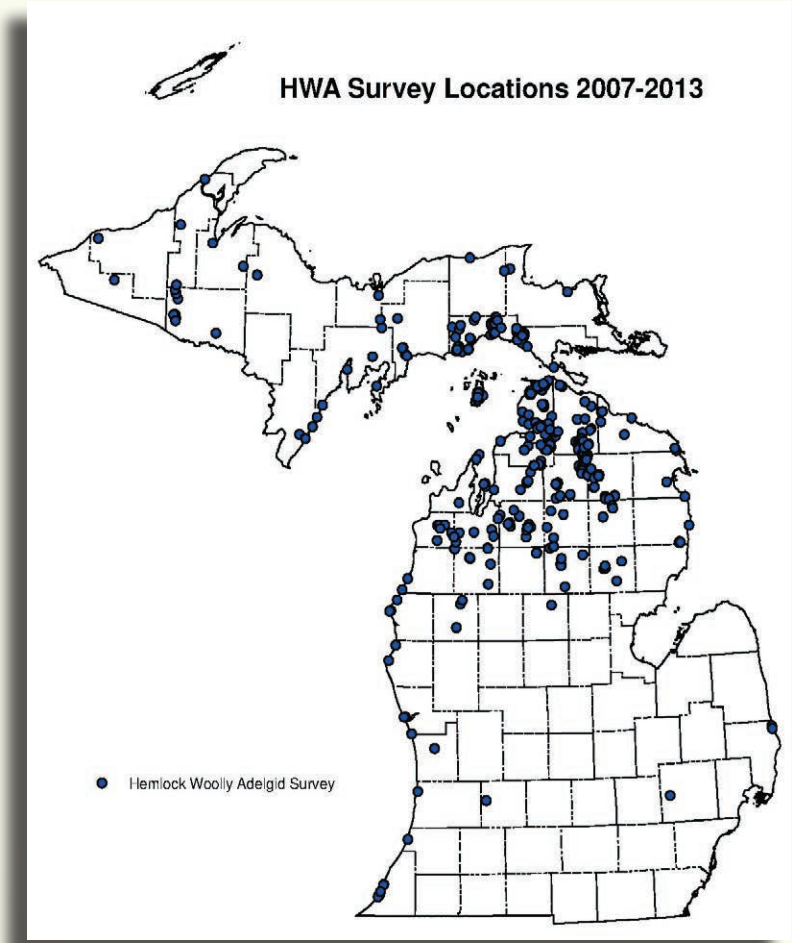
Hemlock Woolly Adelgid

Hemlock woolly adelgid crawlers.

In May 2013, hemlock woolly adelgid (HWA) was detected on landscape trees in Allegan County, a county along Lake Michigan in the southern part of the Lower Peninsula. The Michigan Department of Agriculture & Rural Development (MDARD), charged with regulatory authority, conducted a survey of the area surrounding the newly discovered infestation. Survey crews did not discover any other HWA within the half-mile survey area. Infested trees were removed and destroyed. Healthy trees in the immediate vicinity received treatment with a systemic insecticide to ensure HWA eradication in the affected area. MDARD will continue to monitor and conduct follow-up surveys at this site for the next three years.

The most common mode of long-range HWA dispersal occurs as a result of people moving or transplanting infected nursery stock or landscape trees. The second most common method of long-range HWA dispersal is by birds, with black-capped chickadees and nuthatches being active and abundant in hemlock forests.

In an ongoing effort to help support the Michigan quarantine for HWA, forest health personnel continue to survey for the presence of HWA in high-risk areas of the state throughout the year. Surveys are intensified in and around areas of known introductions. This past season, surveys were focused on the Harbor Springs and Petoskey areas in the northwest part of Michigan's Lower Peninsula.
Bird feeder stations that were established in 2012 (see article in the 2012 Forest Health Highlights), were discontinued in 2013. Intensified annual surveys are still being conducted at these sites and will continue for several years. Several state park sites with permanent and regularly maintained bird feeders located in close proximity to hemlock resources are also being surveyed annually. No HWA were detected during this past season's surveys.



