2016 Forest Health Highlights

Michigan Department of Natural Resources

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Introduction

The National Forest Health Monitoring Program tracks changes in the condition of America's forest land each year. The Michigan Department of Natural Resources Forest Health Program has been a partner in this multi-agency effort since 1995.

Information from ground plots and surveys, aerial assessments and remote sensing is used to help mitigate health issues that threaten the sustainability of Michigan's nearly 20 million acres of forest land.

Notably in 2016, numerous hemlock woolly adelgid infestations were confirmed in the west-central Lower Peninsula and *Heterobasidion* root disease was identified in the Upper Peninsula for the first time.

Acknowledgments

Forest Health Highlights is a summary of the condition of Michigan's forests during 2016 and the work done to preserve and protect them by the Michigan Department of Natural Resources Forest Resources Division (www.michigan.gov/foresthealth) and its partners.

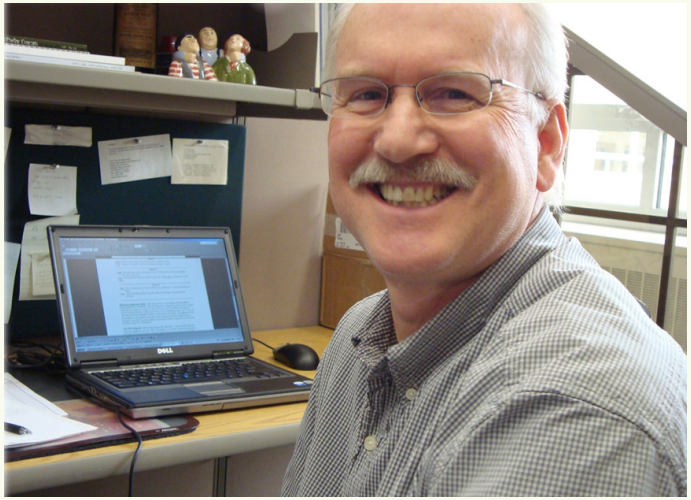
Written by
Michigan Department of Natural Resources Forest Resources Division
Michigan Department of Agriculture and Rural Development
Michigan State University Department of Forestry and the Department of Entomology
United States Department of Agriculture Forest Service

Photographs and design by
Michigan Department of Natural Resources Forest Resources Division
United States Department of Agriculture Forest Service
Michigan Department of Agriculture & Rural Development
Michigan State University

Maps and other information provided by
Michigan Department of Natural Resources Forest Resources Division
Michigan Department of Agriculture and Rural Development
United States Department of Agriculture Forest Service and
Animal and Plant Health Inspection Service
Michigan State University Extension

Cover photo: Webbing and feeding damage from fall webworm near Island Lake Recreation Area in Livingston County, Michigan. Photo by Michigan Department of Natural Resources forest health technician Scott Lint.

Bob Heyd retires



After nearly 38 years of outstanding leadership and vision with the Michigan Department of Natural Resources, marked by a unique perspective on forest health - and life in general - Dr. Bob Heyd has moved on to the honorable ranks of the newly retired.

It's not possible to do justice to Bob's influence in this small space. It's safe to say, though, that the DNR Forest Health Program and 20 million acres of Michigan forest land profited greatly during his time with us.

And so, it's with appreciation and more than a bit of sadness that we bid Bob farewell and wish him a happy and productive retirement.

Well, not everyone, exactly.

High in the top of a balsam fir tree, somewhere deep within a Chippewa County swamp, a little spruce budworm is shaking its tiny head and saying, "Finally - I thought that guy was never going to leave..."

--Roger Mech

Hemlock Woolly Adelgid

The Michigan Department of Agriculture and Rural Development contributed this story.

Hemlock woolly adelgid-infested hemlock branch in Ottawa County, Michigan. Photo courtesy of MDARD.

Hemlock woolly adelgid (HWA) was detected on four properties in Ottawa County and two properties in Muskegon County in 2015. In 2016, HWA was detected on three additional properties in Ottawa County and one in Muskegon County. There are no known established populations of HWA anywhere else in Michigan. Historically, HWA infestations in Michigan have been reported by landscapers, arborists and other alert citizens knowledgeable about HWA and its potential impacts.

Prior to 2015, HWA had been found infesting landscape hemlock in Emmet (2006, 2007, 2010), Macomb (2010/two locations), Ottawa (2010/two locations), Berrien (2012) and Allegan (2013) counties. Steps to eradicate were taken at each of the locations the year HWA was detected. To date, there is no evidence that HWA persists at any of these locations.

So far, no clear source of the current infestations has been found, but a likely source is hemlock nursery stock moved into Michigan from infested areas outside of Michigan. Infested nursery stock would have been brought in either prior to the 2001 Michigan Department of Agriculture and Rural Development's (MDARD) Hemlock Woolly Adelgid Quarantine, or afterward in violation of the quarantine. The exterior quarantine restricts the movement of hemlock into the state and includes a complete ban of movement of hemlock into the state from infested areas.

Surveys in 2016 at the 10 infested sites showed that the infestations ranged in size and scope from a single property with a few infested trees to multiple properties with hundreds of infested trees.

In September and October, mailings were sent to 240 licensed pesticide application businesses and more than 2,000 property owners who work and live in and around the known infested sites. These mailings included a letter describing the problem, information on pesticide treatment options, suggested best management practices, links to additional web-based resources and an invitation to two HWA informational sessions held in early October. Property owners are being urged to inspect their hemlock trees and, if evidence of HWA is found, to treat them.

In late December 2016, MDARD opened a public comment period of 45 days on a proposed Hemlock Woolly Adelgid Interior Quarantine. The quarantine would regulate the movement of hemlock nursery stock, branches, boughs and forest products with bark attached. Exemptions include forest products with the bark removed, including lumber or posts.

The proposed quarantine would establish a regulated area in western lower Michigan. Movement of regulated articles to areas outside the regulated area would be prohibited except under a compliance agreement issued by MDARD. The proposed quarantine would also

Hemlock Woolly Adelgid *continued*

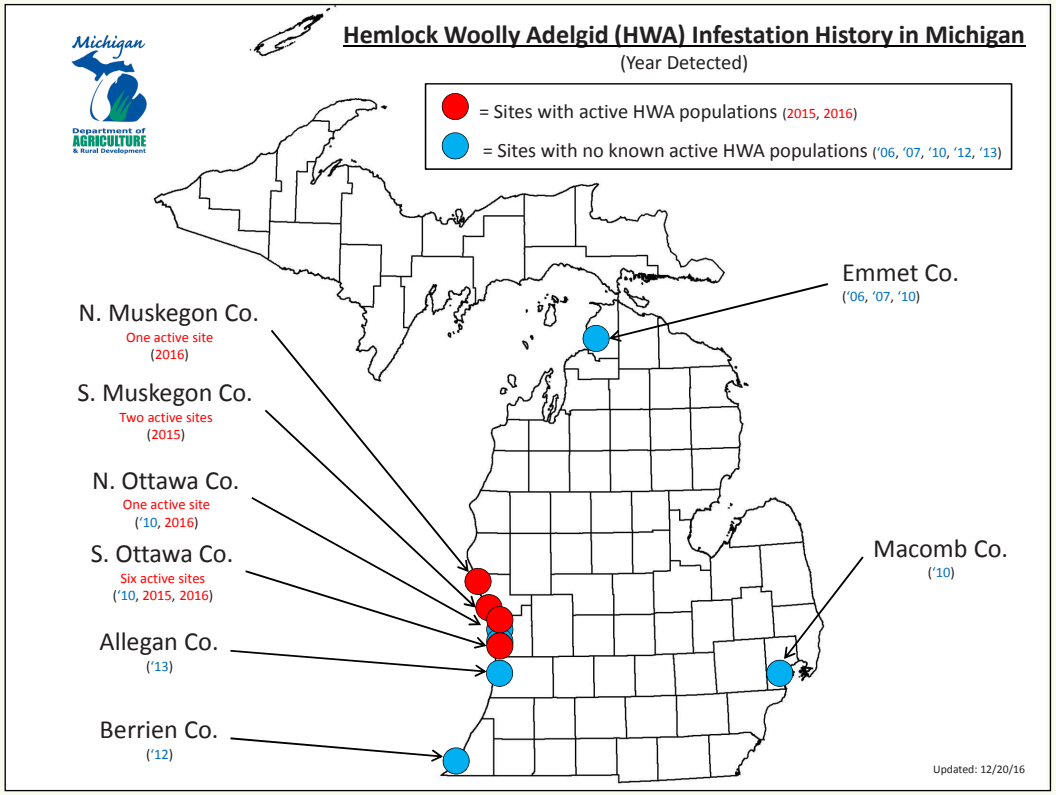
prohibit movement within the regulated area except under compliance agreement. It is anticipated that a final version of the quarantine will be in place in early 2017.

Quarantine details are available by visiting MDARD's quarantine information webpage at: www.michigan.gov/pestquarantines.

An interagency HWA response group is working to develop and implement a statewide response strategy. The response strategy, developed by representatives from MDARD Pesticide and Plant Pest Management Division, MSU Entomology Department, DNR Forest Resources Division and USDA Forest Service, will help with efforts to secure funding for expanded response activities.

Activities at the infestation sites to date have been supported in part by a Forest Health Protection grant from the U.S. Forest Service.

Additional information can be found on pages 47-48 of this guide or on MDARD's HWA webpage at: www.michigan.gov/HWA.



Spruce Budworm

Spruce budworm damage on new growth.

Epidemics of spruce budworm (SBW) periodically cause extensive defoliation and tree mortality in spruce and fir forests across the northeastern United States and Canada. These outbreaks last for 10-15 years and have resulted in the loss of millions of cords of spruce and fir. This year marked the third consecutive year of defoliation in areas of Michigan's western Upper Peninsula, isolated areas in the eastern Upper Peninsula and the northeastern Lower Peninsula.

Spruce budworm threatens the survival of balsam fir and mixed spruce/fir forests in northeastern North America. Large scale SBW outbreaks cause widespread top kill and tree mortality. Mature and over-mature balsam fir-dominated stands can be severely damaged. Susceptible stands often lose 60 to 80 percent of the fir and 20 to 40 percent of the spruce. Mature fir stands may be entirely lost.

This year's defoliation covered many of the same areas as last year, with some minor expansion into previously uninfested spruce/fir resources in the west-central Upper Peninsula. The intensity of the defoliation was generally less in 2016. SBW numbers will continue to increase over the next decade or so. Efforts are underway on DNR-managed forests to identity and harvest newly-defoliated, high-risk mature and older spruce/fir forestlands. The DNR Forest Resources Division reviewed and assessed over 50,000 acres of high-risk spruce and fir stands in 2016. Close to 7,000 acres of timber sales were prepared that included spruce budworm salvage.

About 20 percent of Michigan's spruce and fir resources occur on state forestlands, with 24 percent on federal lands and 56 percent on private or industrial ownership. The vast majority of Michigan's spruce and fir resources are in the Upper Peninsula.

Management recommendations are to harvest spruce and fir at the age of 50 years and to salvage harvestable stands with significant SBW damage.

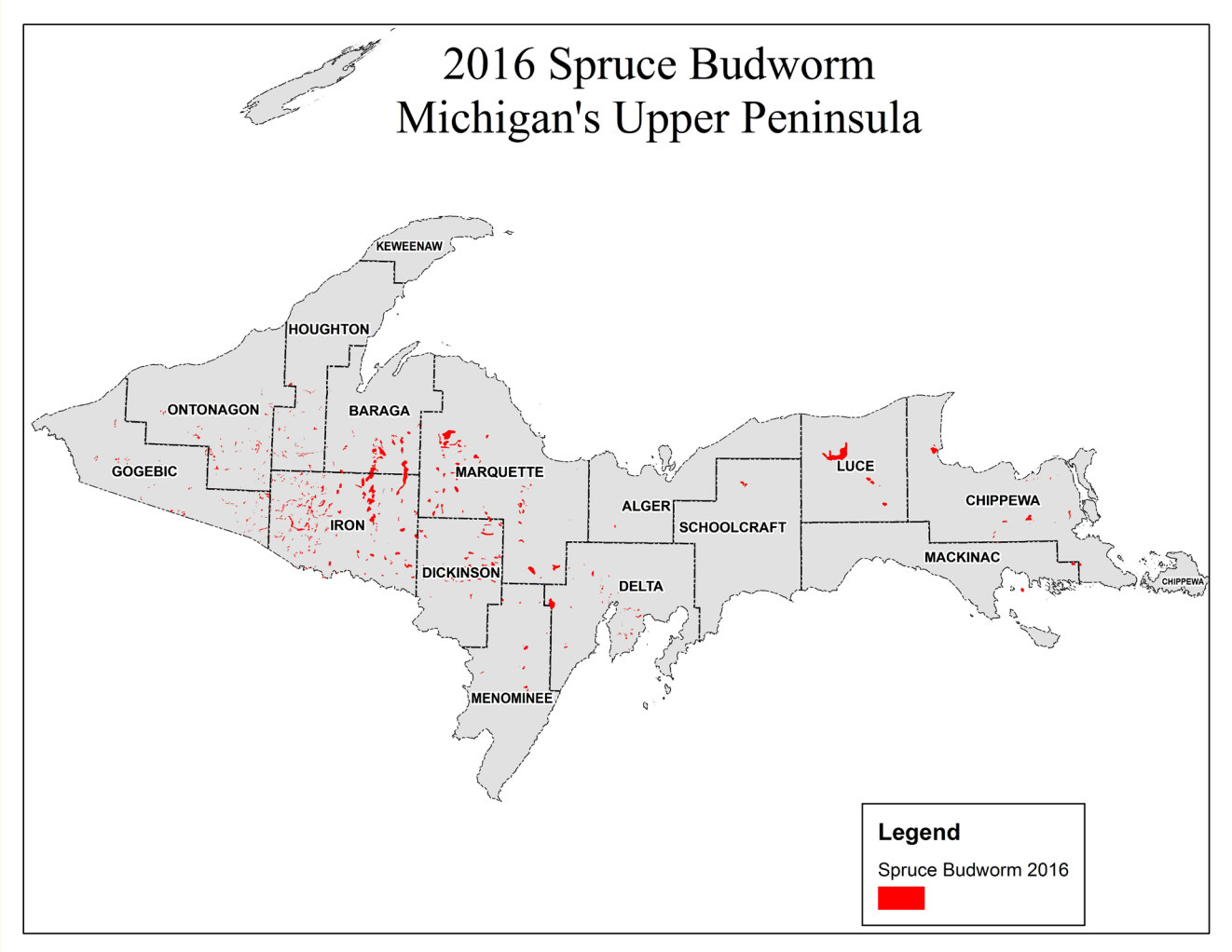
Trees damaged by spruce budworm.

