Michigan Forest Health Highlights 2021

Michigan Department of Natural Resources, Forest Resources Division

Introduction

Despite the ongoing challenges of the COVID-19 pandemic, the Michigan Department of Natural Resources forest health team is back in the field, working to identify and fight threats from native and invasive insects and diseases.

During 2021, Michigan's 10-year, federally required Forest Action Plan was approved. The document offers a roadmap for managing the state's nearly 20 million acres of public and private forests, including strategies to deal with a changing climate.

Aerial surveys detected pockets of oak wilt and oak decline as well as several other issues across the state. These surveys are an important early detection tool to inform forest health decisions and map issues, including 2021's outbreak of the forest pest Lymantria dispar, formerly known as gypsy moth. Responding to widespread reports of defoliation, the forest health team aerially surveyed an estimated 24 million acres. Populations of the moth are expected to crash in many areas before the 2022 season. Learn more about this nuisance moth on page 20.

Michigan DNR Forest Resources Division staff continues to work with federal and local governments and communities to find and treat the hemlock woolly adelgid in five west Michigan counties. This year, an updated statewide strategy helped spur quick mobilization to eradicate the pest from a single tree in a sixth county. Intensive monitoring of the area has not uncovered more activity, and surveys will continue. Collaboration is making a difference, with local Cooperative Invasive Species Management Area groups fighting particularly effective battles against invasive plants and hemlock woolly adelgid.

DNR staff continues to survey red pine stands for Heterobasidion root disease. Several new detections occurred, with implications for management of stands in the vicinity. Continued monitoring and protection of high-risk stands will help ensure a healthy red pine resource into the future.

In addition, new forest threats continue to emerge or are poised to enter the state. The balsam woolly adelgid, confirmed in west Michigan's Kent County for the first time in 2021, is one of these threats. This tiny, sap-sucking insect devastates fir trees and could become a major issue for Christmas tree growers. Spotted lanternfly and Asian longhorned beetle also are on Michigan's doorstep. The spotted lanternfly core infestation is in Pennsylvania, spilling into Ohio and Indiana. The destructive insect is a major nuisance to landowners and could be devastating to grapevines and hops. The black-and-white, wood-boring Asian longhorned beetle also is present in neighboring states and poses a threat to maple trees.

With cooperation and comprehensive plans, the DNR and its partners will continue to monitor and defend against threats to Michigan's forests.

Jeff Stampfly

DNR Forest Resources Division Chief and State Forester

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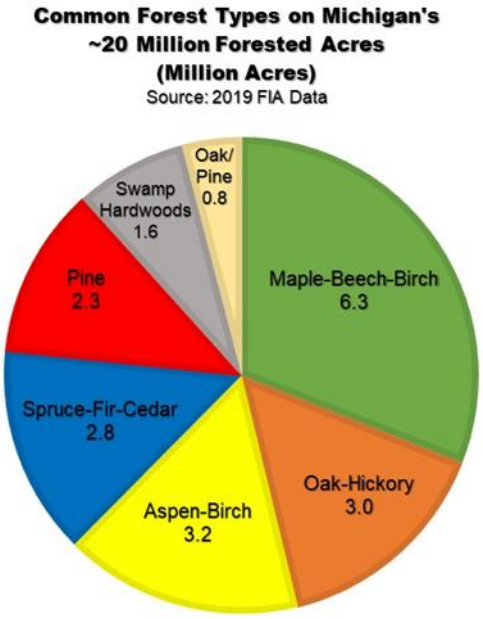
Michigan's forests

Forest resource summary

Of Michigan's 37.4 million acres of land, nearly 20 million acres are forested, with a rich diversity of tree species and forest cover types.

From rolling hardwood hills to swaths of closed-canopy cedar to stands of fire-origin pine, our state is blessed with a vibrant forest resource. Ensuring that the health and vitality of these forests are protected from forest pests and diseases is critically important for environmental, economic and social reasons.

Resilient forests provide essential wildlife habitat, stabilize soils and deliver cleaner water to our lakes, rivers and aquifers. Michigan's abundant forests annually sustain a $35 billion outdoor recreation industry and a $21 billion timber products industry. Perhaps the greatest attribute of the forests in Michigan are their availability to the public. Nearly 7 million acres of forest land are open and accessible for the public to use and enjoy. More than 3.9 million acres are managed by the DNR. This work supports healthy forests that the people of Michigan can enjoy today and into the future.



Michigan forest facts

- **More than half of Michigan is forested, at about 54%.**
- **Michigan forest land ownership is 62% private, 23% state and local, and 14% federal.**
- **It's estimated that Michigan has 14.1 billion trees at least 1 inch in diameter.**
- **The most common tree species in Michigan are red maple, northern white cedar, sugar maple, red pine, quaking aspen and balsam fir.**
- **A tree typically uses 1.5 pounds of carbon dioxide and gives off 1 pound of oxygen to grow a pound of wood.**

Data from Michigan State University, 2019

Weather conditions

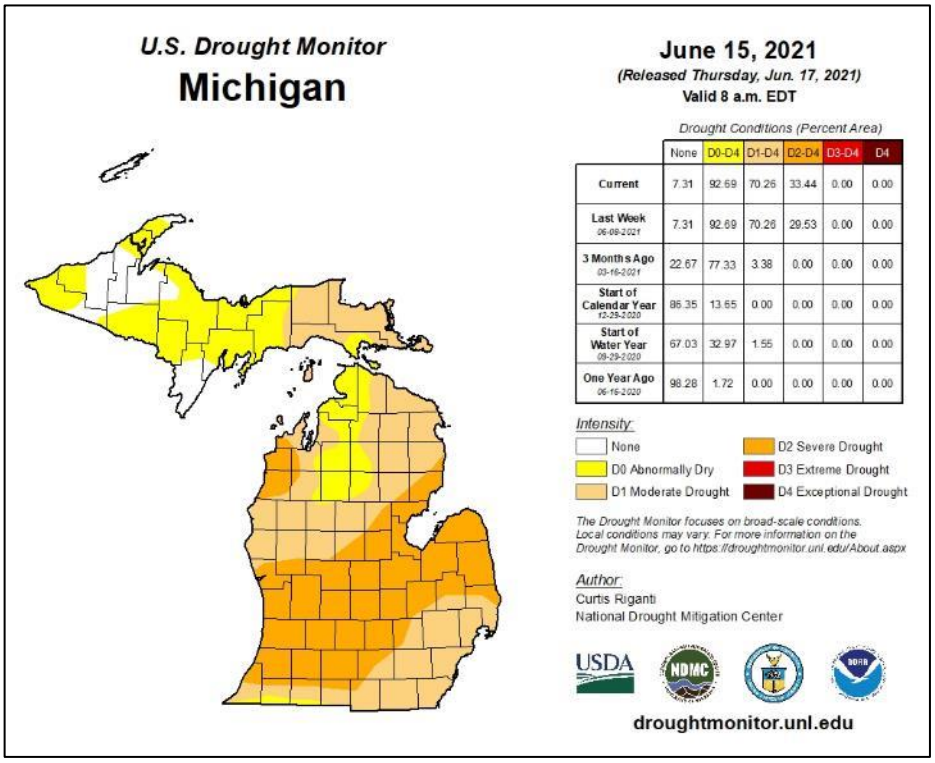
Michigan's climate and the resulting weather play a big role in forest health. Climatic extremes continue to affect the health of Michigan's trees, and even greater impacts are anticipated in the future.

In northern Michigan over the past 100 years, average annual rainfall has increased by nearly 5 inches, with more of that precipitation falling as heavy rainfall events of 3 inches or greater, according to the Northwoods Climate Change Response Framework. Evidence suggests growing seasons will continue to lengthen, with warmer winters and increasing fluctuations in soil moisture extremes. Disturbances such as droughts, wildfires, floods, pest outbreaks and other events are expected to become more frequent, resulting in more economic and ecological loss and damage.

This year, a dry spring across much of the state meant abnormally dry to severe drought conditions in many areas by mid-June. Statewide, the National Oceanic and Atmospheric Administration indicates it was the seventh-driest January to June period on record. Areas with high water tables the past few years transitioned to dry conditions. A swing in conditions occurred in mid- to late summer, when excessive rainfall did more damage than good in some areas, especially parts of the Lower Peninsula.

Although not always initially obvious, these moisture fluctuations in the soil can be a major tree stressor. Root systems can be damaged by excessively wet or dry conditions.

This forces trees to use reserves to regenerate roots. It becomes a factor in tree decline syndromes, where weakened trees become vulnerable to attack by insects and diseases. This leads to eventual dieback and mortality, sometimes years later.