Jack Pine Budworm

The jack pine budworm, *Choristoneura pinus,* is a native insect to North America. Jack pine budworm populations play a historic role in the perpetuation of jack pine forests. Periodic outbreaks lead to dieback and mortality in older jack pine stands. This makes these stands more susceptible to catastrophic fires which result in dense regeneration of young jack pine stands. While modern firefighting efforts and current management practices of harvesting jack pine before it becomes over mature and susceptible to budworm defoliation have minimized the impacts of budworm, outbreaks still occur periodically across Michigan's jack pine forests.

Jack pine budworm populations were expected to increase in 2013. It appears that the cool damp weather during spring 2013 contributed to a decrease in the budworm population across the northern Lower Peninsula. The number of acres defoliated dropped from 46,777 in 2012 to 5,343 in 2013. Jack pine forests 60 years old and older are historically at highest risk. Mortality and dieback are most common in older jack pine stands that have been moderately to heavily defoliated in two or more consecutive years. With the decrease in the population and the number of acres defoliated, the risk of widespread mortality and dieback has also diminished.

Spruce Budworm

Epidemics of spruce budworm (SBW), *Choristoneura fumiferana*, periodically cause extensive damage and tree mortality in spruce and fir forests across the northeastern United States and Canada. Historically, epidemics have occurred on a 30-to 50-year cycle. The last epidemic ended in Michigan in 1982. Outbreaks typically last 10 to 15 years and result in the loss of millions of trees.

The vast majority of Michigan's spruce and fir resources are in the Upper Peninsula. The budworm continues a cycle of building and collapsing. Widespread spruce budworm infestations in 2010 produced little defoliation in 2011. Populations collapsed again in 2013 after building in 2012. The western Upper Peninsula (WUP) has the largest area of budworm activity due to the abundance of over-mature spruce/fir forest. This cycle of SBW defoliation has resulted in top kill and tree mortality in isolated areas of the WUP. It is still unclear if these cycles of SBW defoliation may spell the onset of the next regional SBW epidemic in the Lake States. Ontario has seen the same series of SBW buildup and collapse as the Upper Peninsula. Natural resource professionals in Quebec believe the forests of their province have entered the next regional cycle.

Balsam fir is the species most severely damaged by the spruce budworm. Spruce mixed with balsam fir is more likely to suffer budworm damage than spruce in pure stands. However, in the last few years, spruce plantations without a balsam fir component have been heavily defoliated. Stresses from persistent drought over the last decade are likely contributing to increased spruce budworm activity, especially in spruce plantations. The return to more normal precipitation may help restore the vigor and, thus, reduce the vulnerability of our younger spruce and fir resources to the SBW.

Heavy spruce budworm damage.

Miscellaneous Pests

Spruce Needle Rust

Several areas in the central Upper Peninsula reported spruces discolored by spruce needle rust, *Chrysomyxa ledicola*. Spruce needle rust infects the current year needles only of blue spruce, and occasionally white and black spruce. Rusts require alternate hosts to complete their life cycle. In this case, Labrador tea and leather leaf plants are alternate hosts, providing an overwintering haven in their leaves. The following spring, spores from the alternate host infect newly emerging spruce needles. During summer months, the infected spruce needles produce spores which turn infected trees a pink to orange color. The spores on spruce in turn infect Labrador tea or leather leaf, beginning the cycle once again. Later in the season, infected spruce needles are usually shed. Spruce trees are rarely killed by spruce needle rust. Essentially, the damage is cosmetic. However, it is a problem with Christmas trees and newly planted spruce trying to establish a root system. Trees growing on drier sites, more than 1,000 feet from Labrador tea or leather leaf are much less likely to be infected.

While it rarely kills infected trees, spruce needle rust can seriously affect the value of landscape trees.

Advice for homeowners with infected spruce includes watering the trees by soaking the ground with a hose, avoiding the tree's needles. Wetting needles by using sprinklers will keep needles moist and make them more prone to rust infection. Also, keep weeds and grass mowed around small trees so winds can dry their needles.

For more information, visit www.dnr.state.mn.us/treecare/forest_health/spruceneedlerust.html.

Miscellaneous Pests *continued*

Western Conifer Seed Bug

There continued to be reports of the western conifer seed bug, *Leptoglossus occidentalis*, in and around Michigan homes in 2013. This critter is also known as a "leaf-footed bug" due to the appearance of its hind legs. This is a species of "true bug" (*Heteroptera*) in the family *Coreidae*. It was originally native to the warm-temperate western states of California, Oregon and Nevada. In recent years the western conifer seed bug has expanded its range in the United States and has also become an invasive pest in parts of Europe. An infestation of this bug reduces the quality and viability of conifer seed crops in its native range. The western conifer seed bug becomes a nuisance in the Lake States as it congregates on the outside of buildings in late summer and early fall. It is commonly observed around windows and doors as it seeks overwintering shelter.