Spruce Budworm *continued*

Guidelines include:

1) Monitoring annual SBW defoliation and presence of top kill and tree mortality.
2) Consider harvesting stands with top kill and mortality
3) During an outbreak, prioritize salvage operations by:
    a) Harvesting stands with top kill or mortality.
    b) Harvesting the oldest stands.
    c) Harvesting stands with the highest component of balsam fir.
    d) Harvesting stands with the highest volume.
    e) Recognizing that stands on poor sites may be damaged earlier and to a greater extent.
4) Protecting high value stands with registered insecticides can be cost effective when stands cannot be harvested (salvaged) quickly enough to stay ahead of budworm-induced mortality.

For more information, see: http://www.michigan.gov/documents/dnr/SBW_FAQ_-_FINAL_492925_7.pdf?20151215134857.



Heterobasidion Root Disease

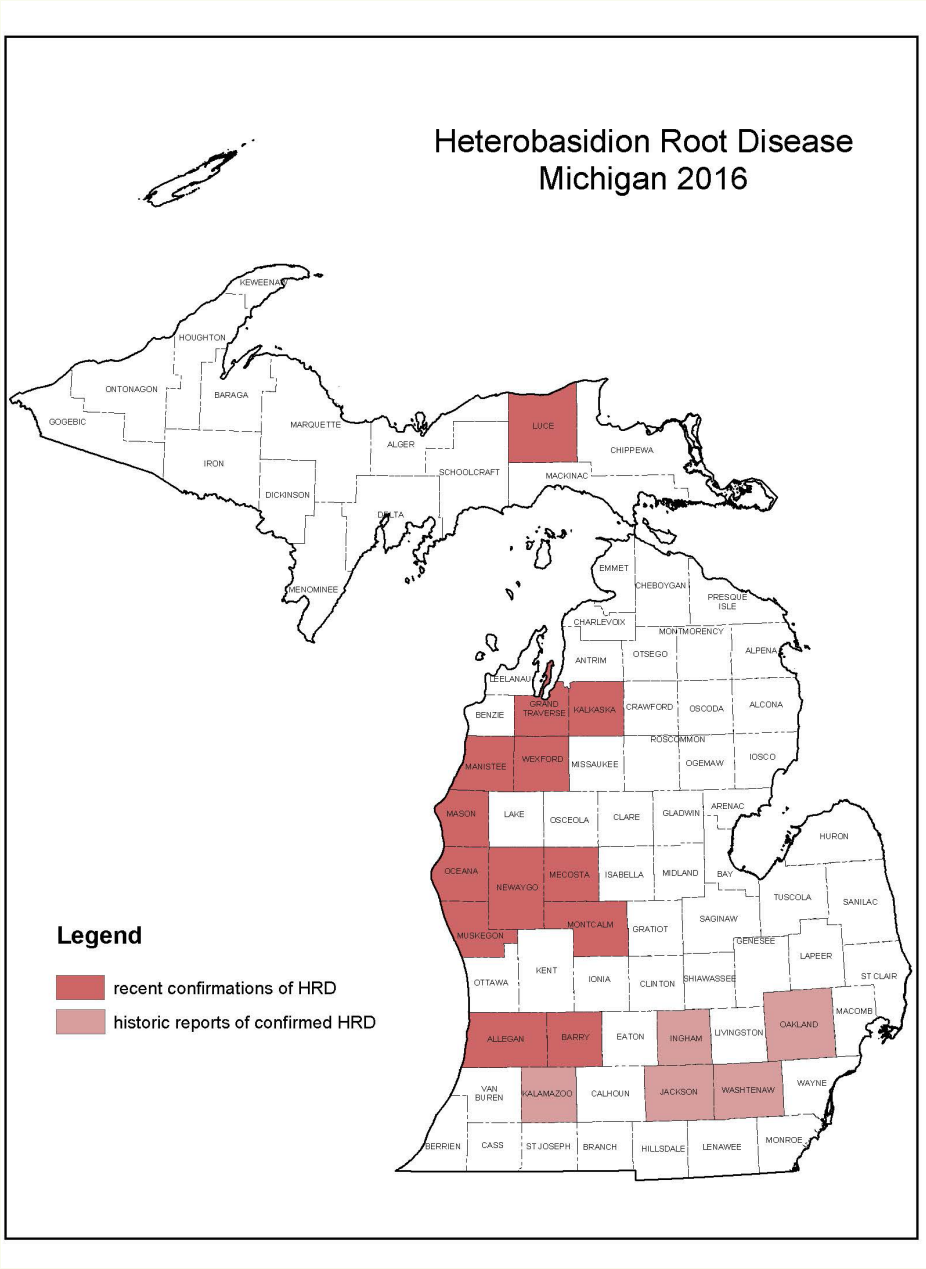
Heterobasidion root disease (HRD) is considered the most destructive fungus in North American forests. Unlike many forest insects and diseases that are attracted to stands stressed by lack of management, HRD is most commonly found in managed forests. Freshly cut stumps provide an ideal entry path for airborne spores of HRD.

Red pine, white pine and jack pine are especially susceptible. To a lesser degree, white spruce, balsam fir and tamarack can also become infected. Stands that have been thinned multiple times are at high risk of infection. Proximity to diseased trees that have formed fruiting bodies (mushrooms) increases the likelihood of infection in adjacent areas.

Trees infected by HRD suffer from thinner foliage, slower shoot growth and reduced height and trunk diameter. Circular pockets of dead and dying trees mark the progression of the disease over time.

Detection efforts continued in 2016, with HRD confirmed for the first time in Mason, Muskegon and Luce Counties. The Luce County detection is the first reliable report of HRD in the Upper Peninsula.

As HRD continues to be found across the state, the Huron-Manistee National Forests (HMNF) and the DNR are taking steps to inform land managers, foresters and timber producers about reducing its impacts. The HMNF has drafted "A Proposal to Prevent the Spread of Heterobasidion Root Disease," which is currently going through a public review and comment period. Meanwhile, the DNR has put together an "Advisory for preventing



Heterobasidion Root Disease *continued*

Top: *The spore-producing fruiting bodies of* Heterobasidion Irregulare *formed on a red pine stump in Barry County.* ***Bottom:*** *Aerial view of damage suspected to have been caused by* Heterobasidion *root disease near Proud Lake.*

Heterobasidion Root Disease of Red Pine in Michigan's Lower Peninsula." This document describes the risks of HRD and provides managers guidance tailored to specific forest conditions. The document is under review by the Forest Resources Division.

Effective HRD management is dependent on accurate risk assessment. A major HRD risk factor is proximity to a source of HRD spores, and efforts to identify and delimit the extent of HRD in Michigan will continue in 2017.

Oak Wilt

Oak wilt was found in ten state parks and recreation areas in Michigan's Lower Peninsula in summer 2016. Parks and Recreation Division staff installed approximately 13,000 feet of vibratory plow line in five state parks. Propiconazole injections were made on trees in the remaining five state parks to preserve campground aesthetics and reduce tree removal costs. Parks and Recreation Division is also experimenting with mechanical girdling to stop the movement of the fungus through roots.

Oak wilt management continues to be a challenge at P.J. Hoffmaster State Park. Park staff estimate that approximately 700 trees have been lost due to five consecutive years of oak wilt infection.

This year, oak wilt was confirmed within the wet-mesic flatwood forest of Belle Isle Park, one of the largest and last remaining areas of its kind in the state. DNR's Forest Health Program and Parks and Recreation Division Stewardship Unit surveyed the island and found oak wilt on just over 45 acres of the 200 acres of forest.

Affected areas were treated with a vibratory plow to stop below-ground movement of the fungus. Over 100 trees will be removed. One of the areas treated includes the state champion 56-inch diameter Shumard oak, which was injected with propiconazole. Due to the sensitive nature of the area, many other trees will be injected rather than removed.

The Michigan Department of Natural Resources Forest Health Program is testing use of funcides as a potential treatment option of oak wilt.

Oak wilt is finding its way to Michigan state parks and recreation areas on infected firewood. Visitors are inadvertently bringing firewood from diseased trees into campgrounds and day-use areas. Sap-feeding beetles carry oak wilt spores from the firewood to wounds on healthy trees, spreading the disease to new areas of the island.

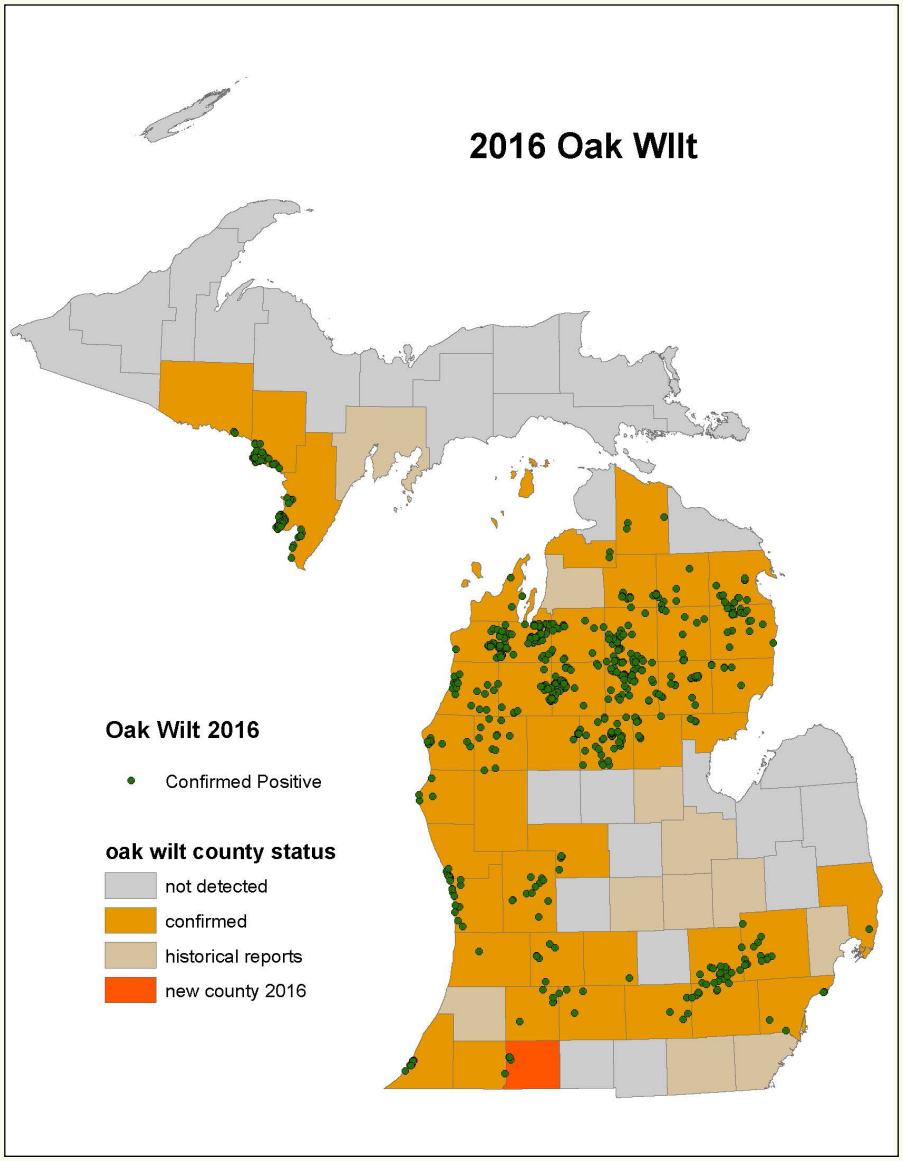
The vibratory plow blade cuts narrow trenches 5 feet deep to separate underground root systems, preventing further spread of the oak wilt fungus to uninfected trees.

A 2002 through 2008 study reported about 30 percent of campers brought firewood from home. Current surveys report 41 percent of campers are bringing firewood to state parks.

Oak Wilt Suppression

The U.S. Forest Service provides oak wilt suppression funds to help remove oak wilt from Michigan's forests. Project goals include: 1) Remove oak wilt from state forest land by detecting and treating infection centers; 2) Educate affected communities to prevent the reintroduction of oak wilt; and 3) Demonstrate an approach that can be used for detecting and effectively removing the threat of oak wilt throughout Michigan.

Oak Wilt *continued*



Upper Peninsula

The Upper Peninsula project is a cooperative effort between the Michigan Department of Natural Resources and Michigan State University Extension. This year's project focused on state forest land in Menominee County. Thirty four oak wilt pockets totaling 44.8 acres were isolated by creating 29,979 feet of root-graft barriers with a vibratory plow. All red oaks within these pockets will be removed via timber sales before April 2017. All sites were reviewed and treatments approved by the USDA Fish and Wildlife Service, affected Native tribes and the State Historic Preservation Office.

Michigan State University Extension continued to evaluate past Upper Peninsula oak wilt suppression efforts. Treated areas remain free of oak wilt with few exceptions. Since the beginning of oak wilt control efforts in this area in 2004, the size of epicenters has grown progressively smaller. Many of the 2016 epicenters were only one or two years old, averaging 1.3 acres. Although much has been achieved, untreated oak wilt pockets remain. Diligence will be needed as we strive to remove the threat of oak wilt to the UP's oak resources.

