



2014 Forest Health Highlights

Michigan Department of Natural Resources



Acknowledgments

Forest Health Highlights is a summary of the condition of Michigan's forests during 2014 and the work done to preserve and protect them by Forest Resources Division, Department of Natural Resources, www.michigan.gov/foresthealth.

Written by:

Michigan Department of Natural Resources Forest Resources Division staff
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 staff
United States Department of Agriculture Forest Service
Michigan Department of Agriculture and Rural Development
Michigan State University

Maps and other information provided by:

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: An Amanita mushroom grows near Piers Gorge on the Menominee River in the Upper Peninsula. While extremely poisonous to humans, Amanita have a mutually beneficial relationship with trees. The mushroom receives carbohydrates from the tree that it uses for energy to grow. In return, the mushroom provides the tree with water and nutrients and protects it from drought and diseases.

Photo by Michigan Department of Natural Resources forest technician Scott Lint.

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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.

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.

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.

A recent Michigan State University study found that the forest products industry contributes \$16.3 billion per year to Michigan's economy in direct, indirect and induced contributions. The goal



of the Michigan DNR is to help the state's forest products industry reach \$20 billion over the next five years.

Michigan's state parks system was started in 1919 and now contains over 100 parks and recreation areas covering 285,000 acres. The parks receive over 21 million visitors a year.

The Michigan DNR also manages nearly 140 state forest campgrounds, including a dozen equestrian campgrounds. Michigan state game areas encompass more than 340,000 acres.

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.

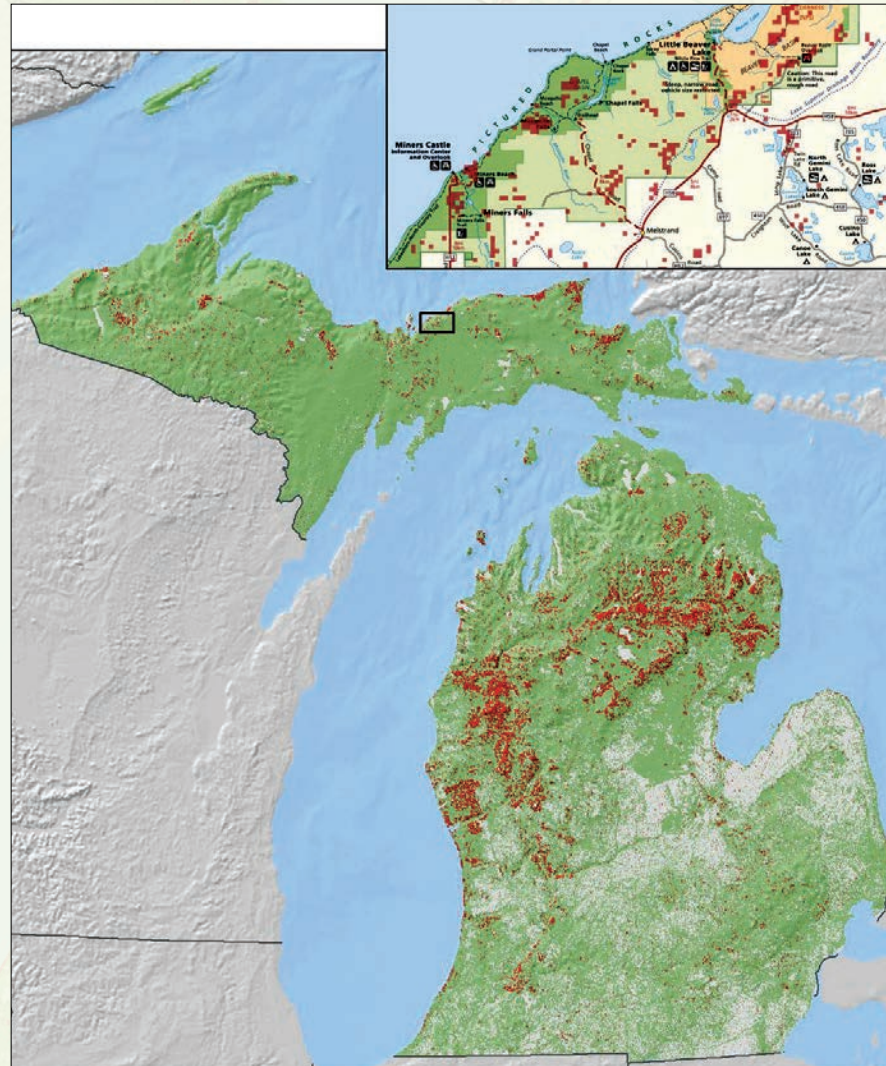
The solution to this growing crisis lies largely in public awareness. Understanding the role humans play in the accidental introduction of exotic pests into our forests is a vital first step in halting the problem.

The 2014 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.

Making Those Forest Health Maps: A Quick Look Behind the Scenes

Forest health maps. They're eye-catching, sometimes controversial and usually pretty informative. And these days, they seem to be showing up everywhere – in newspapers and magazines, on websites and even plastered on roadside billboards.

We get questions rolling in all the time asking: “Where do those maps come from, anyway?” OK, only one question rolled in, but it was a good one. So, here’s a brief behind-the-scenes look at what goes into making these colorful graphics.

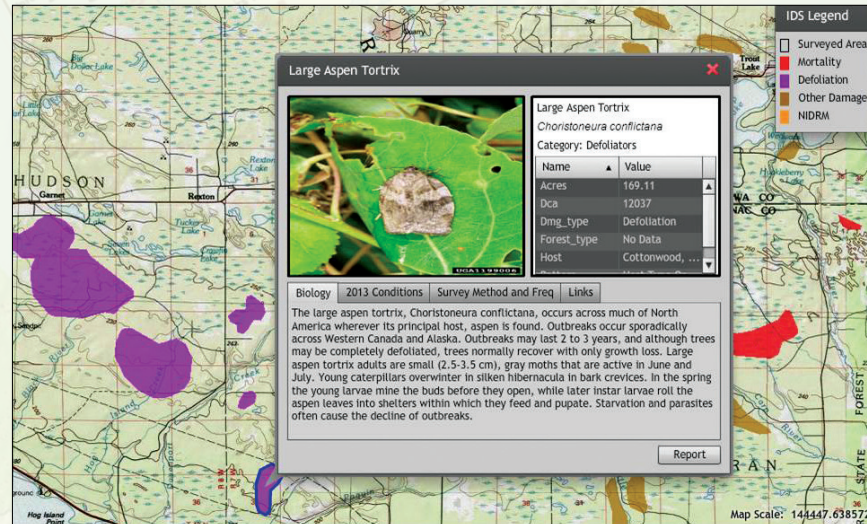


Areas highlighted in red have been determined to be highly susceptible to significant tree mortality caused by major forest pests. Inset map highlights places of concern in Pictured Rocks National Lakeshore. Examples shown on the following pages are a sampling of forest health maps that depict some of the problems that threaten Michigan's forest resources, and the challenges these maps present to the folks who make them.

Forest Health Maps *continued*

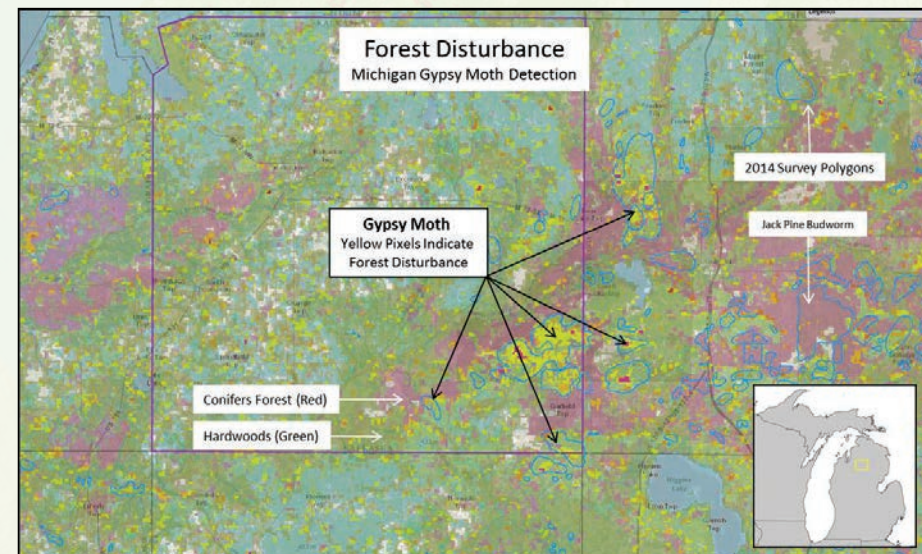
These days, packaging forest health information into concise, easy-to-understand maps requires a lot of high-tech equipment and techniques: computerized “sketchpads” used to precisely document insect and disease activity from the air even as the outbreaks are occurring; high-powered computers that process data with complex mapping software called Geographic Information Systems; high-resolution satellite imagery used to create incredibly detailed map backdrops; and global positioning systems (GPS) that quickly and accurately pinpoint location.

On top of that, it takes experienced computer modelers and cartographers (folks trained in the science of map design and display) using these tools to wade through a mountain of forest health information, whittling it down to a manageable and meaningful collection of lines, points and shapes.

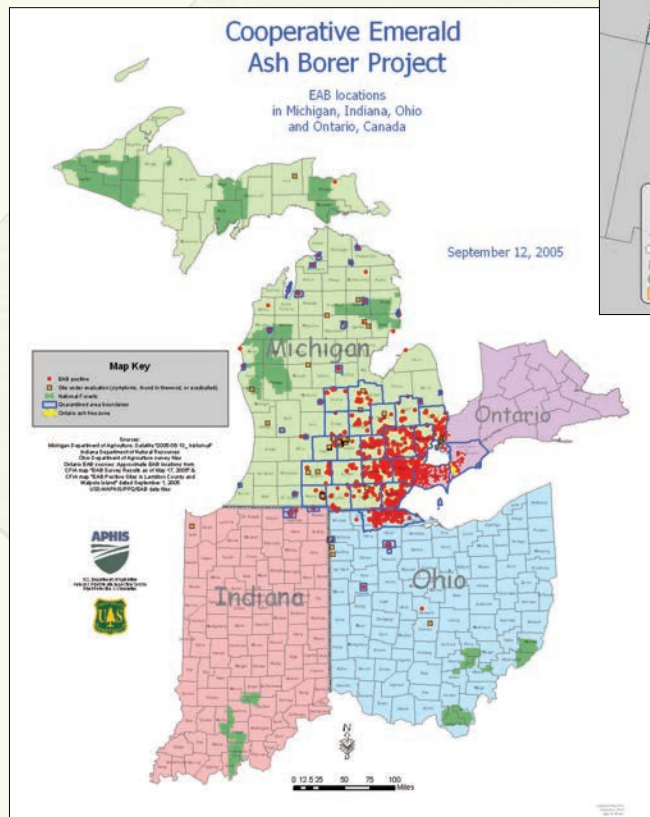
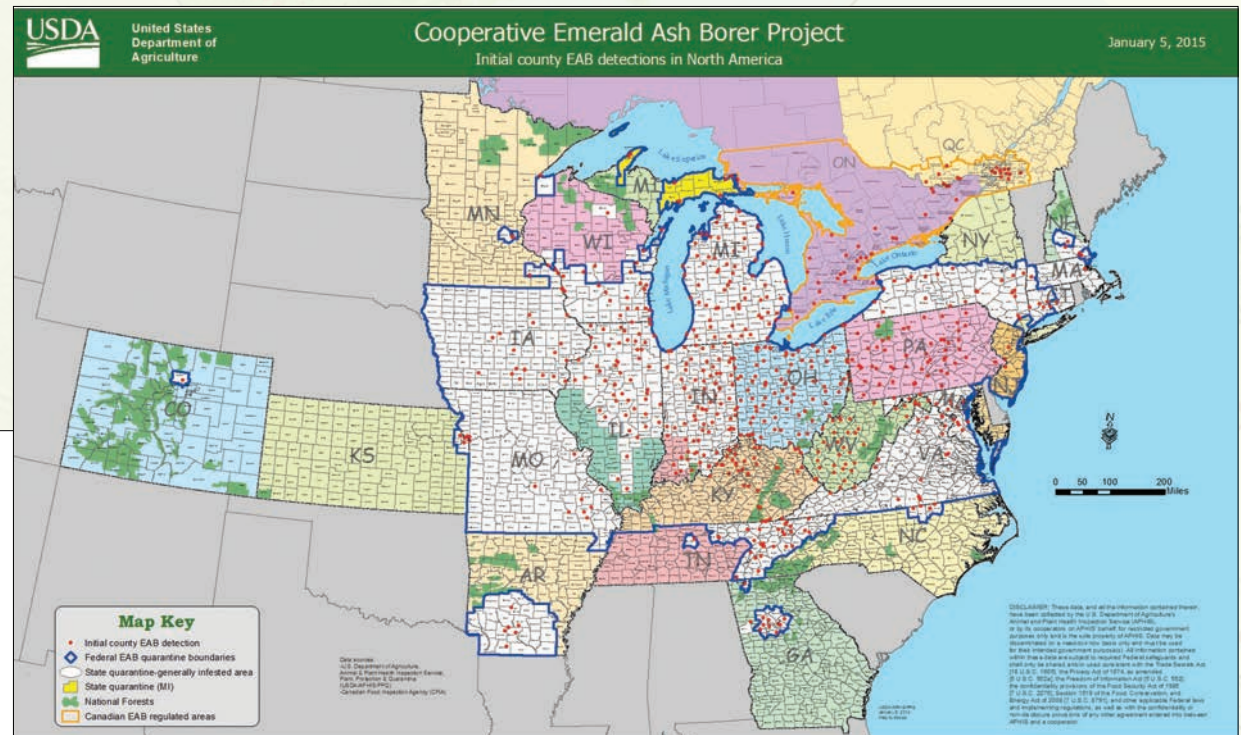


Aerial detection surveys are flown each year to collect data on current and past forest insect and disease activity. This provides essential information to help federal, state and local land managers make more effective decisions including how and when to salvage damaged trees, where to focus on forest restoration efforts, and how to prevent the spread of forest pests. Annual aerial detection survey maps for Michigan and the rest of the country can be viewed at <http://foresthealth.fs.usda.gov/portal>.