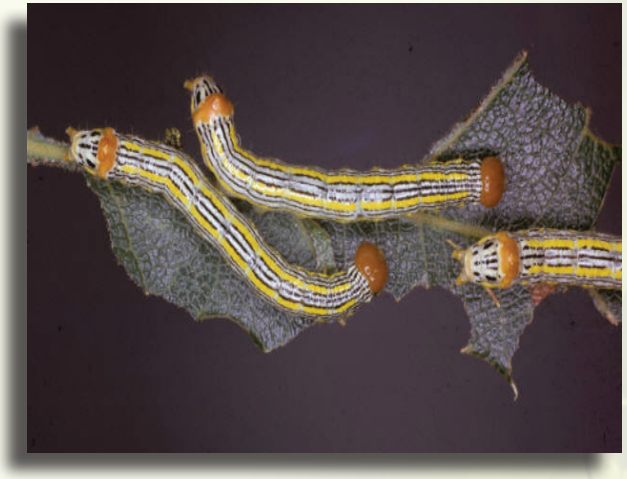
Gregarious Oak Leaf Miner

There were occasional reports of leaf damage on white and bur oaks by the gregarious oak leaf miner, *Cameraria cincinnatiella*, in 2013. Oak leaf miners are the larvae of tiny moths. They feed between the upper and lower surfaces of oak leaves, forming irregular blotch-like areas which appear in August and September. Mined leaves appear rusty or brownish by mid-September and are shed prematurely. Raking and removing affected oak leaves helps to reduce leaf miners which overwinter in the leaves. This late season defoliation has minimal impact on tree vigor. Natural enemies help reduce epidemic populations. Pesticide applications are generally not warranted except to maintain aesthetics in highly managed landscapes.

Miscellaneous Pests *continued*

Orange-Humped Mapleworm

The orange-humped mapleworm, *Symmerista leucitys*, completely defoliated several hundred acres of sugar maple trees in an area south of Beaver Lake in the Pictured Rocks National Lakeshore during 2013. This is the first year of reported defoliation. The 2-inch long caterpillars are marked with a bright orange head and orange hump on top of a rear segment.



The brightly colored caterpillars are yellow-orange with nine longitudinal black stripes on a hairless body. Eggs are deposited on leaves in July. Young caterpillars feed in colonies until nearly full grown, at which time they become solitary feeders. Outbreaks can last for three years or more, but significant tree mortality or crown dieback has not been associated with this late season defoliation. The last such outbreak occurred in the McNearey Lake area of Chippewa County during the 1980s.

Forest Health Cooperator Reports

Protecting the health of Michigan's forests is a challenging task. Universities, state and federal agencies work in partnership to ensure that research and detection activities are effective and timely.

Michigan Department of Agriculture & Rural Development

Outreach

During 2013, MDARD Pesticide and Plant Pest Management Division (PPPMD) conducted 24 forest invasives outreach and education events across Michigan. A total of 970 people were reached through these events. There were a total of 1,170 audience hours logged during these sessions, which covered a variety of forest health issues including exotic forest pest identification, firewood movement and pest reporting. Event attendees included loggers, consulting foresters, municipal foresters, landscapers, arborists, campground owners and managers, master gardeners, tribal representatives and other forest professionals.

Following three forest pest workshops conducted as part of MDARD's 2013 outreach efforts, the relative knowledge gained by attendees regarding Asian longhorned beetle (ALB) was measured using six questions asked of the attendees.

Questions were answered using a scale of 1-5, with 1 indicating "very low knowledge" and 5 indicating "very high knowledge." Among the questions participants were asked was how their ability to report ALB, if discovered or suspected, improved after attending the workshop.

Responses to before-and-after questions indicate that participants' knowledge improved significantly, with an average "after" response of 4.3, compared with an average "before" response of 2.5.