Early-season defoliators such as Lymantria dispar dispar (formerly known as gypsy moths) are more successful during dry springs. That helps lead to large outbreaks like we saw this year.

Native bark beetles colonize pines after moisture stress.

While frost damage alone is not enough to kill trees, the stress can predispose older oak trees to crown and branch dieback or severe nutrient deficiency symptoms, particularly when combined with other stressors such as defoliation by insects or soil moisture fluctuations.

Limited reports of storm damage were received from forested areas of the northern Lower and Upper peninsulas. Localized areas of wind damage were mapped in Mason and Lake counties in the Huron Manistee National Forest and in Gogebic County in the Ottawa National Forest.

In the western Upper Peninsula, several pockets of mortality caused by native bark beetles were reported in red pine plantations that transitioned from excessively wet to dry conditions. Affected stands or portions of stands tended to have water drainage concerns, although red pine has grown well on the sites for many years.

Fluctuating spring temperatures also led to tree stress this year. In parts of both the Lower and Upper peninsulas, unusually warm early spring temperatures were followed by multiple nights of freezing temperatures just before Memorial Day weekend. Frost damage was observed in several species, with oaks hit the hardest. Heavily impacted trees tapped into stored resources and produced a second flush of leaves.

Frost killed tender new growth on many oak trees in 2021.

Surveys and observations

Aerial surveys

DNR aerial operations fleet planes and unpiloted aerial systems.

Each year, the DNR's Forest Health Program and USDA Forest Service survey Michigan's nearly 20 million acres of forest land from the air for insect and disease damage. DNR pilots and aircraft based out of Roscommon, Newberry and Escanaba provide the aviation expertise required to complete the annual missions. Surveys occur throughout the growing season in cooperation with the Forest Service, which conducts aerial surveys on national forest lands.

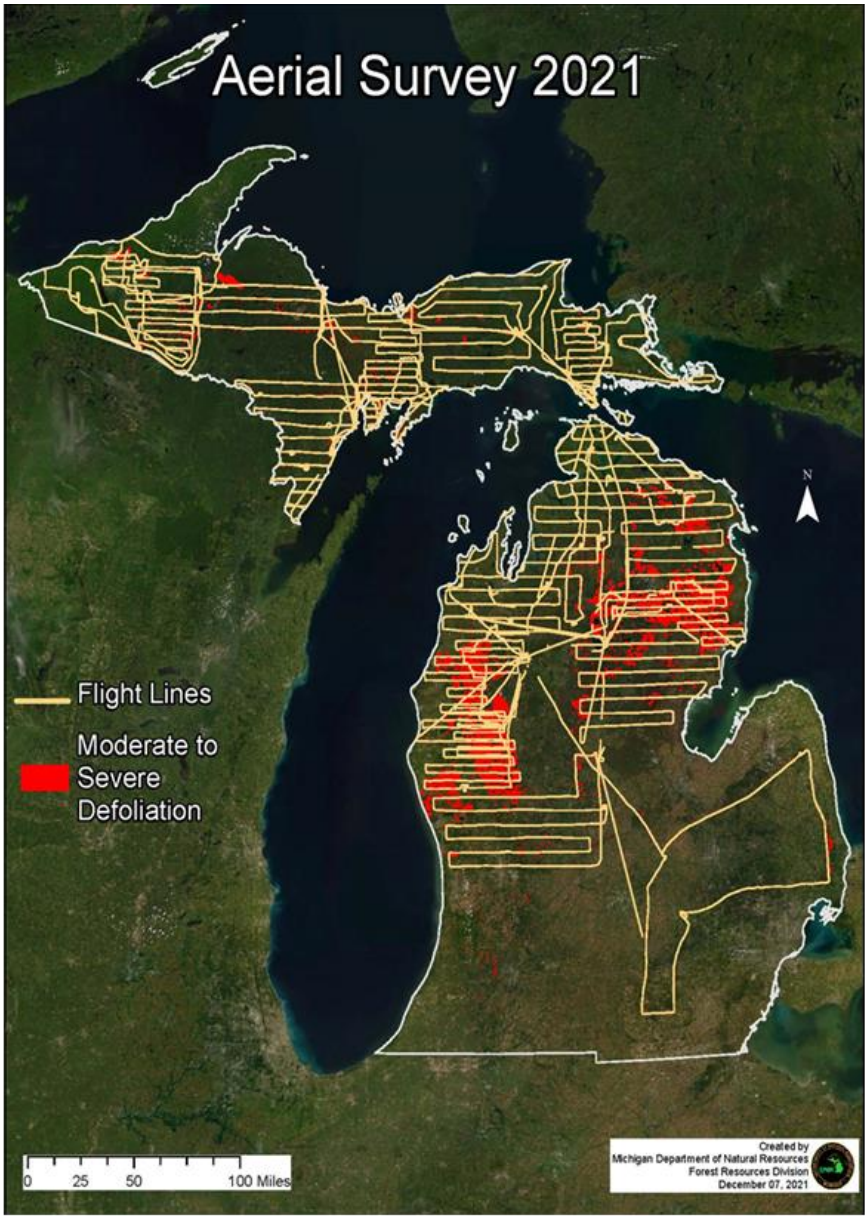
Large areas of defoliation, discoloration, dieback and mortality are mapped during aerial survey missions. Lymantria dispar dispar (formerly known as gypsy moth) was by far the most extensively mapped defoliator to emerge this season. From year to year, aerial survey information is used to monitor damage and changes in pest populations and serves as an early detection tool for emerging problems. Foresters, other natural resources professionals and policymakers use this information to make decisions that improve the growth and health of our forests.

Damage from forest pests is mapped using Digital Mobile Sketch Mapping software on a tablet provided by the Forest Service's Forest Health Assessment and Applied Sciences Team. While the pilot flies predetermined transects, aerial surveyors (sketch mappers) delineate areas of damage they see out the window of the aircraft on satellite imagery as it scrolls by on the screen. Depending on the scope of damage, surveyors select the appropriate scale and shape (grid, polygon, point) to quickly map and then attribute the impacted area. After data is collected, locations of damage are spot-checked on the ground

to ensure accuracy of data collected from the air. Finally, data is uploaded to a national data server to provide forest health staff and other professionals access to near real-time information.

Aerial surveyors are professionals who develop their skills through years of experience. A surveyor must be able to identify tree species from the air and discern damage and the agent responsible. Surveyors must also be able tolerate hours of turbulent flight in a small aircraft without developing motion sickness.

Timing of aerial survey missions is critical, as symptoms may only be visible for a few weeks before growth of new foliage masks their presence. Thankfully many damage agents have been well documented and routinely cause defoliation during the same timeframe each year. This allows surveyors to strategically map out flights to catch as much defoliation as possible during a short window of visibility.



Map showing observation flight lines taken in 2021 for forest health evaluation.

Weather and plane availability can limit suitable days for survey activities. Flights require the absence of fog, low cloud cover, rain or threat of severe weather. Planes are also used by the DNR's fire detection program, which takes precedence over forest health surveys during high fire risk periods.

The ideal scenario for accomplishing survey missions during peak defoliation is to cover maximum ground per day by having two planes aloft in separate areas of the state, each with two surveyors onboard, mapping coverage out both sides of the plane. Despite fluctuating surveyor, aircraft and pilot availability, the forest health team surveyed nearly 24 million total acres across the state during 2021.

Commonly observed tree issues in 2021

Anthracnose-caused brown spots on a white oak leaf, via Joe Obrien, USDA Forest Service.

Anthracnose

Leaves with dark blotchy lesions falling from trees in the spring are symptoms of the fungal disease anthracnose. Anthracnose is common in ash, elm, maple, sycamore, white oak and walnut trees, although other species can be damaged. In 2021, most of the state experienced an abnormally dry spring, which likely minimized damage. However, some localized areas still observed and reported anthracnose this year. The good news is that healthy trees usually regrow leaves during warmer, drier summer weather, and the impact is minimal. Severe repeated infections may weaken stressed trees, but anthracnose does not kill trees.

Good tree care practices, including proper mulching and watering during extended drought, will help maintain tree vigor when high-value trees are severely affected. Sanitation may also reduce symptom development in some years. After leaves drop, rake fallen leaves from around infected trees and destroy them. This will reduce overwintering sources of spores. If you observe noticeable cankers or infected twigs, prune them out and burn them. Remember to clean your pruning tools with 10% bleach solution between cuts to make sure you don't inadvertently spread the disease from branch to branch. Dispose of infected twigs and branches. Proper pruning also can open up canopies to improve air circulation and light penetration, reducing the potential for infection.