The U.S. Forest Service Forest Health Technology Enterprise Team (FHTET) has developed the Forest Disturbance Monitor (FDM) to identify insect defoliation and other potentially damaging forest events as they are occurring: <http://foresthealth.fs.usda.gov/fdm>. Here, the FDM has identified gypsy moth defoliation in the northern Lower Peninsula in near real-time.



Forest Health Maps *continued*



Creating forest health maps presents many challenges to ensure a message is communicated. Mapmakers apply design principles like visual contrast, legibility, uncomplicated symbology and overall balance of map features¹.

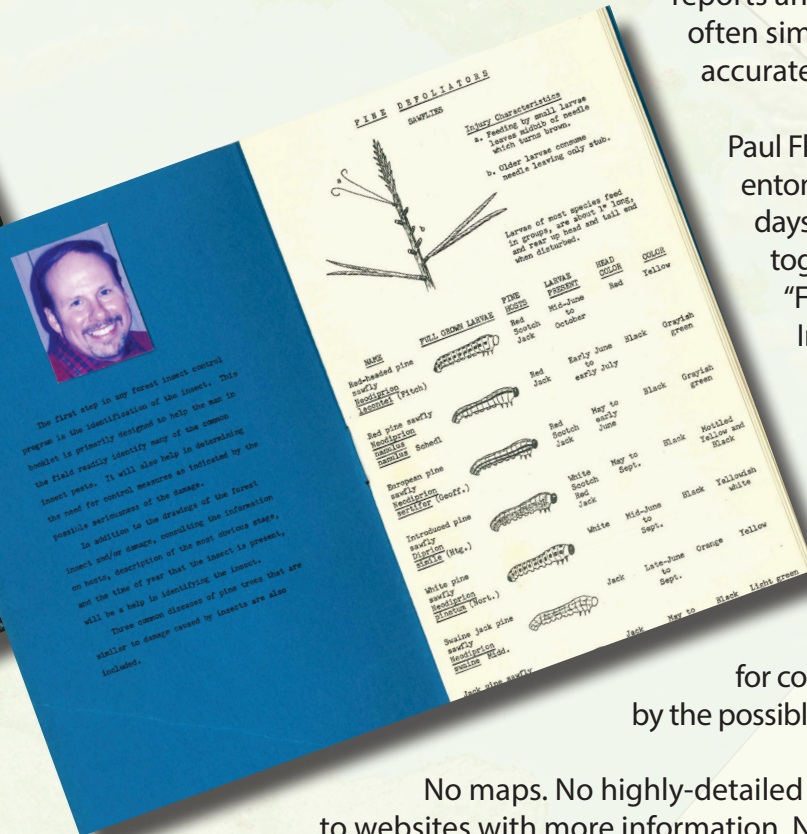
These maps are from different periods of the National Emerald Ash Borer (EAB) Program. Viewed together, they illustrate how map scale determines the overall appearance of a map, as well as the design principles needed to depict, with continuity and clarity, EAB distribution and areas quarantined to help stem the spread of this destructive pest.

Map at left: Emerald ash borer – 2005. Above map: Emerald ash borer - 2014.

¹ Buckley, Aileen, "Make Maps People Want to Look At." *ArcUser* Vol 15, No. 1 (Winter 2012): 46-51. Print.

Forest Health Maps *continued*

The world of forest health wasn't always this involved. In the old days, forest entomologists and pathologists walked the woods observing and recording what information they could, doing their best to compile it with not much more than pen, paper and a good memory. Maps used in annual reports and other publications were often simple and not especially accurate, or were absent altogether.

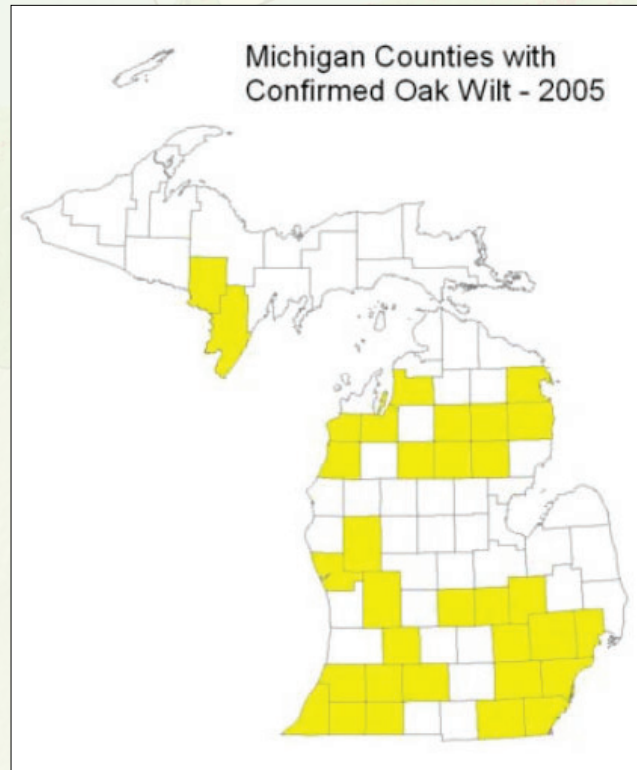


Paul Flink, a Michigan DNR forest entomologist during the fledgling days of the '50s and '60s, put together a pamphlet called "Field Key to Michigan Forest Insects" in 1961 (see image at left). As Paul states in his introduction, "This booklet is primarily designed to help the man in the field readily identify many of the common insect pests. It will also help in determining the need for control measures as indicated by the possible seriousness of the damage."

No maps. No highly-detailed computer images. No links to websites with more information. No GPS coordinates to lead the way. Just some nice, hand-drawn bugs and trees, along with a short description of what to keep an eye out for.

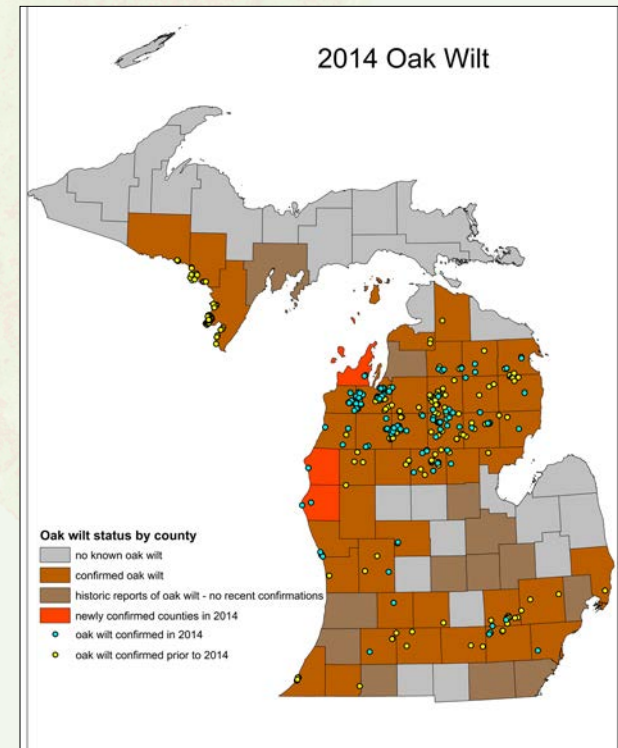
Forest Health Maps *continued*

Nowadays, maps not only identify what and where pests are affecting our forests, they can provide information about where they've occurred in the past, where they're likely to occur in the future, and what the impact will be if action isn't taken.



One of the DNR's first attempts at a statewide oak wilt map from the 2005 edition of the Forest Health Highlights report. Because the DNR lacked a reliable early-detection system for identifying and reporting oak wilt outbreaks, the map shows only whether oak wilt had been reported within a county. Much of the data came from old records, and the methods used to confirm oak wilt were not documented.

The 2014 version of the map provides a much more complete picture of oak wilt in Michigan. Besides pinpointing the location of outbreaks detected in 2014, it shows other locations from recent years, distinguishes recent confirmations using reliable methods from less reliable historical reports, and indicates counties where surveys did not detect oak wilt. This "negative" data has become extremely important in ongoing effort to track exotic invasive pests across Michigan's forests.



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

For a forest pest we don't even have yet in Michigan, Asian longhorned beetle (ALB) continues to command a lot of attention. This large, colorful wood borer can attack and kill well over a dozen species of hardwoods, including maple, birch and other valuable forest and landscape trees.

The Forest Health Program, in cooperation with DNR's Parks and Recreation Division and citizen volunteers, conducted intensive surveys for ALB in state parks and recreation areas across Michigan. For the fourth-straight year, surveyors carefully searched for signs of ALB in over 60 state recreational facilities.



Trees near fire rings that may have been exposed to infested firewood were targeted. Zip codes were used to identify campsites that were visited by campers from ALB-infested areas of the country. To date, no ALB have been detected.

Meanwhile, the battle to contain ALB where the insect has been discovered continues. In Boston, Massachusetts, officials with the U.S. Department of Agriculture declared a 10-square mile area ALB-free for the first time since the insect was detected in 2010. During this four-year period, over 90,000 trees have been inspected, and 2,000 trees treated with systemic insecticides to eliminate ALB larvae infesting the wood.

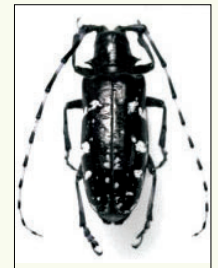
In another Massachusetts infestation, officials are struggling to



Asian longhorned beetle surveyors attend an annual refresher training session.

contain ALB in over 110-square miles of urban and rural forests.

Closer to home, the infestation in Clermont County, Ohio, continues to expand. Nearly 1.4 million trees have been surveyed, and nearly 14,000 infested trees have been destroyed.



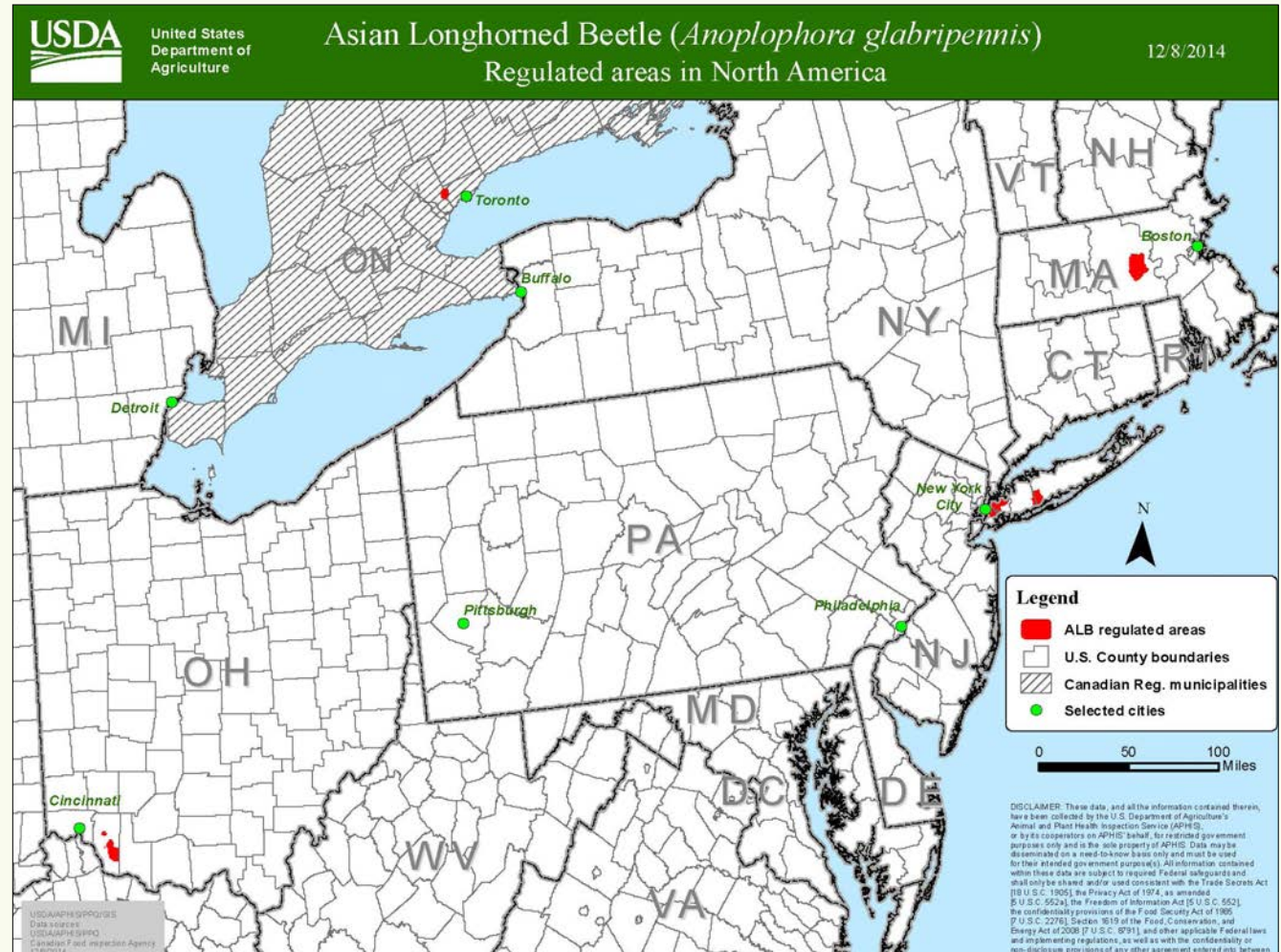
This infestation is of particular concern here in Michigan, where a potentially devastating load of infested firewood is only a four-hour drive away. Public education remains a critical tool in our efforts to keep this

Asian Longhorned Beetle *continued*

pest out, as firewood movement continues to be the vehicle of choice for most exotic forest pests.

For more information about ALB, see <http://asianlonghornedbeetle.com/>.

For information on selecting trees that are resistant to ALB, see <http://www.na.fs.fed.us/urban/WhyAReplacementTreeTable140101.pdf>.