Survey Activities

In November, PPPMD inspectors completed a survey of two sites in Macomb County in the southeastern Lower Peninsula where hemlock woolly adelgid (HWA) was detected in 2010. No evidence of HWA was found during the survey. This was the third post-detection survey that showed no evidence of HWA establishment in the area.

A walnut twig beetle trap suspended from a black walnut tree.

In 2010, when HWA was detected, all infested trees were destroyed and an insecticide was applied to at-risk hemlocks in the two areas. The sites are now listed as eradicated with no future PPPMD activities planned.

Pheromone-based trapping surveys were conducted for walnut twig beetle (WTB) at 56 sites within the native range of walnut in the southern Lower Peninsula. At the time of publication, sample identification was 75 percent complete with no WTB found.

Trapping surveys were completed for 24 high-priority pests not known to occur in Michigan, including longhorned beetles, bark beetles, and defoliating moths, at 24 high-risk sites statewide. Sample identification is expected to be completed during the winter of 2013-14.

Michigan State University

Department of Forestry and Department of Entomology

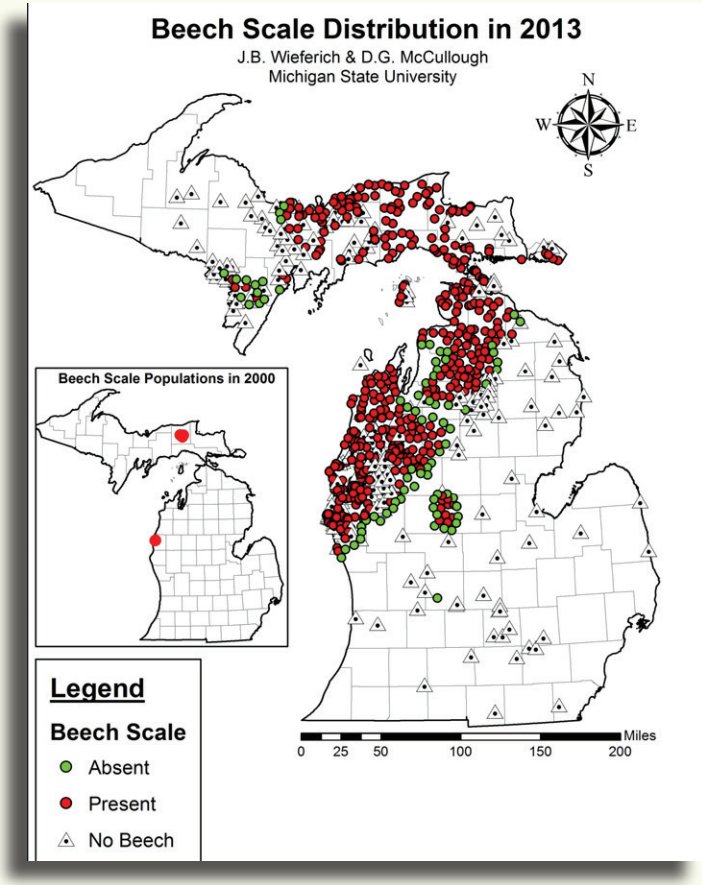
Progression and Impact of Beech Bark Disease in Michigan

Since the discovery of beech scale in Michigan in Mason County (Lower Peninsula) and Luce County (Upper Peninsula) in 2000, we have made steps to better understand the spread of beech scale and the impacts of beech bark disease on Michigan forests.

The advancing fronts of beech bark disease (BBD) in both peninsulas have been monitored annually since 2005. By 2013, beech scale was established across nearly all of the range of beech in the Upper Peninsula. Beech scale is also well-established in the northwestern area of the Lower Peninsula and on islands in Lake Huron and Lake Michigan. The most recently identified and delineated infestation is in the central part of the Lower Peninsula, in Isabella County. In 2013, the area encompassing beech scale infestations totaled approximately 16,575 km^2 and 13,534 km^2 in the Lower and Upper peninsulas, respectively. In comparison, in 2005, only 2,667 km^2 and 6,214 km^2 were infested with beech scale in the Lower and Upper peninsulas, respectively. Annual beech scale spread rates are extremely variable, ranging from less than 1 km/year to greater than 6 km/year since 2005. On average, beech scale infestations have advanced at a rate of 3 km/year in the Lower Peninsula, and 4 km/year in the Upper Peninsula.