Northern Lower Peninsula

In the Northern Lower Peninsula, 11 sites in four counties (Wexford, Missaukee, Kalkaska & Roscommon counties) were treated using 12,350 feet of root-graft barriers. All red oaks within these pockets will be removed via timber sales before April, 2017. All sites were reviewed and treatments approved by the USDA Fish and Wildlife Service, affected Native Tribes and the State Historic Preservation Office.

The NLP oak wilt suppression efforts began last year. Treatments appear effective and will be evaluated in the coming years.

Beech Bark Disease

Beech scale on bole of tree.

Beech bark disease (BBD) has spread widely through Michigan's forests since it was discovered here in 2000. This disease is initiated by a white scale insect that attaches to bark and feeds on sap. Damage from this feeding allows *Neonectria fungi* to invade the tree. The fungus inhibits the flow of sap through infected portions of the tree, causing a general decline in tree health and eventually killing the 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 appear to have a healthy canopy although its main stem is weakened by the fungus. Affected trees are subject to "beech snap," in which the main stem of the tree breaks suddenly. Scale-infested trees are considered "hazard trees" and can pose a serious risk to people, structures and personal property.

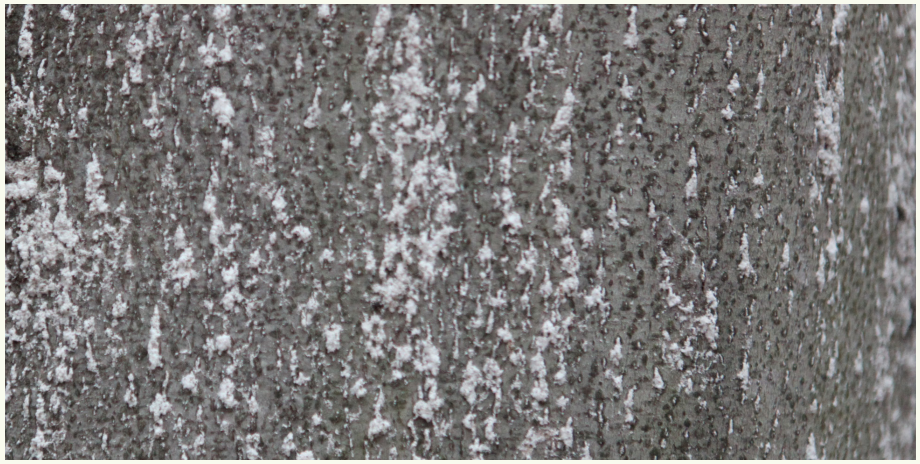
Resistant American Beech Project

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. 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. These genetic studies indicate 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. The Forest Resources and Wildlife Divisions of the DNR have joined forces. Two orchards were completed in 2016 - one at Purdue University's Hardwood Tree Improvement & Regeneration Center and one at Michigan State University's Kellogg Forest. Our vision is the restoration of Michigan's American beech resource.

More information on BBD can be found on pages 44-46 of this guide.



Beech scale close up.

Watching out for Asian Longhorned Beetle

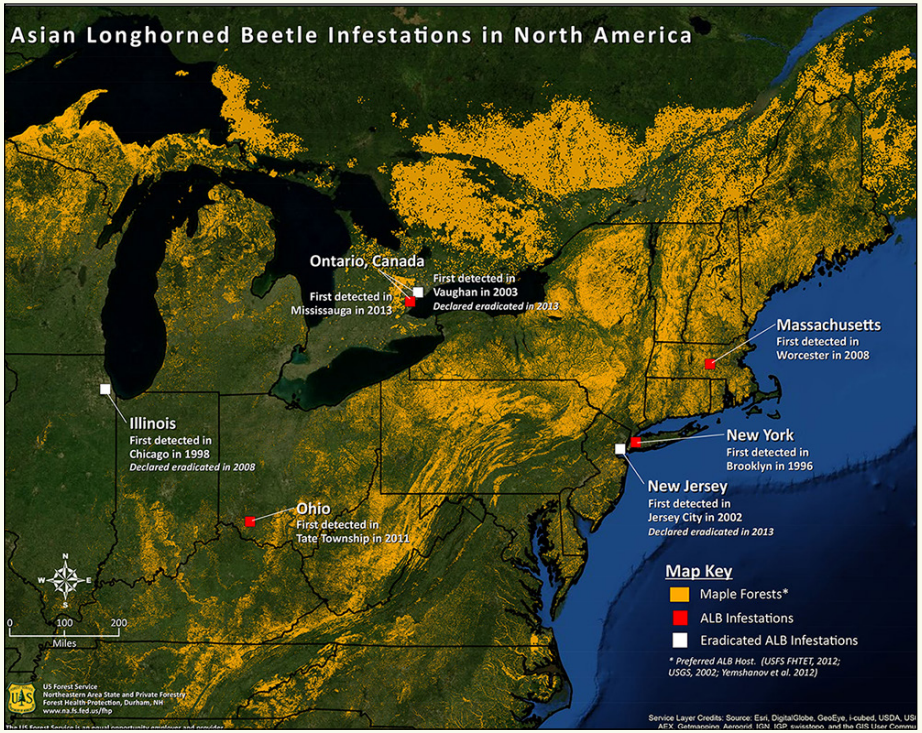
For a sixth consecutive year, Parks & Recreation Division surveyors have given DNR state parks and recreation areas a clean bill of health. No Asian longhorned beetles were found following intensive surveys this summer in 26 recreation facilities across Michigan.

ALB favor maple trees but also attack horse chestnuts, poplars, willows, elms, birch, black locusts and other hardwood species. The adult beetles create ⅜ inch round emergence holes as they chew their way out of infested trees. Small piles of insect droppings (called frass) and wood chips can accumulate at the base of infested trees, also signaling the presence of ALB.

Surveyors target high-risk trees during their searches, looking for signs and symptoms of infestation. Trees growing near fire rings are especially vulnerable in the event ALB emerges from infested firewood.

ALB is currently killing thousands of trees in parts of New York, Massachusetts and Ohio. Surveyors use zip codes to identify campsites visited by campers from these areas who may have brought infested firewood with them.

The ALB infestation in Clermont County, Ohio, poses a particular risk to Michigan forests, as it is only a four-hour drive from our southern border. The beetle continues to thwart eradication efforts there, where surveys of over 1.8 million trees have identified nearly 18,000 infested.

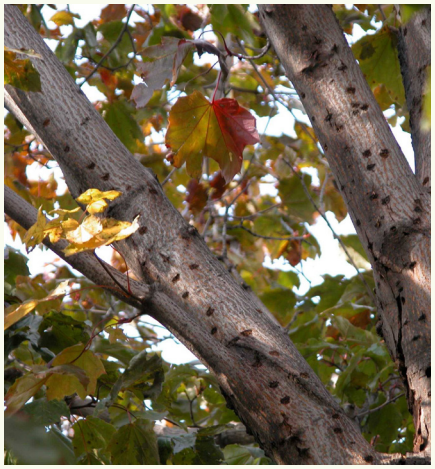


In November, ALB infestations were discovered just north of the village of Bethel, Ohio. These are outside of the 61 square miles of quarantined area.

ALB continues to be intercepted by inspectors at warehouses and ports in many areas of North America. The USDA Animal and Plant Health Inspection Service (APHIS) has established quarantines to prevent these introductions and to discourage accidental spread of ALB from areas already infested. These quarantines require that infested trees and other materials be destroyed.

APHIS has also placed restrictions on solid wood packing material from

Asian Longhorned Beetle *continued*



Top: *Asian longhorned beetle surveyors attend an annual refresher training session.* ***Bottom left:*** *Emergence holes caused by the Asian longhorned beetle (ALB).* ***Bottom right:*** *Cross-section of ALB damage to a stem.*

China to help reduce the movement of ALB out of its native lands.

Closer to home, DNR Parks & Recreation division is restricting movement of firewood into state parks and recreation areas across Michigan. An exemption is being made for firewood obtained within 10 miles of the facility and for firewood that has been certified as kiln-dried.

The Michigan Department of Agriculture and Rural Development (MDARD) has enacted a statewide quarantine that prohibits movement of hardwood firewood into Michigan from or through Ohio or Indiana. The quarantine is aimed at preventing introductions of walnut twig beetle (WTB) into the state. WTB can spread the fungus that causes Thousand Cankers Disease of black walnut. The quarantine includes all hardwood firewood.

Adult ALB are large (¾ to 1½ inches long) with long black and white-banded antennae. The body is glossy black with irregular white spots. If you see a suspect tree or beetle, take photos, record the location, collect any suspect beetles in a jar and report it to the following:

1-800-292-3939 I MDA-Info@michigan.gov

More information on exotic forest pests, including ALB, can be found on pages 29-32 of this guide or at www.asianlonghornedbeetle.com.

Redheaded Pine Sawfly

The redheaded pine sawfly (RHPS) continued to damage young plantation red and jack pine in areas of the Northern Lower Peninsula in 2016. RHPS outbreaks tend to build regionally. The sawfly is easily controlled by spraying. However, if left unchecked, sawflies can deform and kill trees.

The RHPS is an important defoliator of young two-needle pines. Plantations less than 15 feet tall are most susceptible to economic injury. The heaviest infestations commonly occur on pines growing under stress, particularly those at the edges of hardwood forests, on poor soils and where there is heavy competitive vegetation. The sawfly prefers edge trees.

Repeated defoliation can cause top kill, forking and tree mortality. A single moderate to heavy defoliation stunts height growth of infested trees. Complete defoliation in a single year can kill red pine and jack pine.

The larvae feed in colonies containing a few to over a hundred larvae. Early damage, similar to that of most other coniferous-feeding sawflies, is identifiable by the reddish-brown, straw-like remains of needles partially consumed by the young larvae.

Older larvae consume the entire needle, generally stripping a branch of all its foliage before feeding on another.

Early detection and rapid response are the keys to protecting infested sites. Monitoring egg laying and early larval development in June and early July is important to successfully control populations.

Top: *Redheaded pine sawfly eggs.* ***Bottom left:*** *Damage caused by the redheaded pine sawfly.* ***Bottom right:*** *Sawfly larval colony*

White Pine Decline

White pine branch dieback.

As branch dieback and mortality of white pine trees continued in the north-central Lower Peninsula in 2016, we learned new information that moved us closer to possibly solving this mystery. Researchers in the southeastern U.S. have implicated the pine bast scale in dieback and mortality of young white pine trees in several states, including Georgia, North Carolina, South Carolina, Tennessee, Virginia and West Virginia. In summer 2016, they confirmed the pine bast scale on samples of white pine collected in Michigan's northern Lower Peninsula.

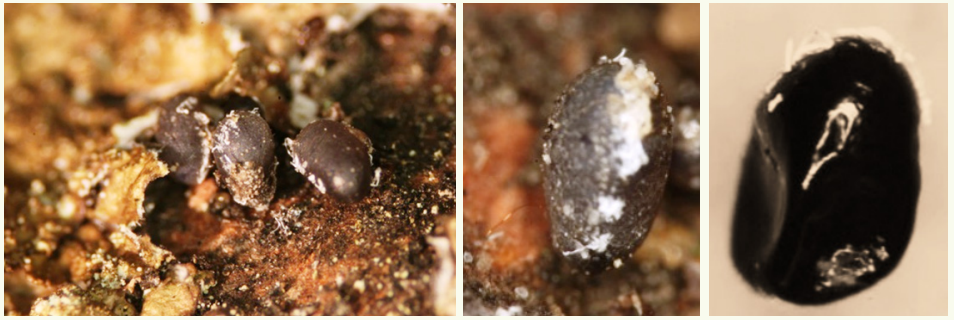
Pine bast scales are sucking insects that insert tiny, straw-like mouthparts (stylets) into the bast of white pine branches. The bast makes up the outside layer of the phloem tissue. Phloem, in turn, is made up of vessels that move sugars produced in the needles to the rest of the tree. The storage cells in the bast are large and especially attractive to hungry scales.

Pine bast scales are native to many areas of the northeastern U.S., including Michigan. They're also well-distributed throughout Ontario, where they were first identified in 1959. While fairly common, pine bast scale historically has not been connected with damage to white pine trees.

That is, until now.

Pine bast scale has only recently been detected in the southeastern U.S., and researchers at the University of Georgia are finding evidence the scale may be associated with fungal infections causing white pine dieback and mortality. A fungus called *Caliciopsis pinea* is responsible for cankers that are girdling branches and main stems of white pine, and it appears it may be finding its way into the tree through feeding holes made by the scale.

Studies are showing a strong correlation between incidence of pine bast scale and white pine dieback. If this has a familiar ring to it, it should. Beech bark disease, which continues to spread steadily across Michigan, works in much the same way. Feeding by exotic beech scale insects creates openings that allow native and exotic fungi to infect and kill beech trees.



Pine bast scale.

White Pine Decline *continued*

Since it was first reported by DNR foresters in the Grayling Forest Management Unit in 2008, dieback and mortality continues to occur widely on understory white pine seedlings and saplings near the Au Sable and Manistee Rivers.

Interestingly, *Caliciopsis* cankers in Michigan are often beneath the fronds of lichens commonly found on white pine. Lichens are organisms made up of algae and fungi living together in a mutually beneficial relationship. Harmless to their host, they frequently grow on the bark of a variety of forest tree species.