Balsam Woolly Adelgid

The Michigan Department of Agriculture and Rural Development (MDARD) established a quarantine to protect the state's balsam fir from the balsam woolly adelgid (BWA). According to the U.S. Forest Service, BWA was accidentally introduced into Maine in 1908 from Europe. It now infests firs in southern Canada, the Pacific Northwest and the northeastern United States. In the eastern United States, vast stands of Fraser and balsam fir have been killed, with serious impacts on timber and Christmas tree industries. For example, in the Great Smoky Mountains National Park, 95 percent of Fraser fir has been killed by BWA.

Balsam woolly adelgid is a sap-feeding insect that attacks true firs, including balsam fir and Fraser fir. The BWA causes twig gouting, kills branches, and eventually kills the tree. Small (less than 1/32nd of an inch) purplish-black adult BWA form white, waxy "wool," that covers twigs, branches and stems of infested trees. Smaller, amber-colored crawlers hatch in mid-summer, which is when the risk of spreading the insect by wind and wildlife is highest. BWA affects firs in forests, seed production, landscaping and Christmas tree farms.

"While we don't have BWA in Michigan, it could be introduced into the state's landscape in a number of ways, including on infested nursery stock, firewood, logs and vehicles and then spread by wind, birds and other animals which can carry it for miles," said MDARD Director Jamie Clover Adams. "And, once it's here, it's difficult to detect and eradicate."

The BWA quarantine generally prohibits the shipment of fir nursery stock and fir timber products into Michigan from infested states. Certain low-risk fir products are exempt, including Christmas trees and wreaths and heat-treated timber products. The quarantine also allows fir seedlings grown under an active pest management program to be shipped into Michigan. See the MDARD "Cooperator



Top: Twig gouting caused by the balsam woolly adelgid. **Bottom left:** Balsam woolly adelgid, small cotton-like balls on balsam fir twigs. **Bottom right:** White cottony balsam woolly adelgid on the trunk of a balsam fir.



Update" on page 43 for more information about the BWA quarantine.

The U.S. Forest Service's Forest Inventory and Analysis Program reports Michigan's balsam fir resource to comprise of 1.9 billion trees. This equates to a volume of 903 million board feet of sawtimber, or 463 million cubic feet of trees. Balsam fir is an important source of pulp and dimensional lumber.

For more info on BWA, visit: <http://www.na.fs.fed.us/pubs/fidls/bwa.pdf>.

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 white scale insect that attaches to bark 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

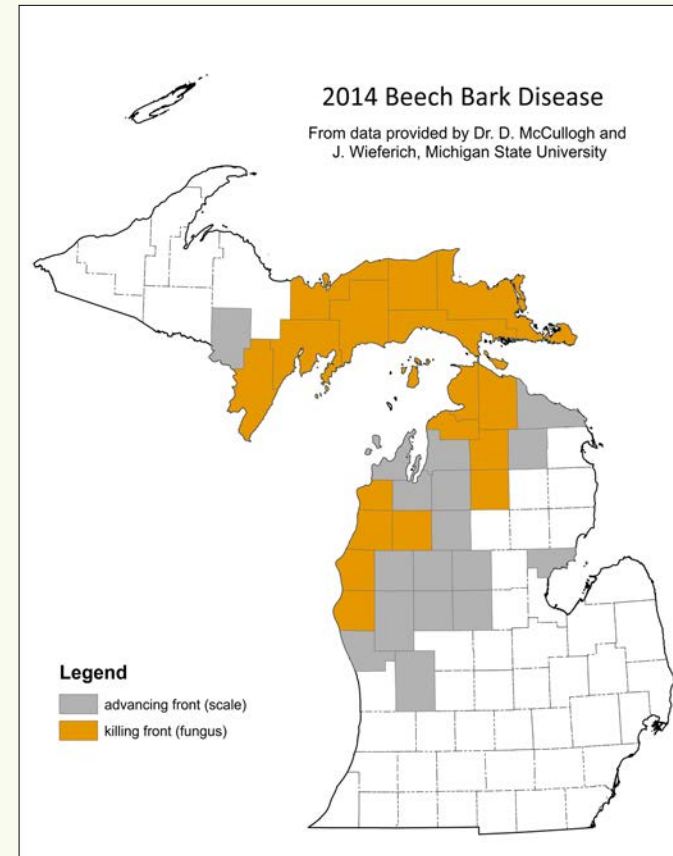


Whitewashing of beech bark caused by beech scale.

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 hazardous trees are removed from state parks and campgrounds to prevent them from falling and possibly hurting people.

According to the latest U.S. Forest Service Forest Inventory and Analysis (FIA) data for the period 2009-2013, there are



29.8 million American beech trees greater than 5 inches in diameter and 3.75 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 beech bark disease expands to the remaining areas of yet uninfested American beech.

Beech Bark Disease *continued*

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 U.S. Forest Service to select and breed American beech trees for resistance to BBD. Beech trees that are resistant to BBD are



Beech tree covered in scale from beech bark disease.

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 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. The DNR Forest Resources and Wildlife divisions have joined

forces to ensure that these orchards are established. The goal is to provide seed

to regenerate resistant seedlings for restoration plantings. The vision is the restoration of Michigan's American beech resource.

Planting of the first resistant American beech seed orchard began in 2011 at the DNR's Tree Improvement Center. The root stock



Yellow crowns of trees infected by beech bark disease are readily detected during aerial surveys.

used for grafting to is from southern Ohio. This is one factor that has contributed to poor performance and survival at the DNR Tree Improvement Center in Brighton, Michigan. Paul Bloese at the Michigan State University Tree Research Center collected American beech seed from northern Michigan and is producing root stock for grafting Michigan-destined resistant seedlings.

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.

Beech Bark Disease *continued*

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 2011 in the Upper Peninsula in an area heavily impacted by BBD. These trees are within an enclosure and will be monitored annually for growth characteristics and continued scale resistance.

Michigan State University Tree Research Center

Paul Bloese, Research Manager

*(In cooperation with Jennifer Koch,
U.S. Forest Service Northern Research Station)*

The Michigan Cooperative Tree Improvement Program (MICHCOTIP) continues to maintain the grafted seed orchard of beech bark disease (BBD) resistant selections in Brighton, Michigan. In addition to maintaining weed control around the planting locations, irrigation and fence lines, 14 new trees were planted in spring 2014. The growth and health of grafted beech at Brighton has been marginal, and the irrigation system was rebuilt by DNR personnel in 2013 to help improve the drought-prone sandy soils. However, despite adequate moisture, the soils may be too nutrient deficient to sustain adequate growth of beech. The survival and growth of the grafts planted in 2014 will help decide if the site can support the beech orchard. To provide an alternative site, plans have been made to establish a second beech orchard at MSU's Kellogg Forest (located near Augusta, Michigan). The new orchard will contain 176 grafts (8 ramets by 22 clones) on 25-by-25-foot hexagonal spacing. Site prep on the Kellogg site began fall 2014 with mowing, and broadcast applications of glyphosate and 2,4-D.

To produce cold hardy rootstock for grafting select beech from the Upper Peninsula, over 600 containers were double sown with beech seed collected by DNR personnel from the Indian Lake Campground

west of Manistique. Although the seed germinated well, after two weeks of normal growth the leaves developed necrotic areas and began to die. Eventually the problem was diagnosed as flower thrips, which in addition to causing feeding damage, serve as a vector for tobacco mosaic virus (TMV) and impatiens mosaic virus (IMV). The thrips were eventually controlled, but there is no treatment for TMV or IMV, and seedlings either outgrow the virus or die. Over 300 beech seedlings were transferred to the lath house for overwintering, but it is unclear how many will be strong enough to survive the winter. The Manistique beechnut crop was extremely meager in 2014, but will be monitored and collected in the future to support ongoing efforts to produce cold hardy beech rootstock.

Progress Report on Beech Scale Resistance Project

*U.S. Forest Service NRW-16 and the
Michigan Department of Natural Resources*

Beech hot callous grafting: A total of 190 graft attempts were made resulting in 142 successful grafts, for an overall graft success rate of 75 percent. Thirteen genotypes of resistant beech (two new to our program this year) from the Upper Peninsula were grafted from scion collected from grafted trees in the Delaware, Ohio, archive or from state lands by cooperators from the Michigan DNR. An additional eight resistant genotypes from the Huron National Forest were grafted by Personnel at the USFS Eastern Region's Oconto River Seed Orchard (ORSO) for a combined total of 236 new grafts.

Rootstock propagation: 1,000 beechnuts collected at Dawes Arboretum (Newark, Ohio) were germinated. We are currently carrying 829 of the resulting seedlings for use as root stock in next year's grafting. We also are carrying 75 seedlings from seed collected by ORSO from Wisconsin. Approximately 60 of those are large

Beech Bark Disease *continued*

enough to graft to this coming winter. We were unable to collect any new beechnuts this year.

Controlled Cross Pollinations: Controlled cross pollinations were carried out between 18 different combinations of parents. Families obtained from these crosses ranged from N=9 to N=101 progeny. An additional 66 open-pollinated seedlings were obtained from Michigan grafts. These seedlings will be screened for resistance and will provide a quality control “snapshot” of the expected output of resistance from seed orchards containing these parental genotypes. Additional genetic information about the inheritance of the scale resistance trait will also be obtained from these studies.

Scale-resistance screening: In 2013, pads containing scale eggs were placed on 140 members of the 1505 x 1504 mapping family. Data was to be collected in summer 2014, but unfortunately a staff member at Holden Arboretum (where the scale screening facility is located) inadvertently treated these beech seedlings with a systemic insecticide making the test invalid. New pads with eggs were placed on these seedlings and data will be collected in summer 2015. In addition, four new full-sib families were challenged with scale eggs.

Scale Workshop held at Holden Arboretum: A training workshop was held by Jennifer Koch and David Carey to demonstrate techniques for collecting beech scale from trees in natural stands, purify the scale eggs away from adults and other debris, and set up scale challenge pads on candidate resistant trees (along with susceptible controls) to confirm their resistance. Attendees at this training session included Jennifer Wright of the Green Mountain National Forest, Ivich Frazier FS State & Private Forestry and Roger Mech of the Michigan DNR. A protocol and accompanying video were published on these techniques and copies of both can be found at: <http://www.treesearch.fs.fed.us/pubs/46347>.



Michigan Department of Natural Resources forest health specialist Roger Mech works with Dr. Ivich Fraser, U.S. Forest Service entomologist, to apply pads containing beech scale eggs to beech trees to test for resistance to the insect.

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. Shoot blight infections are fairly common both in plantations and in naturally regenerated pine. Infected trees produce Diplodia spores on blighted twigs and cones. Diplodia spores rain down from overstory trees to infect understory and nearby seedlings and trees. Residual slash from timber harvests of infected pines harbor spores which infect newly planted seedlings.

Infected trees show no symptoms unless stressed by drought or wounded by events such as hail storms. Moisture stress of newly planted seedlings or seedlings in nursery beds causes a collar rot which often leads to seedling mortality. Hail damage or drought cause shoot blight and stem cankers in larger trees, killing shoots, branches and sometimes terminal whorls of trees.

In the 1990s Dr. Glenn Stanosz at the University of Wisconsin linked the increasing incidence of Diplodia on the landscape to movement of infected nursery stock. Infected border or windbreak red and jack pine were infecting nursery stock. This association was not apparent because unless seedlings are stressed, trees remain symptom-free. In irrigated nursery beds, infected seedlings appeared healthy.

Shortly after this discovery, Michigan surveyed for and detected Diplodia at the Department of Natural Resources' Wyman Nursery. Wyman Nursery produces all of Michigan's red and jack pine planting stock. To reduce risk of Diplodia infection, all mature red and jack pine trees bordering the nursery beds were removed. The jack and red pine nursery stock has been Diplodia-free since these removals. Unfortunately, thousands of infected seedlings had already been unknowingly planted in several areas around Michigan.



Large red pine impacted by diplodia after hail damage.

Prior to the 1970s, a native species of Diplodia, *D. scrobiculata*, occasionally caused shoot blights in red, jack and Austrian pine in Michigan. In the mid-70s, a new, more aggressive species of Diplodia was identified that many feel is an exotic pathogen, *Diplodia pinea*. This is the species that was unknowingly moved out of nurseries into the landscape, and is the one primarily responsible for Diplodia-related problems today.

Diplodia Shoot Blight *continued*

Due to the prevalence of *Diplodia pinea*, and the sudden appearance of impacts in many areas after drought events and hail storms, red pine management methods that maintain trees of various heights (called 'uneven-aged management') is being questioned as a viable option in many areas. For example, in Ontario, Canada, uneven age management for red pine is not recommended due to increased risk of Diplodia infection. On the Huron-Manistee National Forest, where uneven-aged management has been common, Diplodia has killed up to 99 percent of understory seedlings in some areas.

Stands without evidence of Diplodia in the overstory can be considered for unevenaged management. However, these stands must be closely monitored, and the overstory harvested as soon as young trees have become established. Minnesota offers the following guidance for natural and artificial regeneration of red pine:

Natural regeneration in the understory

Diplodia has the greatest impact on red pine seedlings growing in the understory directly below a red pine overstory. Select sites very carefully if you want to establish red pine regeneration under red pine trees:

- If you find blighted red pine seedlings in the understory, Diplodia is likely to be present in most of the seedlings as latent infections and in a few seedlings as shoot blight infections. Thus:
 - It is too risky to attempt red pine or jack pine establishment. White pine is the only pine species that is likely to survive.
 - Diplodia spores move and cause shoot blight an average 2 chains away from infected overstory trees. Maintain a

2-chain buffer from infected overstory pine.

- Red pine shelterwoods and other gap regeneration methods are unlikely to be successful because the openings are usually less than 1 or 2 chains in width.
- If the existing understory seedlings are not blighted and the incidence of Diplodia cone infection is very low (<3 percent), the risk of Diplodia infection is low.

Artificial regeneration in plantations

Diplodia is only a problem in plantations where there is an inoculum source. Spore sources include pole-sized and larger red and jack pine trees that have infected cones and twigs.