In 2002-03, 62 sites were established to collect baseline data on overstory and understory vegetation, and coarse woody material. In 2003, there was no evidence of any beech scale infestation in 39 sites (63 percent), while 12 of the remaining 23 sites had only light infestations of beech scale. There was little or no evidence of beech mortality attributable to BBD in any of the sites.

In 2012, we located and re-surveyed all 62 original impact sites. As



of 2012, beech scale was present in 55 of the 62 sites, including 44 heavily infested sites. Beech mortality was especially high in the eastern Upper Peninsula. Of the Upper Peninsula sites that were infested with beech scale in 2003, 49.4 percent of the overstory beech had died by 2012. Not surprisingly, in the Upper Peninsula sites, volume of coarse woody material (CWM) was three times higher than in 2003 and 68 percent of the fresh CWM pieces were beech. In contrast, in Lower Peninsula sites that were infested in 2003, only 8.5 percent of overstory beech trees had died by 2012. Differences in mortality rates between the Upper and Lower peninsulas of Michigan may reflect variability in the virulence or spread of the pathogen.

- James Wieferich and Dr. Deborah McCullough

Michigan State University

Exotic Forest Insect Survey

Michigan is at exceptional risk for the introduction and adverse consequences of invasive forest pests because of its extensive forest resources and high-risk pathways for exotic pest invasion. In 2013, Michigan State University collaborated with Mike Philip (Michigan Department of Agriculture and Rural Development), Dr. Therese Poland (USDA Forest Service) and Dr. Bob Heyd (Michigan Department of Natural Resources) to identify and survey sites at high risk of exotic forest pest introductions or establishment. Regulatory agencies focus primarily on ports-of-entry, so we conducted our survey in other areas where infested logs, firewood or nursery trees could provide a pathway of introduction for non-native species.

We were particularly interested in exotic cerambycids such as the Asian longhorned beetle (ALB), but we also trapped for bark and ambrosia beetles, buprestids and horntails (*Siricids*). We used a variety of spatial and point source data to develop risk maps for Michigan's Upper and Lower peninsulas. Variables integrated into the risk maps included forest cover type, number and origin of state park visitors, sawmill and campground locations, and linear corridors such as railroad, highways and rivers.

Lures used in our traps included commercially available compounds plus cerambycid pheromones that have only recently been identified by researchers. Trap arrays were set on the ground, in the canopy, or in both locations, in 26 hardwood and 13 conifer sites; they were then checked at intervals of two to three weeks. Traps yielded over 13,000 *Cerambycidae*; 30,000 *Scolytinae/Platypodinae;* 500 *Buprestidae*; 7,000 *Curculionidae* and 100 *Siricidae*. Given concerns about potential ALB introductions, beetles captured on the ALB traps were sorted first and all cerambycids collected in these traps have been identified. Happily, *A. glabripennis* was not captured on any of the ALB traps or any of the other trap collections processed to date. Insect identification and data analysis will continue through the winter and spring.

Michigan State University

Other Forest Health Research

The project team continued work at a forested site near the town of Shepherd in the central part of Michigan's Lower Peninsula. This is an area where a long-term trial of systemic insecticides has been integrated with an intensive study of emerald ash borer (EAB) population dynamics in a forested setting. The site, accessible only by foot, includes two 40-acre parcels with ash and other hardwoods (aspen, alder, maple and oak).

For the past six years, the project has assessed EAB populations and compared density of EAB larvae on trees treated annually, to those treated at intervals of two or three years.

Field work is expected to be complete in winter 2014.

Researchers collect and peel ash logs in search of emerald ash borer larvae.

Michigan Technological University
Forest Health Monitoring Evaluation Project

Maple Decline

Annual evaluation of a network of 120 research plots in sugar maple stands across Michigan's Upper Peninsula, northern Wisconsin and eastern Minnesota took place from 2009 to 2012. Overall mean sugar maple dieback percentage (12.4 percent for all four years, ranging from 0.8 percent-75.5 percent plot dieback) decreased slightly during this time, however, individual stands and trees continued to decline.

Furthermore, new locations of severe sugar maple dieback were being reported by DNR and industry foresters throughout Michigan during this time. Some stands have been seen with over 50 percent dieback in the majority of trees and several areas of high-quality northern hardwoods have been salvaged.