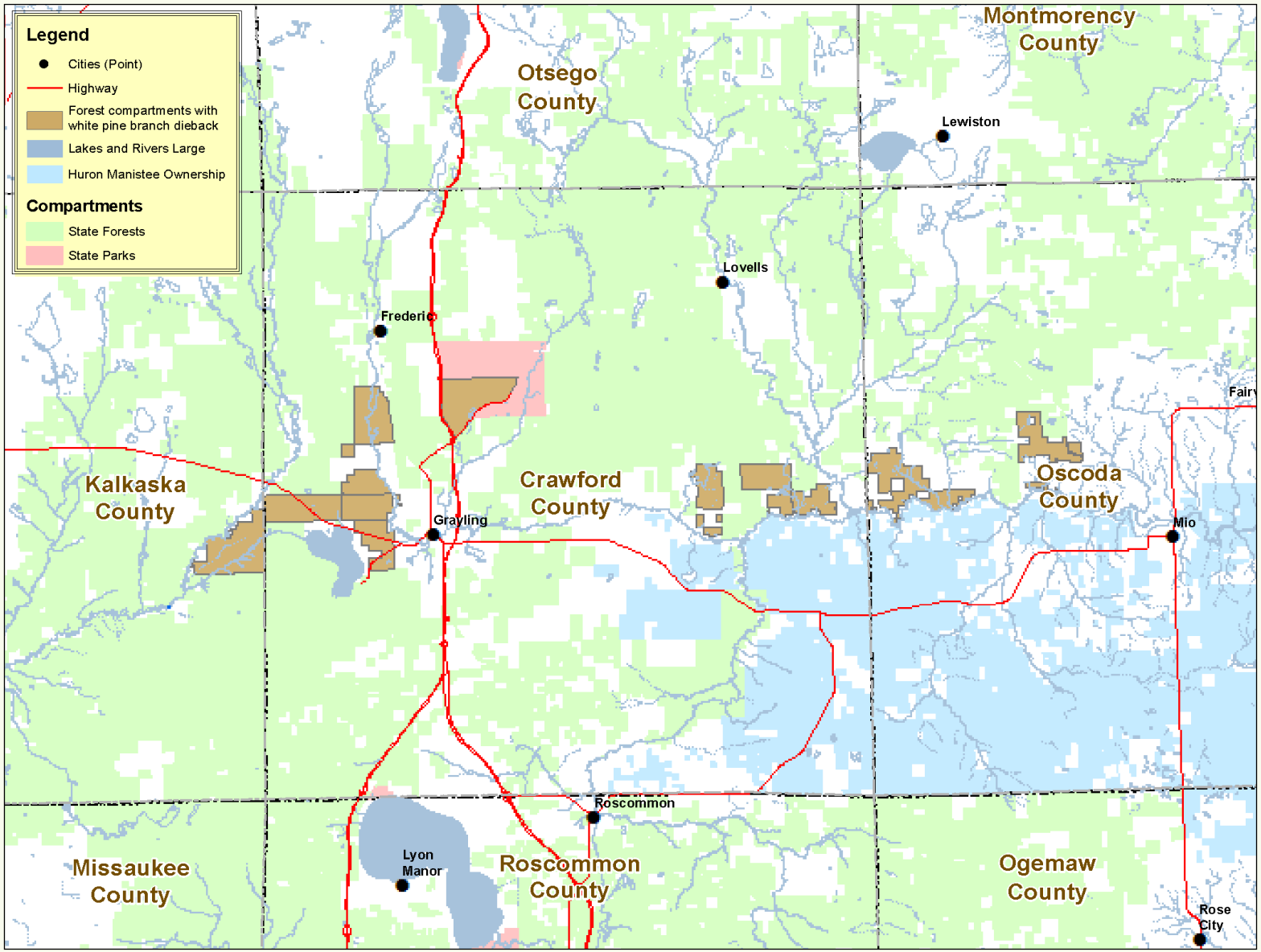
In DNR surveys, pine bast scale is often associated with a particular species of lichen, *Melanelixia subaurifera*, commonly found on branches and small twigs of white pine trees in northern Michigan.

It appears pine bast scale has a two-year life cycle in Michigan, with quite a bit of overlap in the life stages. The crawler stage, which hatches during the summer, can be blown long distances by the wind. This is one explanation for how the scale spreads through the forest.

Thanks to Thomas Whitney, University of Georgia, for contributing information for this article.

Branch cankers on white pine.

White Pine Decline Distribution



Diplodia Shoot Blight

Diplodia shoot blight caused by the fungus *Diplodia pinea* is prevalent in many areas of Michigan. Diplodia affects both red and jack pine. Infections are fairly common in plantations and in naturally regenerated pine.

Infected trees produce Diplodia spores on blighted twigs and cones. Spores rain down from overstory trees and infect understory seedlings and trees. Branches and cones left behind from timber harvests of infected pines also harbor spores that infect newly-planted seedlings.

Mature red pine diplodia pocket.

Infected trees have no symptoms until they're stressed by drought or wounded by hail storms or other events. Hail damage or drought can cause shoot blight and stem cankers on larger trees, killing their shoots and branches. Moisture stress on newly planted seedlings can lead to stem collar rot, which in turn can kill the seedlings.

Due to the prevalence of *Diplodia pinea* and the appearance of symptoms after drought and hail storms, uneven-aged management of red pine (i.e. selection thinning) is being questioned as a viable option. For example, uneven-aged management for red pine is no longer recommended as a general practice in Ontario. And in red pine areas of the Huron-Manistee National Forest, uneven-aged management has resulted in 95-99 percent mortality of understory seedlings in some cases.

Large red pine impacted by diplodia after a hail storm

Stands without evidence of Diplodia in the overstory can still be considered for uneven-aged management. However, these stands should be closely monitored and the overstory removed as soon as regeneration goals have been attained. Minnesota offers the following guidance for natural and artificial regeneration of red pine: http://www.dnr.state.mn.us/treecare/forest_health/diplodia/index.html

Fall Webworm

Many calls about "tent caterpillars" in trees and shrubs were received from around the state beginning in August. The fall webworm is often confused with the eastern tent caterpillar, an insect that produces webbing in branch crotches of fruit trees. The fall webworm produces webbing that encloses the ends of branches of 80 different species of trees and shrubs, not just fruit trees.

The webworm overwinters as a pupa (cocoon) with white moths emerging in late spring. Female moths lay hundreds of eggs on the underside of leaves. The emerging small, hairy caterpillars feed in groups, removing just one surface of the leaf. These leaves turn brown and curl.

As the caterpillars grow and feed, they leave only the larger leaf veins and expand their webbing to enclose more of the infested branches. Webworms persist through August and September in many parts of Michigan.

This mid- to-late season loss of leaves does little harm to the tree. Fall webworms are native insects with many native parasites and predators. Because of this, webworm populations generally last for two years or less.

For more information on webworm, visit: http://msue.anr.msu.edu/news/the_rise_and_fall_of_the_fall_webworm.

Top: *Webbing and feeding damage from fall webworm, near Island Lake Recreation Area in Livingston County, Michigan.* ***Bottom:*** *Webworm feeding.*

Oak Decline

Many of the northern Lower Peninsula's oak forests are experiencing oak decline. Decline is defined as "a gradual and continuous loss of strength, numbers, quality or value."

Tree decline can be described by a model that consists of three factors: 1) predisposing factors, 2) inciting factors, and 3) contributing factors. As the number of factors affecting a forest increases, the amount of tree decline and mortality - and the speed with which it occurs - also increases.

Many of the northern pin oak forests in Michigan are growing on dry, nutrient-poor, sandy soils. Trees in many of these forests are of a similar age, having come about as a result of logging during the early 1900s. Poor soils and old age are serious predisposing factors.

These forests are also periodically defoliated by insects and subjected to serious droughts and late-season frosts. These events deplete the trees' energy reserves and diminish their ability to replenish that energy. These are inciting factors.

When predisposed to decline as described above, and stressed by multiple inciting factors, trees emit chemical signals attracting other insects and diseases. These insects and diseases target weakened trees that are unable to fend off attacks. One common contributing factor to oak decline in Michigan is the two-lined chestnut borer, a native wood-boring beetle.

Trees and forests that are not predisposed to decline are able to withstand the occasional stress of defoliation, frost, drought, wood-boring insects and most root-rot fungi.

It is often the contributing factors – two-lined chestnut borer and *Armillaria* root rot, for example - that are blamed for oak mortality when, in fact, it is a combination of many factors affecting an aging resource growing on poor-quality soils.

Foresters in the Grayling, Baldwin, Roscommon, Gladwin and Kalkaska management units have been working to identify these stands and, where possible, harvesting the declining oak and regenerating these forests to younger, more vigorous trees or replanting some of these areas to pine.

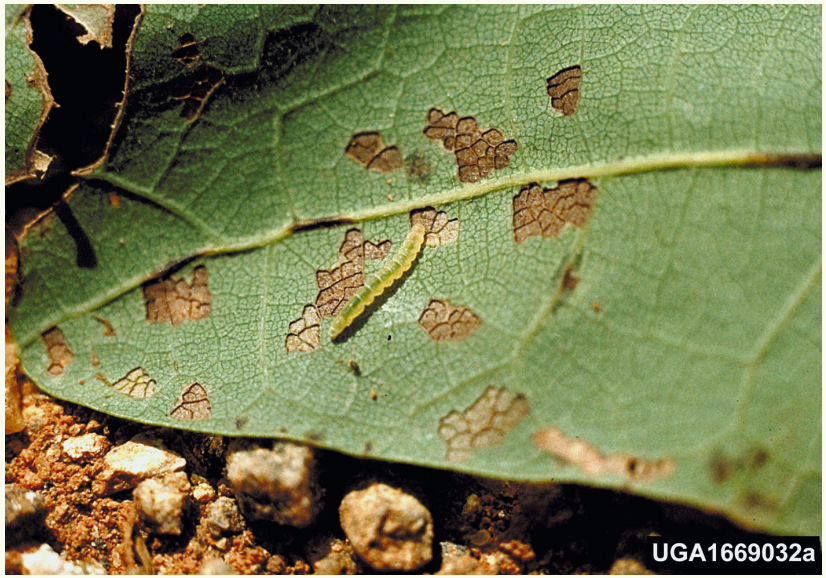
Oak Skeletonizer

During summer 2016, the oak skeletonizer heavily defoliated several areas along the Lake Michigan shoreline, from Pentwater to Grand Haven, with areas around Silver Lake State Park particularly hard hit.

This defoliator prefers red oak trees and is native to Michigan, where it occasionally builds to outbreak levels. The small green larvae feed on the underside of leaves, giving them a skeleton-like appearance. Heavily defoliated trees will develop a brown color as the green leaf tissue is consumed.

Several successive years of heavy defoliation can reduce growth and vigor, but crown dieback and tree mortality rarely occur. Outbreaks typically last only two or three years as native predators, parasites and pathogens build in numbers, causing the oak skeletonizer population to rapidly return to low levels.

This insect is most notable as a nuisance to property owners in outbreak areas. The small larvae spin down from the canopy on fine silken threads and can be a serious annoyance. Tiny, rice-like cocoons can also be a nuisance when they cover outdoor furniture, ornamental shrubs and homes.



Top: *Oak skeletonizer feeding damage. Photo courtesy of James Solomon.*
Bottom: *Oak skeletonizer larvae. Photo courtesy of G. Keith Douce.*

Eastern Larch Beetle

The eastern larch bark beetle (ELB) continues to damage tamarack throughout the Upper Peninsula. Historically, once populations become widespread, ELB acts as a primary invader and attacks healthy stands.

Signs of an ELB infestation include resin flow on the bark during the summer months and yellowing foliage at the bottom of the tree in mid- to late summer. Tree tops often remain green into the fall prior to fall color, making aerial detection of affected stands difficult or impossible. Infested trees fail to leaf out the following spring. In the fall and winter, woodpeckers often remove the bark as they feed on ELB.

Once ELB becomes epidemic, there is no relation between ELB impacts and stand age, upland vs. lowland, or stand size. However, mature trees are more susceptible. Tamarack is shade intolerant, so stress from competition is a factor in well-stocked stands.

ELB also builds populations in wind thrown trees, log piles, snow breakage and logging debris. Removing wood susceptible to infestation helps reduce ELB numbers.

Management guidance is to harvest mature tamarack when rotation age has been attained, and to pre-salvage tamarack stands if edge trees show signs of ELB activity. Once ELB begins feeding in a tamarack stand, it quickly moves throughout the stand. Effects are not generally seen until the following spring, when trees fail to leaf out. Therefore, pre-emptive action is required if trees are to be useful for fiber or lumber.

Tamarack killed by the eastern larch beetle.

Lecanium Scale

Lecanium scale was a hot topic in many areas of the Upper and Lower Peninsula. Calls generally began, "My trees are raining sap on my cars and house." These scales infest both maples and oaks. As they draw sap from trees, they exude a sugary substance known as honeydew.

Lecanium scales are small, spherical insects typically found on a tree's small branches and twigs. Infestations are first active in the spring and early summer as eggs hatch and immature scales called "crawlers" seek feeding sites on the undersides of leaves.

Repeated heavy Lecanium scale infestations can cause branch mortality. Accumulation of honeydew on objects below trees can lead to the growth of black sooty mold.

Both oak and maple trees are affected. Lecanium scales rarely kill mature trees, but they can be harmful to young trees.

Infestations often go unnoticed until either tree symptoms are present or people wonder why their oaks and maples are dripping so much 'sap.' Ants crawling up and down trees are also a sign of a Lecanium scale infestation. Ants feed on the sweet honeydew. Watering infested trees during periods of drought will help maintain tree vigor.

Scale populations are usually kept below damaging numbers by natural enemies, especially lady beetles and tiny parasitic wasps. Many entomologists suggest that pesticides not be used unless absolutely necessary to avoid killing predators and parasites.

For more information on Lecanium scale, visit: http://msue.anr.msu.edu/news/lecanium_scale_numbers_building_on_chestnuts.

Top: *Lecanium scale on an elm branch.* ***Bottom:*** *Lecanium scale with honeydew.*

Porcupine and Squirrel Damage

Bark stripping can occur on a wide range of trees species. Damage high in the branches can be caused by porcupines or squirrels.

Porcupines feed on tree bark during the winter months and seem to prefer the tender branches in the uppermost part of the tree canopy. They also feed on the portion of the trunk near these branches. Porcupine damage often occurs on red pine, but they will also feed on maple, basswood and other species.