- The incidence of infections in young plantations is usually limited to 2 chains from the overstory edge containing mature red pines.
- In most years, a 1-chain buffer strip would be sufficient to limit mortality losses.
- The buffer can be increased to 2 chains on sites where shoot blight is already known to be severe in the natural regeneration in the understory.
- Avoid leaving any live red or jack pine trees on sites intended for artificial red pine regeneration. If some must be left as live trees, choose locations near to the plantation edge and leave clumps of them. This minimizes the area influenced by Diplodia infections.

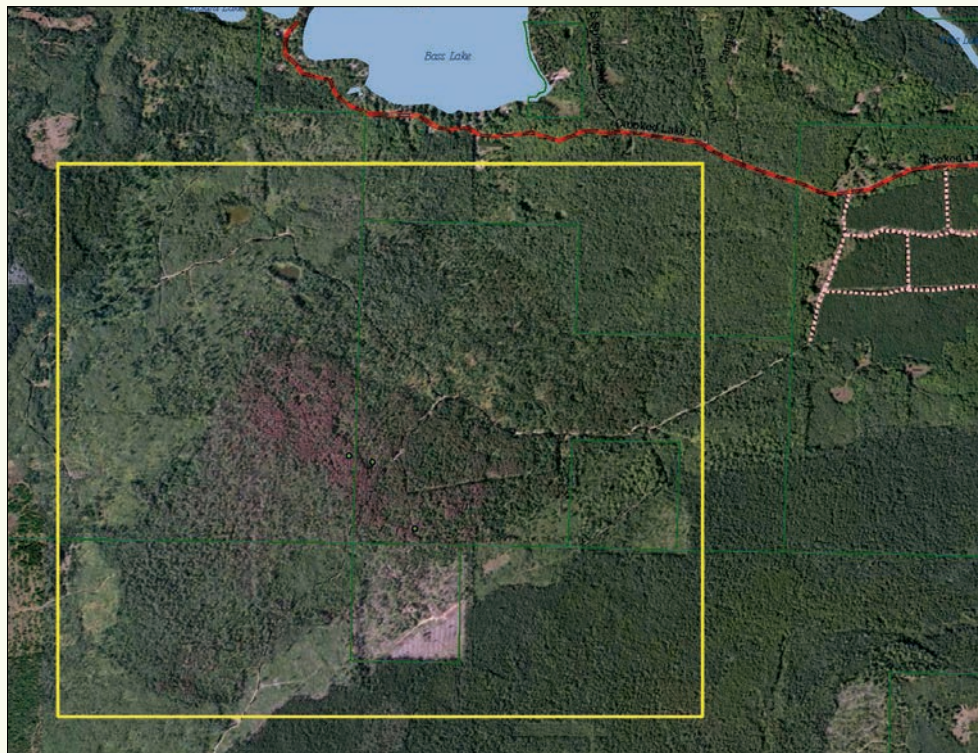
(Excerpts taken from "The impacts of Diplodia infections on red pine silviculture and productivity" written by Jana Albers, Forest Pathologist for the Minnesota Department of Natural Resources. The full article is available at <http://files.dnr.state.mn.us/publications/fid/2014/nov/diplodia-infections.pdf>.)

Diplodia Shoot Blight *continued*

Diplodia Impacted Red Pine Salvage Sale

A severe hail storm in 2012 damaged a large area of red pine in the central Upper Peninsula (See aerial image of impacted area from Google Earth). This was also a year marked by record-breaking droughts. Widespread dieback and top kill of

mature red pine resulted when Diplodia infected hail-damaged branches. A mature 135 acre stand with utility pole and sawlog-size red pine had to be salvaged due to tree mortality and top kill of crowns both from Diplodia impacts and resulting bark beetle, *Ips pini*, impacts.



Left: Mature red pine impacted by Diplodia shoot blight after a hail storm, as seen from Google Earth. **Right:** One hundred thirty five acres of mature red pine salvaged due to Diplodia impacts following hail damage.

Dwarf Mistletoe

Eastern spruce dwarf mistletoe (*Arceuthobium pusillum*) is a parasitic flowering plant that causes the most serious disease of black spruce (*Picea mariana*) throughout its range. Although white spruce (*Picea glauca*) is also highly susceptible, mistletoe is not common on these trees, perhaps because they rarely occur naturally in pure stands.

Witches' brooms are the most visible symptom of dwarf mistletoe infection. Uninfected parts of the tree decline first, leaving most of the living foliage in witches' brooms. The upper crown commonly dies first, so severely infected trees usually have dead tops.



Dwarf mistletoe on twig.

Mistletoe spreads to nearby trees by explosively discharging its seeds. The seeds stick to birds and other animals that move them to susceptible trees, creating new areas of tree mortality.

Mistletoe takes food and water from the tree. Over time this causes reduced growth, loss of vigor, lowered timber quality, reduced cone and seed production, predisposition to other damaging agents, and eventually tree mortality. Where prevalent, dwarf mistletoe is the major cause of reduced black spruce tree numbers. In severely infested areas, stocking levels are so low that a commercial harvest is not an option.

Dwarf mistletoe also kills young spruce saplings, which contributes to reduced tree numbers.



Tree with witches brooms caused by dwarf mistletoe.

In stands managed for timber, mortality caused by dwarf mistletoe is unacceptable. To prevent these losses, the mistletoe should be eradicated from regenerating stands. Any treatment that kills all spruce on the site after a harvest will eliminate dwarf mistletoe. Leaving even 16 infected trees per acre after harvest has allowed dwarf mistletoe to increase and cause serious losses. Harvesting should extend at least 40 meters beyond trees with symptoms to ensure that all latent infections are removed.

For more information refer to U.S. Forest Service Forest Insect & Disease Leaflet NA-PR-04-06 available at: http://www.na.fs.fed.us/pubs/fidls/ed_mistletoe/ed_mistletoe.pdf.

Eastern Larch Beetle

The eastern larch beetle (ELB), *Dendroctonus simplex*, continues to impact tamarack (*Larix laricina*) throughout the Upper Peninsula. This bark beetle became epidemic as tamarack was stressed by two consecutive years of defoliation by the larch casebearer (*Coleophora laricella*) in 2001 and 2002. The repeated droughts of the last decade and associated stresses have contributed to continued ELB activity. Although rainfall has returned to more normal levels the last two years, the ELB is still impacting



stands of tamarack. Historically, once ELB becomes epidemic they act more like a primary invader, attacking healthy stands in addition to those already under stress.

According to the Forest Insect & Disease Leaflet 175 U.S. Forest Service titled Eastern Larch

Beetle by Seybold, S.J., M. Albers and S. Katovitch, ELB outbreaks have been extensive throughout North America beginning in the 1970s. In areas of interior Alaska, 50 percent of the tamaracks were killed in a two-year period. In Minnesota, tamarack mortality has been documented on 162,000 acres (10 percent of their tamarack resource) in the past 10 years with no signs of population collapse.

Signs of attack include resin flow on the bark during summer months and yellowing foliage starting at the bottom of the tree in mid-to-late summer. However, treetops often remain green well into the fall, making aerial detection of affected stands difficult or impossible. These trees fail to leaf out the following spring. In the fall and winter, woodpeckers often remove the bark as they feed on ELB.



Pockets of mortality caused by eastern larch beetle.

Stress often triggers these outbreaks. Defoliation is most often cited as a factor. Other stresses triggering ELB populations include flooding, drought and storm damage. Once ELB becomes epidemic, there is no relation between ELB impacts and stand age, stand size or whether stands are located in upland versus lowland areas. However, as stands age, they do become more susceptible. Tamarack does not grow well in shade, so stress from competing vegetation can increase risk in well-stocked tamarack stands. ELB populations also increase in areas with wind thrown trees, log piles, snow breakage and logging debris. Prompt removal of these trees helps reduce ELB numbers.

Management recommendations include harvesting tamarack when it is still growing vigorously, and to remove tamarack stands if edge trees begin showing signs of ELB activity. Once ELB begins attacking a tamarack stand, it quickly moves throughout the stand. Preemptive action is required if trees are to be useful for fiber or lumber.

Emerald Ash Borer

Michigan's Ash Resource

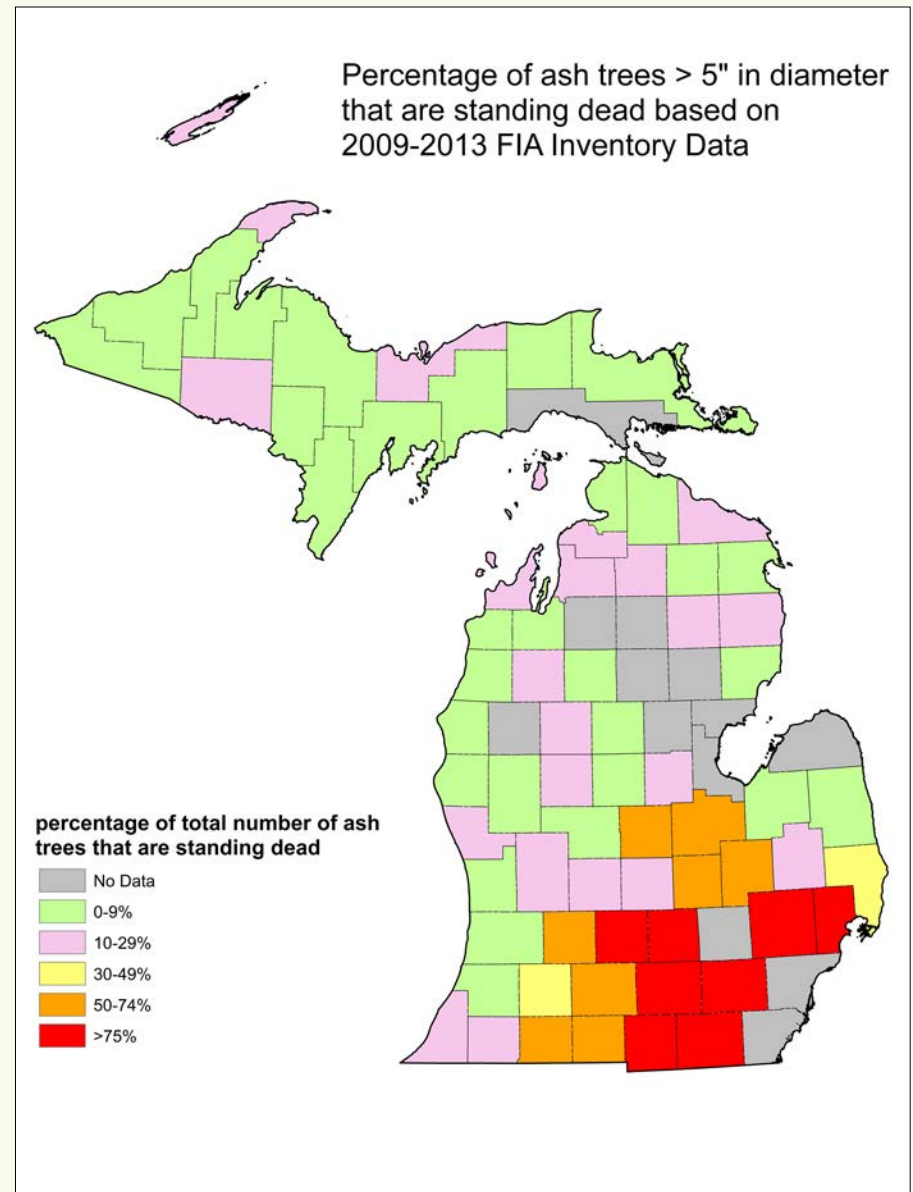
According to the latest U.S. Forest Service Forest Inventory and Analysis (FIA) data, there are 147.6 million ash trees > 5 inches in diameter, and 31.5 million standing dead ash in the same size category. This number does not include ash on non-forest lands, such as cities and urban environments. FIA estimates annual ash mortality in forested environments of 6 million ash > 5 inches in diameter, or an annual lost volume of 79 million cubic feet of ash.



The map at right was derived from FIA data for 2009-2013. The large number of ash lost in Michigan cities and urban environments are not represented. FIA data are estimates based on permanently established plots uniformly distributed across forest lands and woodlots on all ownerships. Each plot represents a large area. The real strength of the data is its measure of forest change over time. Thus, the trends are clear but the numbers are estimates

derived from plot data, sometimes with large standard errors.

The map at right clearly demonstrates the evolution of the devastating impacts of the emerald ash borer on Michigan's ash resources as it spread from southeastern Michigan over a period of 20 years. There are a number of counties that have no data due to few or no FIA plots or a lack of ash in existing plots. These counties have ash mortality, sometimes significant amounts of dead ash in landscapes along travel routes and in urban environments. Many counties represented by light green (0-9 percent) have low levels of



Emerald Ash Borer *continued*

ash mortality due to long-standing forest health problems. Problems include a disease called ash yellows, water table fluctuations and moisture stresses caused by droughts, and natural mortality in overstocked stands due to ash's increasing shade intolerance as it ages.

Thus, you see counties with 10-29 percent ash mortality in the western Upper Peninsula (WUP) where EAB has yet to be detected. The WUP was hardest hit by the periodic droughts of the last two decades. The same areas in the Lower Peninsula were less impacted by drought, so reported mortality can be more clearly attributed to EAB impacts.

Ash mortality above 30 percent clearly represents the significant and devastating impacts of the emerald ash borer above all other issues.