Maple tar spot

Maple tar spot is prevalent on several maple species across Michigan. It's typically apparent starting in August. Black, raised bumps resembling drops of tar may be observed on the upper leaf surface of infected trees. Earlier in the season, you may see pale yellow spots in leaves indicating earlier stages of infection. Tar spot is a cosmetic disease. Although leaves infected with the tar spot fungus often drop early, the disease is not fatal to trees.

To reduce maple tar spot symptoms, remove and destroy fallen leaves, although the impact of this may be minimal if nearby trees also are infected and dropping leaves.

Black, leathery maple tar spots in a close-up image captured by Steve Katovich, USDA Forest Service.

A curled-up leaf is a sign of aspen tortrix ; close-up image by Steve Katovich, USDA Forest Service.

Large aspen tortrix

Large aspen tortrix predominantly affects aspen trees. Caterpillars may cause defoliation of aspen by feeding on buds or leaves and sometimes completely defoliate trees during outbreaks, especially if they feed on buds before leaves flush out. Later in the spring, caterpillars will roll leaves into shelters, which they feed on until they pupate. Outbreaks typically last two to three years before collapsing.

In 2021, parts of Michigan confirmed a sizable population of aspen tortrix defoliating aspen trees in western and central Lower Michigan. An outbreak in the western Upper Peninsula also caused defoliation in isolated areas. Due to the relatively short duration of outbreaks and the resilience of aspen trees, management for this insect is rarely recommended as natural enemies help collapse outbreaks. However, it is thought that starvation and cold weather in the spring are most likely the biggest factors in the collapse of epidemic populations.

Ugly nest caterpillars

Ugly nest caterpillars, Archips cerasivorana, were observed in a few locations in the eastern Upper Peninsula during 2021. Their unsightly webs enclose areas of foliage where they feed, creating a dramatic, Halloween-like scene along roadsides in June.

However, they have a limited impact on forest health. The caterpillar is a native species feeding primarily on chokecherry, black cherry and hawthorn, though other species are also hosts during outbreaks. There is a single generation a year, and natural enemies usually bring outbreaks under control after a year or two of defoliation.

Close-up image of a cluster of ugly nest caterpillars.

Mammal damage: Porcupines, squirrels and other rodents

Porcupines can damage conifer and hardwood trees. Image via the Forestry News blog.

Bark stripping from a variety of animals primarily occurs during winter months and affects many tree species.

Voles, rabbits, porcupines, squirrels or other rodents can cause damage at ground level, on the bole (trunk) of a tree and in the upper branches. In some years and locations, small trees and woody shrubs are impacted heavily by winter feeding, resulting in dieback or death.

A porcupine's diet during the winter months primarily consists of tree bark, twigs and conifer needles. Porcupines prefer the tender branches in the uppermost part of the tree canopy; they may feed on the portion of the trunk close to branches. Porcupine damage often occurs on red pine, but they will opportunistically feed on a variety of hardwood and conifer species. Damage caused by porcupines may lead to crown deformities, making trees more susceptible to insect attack and diseases.

There are a few ways to determine the culprit of winter feeding. Look at the teeth marks, where the damage occurs and if the bark is torn or chewed off flush with the tree. Teeth marks made by porcupines are about 1/8 to 1/4 inch across and are larger than those made by squirrels or smaller rodents such as voles. Porcupines usually chew deeper into the sapwood than other mammals, leaving more pronounced teeth marks behind.

Fox squirrels and eastern gray squirrels also are common offenders when stripped bark is found during winter. Squirrels do not eat the outer bark; they instead remove it to feed on the sweeter-tasting phloem tissue, or inner bark, just underneath. Squirrels seem to prefer sapling-sized sugar maple trees and branches. Telltale piles of bark strips or chunks left lying beneath the tree are helpful in distinguishing whether feeding is by porcupines or squirrels. Squirrels leave behind narrow, half-inch wide strips of bark. Mortality is common in sapling-sized trees. Larger trees with damaged upper branches generally survive, but may become stressed, increasing susceptibility to insects and diseases.

Mice, voles and rabbits are known to gnaw on small trees and woody shrubs. Damage can vary considerably from year to year but is more common during years with extended periods of deep snow. Mouse and vole bark stripping occurs low on the trunk or on branches that have been pushed to the ground under heavy snow. Winter feeding damage becomes apparent in the spring, when the snow melts. Rabbit damage is more obvious as it generally occurs just above the snow line. Mice, vole or rabbit damage around an entire tree trunk will inhibit movement of water and nutrients, leading to tree death or resprouting from the roots. Excessive damage can lead to heavy losses in tree regeneration.

Mammal feeding is a natural occurrence in forests. Tools such as tree wraps may be used by homeowners to protect valuable yard trees from bark stripping or damage.

Insects

Asian longhorned beetle – *Anoplophora glabripennis*, *watchlist species*

A distinctive black-and-white, spotted Asian longhorned beetle.

Keep an eye out for a large, glossy black beetle with irregular white spots and long, black-and-white, striped antennae. The Asian longhorned beetle has not yet been detected in Michigan, but if established it could weaken or kill a large range of tree species.

No new infestations were reported in North America in 2021. In 2020, a detection in South Carolina added that state to a list including Illinois, New Jersey, New York, Massachusetts and Ohio where the beetle has been found. In South Carolina, the insect was first noticed by a resident who reported it to local authorities. As of fall 2021, more than 5,000 infested trees have been detected in a 75-square-mile area of Charleston County. Roughly half of the trees have been removed.

The beetle infests several hardwood species; however, its affinity for maple species is of particular concern to Michigan. More than 50% of trees in the state's cities and towns are maple species; sugar maple is the most common tree species in the Upper Peninsula's forests and grows statewide. The good news is that the beetle moves slowly and has been successfully eradicated where detected early.

One of the closest beetle populations was discovered in 2011 in Clermont County in southwest Ohio. There is still work to be done to eradicate the 57-square mile infestation, but progress is being made. Two satellite infestations were eradicated in 2018.

Adult beetles are large and showy, up to 1.5 inches long, glossy black with irregular white spots and the long, black-and-white striped antennae that give them their name. Although the beetles may be present June through October, frequently the signs first noticed are marks of infestation on trees. These signs include dime-sized scars on the bark from egg-laying pits, 3/8-inch diameter exit holes (about the size of a pencil) and piles of frass (sawdust-like material) below infested areas. Heavily infested branches are prone to breakage and will display extensive tunneling into the wood of the tree. Tree dieback may not occur until after several years of infestation.

Transportation in firewood and packing materials are major concerns for Asian longhorned beetle dispersal. DNR staff and volunteers conduct annual surveys in state parks and recreation areas to raise awareness. Training of arborists, foresters, other natural resource professionals and volunteers continues. Observant and knowledgeable residents will be critical in detecting and reporting this pest early for successful eradication. If you find anything you suspect may be an Asian longhorned beetle, collect the beetle if you can and report it to 1-800-292-3939 or MDA-Info@Michigan.gov.

Balsam woolly adelgid – *Adelges piceae, watchlist species*

Balsam woolly adelgid symptoms include woolly masses on branches.

In summer 2021, balsam woolly adelgid, an invasive pest native to Europe, was detected on several Fraser fir trees at a residential property near Rockford in Kent County. The insect, known as BWA, is a tiny sap-feeder that attacks true fir trees in the genus Abies, including balsam, Fraser and concolor (white) fir. The insect has been on Michigan's invasive species watch list for years because of the potential threat it poses should it become established in Michigan. In 2014, the Michigan Department of Agriculture and Rural Development implemented a balsam woolly adelgid exterior quarantine regulating the movement of fir nursery stock and firewood into Michigan from areas with known infestations.

As evidenced by experiences elsewhere in North America, repeated attacks from BWA can weaken trees, kill branches and, over the course of many years, cause trees to decline or die. The insect damages firs by feeding on the outer portions of tree crowns and on the main stem and large branches. Main stem infestations are usually more serious, with densities sometimes reaching 100-200 adelgids per square inch of bark. In the Appalachian region, high densities often result in loss of the entire tree within two to three years.

Severe infestations of BWA have the potential to affect industries that depend on fir. It is considered a serious pest of forest, seed production, landscape and Christmas trees. The most dramatic damage seen in the United States has been in forested areas, where billions of feet of fir timber have been lost to this insect. There are nearly 1.9 billion balsam fir trees in the northern Lower Peninsula and Upper Peninsula, where balsam fir is the second-most common tree species. Cold winter temperatures in northern Michigan may reduce potential populations should BWA become established. However, snow may insulate some overwintering BWA, protecting them from the cold and allowing them to survive.