The teeth marks made by porcupines in the wood are about ⅛ to ¼ inch across and are larger than those made by squirrels (1/16 inch). The marks usually go into the sapwood as porcupines chew deeper into the tree than squirrels.

Squirrels are another common culprit when gnawed and stripped of bark is found. Piles of bark strips or chunks are often left lying on the snow or ground beneath the tree. This can be helpful in distinguishing feeding by porcupines and squirrels, as squirrels leave behind narrower, ½ inch wide strips of bark.

Excerpts from article by John Ball, "Porcupine and Squirrel Damage to Trees" (Feb. 4, 2015).

The complete article can be found at:
http://igrow.org/gardens/trees-and-forests/porcupine-and-squirrel-damage-to-trees/

Porcupines can damage hardwood trees.

Maple Tar Spot

Maple tar spot was prevalent in many areas of Michigan again this year. Patches of black raised areas on the upper leaf surface of Norway maples and its cultivars were a common sight beginning in August.

Trees infected with the tar spot fungus typically drop their leaves prematurely. Tar spots on infected leaves produce spores that will infect new leaves the following spring if weather conditions are favorable.

Maple tar spot infections occur most commonly in years when spring weather is cool and wet, as has been the case the past few years. Fortunately, this leaf disease causes little damage to trees and no control measures are necessary.

Maple tar spot.

Aerial Survey & Digital Mobile Sketch Mapping

Each year, Michigan's nearly 20 million acres of forested land are surveyed for insect and disease damage by the DNR Forest Health Program. In cooperation with the U.S. Forest Service, these aerial surveys occur throughout the growing season.

Large areas of defoliation by spruce budworm, jack pine budworm, aspen tortix, forest tent caterpillar and gypsy moth are mapped during aerial survey missions. Aerial survey information is used to monitor damage and changes in pest populations from year to year, and serves as an early detection tool for newly emerging problems.

Michigan's aerial survey data is "rolled up" with other states' data into a national summary each year. This is used to help foresters and other resource professionals make sound tactical decisions that affect the growth and health of forests around the state.

DMSM (Digital Mobile Sketch Mapping)

Following extensive testing in 2015, the DNR Forest Health Program used a new Digital Mobile Sketch Mapping (DMSM) ystem to conduct aerial surveys across Michigan in 2016.

Recent widespread insect and disease outbreaks in Michigan, including emerald ash borer and beech bark disease, have been difficult to map accurately because they affect a discontinuous component of large forested areas. DMSM introduces the option of projecting a series of grid cells across the imagery on the screen. Depending on the scope and intensity of the damage, aerial surveyors can select the appropriate scale grid cell to quickly highlight the impacted area.

The flexibility of DMSM helped to streamline our aerial survey mapping effort in Michigan this year. One veteran sketch mapper and one new forester were employed to help accomplish aerial survey data collection this season. Peak defoliation is only visible for a few weeks before growth of new foliage masks its presence, and using two observers in each aircraft doubles the number of acres we are able to cover during survey flights.

Special Survey Projects

In addition to the annual statewide surveys for forest disturbances, the DNR Forest Health Program conducted a low-altitude helicopter survey in southeast Michigan to identify lingering ash trees in the wake of the emerald ash borer. Several living black ash trees previously identified by ground crews were flown to determine if these trees could be detected from a helicopter.

Because many of the lingering ash trees occur in the mid- to lower canopy, it was difficult to identify these trees even at very low altitudes. We were successful in identifying potential areas where it appeared likely that black ash may still be a component of the canopy and where ground crews could direct their detection efforts.

Research on Exotic Forest Pests in Michigan

Michigan State University scientists contributed this story.

By: Sara R. Tanis andDeborah G. McCullough
(Michigan State University)
and Michael Philip
(Michigan Dept. of Agriculture and Rural Development)

Michigan is at exceptional risk for the introduction and adverse consequences of invasive forest pests. Campgrounds on state forest lands attract 22 million visitors annually, including approximately 6 million people who reside in other states; at least a portion of these visitors may be transporting firewood.

A funnel trap is deployed at a recreation site.

Michigan is a major manufacturing center and imports raw and processed commodities, many of which are shipped with wood pallets or crating. Michigan also boasts the fifth largest nursery industry in the country. Potential introduction of exotic forest pests in firewood, solid wood packing material and nursery trees remains an ongoing concern.

Recent estimates indicate exotic forest insects, particularly wood- and phloem-borers, cost households and municipal governments in the U.S. at least $2.5 billion annually. Early detection of exotic forest pests can assist efforts to eradicate, contain or manage populations of potentially invasive organisms and is critical for preventing additional introductions.
Given the risk factors outlined above, exotic phloem- and wood-boring insects are a serious and ongoing threat to Michigan.
The purpose of our study was to conduct detection research at recreation sites that may be at relatively high risk of exotic forest pest introduction and establishment. Subcortical insects (those that feed beneath the bark) are of particular interest because many species are capable of causing extensive tree mortality. These groups include buprestids (e.g., European oak borer), longhorn beetles (e.g., Asian longhorn beetle) , bark beetles (e.g., walnut twig beetle) and horntails (e.g., *Sirex noctilio*).

We compiled risk maps for Michigan using spatial and point data to prioritize trapping sites. We considered forest cover type, state park visitor data, and locations of sawmills, campgrounds, nurseries (import/export) and railroads. For example, Tahquamenon Falls State Park is surrounded by maple-dominated forest and is considered a high risk site because the park attracts many visitors from zip codes where ALB is present.

We selected 30 recreation sites - including several state parks - and 30 additional sites for a related project focused on industrial sites in southern Lower Michigan.

We deployed 383 cross-vane, funnel and paper traps baited with 16 pheromones and/or

MSU scientist collects insects from a cross-vane panel trap at a recreation site.

Research on Exotic Forest Pests in Michigan

host volatiles from May-June 2016 and collected captured insects every four weeks. We collected 7,455 phloem- or wood-borers at the 30 recreation sites (6,173 additional specimens from industrial sites). We identified all metallic wood-boring beetles (*Buprestidae*), longhorned beetles (*Cerambycidae*) and horntail wasps (*Siricidae*) to species. Captured specimens represented 19 buprestid species, 113 cerambycid species and six siricid species.

We did not capture ALB or any of the 17 high priority non-native insects targeted by the surveys. We did capture a few exotic species (e.g., *Agrilus cyanescens*), but all were previously known to be in Michigan. Entomologists from the MI Dept. of Agriculture and Rural Development are currently identifying thousands of bark beetles (*Scolytinae*) captured in these traps.

Two MSU students sort captured insects.

USDA Conducts Forest Pest Surveys of High Risk Areas in Michigan

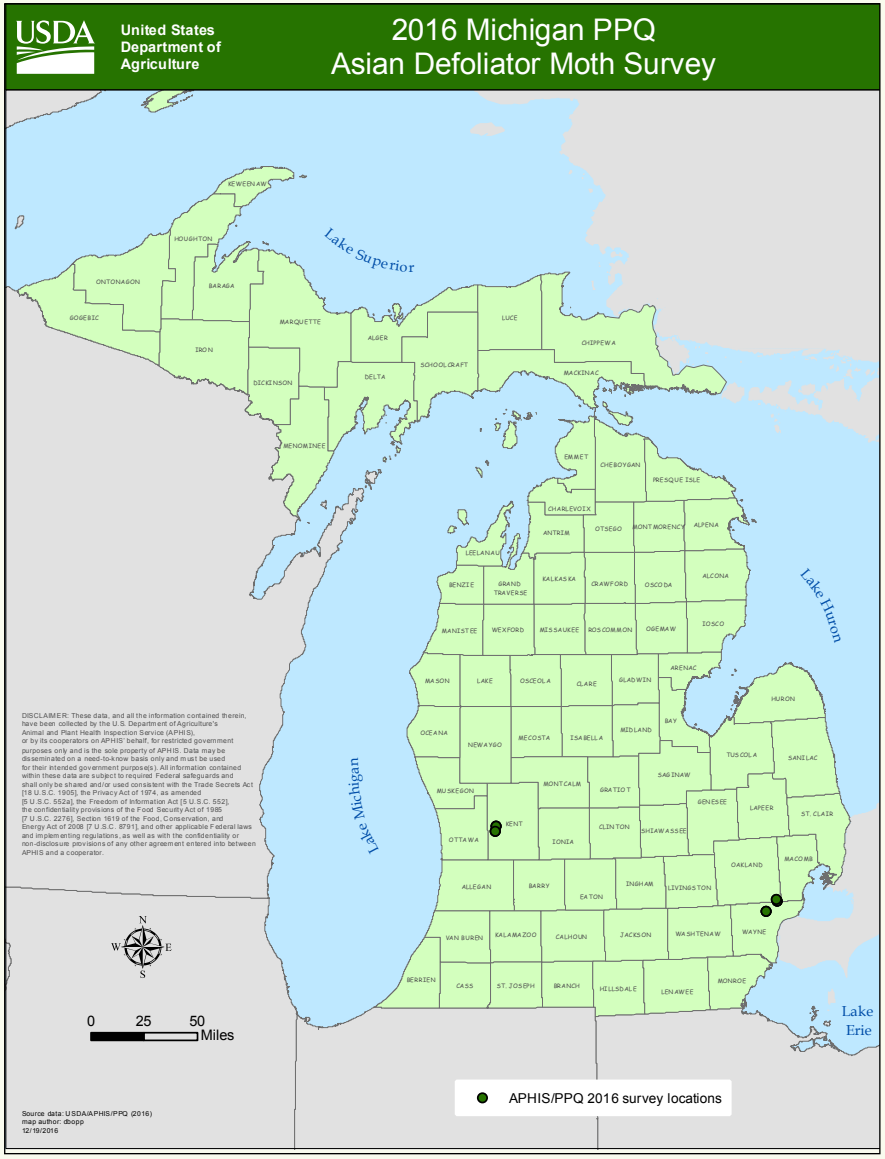
The United States Department of Agriculture contributed this story.

In 2016, the United States Department of Agriculture conducted three forest health surveys: one for Asian defoliator moths, one for exotic wood-boring insects and one for Asian longhorned beetles and citrus longhorned beetles. Results from each of the surveys will be released in 2017.

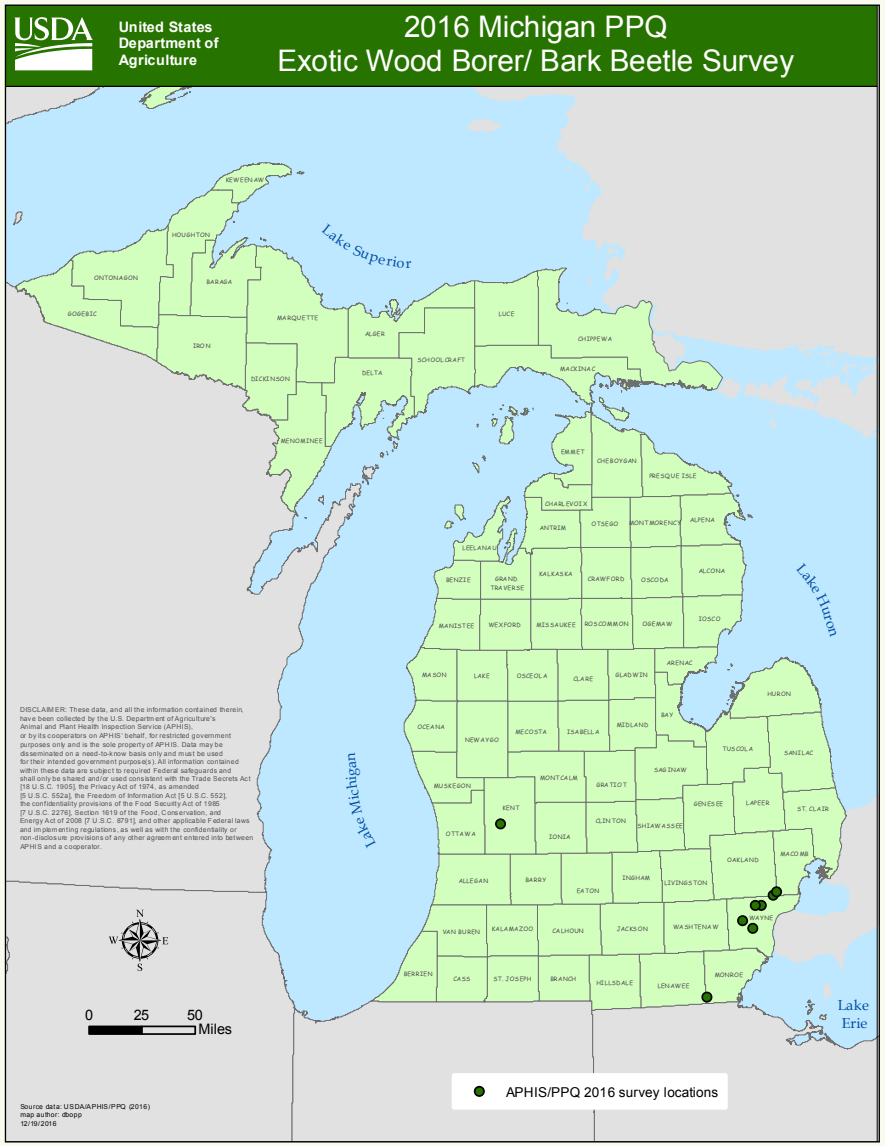
The Asian defoliator moth survey (rosy moth, nun moth and an Asian strain of gypsy moth) was conducted at Detroit Metro Airport, two Detroit area railyards and the Grand Rapids Airport. A total of 24 traps were deployed. Nationwide, ports-of-entry survey efforts are ongoing and results from these surveys will help determine if these pests have become established at or near ports-of-entry in the United States.

The exotic wood-boring insects survey (six-toothed spruce bark beetle, European hardwood ambrosia beetle, pine shoot beetle, various exotic pine sawyer beetles, Mediterranean pine beetle, European spruce bark beetle, six-toothed bark beetle and black spruce beetle) was conducted in eight high-risk commercial locations throughout the state. A total of 40 traps were placed and monitored on a bi-weekly basis from April-July.