Surveys and Quarantines

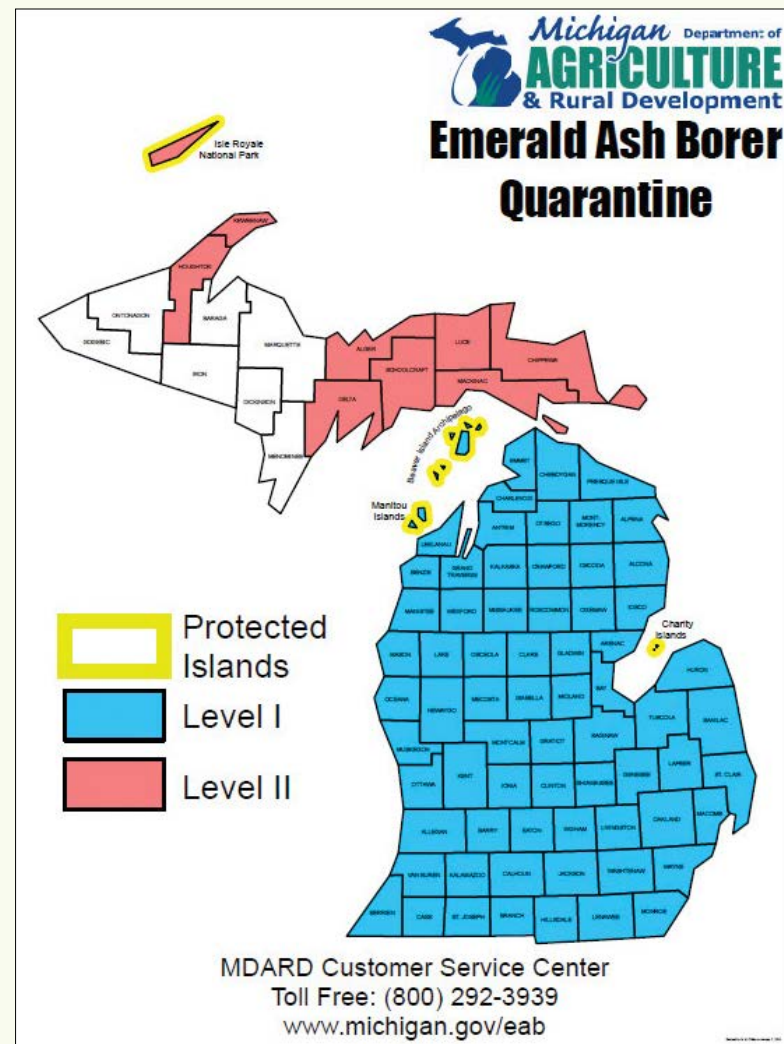
The Michigan Department of Agriculture and Rural Development (MDARD) reports that to date EAB is responsible for the death or damage of approximately 50 million ash trees in Michigan and surrounding states.

The U.S. Department of Agriculture Animal and Plant Health Inspection Service surveyed uninfested counties in the WUP for EAB. They deployed 230 purple traps baited with an aromatic lure known as manuka oil. Traps are placed around high-risk areas such as campgrounds and sawmills and along travel pathways. There were no detections in the un-infested, non-quarantined counties of the western Upper Peninsula in 2014 (see map on page 44).

.....

MDARD revised the EAB quarantine in 2014 to place all Upper Peninsula counties currently quarantined into quarantine Level II.

• **Quarantine Level I Area:** All 68 contiguous Lower Peninsula counties.



• **Quarantine Level II Areas:** The Upper Peninsula counties of Alger, Chippewa, Delta, Houghton, Keweenaw, Luce, Mackinac and Schoolcraft.

Emerald Ash Borer *continued*



Emerald ash borer quickly kills ash trees along city streets removing shade and degrading landscapes.

No new counties were quarantined. MDARD is asking travelers and residents to continue not moving firewood to help prevent the spread of other exotic and devastating insects and diseases like Asian longhorned beetle, thousand cankers disease of black walnut, hemlock woolly adelgid, oak wilt and beech bark disease. The ban on moving firewood north across the Mackinac Bridge remains in effect. The Upper Peninsula counties of Baraga, Dickinson, Gogebic, Iron, Marquette, Menominee, Ontonagon and Marquette remain un-quarantined for EAB.

Additional information about EAB, quarantine details, and a map of the quarantine boundaries are available at www.michigan.gov/eab or www.emeraldashborer.info

Movement of ash and hardwood firewood

- The movement of hardwood firewood and other regulated articles from the Lower Peninsula into the Upper Peninsula

is prohibited unless done so under the stipulations of a valid MDARD Compliance Agreement.

- The movement of regulated articles originating from a Quarantine Level II area is prohibited out of the Level II area without a valid MDARD Compliance Agreement except regulated articles may move from the Quarantine Level II area in the eastern Upper Peninsula into Quarantine Level I of the Lower Peninsula without a Compliance Agreement.
- The prohibition on moving hardwood firewood, and the other articles regulated by the quarantine from anywhere in Michigan to the Beaver Island Archipelago, Big and Little Charity islands, North and South Manitou islands and Isle Royale is still in place.
- Compliance Agreement Treatments: Compliance Agreements are typically utilized by those in the forest products industry who can meet approved treatment methods. Approved treatment methods currently include removing 100 percent of bark and an additional ½ inch of wood or kiln drying or heat treating according to approved treatment schedules.
- Nursery Stock Moratorium: The sale and/or movement of all ash nursery stock within, out of, or into Michigan is prohibited under all conditions. The movement of hardwood firewood and other regulated articles out of the state of Michigan must be done according to federal EAB regulations. Contact your local U.S. Department of Agriculture office for more information.
- Travelers should continue to only use local sources of firewood, burn all they buy, and not take any unused firewood back home or to the next location.
- The ban on moving firewood north across the Mackinac Bridge remains in effect and quarantine violators can still face fines ranging from \$1,000 to \$250,000 and jail time of up to five years.

Hardwood Defoliators

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. Areas of heavy defoliation were observed across parts of the eastern Upper Peninsula and the northeastern Lower Peninsula.



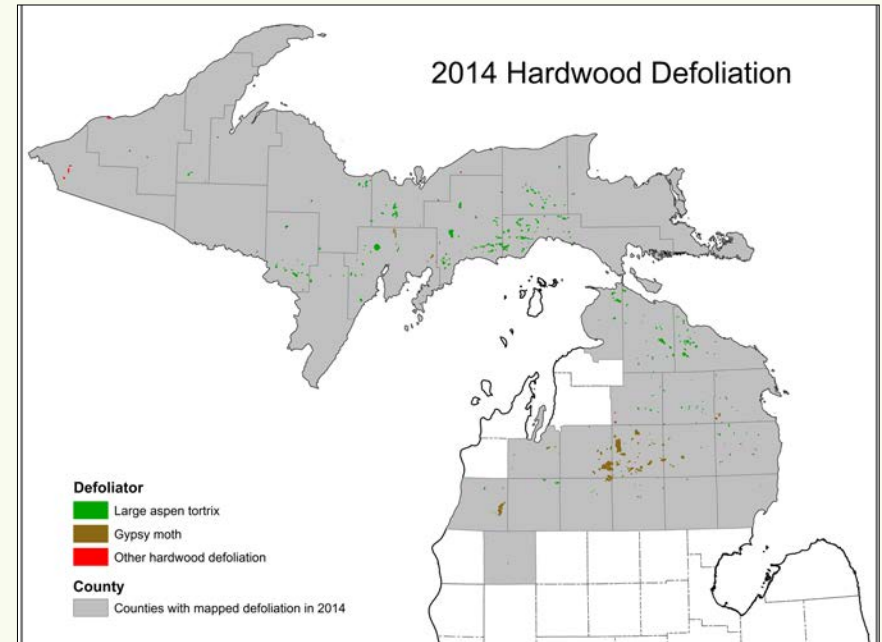
Leaf rolling damage caused by large aspen tortrix.

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 two to three 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.

As a result of natural enemy activity, populations of the tortrix in 2015 are expected to be lower, although scattered, locally heavy defoliation may still occur. Fortunately, with the precipitation levels the past two growing seasons, trees should recover from the defoliation without serious long-term effects.



Large aspen tortrix.

Hardwood Defoliators *continued*

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 in a single season.

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. In addition, two pathogens – one a virus, the other 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. Outbreaks are shorter, too, as natural enemies reduce caterpillar numbers and egg viability.

In 2014, caterpillar activity in the central Lower Peninsula – particularly Crawford and Kalkaska counties – caused significant defoliation to oak and, in some cases, aspen. Isolated pockets of defoliation were also confirmed in eastern Manistee County.

As with large aspen tortrix, long term impacts are not expected to be serious. One exception could be areas of older northern pin oak stands growing on very sandy soils. In these areas, stress from defoliation is compounded by old age and lack of soil nutrients and moisture. These conditions can lead to top dieback and eventual tree death.



Top: Full-grown gypsy moth caterpillar on a white oak leaf. **Left:** Gypsy moth stalked by predatory ground beetle.

Hemlock Woolly Adelgid

The hemlock woolly adelgid (HWA) is an exotic insect, native to Asia, which has become established in the eastern United States. The greatest risk of HWA making its way to Michigan is through the transport of infested nursery stock or landscape trees. Because of this threat, the Michigan Department of Agriculture and Rural Development (MDARD) enforces a quarantine on hemlock originating from outside the state of Michigan.

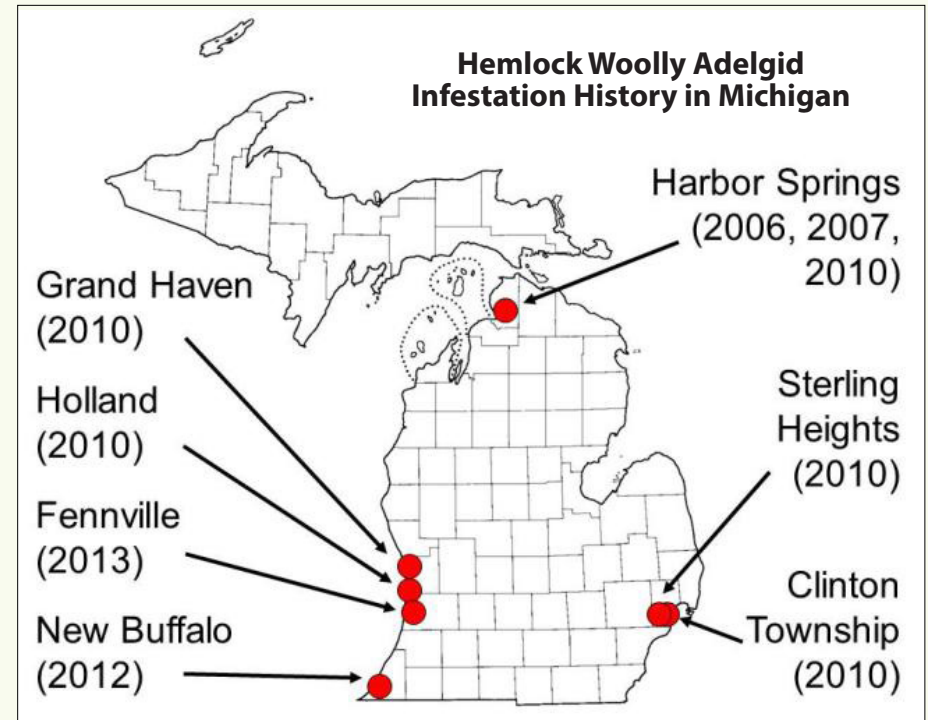


In 2014, MDARD Pesticide and Plant Pest Management Division (PPPMD) continued its follow up work at sites where HWA had been detected in previous years. Activities included insecticide applications to hemlock trees in a buffer area around the infestation sites, and survey

of hemlock trees within a half mile of the infestation sites. Infested trees were removed and destroyed the year they were detected.

The status of each site is as follows:

- Clinton Township/Sterling Heights, Harbor Springs, Grand Haven and Holland: At least three years of follow-up activities have occurred at all sites. Discussions are taking place to determine if the sites can be declared eradicated and what the scope of future monitoring work will be.
- New Buffalo: Follow-up activities at the site will continue at least through late 2015.
- Fennville: Follow-up activities at the site will continue at least through early 2016.



Activities at these sites are supported in part by a Forest Health Protection grant from USDA Forest Service.

In an ongoing effort to help support the Michigan quarantine, DNR Forest Health personnel continue to survey for 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 Allegan State Game Area (in close proximity to the most recent Fennville detection) and in Charlevoix and Emmet counties.

In addition, HWA surveys were conducted for the first time on Beaver Island in cooperation with MDARD this year. Twenty-two students

Hemlock Woolly Adelgid *continued*

from the Beaver Island Community School, along with staff, 10 island residents, tribal and land conservancy representatives and others participated in the training and surveys.

No HWA were detected in Michigan in 2014.

For more information on the biology and North American distribution of HWA see the USDA FS pest alert for hemlock woolly adelgid: http://na.fs.fed.us/spfo/pubs/pest_al/hemlock/hwa05.htm.

**Michigan DNR Brighton Tree Improvement Center,
Michigan State University and MICHCOTIP,
Dr. Deb McCullough and Paul Bloese**

HWA causes extensive damage in eastern hemlock forests in the eastern United States from Maine to Georgia. In 2001, Michigan's Department of Agriculture quarantined the importation of eastern hemlock logs, untreated bark products, seedlings and nursery stock in an effort to limit the threat of HWA to Michigan's native hemlock areas.

Research conducted by the U.S. Forest Service and other agencies have found that native HWA predators show some promise as biologic controls. There have been several small-scale infestations of HWA in Michigan, all of which are believed to have been eradicated. However, as a precaution, the Michigan Cooperative Tree Improvement Program (MICHCOTIP) will establish eastern hemlock hedges at the MSU Tree Research Center (TRC).

This is a cooperative effort by the Michigan Department of Natural Resources and MSU in Brighton. These hedges will provide a substrate for rearing and evaluating potential HWA predators in the event that HWA successfully breaches the MDA quarantine.

In preparation for the field establishment of the hemlock hedges, 250 hemlock seedlings were planted in the TRC nursery beds prior to the 2014 growing season. Field sites for the transplants were treated with herbicides during summer 2014 at Brighton and the TRC to control competing vegetation. All hemlock stock will be field planted in the spring of 2015 at the Brighton and TRC sites.