Early detection and response are crucial to protect the state's natural resources. It is uncertain how long BWA had been on the property where it was identified, and at this point it has yet to be determined if the pest has spread. MDARD is working with other state agencies, partners at Michigan State University and local conservation districts to conduct surveys this winter to determine the extent of the infestation. The infested trees at the residential property were removed once the risk of crawler (the young, mobile stage of BWA) spread passed.

Beech blight aphid – *Grylloprociphilus imbricator*

A beech branch covered in tiny, white beech blight aphids, via Steve Katovich, USDA Forest Service.

Beech blight aphid, like many other minor pests, thrived this year with Michigan's unique climate. Throughout the state, reports came in about a small, white, woolly insect attacking their beech tree branches. These aphids regularly feed on the sap of American beech trees. In many cases, large piles of spongy or tar-like sooty mold forms on excreted honeydew under heavily infested branches. Rarely do the aphids cause enough damage to affect overall tree health. In dense colonies, twigs or branches may show some signs of dieback, but infestations rarely persist, and trees will recover.

Beech blight aphids also are called "boogie-woogie" aphids because disturbed colonies will lift their abdomens in unison and sway back and forth, presumably as a warning to predators. These aphids have needle-like mouth parts and can also "bite" predators or observers who allow the aphids to contact their skin.

Brood X cicadas – *Magicicada septendecim*

In addition to normal forest health concerns, every 17 years in early summer, southern Michigan sees an outbreak of periodical cicadas. This is part of "Brood X," one of 15 groups of periodical cicadas. Depending on the brood, they develop every 17, or sometimes 13, years before emerging out of the ground. Early years are spent as juveniles or nymphs feeding on fluid from tree roots.

Close-up image of Brood X cicada

Multiple related species of periodical cicadas can occur within a brood. However, only one species is known to occur in Michigan, Magicicada septendecim. Three additional species occur across several eastern states during Brood X emergence. Brood X is common across the eastern United States, but only occurs in localized areas in southern Michigan. Synchronized emergence is believed to overwhelm predators and ensure survival of the species. After they emerge, cicada nymphs shed their exoskeletons and become winged adults. As adults, they fly, mate and lay eggs in twigs for several weeks before dying. While the damage caused by years of feeding from roots is minimal, wounds associated with egg-laying by heavy infestations may cause significant branch tip dieback. This year, several reports of trees sustaining damage from cicadas were received. The damage to mature, established trees is typically minor, and most trees will rebound with little issue. The next predicted emergence of Brood X is in 2038.

Larch beetles cause patchy, bare spots.

Eastern larch beetle – *Dendroctonus simplex*

Tamarack damage from eastern larch beetle was limited this year, resulting in few reports and no new mortality mapped during aerial survey. However, the last outbreak of this native pest caused extensive tree deaths across the north central and western Upper Peninsula. Historically, outbreaks have lasted a few years, but other states have discovered a change in eastern larch beetle population dynamics. As of 2021, Minnesota was in its 20th consecutive year of an eastern larch beetle outbreak. Research suggests climate trends toward longer growing seasons have made this possible.

Signs of a new larch beetle infestation include resin flow on the bark during the summer and yellowing foliage at the bottom of the tree in mid- to late summer. Tops of affected trees may remain green into the fall, then fail to leaf out in the spring. Timing of symptoms can make damage difficult to map during annual aerial surveys. It is much easier to diagnose larch beetle damage on the ground. Trees may have loose bark that can be peeled off to display beetle tunnels underneath. These trees also can be identified by woodpecker damage; woodpeckers often remove bark as they feed on beetles.

Management guidance is to harvest mature tamarack when rotation age has been attained, and to harvest tamarack stands if edge trees show signs of beetle activity. Once eastern larch beetles begin feeding, they quickly move through a stand. Preemptive action is required if trees are to be used for lumber or fiber. Eastern larch beetles also build populations in wind-thrown trees, log piles, snow breakage and logging debris. Removing abandoned piles of wood, which can be susceptible to infestation, helps reduce beetle numbers, too.

Aerial image showing larch beetle damage in the Upper Peninsula.

Hemlock woolly adelgid – *Adelges tsugae*, *watchlist species*

Introduction

Hemlock woolly adelgid, an invasive forest pest native to east Asia, continues to be an issue for eastern hemlock trees in Michigan. This small insect – known as HWA – feeds on the sap of hemlock trees. If left unaddressed, it can kill trees four to 10 years after infestation. HWA was first detected infesting hemlock trees in eastern North America in 1951 and has since killed millions of trees. In 2021, hemlock woolly adelgid was present in five west Michigan counties: Allegan, Mason, Muskegon, Oceana and Ottawa.

Michigan is home to 176 million hemlock trees. These trees play an important role in our natural communities, and their loss would harm water quality, wildlife habitat and tree species diversity. Hemlocks provide stabilization for sand dunes, offer wildlife habitat and play a role in microclimates of cold-water trout streams.

A survey crew inspects hemlock trees for signs of adelgids.

Collaboration and coordination

The Michigan HWA Coordinating Committee uses information gathered from researchers and staff managing HWA in other states to update the Hemlock Woolly Adelgid Statewide Strategy. Written in 2017 and updated in 2021, this document outlines the strategy used by all partners working to address hemlock woolly adelgid in Michigan. It highlights some of the most important aspects for controlling HWA: prevention/regulation, survey, treatment, data integrity/technology, research and education/outreach.

This year, the seventh annual U.S. and Canada Hemlock Woolly Adelgid managers meeting was held online to allow researchers and managers to share information with state, federal and international agencies. This meeting is a valuable experience for Michigan participants to share and receive information to improve HWA management across the northeastern states and Canada.

HWA collaborators

Federal agencies: USDA Forest Service State and Private Forestry, Huron-Manistee National Forest and Northern Research Station, and the Pictured Rocks and Sleeping Bear Dunes national lakeshores.

State agencies: Michigan departments of Agriculture and Rural Development; Environment, Great Lakes, and Energy; and Natural Resources.

Local Cooperative Invasive Species Management Areas and affiliated organizations: CAKE, Lake to Lake, North Country, SW x SW, Three Shores and West Michigan CISMAs, Northwest Michigan Invasive Species Network and Wild Rivers Invasive Species Coalition.

University partners: Grand Valley State University, Michigan State University and Michigan Technological University.

A branch with white hemlock woolly adelgid ovisacs.

Prevention

Two quarantines are in place to prevent further introductions of HWA into Michigan and dispersal of the insect from populations now in the state. An internal quarantine, put in place in July 2017 and revised in 2020, restricts movement of hemlock plant material out of and within the five infested counties (Allegan, Mason, Muskegon, Oceana and Ottawa). An external quarantine initiated in 2001 restricts the movement into Michigan of potentially infested materials from states and Canadian provinces known to have HWA infestations.

The current HWA populations in Michigan were introduced through infested nursery stock planted in landscapes either before the external quarantine was put in place or in violation of that external quarantine.

Survey and monitoring efforts

A forest health technician inspects a hemlock tree.

Surveys for HWA that inform the statewide strategy and local management continue to be a top priority. These efforts have been ongoing since 2016 and focus on areas at high risk of infestation along the Lake Michigan coastline in the Upper and Lower peninsulas. To date, over 110 miles of Lake Michigan shoreline in southwest Michigan remain infested. No established HWA populations have been detected in the vast majority of Michigan hemlocks farther north. Previous survey and modeling efforts led by Michigan State University have allowed us to map the state hemlock resource. This hemlock map is a vital component of HWA management, expediting future survey, treatment and prioritization efforts on public lands.

Surveys in 2021 identified two outlying populations. Pentwater State Game Area is the first detection on a state game area and is the farthest east in previously infested Oceana County. The Platte River Campground, located on Sleeping Bear Dunes National Lakeshore, had a single infested tree, and it was the first detection on federal lands in Michigan as well as the first detection in Benzie County. This site was extensively surveyed, resulting in no additional detections in the broader area. Note, Benzie County is not referred to as an infested county, as all known infestations have been removed and destroyed.

Since the first detection of HWA on DNR-managed public land at P.J. Hoffmaster State Park in 2017, the DNR has actively surveyed hemlock trees on state park lands. A crew of four to 10 Michigan Civilian Conservation Corps forest health technicians was established to respond to this and other forest health threats. Remarkably, these staffers have hiked about 15,000 miles through state parks and recreation areas since 2017, looking for and treating HWA.