Additionally, visual Asian longhorned and citrus longhorned beetle surveys were conducted at each of these locations. These surveys were conducted in high risk areas within six metropolitan cities in Michigan's Lower Peninsula: Ann Arbor, Detroit, Grand Rapids, Muskegon, Kalamazoo and Benton Harbor/St. Joseph. A total of 100 sites were surveyed. Industrial



USDA Conducts Forest Pest Surveys of High Risk Areas in Michigan



areas receiving foreign wood packaging material were targeted as the highest priority followed by street trees in residential areas, parks and cemeteries. As part of the survey, a block of host trees (5–15) at each site were visually inspected for signs and symptoms of ALB and CLB.

For more information about USDA APHIS PPQ visit www.aphis.usda.gov/aphis/ourfocus/planthealth

Emerald Ash Borer

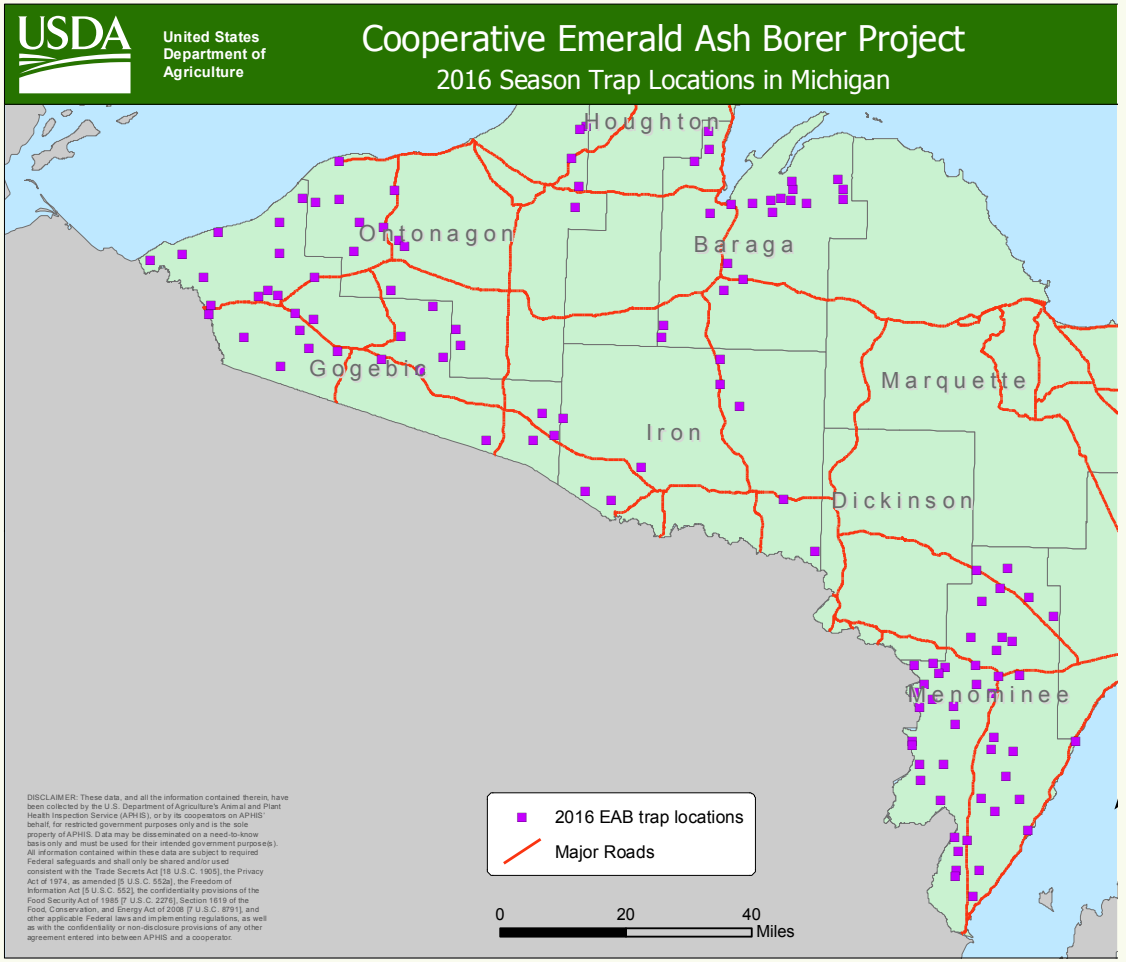
The Michigan Department of Agriculture and Rural Development contributed this story.

The United State Department of Agriculture Animal and Plant Health Inspection Service (APHIS) 2016 emerald ash borer (EAB) survey efforts in the western Upper Peninsula identified two additional counties, Marquette and Dickinson, as infested.

As a result, in early 2016 the Michigan Department of Agriculture and Rural Development (MDARD) revised the EAB quarantine to add Baraga, Dickinson, Marquette, and Menominee counties to the existing Quarantine Level II area. Although there were no positive trap catches in Baraga and Menominee counties in 2016, they are close to infested counties and there is a low level of confidence that EAB is not already there.

EAB quarantine requirements for regulated articles moved entirely within Michigan are unchanged. Firewood that has been certified for the Federal EAB quarantine by USDA-APHIS is exempt if it is packaged, bears a USDA compliance stamp and is clearly marked with the producer's name and address. All hardwood firewood (not just ash) not certified remains listed as a regulated article in the EAB quarantine.

In 2016, USDA-APHIS deployed 122 purple panel EAB traps in the Upper Peninsula counties of Baraga, Gogebic, Iron, Menominee and Ontonagon. One trap in Baraga County captured an adult beetle. No quarantine revision was necessary as a result since Baraga County had already been quarantined.



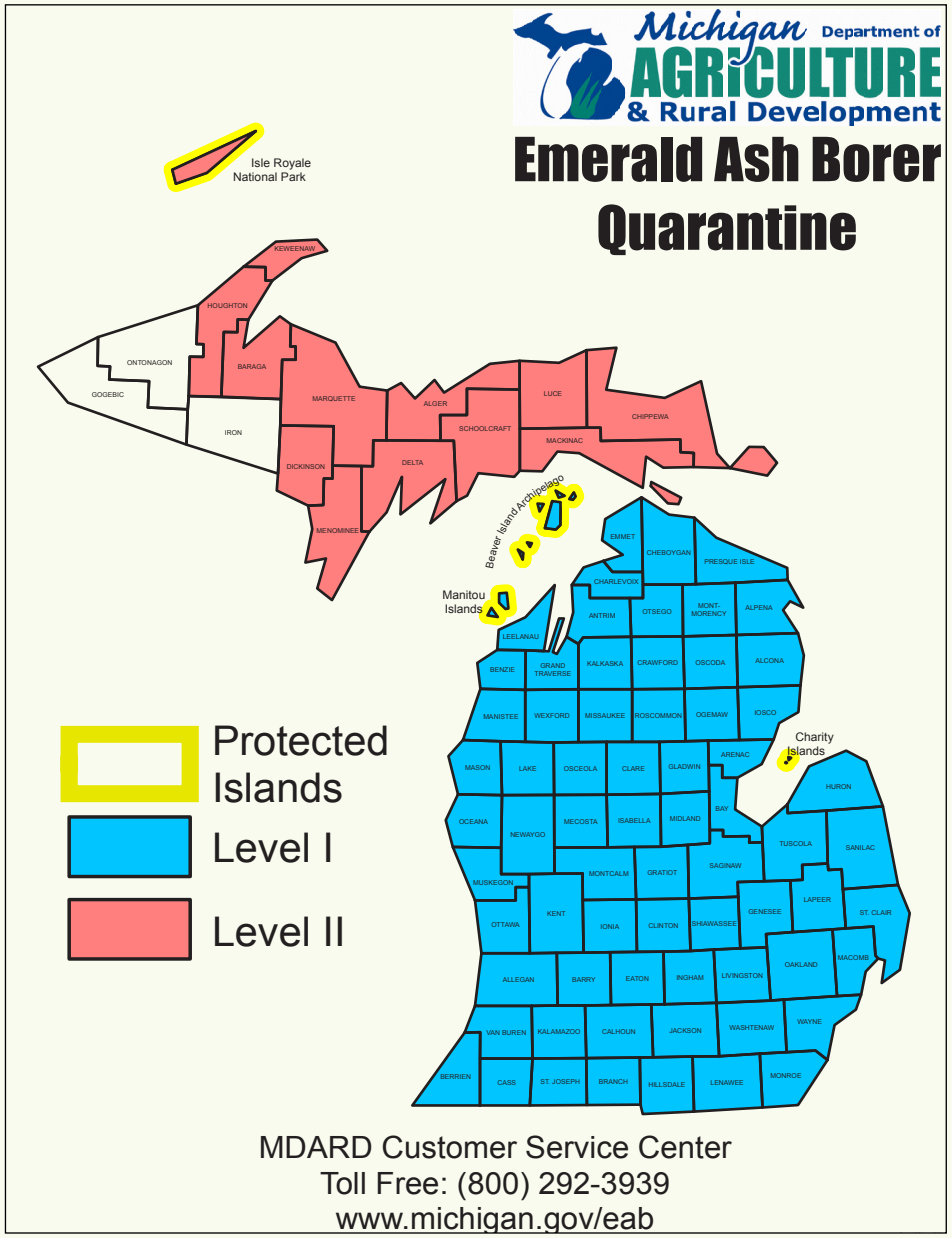
Emerald Ash Borer *continued*

Ash trees killed by EAB. Photo courtesy of Leah Bauer, USDA Forest Service Northern Research Station, Bugwood.org.

Since 2012, trap placement has been based on a survey sampling design developed in collaboration with the APHIS EAB Program and the U.S. Forest Service Forest Health Technology Enterprise Team.

Michigan Department of Agriculture and Rural Development (MDARD) staff continued to renew and issue intra-state compliance agreements as necessary. MDARD maintains approximately 60 compliance agreements with receivers, brokers and shippers. A majority of these entities are in the UP or otherwise involved with the intrastate movement of regulated materials into or within the UP.

MDARD staff continued to conduct compliance inspections with EAB compliance agreement holders and write phytosanitary certificates for ash logs and lumber shipped internationally. The movement of any article regulated by the EAB Quarantine from the Lower Peninsula to the UP continues to be prohibited, except with a valid compliance agreement. For more information about EAB visit www.emeraldashborer.info or visit the MDARD EAB website at www.michigan.gov/eab.



Emerald Ash Borer Biocontrol

The United States Forest Service contributed this story.

The emerald ash borer (EAB), an invasive beetle from Asia spreading throughout North America, causes widespread mortality of ash trees. EAB was first discovered in southeast Michigan and nearby Windsor, Ontario in 2002 and, despite efforts to eradicate this destructive forest pest, now occurs in 31 states and two Canadian provinces.

In 2007, biological control of EAB began in southern Michigan after APHIS issued permits for release of three EAB parasitoid species from China: two larval parasitoids, *Tetrasthichus planipennisi* and *Spathius agrili*, and an egg parasitoid, *Oobius agrili*.

In 2009, subsequent to field recovery of the introduced parasitoids in Michigan, USDA initiated the EAB Biocontrol Program and constructed the APHIS EAB Biocontrol-Rearing Facility in Brighton, Michigan. Later, release of *S. agrili* was limited to areas south of the 40th parallel due to lack of sustained establishment in northern states.

A third EAB larval parasitoid, *Spathius galinae* from the Russian far east, was approved for release north of the 40th parallel in 2016.

The EAB Biocontrol Program includes 1) the APHIS EAB Biocontrol-Rearing Facility in Brighton where parasitoids are mass-reared, packaged and shipped; 2) scientists and land managers in various regions of North America involved in EAB biocontrol; 3) the EAB Biocontrol Release and Recovery Guidelines, which provide information on release-site selection, parasitoid biology, release, recovery methods, EAB biology and ash health; and 4) www.mapbiocontrol.org, an online database

Left: *Adult emerald ash borer. Photo courtesy of Deborah Miller, U.S. Forest Service.*
Right: *Atanycolus, a native larval ectoparasitoid of Agrilus that attacks emerald ash borer. Photo courtesy of Houping Liu, MSU.*

where the guidelines are found and cooperators enter geospatial data on parasitoid releases and recoveries.

Parasitoids have been released in most EAB-infested states. Not surprisingly, more parasitoid releases have been done in states with a longer history of EAB, more ash trees and scientists or land managers actively involved in research or management of EAB using biocontrol.

Guidelines recommend that parasitoids be released for two consecutive years at a chosen location, and recovery work start at least a year after these releases are complete. Consequently, only limited parasitoid recovery data are available from southern states where releases began more recently. Using a variety of sampling methods, *O. agrili* and *T. planipennisi* have been recovered as far

Emerald Ash Borer Biocontrol *continued*

Tetrasthichus planipennis, an EAB larval endoparasitoid. Photo courtesy of David Cappaert, Michigan State University.

north as Michigan's Upper Peninsula and Minnesota, and as far south as southern Indiana and Maryland.