Heterobasidion Root Disease

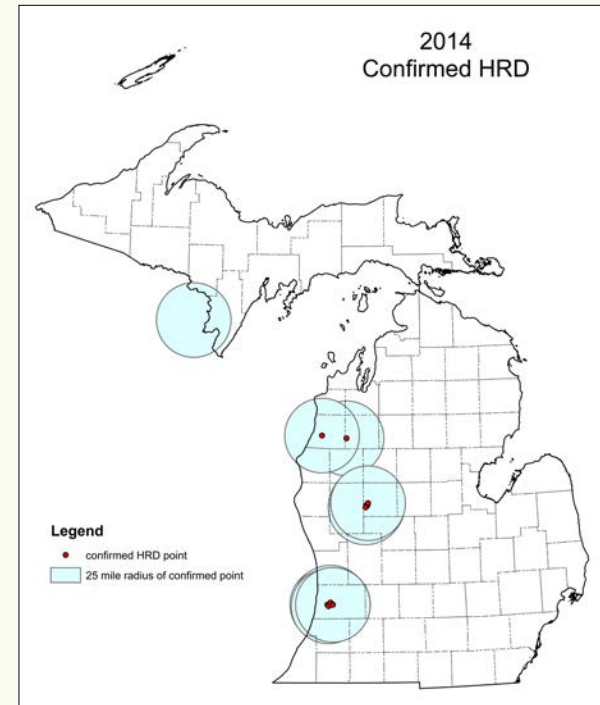
Unlike many forest insects and diseases that are attracted to stands stressed by lack of management, *Heterobasidion* root disease (HRD) is most commonly found in actively managed forest stands. In Michigan, red pine, jack pine and white pine are most susceptible. Fresh-cut stumps provide an ideal entry 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 slower 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 irregulare* (formerly *Heterobasidion annosum*), this disease is considered among the most destructive fungi in North American forests.

The Michigan Department of Natural Resources Forest Health Program, in cooperation with partners in Wisconsin and Minnesota, has been awarded a National U.S. Forest Service Forest Health Monitoring, Evaluation and Monitoring grant. This grant will facilitate intensified efforts to delimit HRD across Michigan, Wisconsin and Minnesota over the next two years.

Using aerial survey detection, numerous sites with pockets of pine mortality in actively managed stands have been identified as a pool of possible survey sites. Survey and sampling protocols are being developed. As part of that process, several of these sites were surveyed and sampled in the late fall of 2014. Samples are being sent to Michigan Technological University's laboratory for culture and analysis. As a result of these surveys, a number of HRD infections were newly identified in Manistee and Mecosta counties in late November and December.

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.



Left: Newly formed fruiting bodies (conks) found on a tree that was killed by *Heterobasidion* root disease (HRD). **Right:** Small conks can frequently be found on saplings killed by HRD.

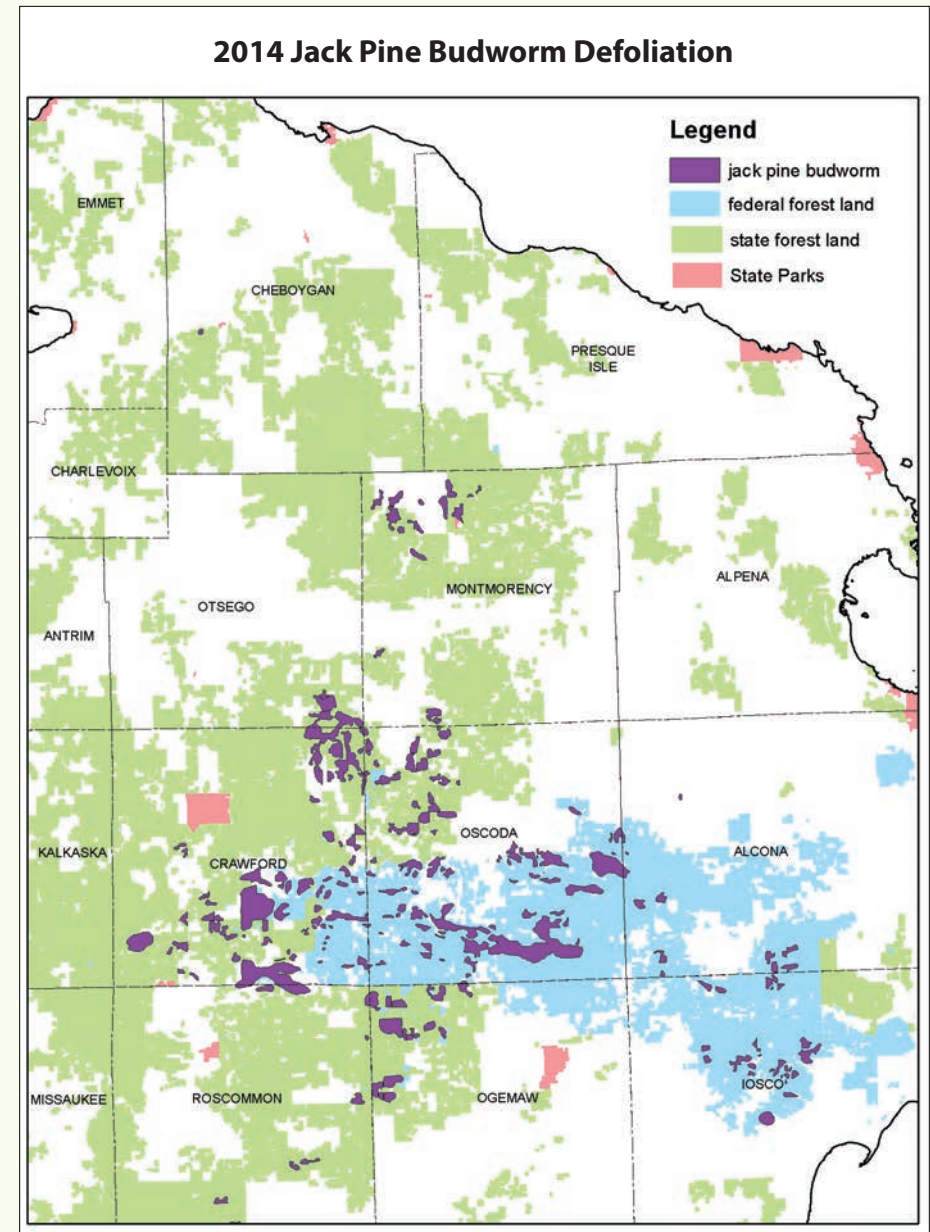
Jack Pine Budworm

Jack pine budworm populations continue to fluctuate significantly over the last several years. Nearly 102,000 acres were defoliated by jack pine budworm in 2014, up significantly from 5,343 acres in 2013. Most of this defoliation occurred in the central northern Lower Peninsula.

The jack pine budworm, *Choristoneura pinus*, is a native insect to Michigan. Periodic outbreaks can lead to dieback and mortality in older, over mature jack pine stands. Current management practices of harvesting older stands of jack pine help to reduce the risk of widespread mortality.



Above: Jack pine budworm. Right: Jack pine tree damaged by jack pine budworm.



Oak Wilt

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 area, oak wilt spreads through root connections to adjacent oak trees.

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.



Sap-feeding "picnic beetles" spread the oak wilt fungus to trees with fresh wounds.

The oak wilt fungus moves from tree to tree in two ways. It is transported from tree-to-tree through underground root connections, and it is spread overland by sap beetles.

New oak wilt areas occur 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. 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



An active oak wilt disease pocket. Note that trees that died in 2014 still have some leaves attached.

carrying sap beetles between April 15 and July 15. Most new oak wilt outbreaks can be traced to damage from pruning, construction and other tree-wounding activities, and from heavy winds.

Oak wilt is established widely in the southern Lower Peninsula, with spotty distribution in the northern Lower and Upper Peninsulas. As the public moves northward into forested areas, the risk of spreading this disease grows. People unknowingly cut oak wilt-killed trees for firewood. This wood is then taken to camps or on camping trips, where it will serve as a source of inoculum to infect nearby oaks wounded in the spring or early summer.

Oak Wilt *continued*



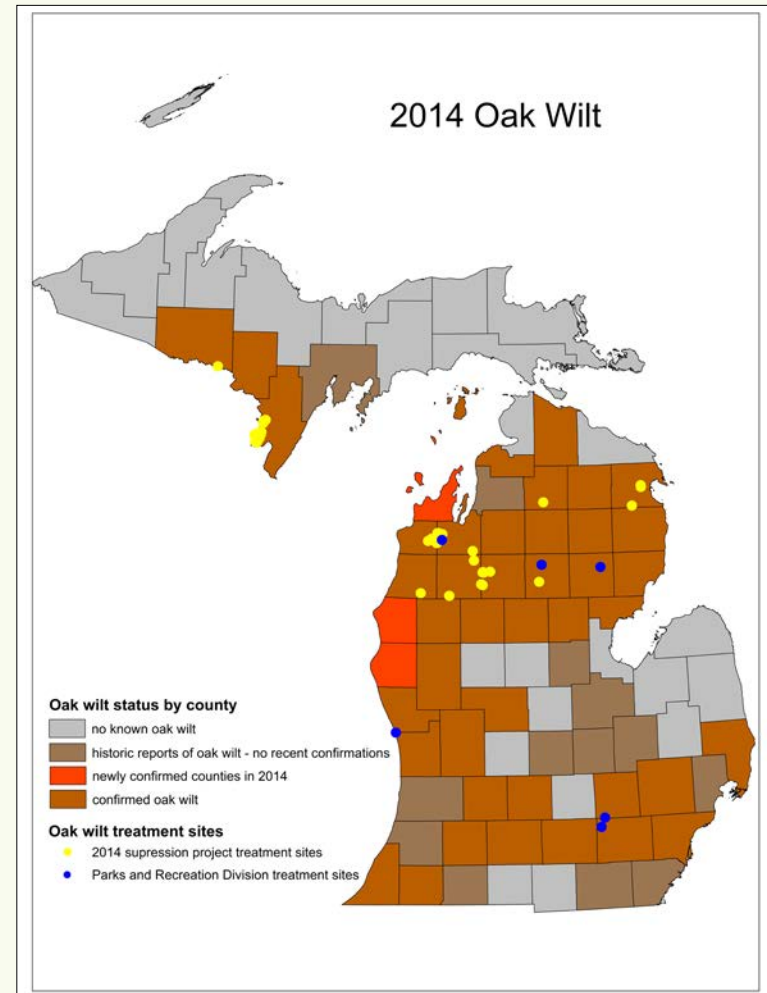
An active oak wilt disease pocket adjacent to a utility power line. Sap bleeding from fresh pruning wounds attracted sap beetles carrying oak wilt fungal spores. The disease is beginning to spread below ground to adjacent oak trees through root grafts. Oak wilt could have been prevented by not pruning between April 15 and July 15.

Michigan's Oak Resource

U.S. Forest Service Forest Inventory and Analysis (FIA) data shows there are 149 million red oak trees in Michigan greater than 5 inches in diameter. There are 68 million red oak with diameters greater than 11 inches. This equals a volume of 11.9 billion board feet growing on 3.9 million acres of Michigan forest land. Ownership of this oak forest land 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 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 an over mature northern pin oak resource.

Oak Wilt *continued*

Additionally, new infections started by movement of firewood are difficult to confirm.

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 to the cause.

The Michigan DNR and Michigan State University, Department of Plant, Soil and Microbial Sciences have stepped up efforts in recent years to detect and confirm oak wilt in Michigan.

A grant from the U.S. Forest Service has funded an effort to detect, confirm and record oak wilt occurrence. As this information becomes available, researchers can begin to investigate the distribution and scale of the problem. Knowing where oak wilt occurs also helps provides guidance for prevention and suppression activities.

During the 2014 oak wilt field season, more than 174 different field sites in 31 counties were visited, resulting in 153 newly confirmed oak wilt areas. In addition, more than 150 landowners and members of the public were provided information about the disease.

A renewed emphasis in state-managed lands was part of detection efforts in 2014, including surveys of more than 60 state campgrounds, recreation areas and parks in 22 counties.



The vibratory plow blade used to treat infected stands of oak was specially designed and built at the Michigan Department of Natural Resources' Forest Fire Experiment Station in Roscommon. The plow cuts narrow trenches 5 feet deep to separate underground root systems, preventing further spread of the oak wilt fungus to uninfected trees.

Treating Oak Wilt on State Forest Land and in State Parks and Recreation Areas Upper Peninsula

The U.S. Forest Service has provided Oak Wilt Suppression funds to help remove oak wilt from Michigan's forests. The DNR and Michigan State University Extension worked together in 2014 to:

Oak Wilt *continued*

- Remove oak wilt from state forest land in the Upper Peninsula by detecting and treating infection centers.
- Educate affected communities to prevent the reintroduction of oak wilt.
- Demonstrate an approach that can be used for detecting and effectively removing the threat of oak wilt throughout Michigan.

This year's project focus was the Shakey Lakes Area of Menominee County and a small area of eastern Iron County. Forty-six oak wilt pockets totaling 100 acres were isolated by creating 36,264 feet of root-graft barriers with a vibratory plow (see Figure 3.) All red oaks within these pockets will be removed before April 2014.

Michigan State University Extension continued to evaluate past oak wilt suppression efforts in 2014.

Treated areas in Menominee and Dickinson counties remain free of oak wilt with few exceptions. Although much has been achieved, untreated oak wilt pockets remain. Diligence will be needed as the DNR strives to remove the threat of oak wilt to the Upper Peninsula's oak resources.

Lower Peninsula

Thirty-one oak wilt infection centers on state and federal forest lands in eight counties in the northern Lower Peninsula (Alpena, Benzie, Grand Traverse, Manistee, Missaukee, Otsego, Roscommon and Wexford) were treated in 2014. Sites were reviewed as described above for the Upper Peninsula oak wilt treatments. A vibratory plow was used to create 21,925 feet of root graft barriers to a depth of 5 feet. All oak within the infection centers will be removed before April 2015. Two of the treated sites were in the Huron Manistee National Forest.



A stand of infected trees are marked for treatment, which involves using a specialized plow to sever underground root systems to separate infected and uninfected stands of oak.

State Recreation Areas

DNR Parks and Recreation Division identified and treated oak wilt at six state parks and recreation areas statewide. Detection of new pockets is often found in association with campgrounds, cabins and fire rings, indicating transport of infected firewood to be a major cause of infections. Approximately 7,500 feet of line was installed using a vibratory plow at Interlochen, South Higgins Lake and P.J. Hoffmaster State Parks and Rifle River, Waterloo and Pinckney Recreation Areas. Additionally, fungicide injections and herbicides were used at P.J. Hoffmaster State Park to treat locations not accessible by heavy equipment.

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 that collapsed in 2013 after building in 2012 once again became epidemic in 2014.