This year, detection surveys were performed at these state parks, recreation areas and linear trails: Orchard Beach, Leelanau, Petoskey, Fisherman's Island, Young, Interlochen and Newaygo state parks; Kal-Haven and Van Buren linear trails; and Tippy Dam and Bass River recreation areas. New hemlock mapping was added for Fisherman's Island, Interlochen and Newaygo state parks and Tippy Dam Recreation Area so that agency partners have a better idea of locations of hemlock resources to ensure their protection more efficiently. Surveys also continue within the quarantine area at Saugatuck Dunes, P.J. Hoffmaster, Muskegon, Duck Lake, Silver Lake and Ludington state parks. In total, 3,336 acres were covered both in and outside of the five-county quarantine area in 2021, with no new detections north of Ludington or south of Saugatuck Dunes state parks on state park-administered land.

The DNR's Forest Health Response Team took the lead on surveying federal and state lands outside of those administered by state parks. Forest health staff surveyed more than 1,000 acres in 2021,

prioritizing the northern extent of known infestations. The bulk of the survey was conducted, with help from local national forest staff, at Nordhouse Dunes Wilderness Area within the Huron-Manistee National Forest. This area has abundant hemlock and is just north of infested trees in Ludington State Park.

Cooperative Invasive Species Management Areas surveyed private and local public lands along the Lake Michigan coastline in both the Lower and Upper peninsulas. These surveys focus on lands within 5 miles of Lake Michigan while looking at various infestation risk factors. CISMAs formally surveyed over 8,800 acres during 2021. Several new infestations were identified, primarily within a mile of Lake Michigan in Mason County near known infestations.

A crew member treats a tree to protect it from HWA.

Treatment

Survey data is reviewed and used to plan treatments to limit the spread of HWA into uninfested areas, protect the vast, uninfested northern hemlock resource and protect critical dune habitat for species that rely on hemlock to survive. Treatments by both DNR and CISMA staff took place on state, federal and private land.

HWA has been treated in 10,232 trees and 283 acres at eight state parks: Saugatuck Dunes, Holland, P.J. Hoffmaster, Muskegon, Duck Lake, Charles Mears and Ludington. Ludington State Park, the northernmost known infestation on state-managedland, was detected in October 2020, leading to increased efforts in Mason County. Since the initial detection, Civilian Conservation Corps staffers have detected 38 additional infested trees at Ludington State Park. All infested trees and neighboring trees have been treated.

Land ownership	2021 hemlocks treated	2021 treatment inches	2021 acres treated	Total* hemlocks treated	Total treatment inches	Total acres treated
Federal lands	64	591	3	64	591	3
State lands	2,419	28,702	430	2,419	28,702	430
State parks	10,232	75,232	283	40,790	262,997	2,230
Private & local public	24,846	164,568	1,689	75,282	498,091	4,540
Totals	37,561	269,093	2,405	118,555	730,381	7,203

**Total includes treatments since 2017.*

Hemlock forecast and outreach resources

Most of the hemlock range in the state is separated from currently known infested areas. Treatment options exist and can be implemented over a broad scale within infested sites. Over the last five years, a total of 7,515 acres and 118,491 trees have been treated. In addition, HWA appears to be susceptible to extremely cold winter temperatures. It is possible the insect may not survive winter in Michigan's northern and inland forests. Ongoing research from Michigan State University will help improve understanding of winter mortality.

Coordinated efforts from local, state, federal and international agencies and institutions should substantially improve prevention, detection and treatment. This provides time to refine long-term, integrated management tactics. Statewide outreach and education on hemlock woolly adelgid continues, reaching more than 800,000 people this year.

Funding from the Michigan Invasive Species Grant Program, Great Lakes Restoration Initiative, Recreation Passport and fundraising efforts supported by Bob Ross International helped make these HWA efforts possible.

If landowners suspect hemlock woolly adelgid is present on their property, it is important to know which insecticides and application methods work best to protect trees. In 2021, the DNR Forest Health Program added capacity to help communities and individuals faced with hemlock woolly adelgid issues.

Further information

Landowners with possible HWA or those interested in discussing treatment options should contact Drew Rayner, DNR West Michigan hemlock woolly adelgid coordinator, at RaynerD1@Michigan.gov or 517-231-8763 for assistance. Additional help may be available through local cooperative invasive species management areas or certified arborist/tree care professionals. Those interested in treating their trees should follow guidance provided in the MSU Extension Bulletin: "How to treat hemlock trees for hemlock woolly adelgid."

For more information on identification, known distribution, reporting or treatment, visit Michigan.gov/HWA.

Lymantria dispar dispar

Lymantria dispar dispar, formerly known as European gypsy moth, continued to defoliate trees across the Lower Peninsula and a few areas in the Upper Peninsula in 2021. Roughly 1.2 million acres of land with greater than 50% defoliation were mapped during aerial survey flights of about 24 million acres.

With populations now naturalized across the state, outbreaks are cyclic, rarely lasting more than two or three years before collapsing naturally. Healthy forests usually tolerate the defoliation.

Several areas heavily defoliated in 2019 and 2020 had a population collapse in 2021. In many areas with defoliation, we saw a mass caterpillar die-off and observed small, unhealthy egg masses. This suggests a population collapse to background levels as early as spring of 2022. Unfortunately, assessments in other areas that saw heavy defoliation in 2020 and/or 2021 suggest some defoliation may continue in 2022 as localized populations may continue to build.

Hungry caterpillars can quickly defoliate trees.

The last significant Lymantria outbreak was recorded in 2009-2010, when roughly half of this year's defoliation was mapped during the peak. Defoliation seen over the last several years has been driven by unusual precipitation and long dry spells. In some areas, a late frost caused severe damage in 2020 and 2021, stressing oaks early in the growing season. Stressed oaks help trigger outbreaks, allowing insect populations to build rapidly. Once populations start to build, predators, parasitoids, a fungus and virus help control and reduce population sizes. Unfortunately, these factors typically lag behind Lymantria populations, allowing for a year or two of heavy defoliation before outbreaks end. Generally, the impact to healthy forests and deciduous trees from a couple years of severe defoliation are minimal.

The moth was not always naturalized in Michigan's forests. First discovered in Lansing in the 1950s, Lymantria populations spread rapidly and today can be found statewide. By the 1990s, outbreaks were large and long-lasting, causing significant oak decline. To help reduce the effects of caterpillars feeding on host species, state agencies and partners introduced Entomophaga maimaiga, a fungus that only infects and kills Lymantria and plays a key role in population collapse. Now, short outbreaks occur every seven to 10 years.

Most healthy deciduous trees can withstand severe defoliation from Lymantria attacks for a few consecutive years with no long-term impacts. Trees generally recover, releafing later in the summer. However, trees subject to drought or other stressors may start to decline after a few consecutive years of defoliation. Other insects and diseases may begin to attack trees, eventually leading to tree death. There are things landowners can do to help reduce the impact to trees. To help high-value yard trees

survive, deep watering during extended dry spells that follow defoliation is the most important action. A light fertilizer application in late fall can also help trees rebound from stress caused by defoliation.

During an outbreak, one control option is the use of a Btk spray. Btk refers to a native bacterium found in the soil that kills Lymantria caterpillars but has little impact on animals or many other insects. The spray is most effective during mid- to late May, depending on spring temperatures. Spraying should occur after egg hatch but before caterpillars reach 1 inch long. Aerial applications of Btk can be highly effective, killing up to 80% of caterpillars, but is expensive and often unnecessary. Spraying too much can reduce the effectiveness of processes that cause outbreaks to collapse naturally and may require continued regular spraying for relief. Spraying is only recommended for landowners experiencing major outbreaks. To increase efficiency and reduce costs, communities, homeowner associations, townships or counties may collaborate during outbreaks to spray targeted residential areas. Planning aerial applications can take several months and should start with an egg mass survey in the fall to determine if applications may help during the following year.

During late fall or winter after leaf drop, egg mass surveys can provide an idea about populations the next year. If you see an abundance of egg masses on a few trees, you may have a sizable outbreak next spring. One of the biggest mistakes surveyors make is that they count old egg masses with new ones. After a heavy defoliation event, old egg masses will persist; exclude them from egg mass surveys. New masses are a tan/brown color and are soft to the touch but firm. Old masses are faded, look white and often have holes where the caterpillars or parasitoids have hatched and come out.

While conducting the survey, scrape egg masses in a bucket of soapy water or collect to burn or soak later. Just scraping egg masses will not kill the eggs, they must be soaked or burned. Soak masses for about 48 hours. Each mass carries 200 to 600 eggs. By collecting egg masses after late fall, you let parasitic wasps that kill Lymantria eggs first complete their life cycle. Every mass removed will reduce spring caterpillar numbers.

Fuzzy brown Lymantria egg masses are laid by adults in autumn.

These techniques can help make life more enjoyable during outbreaks but will not remove outbreaks from the area completely. These techniques are meant to help reduce the nuisance around your home, while the predators, parasitoids, virus and fungi take hold and collapse the outbreak for you.