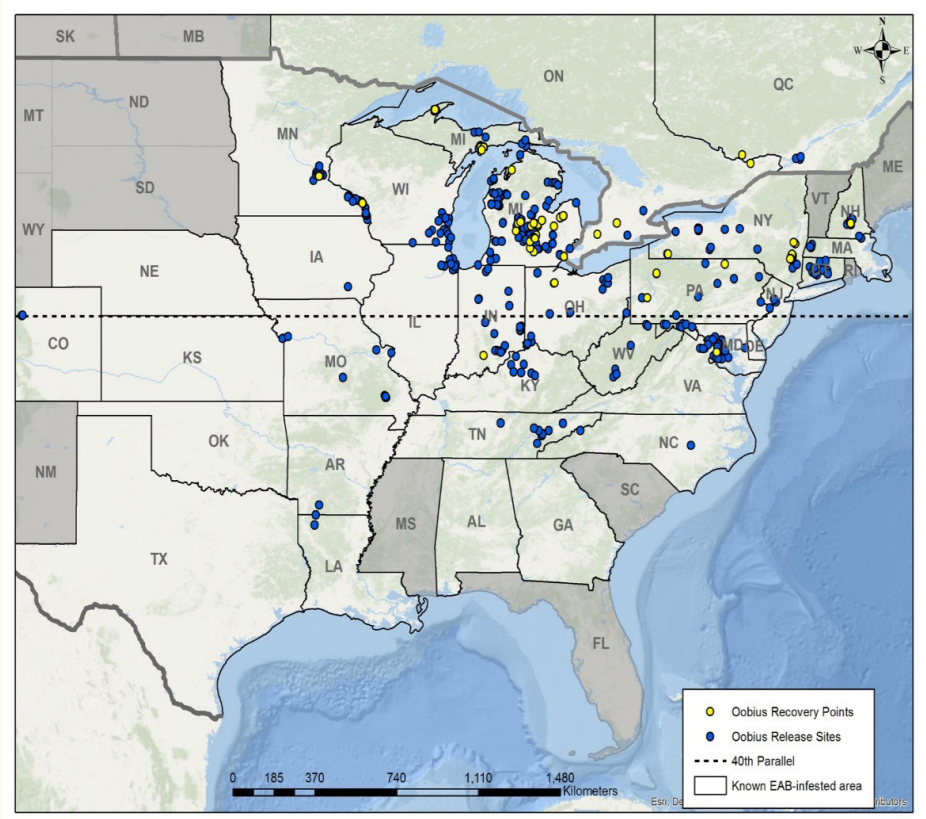
Although the long-term success of EAB biocontrol on survival and reproduction of North American ash species will remain unknown for many years, results from nine years of research on EAB biocontrol in southern Michigan are encouraging. These results show sustained establishment and spread of T. planipennisi and *O. agrili* in surviving green and white ash trees.

The decline in EAB larval densities in trees sampled from 2009 to 2014 was correlated with increased parasitism by native parasitoids at peak EAB densities, followed by *T. planipennisi* at low EAB densities. Combined EAB mortality from woodpeckers, introduced and native parasitoids, tree resistance and disease resulted in an approximate 90 percent reduction in the number EAB larvae in trees. Ash inventories show increasing numbers of ash sprouts, saplings and small to medium trees at these study sites. Researchers are hopeful that *S. galinae,* with its longer ovipositor that can penetrate thicker bark, will establish and protect larger ash trees from EAB.

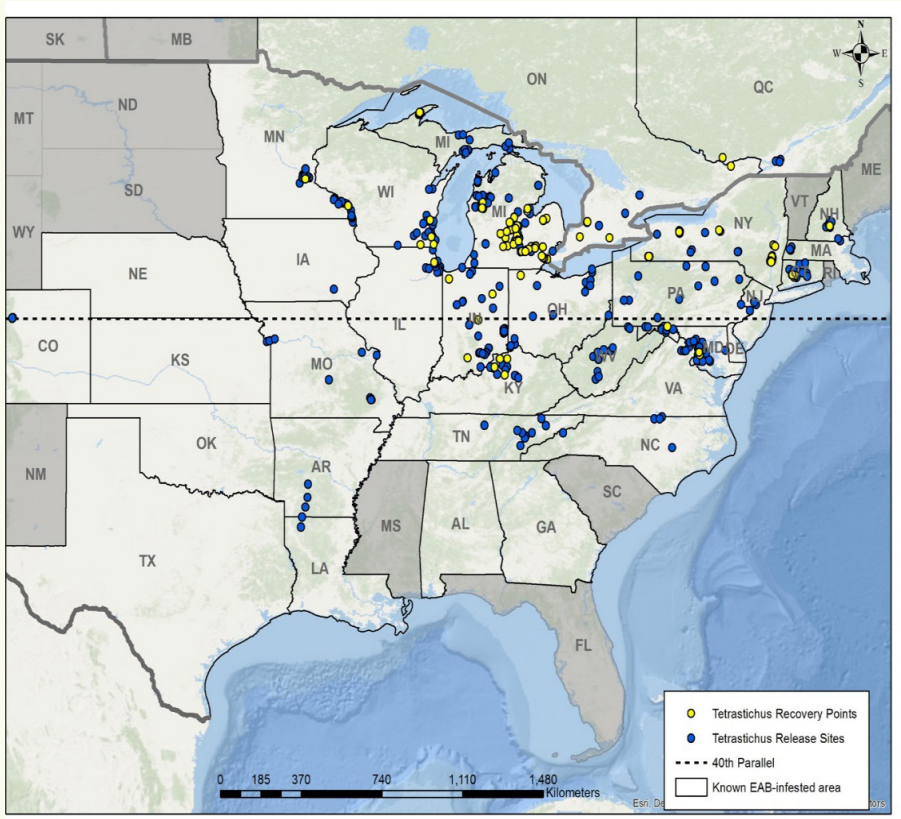
Leah Bauer[1, 2], Juli Gould[3], Jian Duan[4], Roy Van Driesche[5], Erin Morris[2] Amos Ziegler[2], Travis Perkins[2], and Therese Poland[1,2]

[1]USDA FS NRS, [2]Michigan State University, [3]USDA APHIS CPHST, [4]USDA ARS BIIRU, and [5]University of Massachusetts

Emerald Ash Borer Biocontrol *continued*



Oobius *release and recovery sites.*



Tetrastichus *release and recovery sites.*

Interactions of Paclobutrazol and Systemic Neonicotinoid Insecticides

Michigan State University scientists contributed this story.

By: Sara R. Tanis, Andrew R. Tluczek, Deborah G. McCullough and James B. Wieferich

Applications of plant growth regulators are increasingly promoted by arborists to alleviate stress, improve tree vigor, and reduce above-ground growth to prevent trees from outgrowing their space, thereby reducing pruning costs. Previous studies indicate that in some ash species, paclobutrazol (PB), a gibberellin inhibitor, decreases individual leaf area, shoot length and radial growth and increases root-to-shoot ratios.

The purpose of our study was to assess potential synergistic interactions between PB and two systemic insecticides, an imidacloprid (IMI) product and a dinotefuran (DINO) product commonly used to protect landscape ash (*Fraxinus spp*.) trees from emerald ash borer (EAB) (*Agrilus planipennis Fairmaire*). Our goal was to determine if PB application could increase efficacy or persistence of insecticides by reducing leaf area and aboveground stem growth. If PB reduces the amount of insecticide or number of applications required for efficacious EAB control, treatment costs would be reduced.

In September 2012, we initiated a study in an 11-year-old ash plantation at MSU's Tree Research Center. We randomly assigned 72 trees repesenting four ash species to one of six treatments. Ash species included blue ash *(F. quadrangulata*), green ash (*F. pennsylvanica*), white ash (*F. americana*) and Chinese ash (*F. chinensis*). Treatments included (1) untreated control, (2) PB, (3) DINO, (4) DINO+PB, (5) IMI and (6) IMI+PB.

The PB, which persists for three years, was applied as a soil drench of ShortStop® in October 2012 and 2015. Trees treated with DINO received a basal trunk spray of Safari® in June of 2013 and 2014, while trees treated with IMI received a soil drench of Mallet® in May of 2013 and 2014. Control trees were not treated.

In July of 2014, 2015 and 2016, we clipped leaves from each tree for adult EAB feeding and mortality bioassays, and analysis of IMI and DINO residues by a colleague at USDA APHIS. Each August, we assessed plant growth regulator (PGR) affects by measuring leaf area of treated and untreated trees.

Results to date show PB reduced leaf area of all ash species, regardless of whether trees were treated with an insecticide. Foliar residue levels did not differ between DINO and DINO+PB or between

Interactions of Paclobutrazol and Systemic Neonicotinoid Insecticides

IMI and IMI+PB trees. Chinese ash had >50% higher foliar DINO concentrations and blue ash had 3-fold higher foliar IMI concentrations than the other ash species. Foliar concentrations of DINO and IMI were similar among the other three ash species.

While the PB applications reduced leaf size, it did not affect leaf area consumed by EAB nor EAB survival on any ash species. In green ash, however, EAB adult survival was lower on DINO+PB trees than on control, PB and DINO trees. We are continuing to assess foliar residue levels from 2016, radial growth of trees and synergistic effects between PB and insecticides among ash species.

Effects of Emerald Ash Borer on Riparian Forest Structure

Michigan State University scientists contributed this story.

By: Patrick Engelken and Deborah G. McCullough

Since its detection in 2002, emerald ash borer (*Agrilus planipennis*) has caused widespread mortality of ash trees across much of the northeastern United States. Initially detected in Detroit, populations of emerald ash borer have been confirmed in 30 states and two Canadian provinces.

This rapid loss of a common overstory tree can cause cascading effects within ecosystems. These effects could be especially significant within riparian forests that exert influence on surrounding forests and waterways as well as downstream.

Mortality of riparian ash could alter levels of leaf litter, sunlight and woody debris available to the forest floor and to streams, with subsequent effects on communities of microorganisms and invertebrates. Information on forest re-growth within openings created by EAB-caused tree mortality is also important.

During summer 2016, six sites were established in forest canopy openings (gaps) resulting from ash mortality along streams in southern Michigan. We recorded size, species and condition of overstory trees within the gap and in the surrounding forest at each site. We also surveyed seedling and sapling regeneration, shrubs and herbaceous plants, and coarse woody debris. Leaves and leaf litter were collected periodically to assess microbial communities.

Left: *Surveying vegetation in a transect at the edge of a canopy gap.* ***Right:*** *First order stream running through a field site near Battle Creek, Michigan.*

Data analysis is underway to evaluate EAB impacts as it relates EAB-caused changes over time. Potential establishment or spread of invasive plants within canopy gaps formed by dead ash is of particular interest. Field surveys will continue in 2017.

Ecological Services of Ash Trees: Costs & Benefits of Protecting MSU's Trees

Michigan State University scientists contributed this story.

By: Sarah J. Greene and Deborah G. McCullough

Emerald ash borer (EAB), *Agrilus planipennis Fairmaire*, was first discovered in southeast Michigan in 2002 and has become the most destructive and costly forest insect to date. An array of plant-related industries, property owners, municipalities and state agencies have been affected by EAB impacts and associated regulations.

Highly effective systemic insecticide treatments to protect ash trees from EAB have become readily available in recent years. Treating ash trees protects the benefits, or ecological services, provided by these trees in urban areas, such as reducing air pollution, storm water runoff, and costs of heating and cooling buildings, storing carbon and contributing to the aesthetic value of landscapes. Whether these benefits offset the costs of treating the trees, however, is an important question posed by many municipal foresters and arborists.

To address this question, it is necessary to quantify the economic benefits provided by urban trees. A free downloadable software suite, iTree™ (www.itreetools.org), is widely used as a means to quantify ecological services provided by trees of specific species and sizes.

Our goals were to (1) acquire information on the costs of treating ash trees on Michigan State University's campus to protect them from EAB, (2) quantify ecological services of these trees and (3) compare the value of these ecological services with treatment costs.

In 2014, we acquired information on the number and location of ash trees on the developed portion of the MSU campus. Each tree was examined and we recorded variables such as species, DBH, height and canopy diameter, and evidence of EAB (e.g., woodpecks, old larval galleries, adult EAB exit holes). Variables were used in the iTree™ software to estimate the extent and monetary value of benefits provided by the MSU ash population. Insecticide treatment history from 2005-2014 was acquired from campus arborists.

We identified and evaluated 161 trees representing seven ash species, including white ash (*Fraxinus americana Linnaeus*) which comprised 65 percent of all the trees ash, along with green ash (*F. pennsylvanica Marshall*) which made up 21 percent of the trees. Insecticides used included imidacloprid applied as Imicide®, Merit®, Quali-Pro® and IMA-jet®, and emamectin benzoate applied as TREE-äge®. Expenditures for product, labor and transportation over the 10-year period amounted to $50,400.

Value of the benefits provided by these ash trees to date totals $194,830. In addition, the trees contribute an estimated $1,382 in services each year and currently store approximately $12,500 worth of carbon. An alternative means to estimate tree value within the iTree™ software is based on costs of replacing a given tree with another similarly-sized tree of the same species. Total structural value of the MSU ash trees was estimated at $471,705.

Given the benefit-to-cost ratio, it seems clear that there are economic, ecological and aesthetic reasons to protect ash trees in landscapes from EAB.

White Ash Survival in Forested Sites in the Core of the EAB Invasion

Michigan State University scientists contributed this story.

By: Molly Robinett and Deborah McCullough

Since its discovery in 2002 in the Detroit-metro area, emerald ash borer (EAB) (Agrilus planipennis Fairmaire) has caused catastrophic levels of ash mortality. Plots established in areas of southeast Michigan and Ohio showed more than 99% of the white ash (Fraxinus americana L.), green ash (F. pennsylvanica Marsh.) and black ash (F. nigra Marsh.) were killed by this destructive pest by the mid 2000's. We have noted, however, that a high proportion of white ash trees remain alive in some sites in southeast and south central Michigan, despite 12-15 years of EAB presence.

Clear Pestick is applied to a green-light purple double decker trap. A live white ash is in the background.

In 2014, we identified and scouted 70 areas of public forest land using an atlas. We selected 28 sites where white ash trees were abundant, both live and dead. A center point was established in the midst of the white ash and a 1.5 km radius around each point was delineated. We inventoried forested land within the delineated area using variable radius plots (10 baf prism) to document species, DBH and canopy condition of trees ≥ 6 cm.

In 2015, we established four fixed radius macroplots (18 m radius) within a one-hectare area centered in each site. White ash and other trees (6 cm or larger) were counted, measured and canopy condition assessed. Regeneration (seedlings, saplings and recruits) was recorded by species in smaller fixed radius plots within each macroplot.