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, much of it in areas of the WUP. It is still unclear if these cycles of SBW defoliation may point to the onset of the next regional epidemic in the Great Lakes Region. Quebec believes it has already entered the next regional cycle. Ontario has experienced a similar history of SBW buildup and collapse as in Michigan's Upper Peninsula.

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



Heavy spruce budworm damage.

plantations without a balsam fir component have been heavily defoliated. The return to more normal precipitation may help restore the vigor and reduce the vulnerability of our younger spruce and fir resources to the SBW.

Current management guidance is to harvest spruce and fir when they reach rotation age, or presalvage harvestable stands where SBW impacts are causing top kill or tree mortality.

Weather Impact: Cold, Really Cold 2014

The past two years have seen a return to normal and above precipitation. The Great Lakes have returned to normal levels. However, it will take a few years of adequate rainfall for trees to rebuild energy reserves and corresponding defenses to pest attacks after the significant drought events of the past decade.

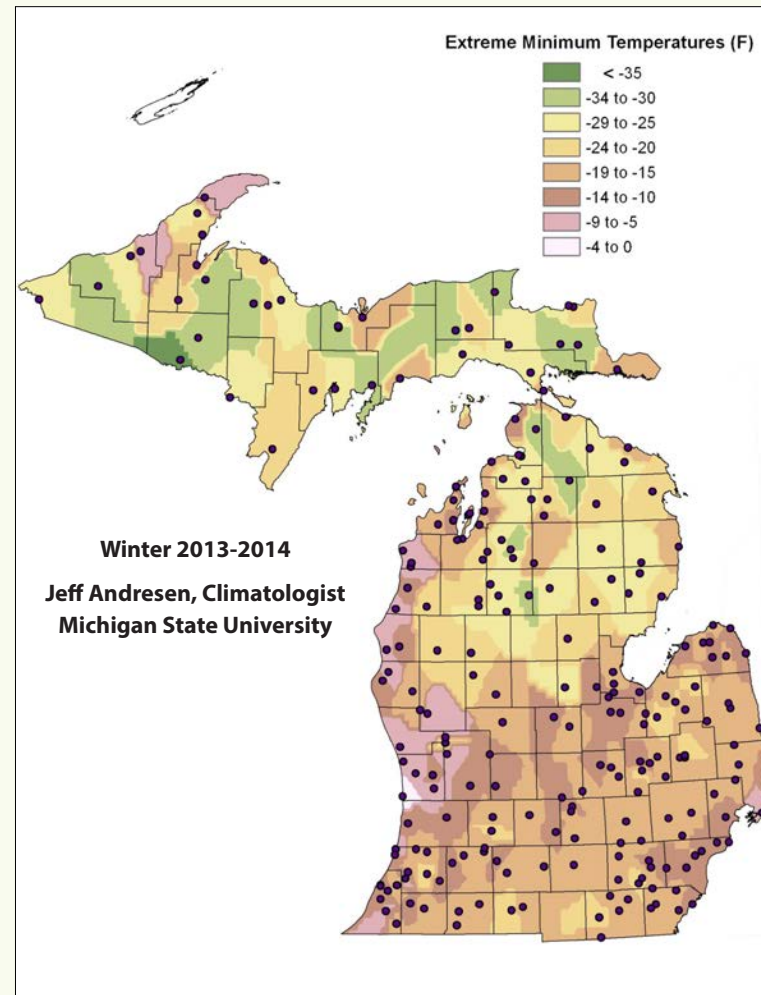
A new stress event visited Michigan in the winter 2013-2014. Michigan had a record breaking string of extreme cold weather that affected the entire state.

Although cold generally did not appear to seriously affect native trees and shrubs, exotic species growing near the limits of their cold hardy zones were often damaged. Because of this unusual event, this year's Forest Health Highlights includes a Michigan Nursery and Landscape Association report on the impacts of last winter on landscape plants. The following reports are from areas in the Southern Lower Peninsula where much of Michigan's landscaping industry is concentrated.

Selected Observations from "Horticultural Landscape Perspectives" Michigan Landscape and Nursery Association

Browsing damage

Extensive damage from rabbit, mouse, and deer feeding due to the extreme cold and heavy snow levels. Deer damage in rural and urban areas as deer sought supplemental food. Unusually deep and long lasting snow cover provided cover for voles, letting them make tunnels to their favorite food source.



Often what initially appeared to be winter damage was girdling of the cambium by rodents. Species commonly girdled include *Hydrangea quercifolia* (Oakleaf Hydrangea), *Thuja* (Arborvitae), *Euonymus alatus* (Burning bush) and *Ilex verticillata* (Winter Holly).

Weather Impact *continued*

Winter Burn/Salt Injury

Broadleaved evergreens have been hit hard by the winter conditions. Damage includes foliage desiccation and death of terminal buds. The snow level indicates the line between healthy and damaged foliage. Species commonly damaged include:

- *Pinus strobus* (white pine)
- *Chamaecyparis* (falsecypress)
- *Taxus* (yew)
- *Buxus* (boxwood)
- *Ilex crenata* "Sky Pencil"
- *Thuja* (arborvitae)
- *Rhododendron*
- *Abies concolor* (concolor fir)
- *Picea glauca* "Conica" (dwarf Alberta spruce)
- *Rosa* (rose)
- *Mahonia*

We will also likely see dieback on some deciduous trees and shrubs, especially anything that might be considered marginally hardy such as *Liquidambar* (sweetgum), *Cercis Canadensis* (Redbud), *Cedrus atlantica* (Atlas cedar) and *Taxodium distichum* (baldcypress).

Split bark on *Pyrus* (pear) and *Prunus* (cherry) was common. Worse affected was *Prunus persica* (peaches).



Different species impacted by winter burn.

Minor Pests

Jack Pine Tip Beetle

The jack pine tip beetle, *Conophthorus banksianae*, caused noticeable damage across much of the northern Lower Peninsula this year, particularly on sapling and small pole-size trees. While the damage can be visually striking, it is limited to a few inches of the shoot tips, and injured or dead tips drop from the trees in the fall. The affect is similar to that of a light pruning and is generally harmless to the tree.



Jack pine tip beetle damage.



Rose chafer

Rose Chafers

Rose chafers are small beetles with long, spiny legs. They have an olive or tan-colored body. While rose chafers get their name because they are frequently found on roses, they also damage grapes, raspberries and strawberries. In summer 2014, rose chafers were found in hardwood forests of the western Upper Peninsula where they fed on the leaves of trees and shrubs in hardwood forests. Rose chafer feeding leaves only the larger leaf veins. The larvae are grubs that feed on roots of grasses and weeds. Adults become active in late May or early June and live four to six weeks.

Minor Pests *continued*

Maple Tar Spot

Maple tar spot (*Rhytisma* spp.) was prevalent in many areas of Michigan again in 2014. It has been a common sight for the last several years on Norway maples as the fall season approaches. Patches of raised black areas on the upper leaf surface of Norway maples begin appearing in August and darken as the season progresses.

Trees infected with the tar spot fungus typically drop their leaves earlier than normal in the fall. Tar spots on infected leaves produce spores that will infect new leaves next 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 for the last few years. Fortunately, this leaf disease causes little damage to trees and no control measures are necessary.



Maple tar spot



Twig pruner

Twig Pruner

Twig pruner, *Anelaphus villosus*, caused noticeable damage, primarily in oaks, across much of Michigan this year. In the spring, larvae bore into small twigs or branches ¼ to 1 inch in diameter. The larvae burrow down the center of the twig and cut it from the tree, leaving a smooth-cut surface with a small oval-shaped hole in the center. The branches break off and eventually fall to the ground where the larvae continue to feed and overwinter. Pupation and adult emergence occur the following spring.

Severe infestations can be a nuisance for homeowners as debris from falling branches litter urban areas, campgrounds and parks. Pruned branches can be collected in the fall and winter and burned to reduce the twig pruner population in residential areas. Natural enemies will control the twig pruner in forested areas.

Minor Pests *continued*



Oak lecanium scale

Lecanium Scale

It is not unusual to find Lecanium scales on oaks. Occasionally, high-scale populations reduce tree vigor enough to cause branch mortality or crown dieback. Landscape or ornamental red and white oaks are mostly commonly affected.

Scales commonly infest smaller branches and twigs during the spring and early summer. Eggs are produced underneath the female in late spring. Eggs hatch in early summer and the immature insects seek feeding sites on the underside of leaves. In late summer, they migrate to twigs where they overwinter. Insect parasites and predators are normally effective in controlling infestations. Insecticides targeting immature scales in early-to mid-summer are effective.

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 and Rural Development

Outreach

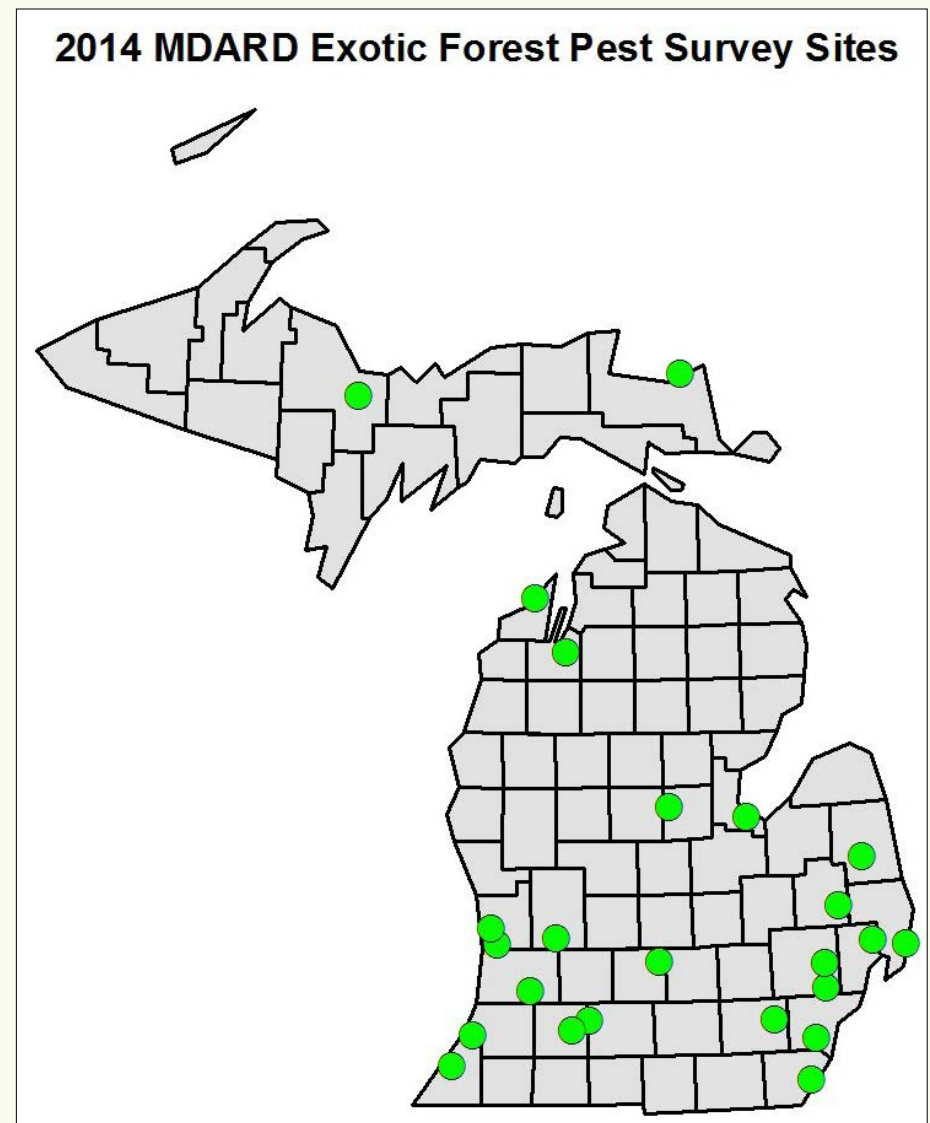
During 2014, the Michigan Department of Agriculture and Rural Development Pesticide and Plant Pest Management Division (PPPMD) conducted 16 forest invasives outreach and education events across Michigan. A total of 650 people were reached through the sessions which covered a variety of forest health issues including exotic forest pest identification, firewood movement and pest reporting. Event attendees included loggers, consulting foresters, municipal foresters, landscapers, arborist master gardeners, garden show attendees and other forest professionals. Numerous other similar sessions were supported by PPPMD through the provision of media presentations and printed outreach and educational materials.

Survey

Trapping surveys targeting 23 high-priority exotic forest pests, including longhorned beetles, bark beetles, and defoliating moths, were conducted at 24 high-risk sites statewide. Sample identification will be completed in early 2015.

Quarantine

Balsam Woolly Adelgid Quarantine – On June 24, 2014, MDARD established a quarantine to protect fir trees from balsam woolly adelgid (BWA), an exotic pest which has caused the death of millions of fir trees in North America. The BWA quarantine generally prohibits the shipment of fir nursery stock and fir timber products into Michigan from infested states. Fir nursery stock and forest products from non-infested areas are allowed, although they must be accompanied by a phytosanitary certificate indicating the place of origin. Certain low risk fir products are exempt, including Christmas



Michigan Department of Agriculture and Rural Development *continued*

trees and wreaths and heat-treated timber products. The quarantine also allows fir seedlings grown under an active pest management program to be shipped into Michigan.

The BWA quarantine imposes strict restrictions on shipment of true fir species (*Abies spp.*) into Michigan from infested states and provinces.

- a. Infested states include California, Idaho, Maine, New Hampshire, New York, North Carolina, Oregon, Tennessee, Vermont, Virginia, Washington and West Virginia.
- b. Infested Canadian provinces include British Columbia, New Brunswick, Newfoundland, Nova Scotia and Prince Edward Island

Fir products exempt from the provisions of this quarantine include fir forest products with the bark removed, forest products with bark attached that have been heat treated or treated with wood preservative compounds, seeds and cones of fir species and composted or shredded fir bark and mulch.