Relationships were examined in the research plots between sugar maple dieback and growth, habitat, ownership, climate, soil, foliage nutrients and the maple sapstreak pathogen. Heavy forest floor disturbance due to exotic earthworms was significantly related to the level of sugar maple dieback in all evaluation models. Perturbation of soil nutrient cycling and poor soils is likely predisposing or contributing to dieback. The decreasing trends in total winter snowfall, length of stay on the ground, and the number of days with freezing temperatures were also significantly correlated with sugar maple growth rates. Sapstreak, *Ceratocystis virescens*, may be contributing to dieback in some stands, but was not related to the amount of dieback in timberlands across the region.

- Dr. Tara Bal and Dr. Andrew Storer

Healthy crowns, abundant regeneration, herbaceous species, thick duff layer, coherent when picked up, and no worm sign evident.

Unhealthy maple, little regeneration, low herbaceous diversity, only last year's leaves on forest floor with almost all maple leaves consumed and abundant earthworm sign.

Michigan Technological University

Forest Health Monitoring Evaluation Project continued

The next step will be to determine methods to help forest managers prevent, anticipate, manage, or salvage stands with sugar maple decline. Exotic earthworms may be either impacting trees directly or exacerbating other stresses such as climate change or herbivory by consuming the forest floor duff layer that protects roots.

We anticipate further investigation and development of silvicultural guidelines given the complex etiology underlying maple dieback and decline in the Great Lakes Region.

Michigan Technological University
Forest Health Monitoring Evaluation Project

Hannahville Indian Community

The Hannahville Indian Community, along with Michigan Technological University's (MTU) School of Forest Resources and Environmental Science, conducted emerald ash borer (EAB) surveys on tribal lands in Menominee County, in Michigan's Upper Peninsula. The surveys included the deployment of 40 purple prism traps and an ash inventory of 149 acres. The traps were placed on roadways and areas of public use, while the ash inventory surveys were conducted in residential and public use areas of tribal lands. Signs of EAB activity include the presence of serpentine (s-shaped) galleries and D-shaped exit holes. All 40 traps were found to be negative and all the ash trees surveyed were found to have no signs of EAB. Some of the ash trees showed symptoms, but not signs, which could be caused by site conditions. Symptoms of EAB activity include tree crown dieback, sprouts, bark splits, and a lot of woodpecker activity. During the inventory work, beech trees were also surveyed and checked for beech bark disease. All of the beech trees were found to be negative for the disease.

State Lands Ash Inventory

Ash inventory surveys in Michigan's western Upper Peninsula were funded through a federal Great Lakes Restoration Initiative grant. These surveys were conducted in 2012 and 2013 in Ontonagon, Baraga, Iron, Dickinson, Marquette and Menominee counties. Gogebic County was not included in the survey work due to forest stands not meeting the criteria for inventory.

The surveys, conducted by the DNR's Forest Health Program and MTU's School of Forest Resources and Environmental Science, were carried out in areas believed to be beyond EAB activity in the state. The inventoried stands were composed of 10 percent or more of upland ash (white and green). All areas included in the survey were found to be negative for any definitive signs of EAB activity. None of the 119 stands had any signs of EAB, though some of the ash trees showed symptoms of decline in overall health. This is commonly caused by site conditions such as long term effects of weather, but there is still a possibility that it may be due to EAB.

Heavy beech scale infestations give a white-washed appearance to the bark.

Beech trees were also surveyed during the inventory work, for possible occurrence of beech bark disease. For this project 5,101 acres were inventoried in all six counties. Menominee County is approximately 60 miles west of the Delta County SLow Ash Mortality (SLAM) pilot project site. The Delta SLAM site is heavily infested with EAB and biological control was applied in 2010 and 2011 through release of three species of parasitic wasp. In 2012, it was found that the three parasitic wasps; Oobius agrili, *Tetrastichus planipenni*, and *Spathius agrili* had established at the site. With

Michigan Technological University

Forest Health Monitoring Evaluation Projects continued

establishment of the parasitic wasps at the Delta SLAM site, it is anticipated that the wasps will follow EAB activity and keep the population at lower levels as it moves into the more western counties of the Upper Peninsula.