A total of 2,546 white ash trees were recorded in the 28 sites. Most white ash (74 percent) are alive and 96 percent had less than 50 percent canopy dieback. The proportion of white ash basal area that was alive in 2015 ranged from 62 to 99 percent in 24 sites, while all or nearly all white ash were dead in 4 sites. Not surprisingly, white ash accounted for 66 percent of the recruits, 76 percent of the saplings, and 74 percent of all seedlings. Green ash, American elm, sugar maple, black cherry and hawthorn were also relatively abundant.

We monitored EAB population levels in 2014-2016 using two double-decker traps consisting of two purple or green prisms attached to a 3 m tall PVC pipe and baited with cis-3-hexanol or Manuka oil between June and September. A total of 580, 585, and 932 EAB were captured in 2014, 2015 and 2016, respectively.

In 2014 and 2015, green panels caught the most EAB adults, whereas in 2016, the light purple panels caught the most beetles.

White Ash Survival in Forested Sites in the Core of the EAB Invasion

Measuring DBH of a live white ash tree. White ash survival rates and the area of live and dead white ash phloem were calculated using DBH in 30 sites.

Captures were male-biased, with 69-77 percent of the beetles caught each year male. The amount of living white ash phloem available for EAB to feed on explained little variation in the number of EAB adults captured in traps in any year.

This weak relationship indicates local EAB populations are not limited by phloem availability. Spatial analyses using variables recorded within the 1.5 km radius around each site are currently being analyzed to determine if specific conditions are consistently associated with relatively high or low white ash survival.

Can Systemic Insecticides Control Beech Scale (and thus Beech Bark Disease)?

Michigan State University scientists contributed this story.

By: Deborah G. McCullough andJames B. Wieferich

High value American beech (*Fagus grandifolia*) trees in residential and urban landscapes, as well as beech in forests, can be killed by beech bark disease. Beech bark disease (BBD) occurs when non-native beech scale insects (*Cryptococcus fagisuga*) facilitate infection of the tree by a non-native *Neonectria* fungus that kills cambium. Several studies have focused on BBD impacts in forests and silvicultural options for northern hardwood stands with significant beech components. However, there is little information on effective options for protecting valuable beech trees in landscape settings.

We conducted trials in 2014-2016 to evaluate effectiveness of selected insecticides for controlling beech scale. In 2014, we began testing TreeAzin®, a recently developed azadirachtin product applied via trunk injection. Azadirachtin is not toxic to birds and mammals, but does affect many insects, often by disrupting molting or reproduction. Bark punches collected before treatment and periodically after treatment were examined under a microscope to count live and dead scale insects.

Unfortunately, this product did not significantly reduce beech scale density or survival rates. We suspect the tiny scale insects, which insert their piercing-sucking mouthparts through the bark and into phloem parenchyma cells, may not encounter the insecticide, which is transported in xylem cells. It is also possible that azadirachtin simply has little effect on this particular insect.

Can Systemic Insecticides Control Beech Scale (and thus Beech Bark Disease)?

In 2015-2016, we evaluated Safari®, a dinotefuran product applied by spraying the lower 4-5 feet of the bark. We know from previous research that dinotefuran, which is highly soluble, moves through bark and into xylem, and then is transported to the canopy (much like a trunk injected product). Basal trunk sprays of dinotefuran or other insecticides are sometimes mixed with Pentra Bark®, a non-toxic detergent that can act as a surfactant or facilitate bark penetration by insecticides.

We hypothesized that the detergent activity of the Pentra Bark alone might affect the scale insects, perhaps by dissolving the wax around the insects and/or by disrupting membrane function. In this study, we set up 12 blocks, each consisting of three infested beech trees. We sprayed the lower 5 feet on the trunk of one tree per block with water as a control. A second tree was similarly sprayed with Safari and the third tree was sprayed with Pentra Bark. Bark punches were again taken to assess pre- and post-treatment mortality.

Results showed the water spray had little effect on the scales; scale density and survival rates were the same above and below the spray line. The Safari spray killed 100 percent of the beech scale insects that were directly sprayed but did not affect scale insects above the spray line. This means that the entire trunk and large branches would need to be sprayed to adequately protect the trees.

The most notable result, however, was that Pentra Bark spray was as effective as the Safari spray. This product could provide a viable option for protecting large, high value beech trees in areas where beech bark disease is well-established.

Beech Scale Population Dynamics

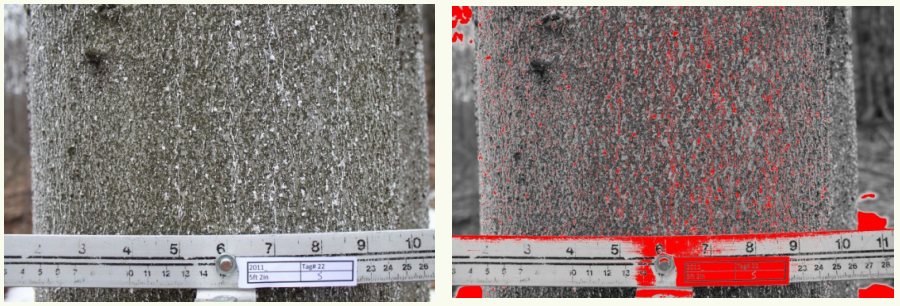
Michigan State University scientists contributed this story.

By: James B. Wieferich, Deborah G. McCullough, Louise Labbate and Daniel Wieferich

We continued a long-term study to monitor density and spread of beech scale (*Cryptococcus fagisuga*), the invasive insect associated with beech bark disease. In 2007, we established a plot with an 8 m radius at 14 sites in three different counties in Lower Michigan. All beech trees (> 6 cm dbh) within the plots were tagged. Each of the 144 trees was visually examined and beech scale abundance was ranked from 0 (absent) to 3 (heavily infested). Two digital photos were taken at the same height on opposite sides of the trunk. Photos can be analyzed using ImageJ V1.43 software to calculate the area of the photo covered by the white wax produced by beech scales. Area of wax in the image is then used to estimate beech scale density (per cm^2) with a regression equation we previously developed.

Each year, we return to the sites at least once to re-assess the same trees and take digital photos of the same locations on the tree trunks. In 2007, the average DBH of the trees was 24.6 ± 1.2 cm and ranged from 6 to 86.4 cm. As of 2016, the average DBH was 25.5 ± 1.3 cm and ranged from 6.2 to 86.2 cm, so we know the trees have grown a bit. When we began the study in 2007, two of the 14 sites had no infested trees. Trees at one site became infested in fall 2007 and by summer 2011, all trees in this plot were infested. Trees at the second site were not infested until summer 2010, but all trees were colonized by summer 2011.

To date, 18 of the 144 trees have been killed by BBD, including eight trees that were uninfested when we began the study in 2007. Of those eight trees, one died after four years of infestation, one



Area of white beech scale wax is calculated within each photo using imaging software, then used to estimate beech scale density.

succumbed after six years, four died after seven years and two died after eight years of infestation. Beech scale density averaged 28.6 ± 1.3 scales per cm^2 in 2007 and increased to 61.8 ± 2.3 scales per cm^2 in 2012. Scale density in 2016 declined over the past few years and in 2016, averaged 48.2 ± 0.7 scales per cm^2. Lower scale densities in the past three to four years probably reflects mortality of trees that were heavily infested in past years.

HWA and Winter Temperatures in Michigan

Michigan State University scientists contributed this story.

By: Deborah G. McCullough, James B. Wieferich and Jeffrey A. Andresen

Hemlock woolly adelgid (*Adelges tsugae Annad*) has killed thousands of trees in the eastern U.S. since it was first detected in Virginia in 1951. Localized infestations of hemlock woolly adelgid (HWA) were identified in Ottawa and Muskegon Counties in 2015 and 2016, all of which likely originated from infested nursery trees imported from other states. Millions of hemlock grow in Michigan forests and thousands have been planted in landscapes. Hemlock provide critical wildlife habitat and are especially important in riparian areas.

The adelgids, which are only 1.5 mm long, pierce the base of hemlock needles and suck nutrients from cells along the vascular tissue in the shoots. Adelgids secrete waxy "wool", called ovisacs, as they feed, which protect them from predators and desiccation.

There are two overlapping HWA generations each year. One generation feeds for only a few weeks in spring, but the second generation feeds from fall, through winter and into the spring. Evidence from northeastern states and high elevation regions in the southeast indicates extreme cold winter temperatures can cause substantial HWA mortality. Winter mortality could have important implications for HWA distribution and dynamics in Michigan.

In fall 2016, we selected four infested hemlock trees in southern Muskegon County. Two trees are growing in dense wooded areas where they are largely protected from sun and wind exposure, while the other two trees are open-grown and fully exposed.

We attached micro-temperature sensors at three heights and four aspects on each tree. Forestry personnel from the Baldwin field office of the DNR provided a scissor lift, enabling us to access the upper canopy of a very tall, exposed tree. Wires connect these sensors to dataloggers. Solar panels power the dataloggers and modems, which transmit the temperature data back to the MSU campus.

MSU scientists place sensors in infested hemlock trees.

We are currently monitoring HWA density and survival rates on these trees, as well as other infested trees on the site. We should be able to determine whether very cold temperatures or temperature patterns are associated with HWA mortality. We will also be able to monitor HWA life stages during the year.

Eastern Hemlock - Establishing Hedges to Rear Native HWA Predators

Michigan State University scientists contributed this story.

FY2016 Summary of Cooperative Forest Health Research Between Michigan State Cooperative Tree Improvement Program (MICHCOPTIP) & MI DNR

Research conducted by the USFS and other agencies indicates that some native hemlock woolly adelgid (HWA) predators show potential as biologic controls. Currently, the preferred method for rearing and evaluating HWA predators is to increase their numbers on eastern hemlock hedges tented with insect screening.

In anticipation of the need to rear HWA predators, eastern hemlock hedges were planted in spring 2015 at the State Forest Tree Improvement Center (SFTIC) near Brighton and MSU's Tree Research Center (TRC). Each planting comprises 120 transplants planted on 4 feet by 10 feet spacing and will be managed as 6 feet-8 feet hedges.

Hemlock plantation at the MSU Tree Research Center.

During the 2016 growing season, MICHCOTIP personnel made a spring herbicide application followed by a mid-summer application to control competing vegetation in both plantings. The SFTIC and TRC plantings were irrigated as needed. Mortality was minimal in both planting, and at the end of the 2016 growing season both plantings were healthy and averaged around 3 feet in height.

Susan Bentz of the USDA Agricultural Research Service has investigated the resistance of Tsuga species and hybrids to HWA and their potential as landscape alternatives to native hemlock. To see if some of these hybrids are cold hardy in northern Michigan, Dr. Benz sent 10 bare root seedlings each of *Tsuga diversifolia x sieboldii* and *T. chinensis x caroliniana* to the TRC in spring 2016. MICHCOTIP personnel established the seedlings in one gallon pots and raised them through the 2016 growing season.

Plans call for this potted stock to be overwintered at the TRC and field planted by MI DNR personnel spring 2017.

MISGP awards $3.6 million to partners

The Michigan Invasive Species Grant Program (MISGP) is administered by the Michigan DNR in cooperation with the Departments of Agriculture and Rural Development and Environmental Quality and is part of a state-wide initiative launched in 2014 to help prevent and control invasive species. In early 2016, the MISGP awarded 19 grant projects totaling $3.6 million in grants that seek to strengthen partners' efforts in:

- Preventing, through outreach and education, new introductions of invasive species.
- Monitoring for the introduction of new invasive species and the expansion of current invasive species.
- Responding to and working to eradicate new findings and range expansions.
- Strategically managing and controlling key colonized species.

Grant amounts ranged from approximately $35,000 to $350,000, and recipients included nonprofit organizations, universities, conservation districts and other units of government. Grant applicants were asked to commit to providing at least 10 percent of the total project cost in the form of a local match.

A portion of the funding supported Cooperative Invasive Species Management Areas (CISMAs), including five new CISMAs that will provide local leadership for invasive species detection and management in 13 counties, as well as continuing CISMA efforts in seven counties.

West Michigan CISMA, covering Allegan, Kent, Montcalm, Muskegon, Newaygo, Oceana and Ottawa counties joined the Michigan Department of Agriculture and Rural Development's initial efforts to survey for Hemlock Woolly Adelgid (HWA) infestations in Ottawa and Muskegon counties. The CISMAs' continued involvement and leadership greatly enhances the ongoing HWA management effort in addition to their numerous other contributions in the region.

Another funded project, led by the Manistee Conservation District, implemented oak wilt treatments at strategic locations over a 10 county area in west and northwest Michigan. In addition to on-the-ground treatments, the project also has a significant education and outreach component to arm the public with information and awareness that aids in slowing or preventing the unintentional spread of the disease. This project finished its first of two years, and involved the contributions of a diverse set of partners including private companies, non-profit organizations, government agencies and concerned citizens.

Several MISGP funded projects aim to reduce the introduction and spread of invasive species via pathways such as firewood and recreational activities through education and outreach. Michigan State University received a grant to cooperatively evaluate Michigan's firewood supply chain. Specifically, the project seeks to work with the firewood industry to understand what practices are being used to reduce the risk of transferring invasive species. This information will allow for targeted outreach to promote firewood manufacturing and marketing practices that reduce the risk of transporting invasive species. Recreational trail users were the focus of an MISGP outreach project led by the North Country CISMA. With emphasis on invasive species decontamination, this project seeks to provide information on how to effectively clean

MISGP awards $3.6 million to partners

vehicles, animals and gear with a call to action for trail users to take steps to reduce the risk of spreading invasive species.

Invasive species pose significant risk to Michigan's world-class natural resources, and funding through the MISGP is vital to our continued fight against these invaders. These important grant dollars aid efforts to battle invasive species. MISGP and its partners' hard work goes a long way toward protecting our natural resources, as well as the many recreational and economic opportunities tied to Michigan's woods and waters.

Learn more about invasive species in Michigan at www.michigan.gov/invasives.

MISGP awards $3.6 million to partners

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