For more information on BWA visit the following websites:

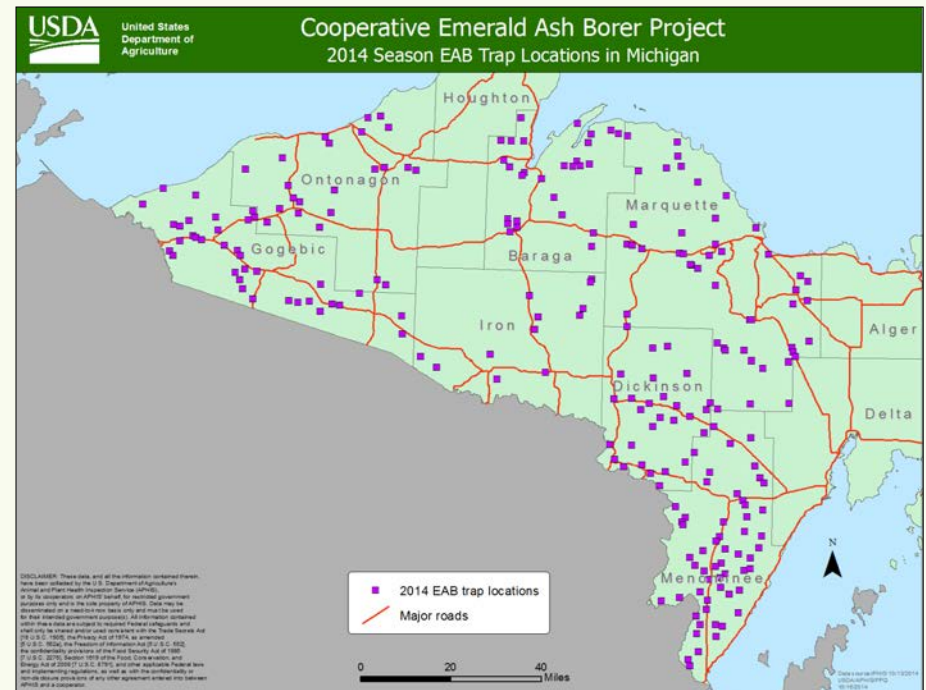
- www.michigan.gov/exoticpests (MDARD)
- www.michigan.gov/invasivespecies (DNR)

Hemlock Woolly Adelgid

For an update on MDARD's activities regarding hemlock woolly adelgid, please see page 28.

Emerald Ash Borer

USDA's Animal and Plant Health Inspection Service (APHIS) continued



to survey the uninfested counties of the western Upper Peninsula for emerald ash borer (EAB). They deployed purple panel traps baited with aromatic lures (manuka oil and (Z)-3-hexanol). Trap placement is based on a survey sampling design developed in collaboration between the APHIS EAB Program and the USFS Health Technology Enterprise Team.

The sampling design model pre-selects geographic locations in which to deploy traps that have the highest probability of pest detection. Of 230 traps set in 2014, there were no detections in the uninfested, non-quarantined counties of the western U.P.

Michigan Department of Agriculture and Rural Development *continued*



No new Michigan counties were added to the EAB quarantine in 2014. EAB quarantine requirements for regulated articles moved entirely within Michigan are unchanged. Hardwood firewood (not just ash) remains listed as a regulated article in the EAB quarantine.

There is still a general advisory against moving any firewood due to associated accidental introduction or spread of potentially devastating forest pest such as EAB, Asian longhorned beetle, oak wilt and others. People are encouraged to purchase firewood close to where they will use and not move any unused firewood.

For more information about EAB visit www.emeraldashborer.info or visit the MDARD EAB websites at www.michigan.gov/eab.

Michigan State University 1/5/15

Summary of Selected Research Projects Underway in 2014

From: Molly Robinett, Sara R. Tanis, Andrew R. Tluczek, Alyssa Wethington, James B. Wieferich and Deborah G. McCullough

Can a Systemic Azadirachtin Insecticide Protect High-Value Beech Trees from Beech Bark Disease?

American beech trees in Michigan, including high-value landscape trees in residential and urban landscapes, are threatened by beech bark disease. This invasive forest pest complex begins when the non-native beech scale insects (*Cryptococcus fagisuga*) colonize the trunk or branches, where they feed on sap in phloem tissue.

Beech scale infestation facilitates subsequent infection by the *Neonectria spp.* fungi, which causes areas of phloem and cambium to die, eventually leading to tree mortality. Systemic insecticides to protect high value beech trees from beech scale infestation and subsequent infection by the fungal pathogen have not been well-evaluated. The problem is complicated by concerns about whether systemic insecticides could be translocated into beech nuts, an important source of hard mast for many wildlife species.

We began evaluating the ability of TreeAzin to effectively control beech scale in 2014 at two study sites; one near Ludington, Michigan, and another in Ontario. The active ingredient in this newly developed product is Azadirachtin, a compound that may kill, repel or reduce reproduction of many insects. This compound, however, is not toxic to birds or mammals.



Left: James Wieferich examines beech scale wax to assess egg production and viability. **Right:** Dr. Deborah McCullough, Michigan State University professor, injects an infested beech tree with TreeAzin.

To identify optimal timing for insecticide injections, we are monitoring beech scale fecundity, egg hatch rates, development rates and survival of scale life stages. Pre-treatment beech scale density (scales per cm²) was estimated by counting scales on 384 bark sample removed with a

Michigan State University *continued 1/5/15*

bark punch. We examined more than 6300 individual scales and determined an average of 89.0 ± 1.8 percent of scales were alive. We treated trees with the TreeAzin product in July, ideally to control mature and actively feeding adult scales. We also artificially infested two small areas on treated and untreated trees with a known number of beech scale eggs. We expect to return to both sites in 2015 to evaluate survival of beech scale on the treated and untreated trees, including the scales that were introduced as eggs in 2014. Trees will be retreated and scale survival will continue to be evaluated.

White Ash Survival in Forested Sites in the Core of the Emerald Ash Borer Invasion

Catastrophic levels of ash mortality caused by emerald ash borer (EAB) have been recorded in areas of southeast Michigan and Ohio, where up to 99 percent of the white ash (*Fraxinus americana* L.), green ash (*F. pennsylvanica* Marsh.) and black ash (*F. nigra* Marsh.) trees have died. We have observed, however, an unexpectedly high proportion of overstory white ash trees remain alive in some sites in southeast Michigan, despite the presence of EAB for eight or more years.

In 2014, we scouted 45 large forested parks and wildlife areas across southeast and central Michigan, identified 28 sites with a substantial white ash component, then used a combination of variable and fixed radius plots to document species, diameter at breast height (DBH) and canopy condition of overstory trees (>6 cm DBH). Number, basal area and phloem area were determined for live and dead white ash. Rates of white ash mortality varied across sites, ranging from <10 percent to nearly 100 percent.

Associations between white ash survival, land use categories and



Molly Robinett prepares to measure diameter at breast height (DBH) of a healthy white ash tree.

site factors will be assessed using field surveys overlaid with spatial data in a GIS. We also monitored relative EAB population levels using two double-decker (DD) traps in each site. Traps consisted of two purple prisms or one purple and one green prism attached to a 3 m tall PVC pipe. Traps were baited with cis-3-hexenol or cis-3-hexenol and manuka oil from June to September. Overall, a total of 580 adult EAB were captured and captures were similar across sites, including areas where <10 percent of the white ash trees were alive. Male EAB dominated captures in all sites, comprising 79 percent of the total capture. We expect to continue surveys and analyses in 2015.

Recovery of Ash Trees Treated with Tree-Age

Systemic insecticides are increasingly used to protect high value ash trees from emerald ash borer (EAB). Results from several

Michigan State University *continued*



A green ash tree treated with TREE-äge in 2011 (left) is shown in 2014 (right). It appears to be recovering from its previous emerald ash borer injury.

field studies, including at least five of our projects, have shown the insecticide product sold as TREE-äge, with the active ingredient emamectin benzoate, provides nearly 100 percent control of EAB for up to three years.

Given this level of efficacy, it seemed likely that trees with low or even moderate canopy decline might recover if treated with TREE-äge. At some level of damage, however, trees will be unable to successfully

transport the insecticide to the canopy and succumb to the beetle. To assess the ability of trees treated with TREE-äge to recover from EAB injury, we selected pairs of ash trees with varying levels of EAB damage in 2009 in forested sites dominated by green ash trees where EAB populations were very high.

Paired trees were of similar size, growing near each other and exhibiting similar levels of EAB damage. Condition of each pair of trees ranged from relatively healthy (<20 percent canopy transparency or dieback) to severely injured (>80 percent canopy decline). One tree of each pair was randomly assigned to be trunk-injected with TREE-äge at the lowest label rate (0.1 g ai per DBH inch) using the ArborJet QUIK-Jet system. The other tree was left untreated. Trees were subsequently retreated in 2011 and 2013. Trees were evaluated annually in mid-summer from 2009 to 2014 to assess canopy condition.

By August 2012, all untreated control trees were dead, including trees that appeared healthy in June 2009. Trees that had already sustained substantial damage from EAB larvae and had >60 percent canopy transparency or dieback in 2009 were not protected by the TREE-äge treatment; all were dead by 2012.

All trees treated with TREE-äge in alternate years survived if estimated canopy transparency or dieback in 2009 was less than 60 percent. Evaluation in July 2014 showed surviving trees have largely recovered; canopies are thick and new wood is being laid over old EAB galleries. Results indicate the importance of treating valuable landscape ash trees before serious canopy decline is apparent.

Michigan State University *continued*

Collaborative Evaluation of Emerald Ash Borer Trap Designs and Lures

We collaborated with several entomologists from the U.S. Forest Service, Canadian Forest Service and the Ontario Ministry of Natural Resources to evaluate different emerald ash borer (EAB) trap designs and lures. Trap designs included dark purple, dark green and light green coroplast prisms, each baited with cis-3-hexanol or cis-lactone



Double decker emerald ash borer trap with a green and purple prism.

lures and a green funnel trap baited with cis-3-hexanol. The individual prisms and the funnel traps were hung on branches in the canopies of ash trees.

The study also included two double-decker trap designs; one with two dark purple prisms baited with cis-3-hexanol and manuka oil, and another with one green

and one light purple prism baited with a 2x rate of cis-3-hexanol. Double-decker traps, which have two prisms zip tied to a 10-foot tall PVC pipe that slides over a t post for support, are designed to be placed in full sunlight, roughly 5-10 meters from ash trees.

Traps were installed in two sites with low or low to moderate EAB densities and checked from June through September. A total of 849 beetles were captured and 73 percent of those were males. Green traps have previously been shown to attract males while purple is more attractive to female beetles. Overall, double decker traps captured the highest percentage of beetles (67.5 percent) at both sites. Overstory trees were tallied by species, measured and



Sara Tanis prepares to launch a Big Shot to hang a woodborer trap in the canopy.

canopy condition of ash trees was assessed in plots established around each trap. Data from our sites will be pooled with data from other sites in Ohio, Pennsylvania and Ontario to evaluate variability of EAB captures among trap types and the influence of site factors on trap effectiveness.

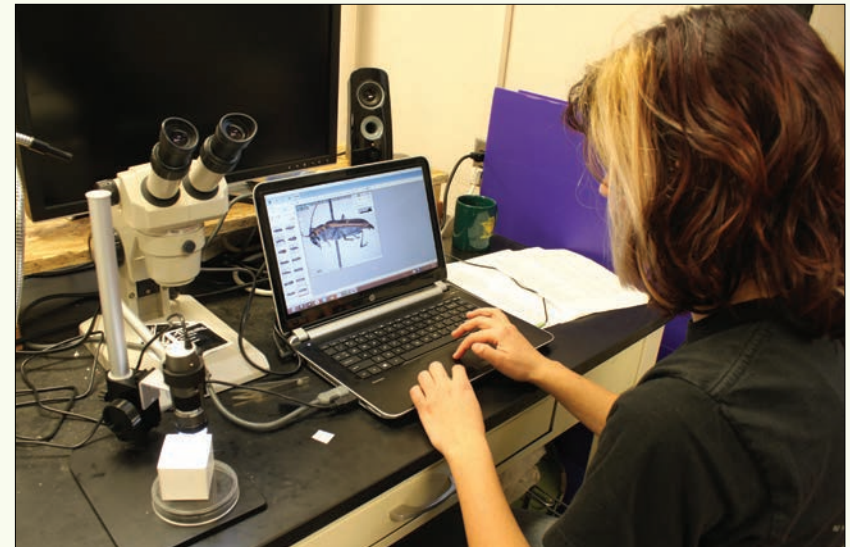
Michigan State University *continued*

What's Under the Bark?

Woodborer Communities in Michigan

In 2013, we collaborated with Therese Poland (U.S. Forest Service), Mike Philip and John Bedford (Michigan Department of Agriculture and Rural Development), and Bob Heyd (Michigan Department of Natural Resources) to survey sites at high risk for introduction and establishment of invasive forest pests, including Asian longhorned beetle, thousand canker disease of walnut or hemlock woolly adelgid. Much of the survey was based on traps baited with lures for cerambycids (longhorned beetles), buprestids (metallic wood-borers), and bark beetles. Traps baited with commercial lures, plus some novel compounds recently identified by researchers in CA and IL, were set in campgrounds, plant nurseries, sawmills and other areas ranked as high risk. Visual surveys of hemlock and black walnut trees were also conducted.

A total of 285 traps deployed in 24 sites across Michigan captured almost 55,000 beetles along with more than 170 siricids (horntails). The insects were captured, sorted and identified in 2014. In addition, thousands of trees were visually inspected for evidence of hemlock woolly adelgid, Asian longhorned beetle and thousand cankers disease. Happily, no invasive woodborers were captured and all visual inspections were negative. More than 125 cerambycid species, 20 species of buprestids and four species of siricids were identified and Mike Philip identified at least 50 different bark beetle species. Data analyses are underway to compare effectiveness of lures, identify indicator species associated with specific forest cover types and evaluate woodborer communities in hardwood and conifer sites. Digital images were taken of the dorsal, ventral, and side views of a male and female representative of each cerambycid and buprestid species using a Dino-Lite digital microscope. Photos include a scale, the date and collection location. We expect to assemble photos into an online database for use by other entomologists, scientists and educators.



Top: Alyssa Wethington takes a digital image of an adult longhorned beetle, *Saperda tridentata*. *Left:* A side view of a *Saperda tridentata* beetle captured in the woodborer survey.

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