Oak Wilt

The U.S. Department of Agriculture Forest Service, Forest Health Protection Program, has provided funding for collaborative work between the Michigan DNR's Forest Health Program and MTU's School of Forest Resources and Environmental Science. This collaboration is a continuing project to rid the Upper Peninsula of oak wilt and to monitor sites that were treated for oak wilt control in 2012. In 2013, 45 oak wilt sites in Menominee County were surveyed, with 31 sites confirmed positive, either by the presence of pressure pad or by fungal culture. Three oak wilt escapes were found from the 2012 vibratory plow treatments.

After determining sites with oak wilt within Menominee County, a total of 36,908 feet of vibratory plow lines were created. As part of the control effort, 85 acres of oak dominated stands were harvested, allowing for protection of 7,473 acres of oak forest.

Three sites in Iron County that were treated in 2012, were surveyed in 2013 to evaluate the effect of the treatments. Two of the sites were determined to be negative for oak wilt, while the third was found to be positive. To help prevent the spread of oak wilt from the infected site, the DNR bermed the road and posted signs stating that it was positive for oak wilt and to please not remove wood for firewood. The Michigan DNR and collaborators will continue monitoring all treated sites for possible oak wilt escapes, as well as to observe the efficacy and durability of the vibratory plow trench in containing and controlling oak wilt.

U.S. Forest Service
Northern Research Station Update
Other Cooperative Forest Health Activities

The European oak borer (EOB), *Agrilus sulcicollis*, was first discovered in North America in 2008, with populations being found in Michigan (Haack et al. 2009) and Ontario, Canada (Jendek and Grebennikov 2009). However, evidence was later found to prove that EOB had been present in North America for well over a decade given that some previously collected specimens were subsequently identified that dated back as far as 1995 in Ontario and 2003 in Michigan. Currently, EOB has been found in 10 counties in southern Michigan, as well as two counties in New York, and six counties in Ontario, Canada. Intensive delimiting surveys were never conducted for EOB so its range in North America is likely much larger.

Given that EOB is exotic and is closely related to the emerald ash borer (*Agrilus planipennis*), its initial discovery raised considerable concern on what impact it may have on North American oaks especially when combined with the native twolined chestnut borer (TLCB) as well as other oak pests. In recent years, we have conducted several studies on the biology of EOB in Michigan and most of these results will be published soon (Petrice and Haack 2013).

We found that EOB has a life history similar to TLCB, in that:

- Mature overwintering larvae pupate in spring;
- Adults emerge a few weeks later and lay eggs during summer;
- Adults are attracted to purple traps; and
- Larvae hatch from eggs and tunnel to the cambial region where they feed through the summer and fall.

Some of the main differences between EOB and TLCB are:

- EOB adults emerge and fly earlier in the spring compared to TLCB;
- Both species are medium sized *Agrilus* but EOB adults are bright blue or bluish green, while TLCB are olive or bronzy green with two distinct yellowish stripes on their upper surface;
- EOB galleries usually run parallel with the wood grain and TLCB galleries usually run perpendicular to the wood grain; and
- EOB develops in recently dead host material while TLCB prefers stressed but alive hosts.

U.S. Forest Service
Northern Research Station Update
Other Cooperative Forest Health Activities continued

- In addition, we found important differences in larval morphology that allow these two *Agrilus* species to be distinguished. So far, we have reared five species of parasitic Hymenoptera from EOB, of which three of these species are known to attack TLCB. We also found that EOB can reproduce in black oak, English oak, red oak, white oak, and most likely other oak species given that these were the only four oak species that we tested. Given EOB's preference for dead trees and the fact that EOB has been present in North America for over a decade with no direct association with oak mortality, it appears that EOB will not be an aggressive tree killer as TLCB commonly is, especially during periods of drought.

Adult European oak borer on oak leaf.

Haack, R.A., Petrice, T.R., and Zablotny, J.E. 2009. The first report of the European oak borer, Agrilus sulcicollis (Coleoptera: Buprestidae), in the United States. Great Lakes Entomologist 42: 1–7.

Jendek, E., and Grebennikov, V. V. 2009. Agrilus sulcicollis (Coleoptera: Buprestidae), a new alien species in North America. The Canadian Entomologist 141: 236-245.

Petrice, T.R. and Haack, R.A. 2013. Biology of the European oak borer in Michigan, United States of America, with comparisons to the native twolined chestnut borer. The Canadian Entomologist (in press). doi:10.4039/tce.2013.58.

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