Learn more

Michigan State University Integrated Pest Management: Lymantria dispar webpage, surveying *Lymantria dispar* egg masses to forecast next year's population

MSU video: Gypsy moth history, impacts and tips for surviving an outbreak

Newaygo Gypsy Moth Forum video: Gypsy Moth presentation

Redheaded pine sawfly – *Neodiprion lecontei*

The DNR received several reports of defoliation of young jack pines in northern Luce County by the redheaded pine sawfly. The damage appears to be centered near the mouth of the Two-Hearted River in the areas affected by the Duck Lake Fire in 2012. This was the third year of defoliation in the core affected area. Surveys for eggs and young larvae in June and early July indicated populations were not expanding into uninfested areas. However, additional surveys will be necessary in 2022.

Redheaded pine sawfly is a significant native defoliator of young jack and red pines. Plantations with trees less than 15 feet tall are most susceptible to economic losses. The heaviest infestations commonly occur on pines growing under stress, particularly those at the edges of hardwood forests, on poor soils or where there is heavy competition from adjacent vegetation. Repeated defoliation can cause top kill, forking and tree death. A single, moderate to heavy defoliation event stunts the height of infested trees. Complete defoliation is usually sufficient to kill red and jack pines.

Redheaded pine sawfly larvae consume the foliage of a conifer tree.

The larvae feed in colonies containing a few to more than 100 larvae. Early damage is like that of most other coniferous-feeding sawflies. It is characterized by the reddish-brown, strawlike remains of needles partially consumed by the young larvae. Older larvae devour the entire needle, generally stripping a branch of all its foliage before feeding on another.

Outbreaks tend to occur regionally and build rapidly, but usually collapse after a few years when natural enemies and diseases bring populations back to normal levels.

The last significant outbreak collapsed in 2017 and was centered on the northern Lower Peninsula.

The larvae are easily killed with insecticides when young. However, treatment is not always necessary. Early detection and rapid response are the keys to protecting infested sites. Young jack and red pine plantations at risk of defoliation should be monitored for egg-laying and early larval development in June and early July to determine the need for treatment.

Spotted lanternfly – *Lycorma delicatula*, *watchlist species*

Spotted lanternfly was first discovered in North America in 2014 in southeastern Pennsylvania. Over the past seven years, lanternfly populations have been detected in 11 northeastern states including Connecticut, Delaware, Indiana, Maryland, Massachusetts, New Jersey, New York, Ohio, Virginia, West Virginia and Pennsylvania. The most recent detection occurred in July 2021, in Indiana.

Adult spotted lanternfly, via L. Barringer, Bugwood.org.

No live spotted lanternflies or evidence of establishment have been found in in Michigan. However, as in other states, dead adult spotted lanternflies have been found in shipments from infested areas. In mid-October 2020, a shipment of nursery stock from Pennsylvania to mid-Michigan arrived with a single dead adult. Later that year, two more adults were found dead on a shipment of building supplies in southeast Michigan. In November 2021, another dead adult was found in a shipment of pasta sauce from New Jersey. Investigations conducted by the Michigan Department of Agriculture and Rural Development and the USDA Plant Protection and Quarantine Program found no other evidence.

Spotted lanternflies feed on a variety of species ranging from fruit and ornamental to woody trees, with a strong preference for tree of heaven. Among Michigan's native trees, black walnut, oak, willow, maple and sycamore are at risk of damage, as well as fruit and nursery crops such as grapes and hops. Damage is caused when the lanternfly sucks sap from host plants and excretes large amounts of sugar water called honeydew. Black, sooty mold grows on the honeydew, coating leaves and reducing the photosynthesis potential of affected plants. Very young trees can be killed as a result. Feeding also can reduce plant vigor and create oozing wounds susceptible to secondary infections.

Immature lanternfly, via L. Barringer.

Spotted lanternflies have four larval stages before reaching the adult life stage. In the first three life stages, the insect is small and black with white spots. In the fourth stage, it also develops red patterns on its back. Adult spotted lanternflies are roughly 1 inch long. Their folded wings are gray to brown with black spots. Open wings reveal a yellow-and-black abdomen and bright red hind wings with black spots that have black-and-white bands at the edge. Egg masses are laid in late fall on almost any surface in the vicinity of infested trees and are easily moved to new locations. Initially, egg masses look like fresh putty or clay. As egg masses dry out, they crack and begin to look like dried mortar. Each mass can contain 30 to 50 eggs.

Introduction incidents across the northeast states illustrate how easy it is for this species to move about. To make sure Michigan is ready to respond, MDARD is working with federal, state and local partners to develop response plans and communication strategies to ensure a rapid, well-planned response when spotted lanternfly is detected. If you suspect you have observed a spotted lanternfly in Michigan, consult the Invasive Species Program spotted lanternfly webpage to find more information. Take photos, record the location and call 1-800-292-3939 or email MDA-Info@Michigan.gov.

Spruce budworm – *Choristoneura fumiferana*

Spruce budworm webs on damaged needles.

Spruce budworm is considered the most damaging conifer defoliator in North America.

In Michigan, this native insect is part of a natural cycle associated with maturing balsam fir and mixed spruce/fir forests, most of which occur in the northern Lower and Upper peninsulas. Historically, epidemics have occurred on a 30- to 50-year cycle. Outbreaks usually last 10 to 15 years and can result in the loss of millions of trees.

After the last epidemic in Michigan ended in 1982, spruce budworm remained at low levels statewide for many years. It wasn't until the mid-2000s when populations started building in isolated areas of the Upper Peninsula. After widespread defoliation in 2010, additional defoliation has been quite variable from year to year in the Lower and Upper peninsulas. Most recently, extensive defoliation occurred in many areas in 2020 prior to a partial collapse of populations this year.

During aerial surveys this year, a few localized pockets of spruce budworm-related defoliation and mortality were observed across the Upper Peninsula. However, most of the damage was observed in the central northern Lower Peninsula and the central and western Upper Peninsula. While predicting the future of insect outbreaks is challenging, in some areas of the western Upper Peninsula, spruce budworm may be running out of vulnerable host trees. Defoliation may continue in other local areas.

Browning needles and loss of vigor are signs of spruce budworm.

We anticipate localized defoliation may continue while vulnerable mature and overmature balsam-fir stands remain. Infested stands often lose 60 to 80% of fir trees and 20 to 40% of white spruce trees. Recommendations for management are to harvest spruce and fir trees when they reach 50 years old and to salvage stands with significant budworm damage. If the spruce or balsam trees are dying, it is important to cut and transport logs to a mill within one year to retain timber value.

Diseases

Beech leaf disease – *watchlist*

Michigan continues to be on high alert for a new invasive species, beech leaf disease, which threatens American beech. American beech is a keystone species for states in the northeast and was already struggling with the devastating beech bark disease since its introduction in Nova Scotia around 1890.

Leaves curl and twist in the later stages of beech leaf disease.

In 2012, beech leaf disease was discovered in Ohio. In subsequent years, extensive surveys of the northeastern states have been conducted. As of 2021, the disease has been confirmed in eight states and a Canadian province. Research is ongoing as to how the disease spreads, how it infects trees or how long it may take before visible symptoms are formed. While this disease appears to be spreading, the rate of spread is unclear. Some detections may have occurred several years after disease establishment, as awareness and survey efforts increase.

Early observations of beech leaf disease suggested the disease mostly affects saplings or regenerating beech. More recent research indicates that beech leaf disease attacks mature trees as well as saplings. It damages tree buds and leaves, leading to loss of vigor and, in areas with a long history of disease symptoms, death. In some areas, mortality is being reported six to 10 years after initial symptoms appear. Concerningly, beech bark disease-resistant American, Oriental and European beech trees appear to be susceptible to symptoms of this new disease. While research shows a nematode, or microscopic worm (Litylenchus crenatae), is involved in symptom development, other factors possibly play a role.

Beech leaf disease has been detected less than 15 miles from the Michigan/Ontario border near Detroit and continues to spread in Ohio. Plantings of beech originating from infected areas may also be of concern. Collaborations between the DNR, USDA Forest Service, and Michigan State University and University of Michigan researchers are developing and implementing survey efforts across high-risk areas in southern Michigan. The focus area continues to be in southeast Michigan and known beech plantings that may have been exposed to beech leaf disease before coming to the state. Thankfully, beech is sparse in southeastern Michigan, but enough beech is present to warrant concern. Beech leaf disease was added to Michigan's watchlist in 2020 to help spread awareness of the disease.

Initial beech leaf disease symptoms are dark, slightly thickened bands between leaf veins. As the infection becomes more severe, leaves may appear to be distorted or puckered. Severely affected leaves

may drop early. Eventually, canopies become sparse with small, chlorotic (yellow) or dark, leathery, puckered or swollen leaves. Symptoms tend to get progressively worse from one year to the next. Over time, nearby trees develop symptoms.

If you suspect beech leaf disease in Michigan, consult the website Beech Diagnostics to rule out other possibilities, take photos, record the location and email DNR-FRD-Forest-Health@Michigan.gov or call 517-284-5895.

A view into beech canopy shows thinning leaves.

Heterobasidion root disease – *Heterobasidion irregulare*

Close-up view of the mushroom-like fruiting body of the HRD fungus.

Heterobasidion root disease, or HRD, caused by the fungus Heterobasidion irregulare, is native to Michigan. It is one of the most economically and environmentally destructive fungal pathogens to forests in North America.

Red, white and jack pine, along with other conifer species, are susceptible to HRD infections. Plantations are especially vulnerable to infections after thinning. Actively thinned or harvested stands open pathways for HRD to spread into new areas. That puts managed stands at higher risk for infection than unmanaged stands. Recent detections in Michigan have occurred in actively managed red pine plantations at least five years after thinning operations, although crown symptoms can appear earlier.

Ongoing survey activities confirm HRD in 20 Lower Peninsula counties and two counties in the eastern Upper Peninsula. Many detections have occurred when pockets of dead pine are identified during aerial survey activities, following reports from field staff or reports made through reports from the public.

A first detection in Gratiot County in 2021 confirmed HRD on private land from a report made through the forest health HRD online viewer and on-the-ground follow-up by the DNR Forest Health Response Team. Additional detections in Emmet and Grand Traverse counties were confirmed and delineated by Forest Health staff in 2021.

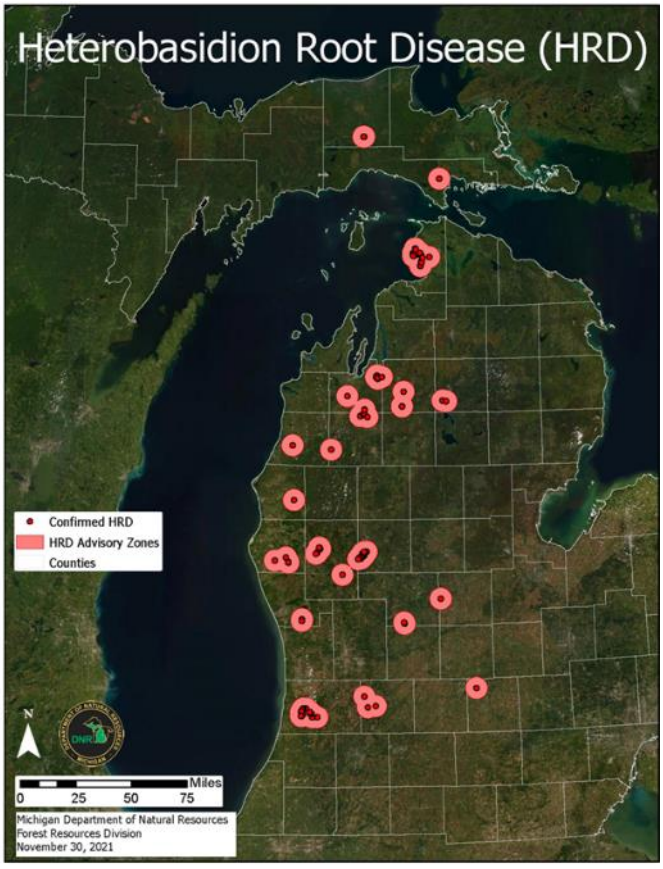
Infections occur when fungal spores land on freshly cut stumps. After the spores germinate, the fungus slowly grows through root grafts, which are roots that grow together, connecting adjacent trees. HRD spreads 3-6 feet per year after establishment and will slowly develop a pocket of dead trees.

HRD is most easily identified in the fall when the “fruiting bodies,” or mushroom-like growths, are more obvious at the base of affected stumps and trees. The fruiting bodies are leathery brown on top and white on the bottom with elongated pores or tiny holes, rather than gills seen in other common fungi.

The risk of infection to nearby areas through fresh-cut stump surfaces increases with the abundance of fruiting bodies and spore production. Once the disease is present, it becomes impossible to grow susceptible species on that site for several decades or more.

Currently, on state-owned land, an “advisory zone” of 5 miles around known infection sites is considered at increased risk for infection. DNR forest health staff assesses red pine plantations scheduled to be treated or cut within the zone. If the risk of HRD infection is determined to be high, restrictions are placed on the sale. These sale specifications include winter logging from Jan. 1 to March 31, when spore production is suppressed, or a stump treatment to prevent infection. When stump treatment is required, one of two products (Cellu-Treat or RotStop C) must be applied to stumps after cutting. In the Huron Manistee National Forest, restrictions are placed on all red pine timber sales within 25 miles of known infection sites.

A forest health expert confirms HRD infection.



Red spots on the map show known HRD infection locations.

These restrictions in the national forest include winter logging from Jan. 1 to Feb. 28 or stump treatment. Treatment should also be considered on private lands in high-risk locations to protect red pines.

An interactive, online HRD map shows current confirmed locations of the fungus in Michigan and the 5-mile advisory zone as well as locations where surveys did not detect HRD.

The map also includes an identification bulletin and tools for reporting new or suspected locations of the disease for follow-up by DNR forest health staff.

To use the map, visit Michigan.gov/ForestHealth and enter information into the interactive map using the “View and report Heterobasidion root disease locations” link. Reporting potential infection areas helps protect forests for future generations.

Oak decline and oak wilt

Oak decline

Oak decline has been an issue for oaks in Michigan in recent decades. It is most common in the northern Lower Peninsula but can occur statewide where oak is present. It is most frequently associated with northern pin oaks, northern red oaks and, occasionally, black oaks.

Oak decline occurs when several factors work together to kill trees. Many oak forests were generated after widespread logging in the early 1900s. They contain trees of a similar advanced age and are growing on poor sites characterized by dry, nutrient-poor, sandy soils. These factors set the trees up for decline. In recent years, these older forests have also been periodically defoliated by insects such as Lymantria dispar (formerly gypsy moth) and subjected to drought and late spring frosts that younger, more vigorous trees can tolerate but older ones cannot.

When a tree's energy reserves are depleted, it becomes more attractive to insects and diseases that don't usually affect healthy oak trees. These insects, such as two-lined chestnut borer, and diseases, including Armillaria root rot, are often blamed for tree death despite the other factors involved. A look at the rings on a tree killed by oak decline often shows extremely narrow rings at the edge, indicating tree vigor declined long before any symptoms became apparent.

As Michigan's oak forests continue to age and fluctuations in climate increase, oak decline is anticipated to increase. DNR forestry staff works to identify stands at risk and, when possible, harvest declining trees. This helps to regenerate younger oak stands and other species better suited to local site conditions.

Oak wilt

Oak wilt is an invasive fungal disease that kills thousands of oaks in Michigan each year. Although oak wilt was first identified in 1944, the extent of the disease didn't become apparent until the 1980s. Today, oak wilt is spreading into new areas.

A pocket of oak-wilt killed trees in Dickinson County.

Red oak species are vulnerable to oak wilt and may die within weeks of infection. The fungus spreads into the roots, eventually moving to nearby trees through connected root systems. The spread creates an oak wilt "epicenter," or pocket, of dead and infected trees.

New locations may become infected under the right conditions, with a fresh tree wound during the high-risk period of April 15 to July 15, when active insects and viable spores are present. In areas of the state where oak wilt is active, it is important to refrain from pruning or otherwise wounding oaks during this high-risk period to reduce new infections. Without a wound that penetrates the bark of an oak, a

new infection cannot occur. A wound could be a pruned branch or a branch broken in a storm. Trees, logs and firewood from trees killed by oak wilt produce infectious spores the following year. When firewood from infected trees is moved to new areas, oak wilt can spread, with devastating impacts.

Unlike other invasive pests such as Dutch elm disease, beech bark disease and emerald ash borer, with oak wilt we can use early detection and treatment to protect oak trees that would otherwise be killed. The DNR has been working for at least 70 years to prevent the spread of oak wilt on state-managed lands by severing root systems between trees. Experimental trenches were dug by hand between infected and healthy oak trees at Proud Lake State Recreation Area in 1951. In recent years, the DNR has used a vibratory plow to sever tree roots and prevent the spread of the disease from infected trees to healthy ones. While the technique has been effective, it cannot be used on rocky ground, steep hillsides or residential areas with buried utility lines.

In the past two years, the DNR Forest Health Program began testing a new technique using herbicides as an economical treatment. It has shown promise in trials elsewhere and can be used where trenching is not possible. The herbicide treatment relies on killing oak root systems before the fungus can invade and spread to adjacent trees. Healthy oak trees surrounding an epicenter are girdled by making two cuts around the trunk near the tree base, through the bark and into the wood. Triclopyr herbicide is applied to the girdle. Research suggests it may take multiple years for root systems to die and consequently, the technique is being used on a limited basis at a few sites and monitored to collect data on efficacy. The technique is not currently recommended for widespread use.

Oak wilt is widespread across much of the Lower Peninsula. In the western Upper Peninsula, oak wilt is common along the Wisconsin border from Iron County south. See the interactive online oak wilt map created by the DNR for confirmed and suspected locations and data on treatments. Visit Michigan.gov/ForestHealth and "View and report oak wilt locations."It is important to note that many oak wilt infections go undetected, and the map does not reflect the full extent of oak wilt in Michigan.

Oak wilt	Oak decline
Fast-acting, aggressive condition	Slower, less aggressive condition
Rapid symptoms, can kill within weeks	Long-term symptoms over multiple years
Small pockets of dead trees	Widespread decline/weak trees on landscape
Caused by fungal oak wilt disease	Caused by several factors

Learn more

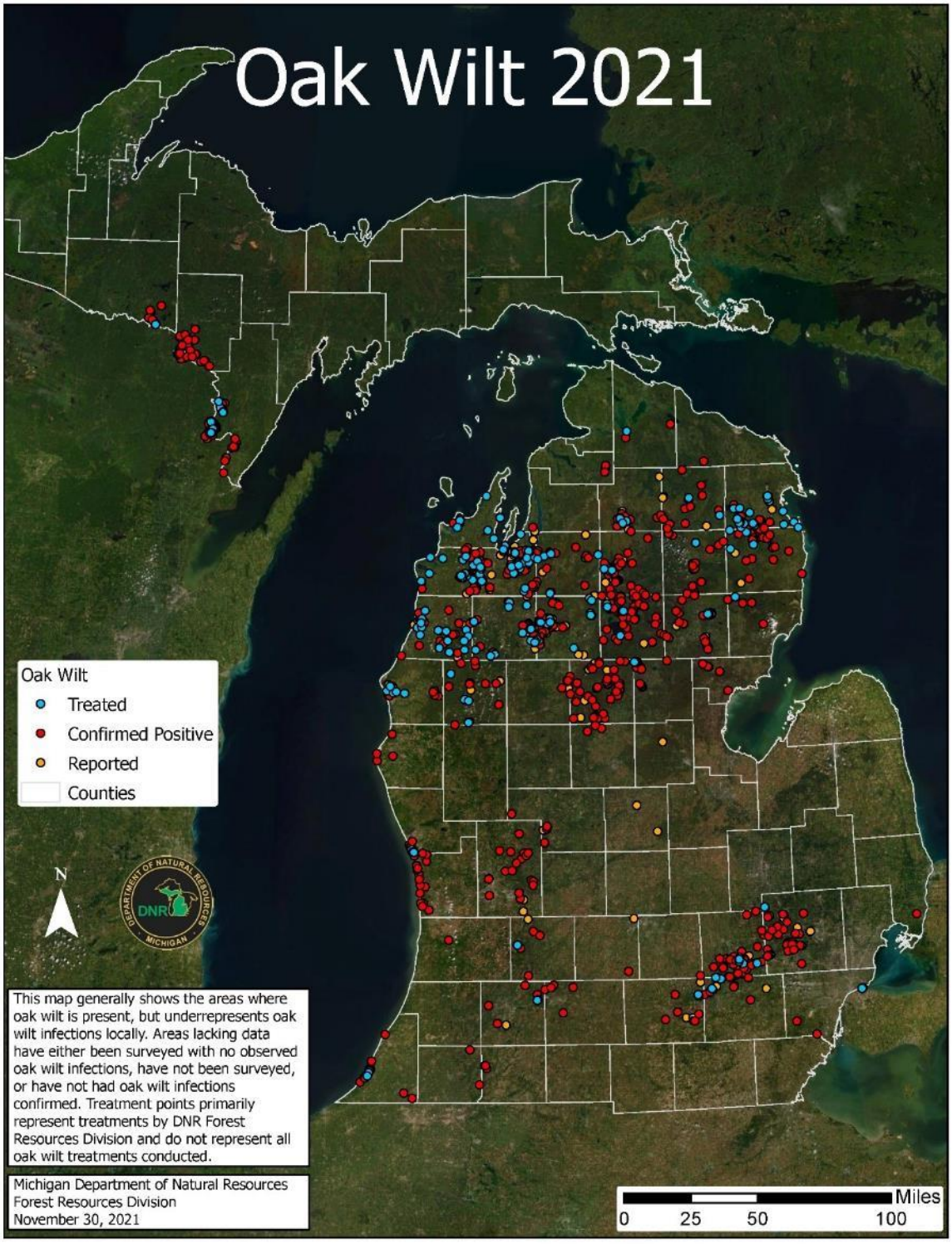
A variety of programs address the threat of oak wilt and oak decline on private land:

Michigan Department of Agriculture and Rural Development Forestry Assistance Program.

Michigan DNR Forest Health Program: Email DNR-FRD-Forest-Health@Michigan.gov.

Michigan State University Extension: Ask Extension service.

Oak-wilt trained private arborists.



Map of confirmed, treated and reported oak wilt locations.

Invasive plants

Himalayan balsam – *watchlist species*

Himalayan balsam is an annual herbaceous plant that thrives on lands near lakes or rivers, called riparian areas. This species competes heavily with native species and has been detected in both the eastern Upper Peninsula and the western Lower Peninsula. A site in west Michigan was treated in 2017, and no additional plants have been detected at this site.

Himalayan balsam has increased greatly in both density and area throughout the eastern Upper Peninsula over the past few years. In 2021, the Three Shores CISMA removed the largest amount of Himalayan balsam biomass ever from the region, consisting of 82 contractor bags across 8 acres compared to just nine contractor bags across 2.9 acres in 2019. Himalayan balsam is easily hand-pulled, as it has an extremely shallow root system. Before removing the plant from the ground, it is important to check for seed pods. If present, carefully remove these seed pods from the plant and bag them to discourage pod rupture and rapid seed dispersal. Then, dispose of remaining plant material in bags.

A volunteer stands next to a thick clump of Himalayan balsam.

Kudzu is a fast-growing, aggressive vine.

Kudzu – *watchlist species*

Kudzu is a climbing perennial vine that can grow rapidly, smothering or shading out native plants. These vines can grow 100 feet, and each plant can produce upwards of 30 vines. This species has been present in Michigan since at least 2012, with infestations detected in Allegan and Benzie counties. These sites have been under management, and until 2020, no additional sites had been detected. Since 2020, eight new detections have occurred in Barry, Bay, Manistee and Van Burren counties. These sites were detected by local CISMA staff, and these local organizations are taking the lead and working with landowners to address the infestations. Many of these sites were treated in 2021 using herbicide, and follow-up treatments are planned.

Japanese stiltgrass – *watchlist species*

Japanese stiltgrass spreads rapidly and can form dense carpets in natural and landscaped areas, replacing native vegetation. Each plant can produce anywhere from 100 to 1,000 seeds that remain viable in the soil for three to five years. This species has a distinctive appearance, with a silvery-white midrib on each delicate, lance-shaped leaf and a weak, slender stem. It can grow up to 6 feet if left untreated in favored conditions. Japanese stiltgrass has been identified in Washtenaw, Cass and Kent counties.

Stiltgrass was first identified in Washtenaw County in 2017 in Scio Township. After confirming the identity of the plant and treating known populations in the first year, local organizations came together to document its spread and implement plans to control this species.

Known stiltgrass locations, indicated with blue markers.

Stiltgrass has distinctive, pointed leaves.

The newly formed Washtenaw Stiltgrass Working Group identified new populations on private and public property. A stiltgrass coordinator position was created in 2019 to educate the public about this species and facilitate treatment on private land.

Japanese stiltgrass was also detected in Cass County in 2017 and has been under management from the SW x SW Corner CISMA. Currently, one known infestation extends over three properties. Plans are in place to continue infestation management and reduce the risk of spread. The last known infestation, detected in 2020 in Kent County on two adjacent properties, has been under management for the past two seasons by the West Michigan CISMA.

This species has the potential to spread rapidly and should be a priority for survey and management throughout Michigan. Herbicide treatments have shown success in controlling this species, but it is important to start management early.

Research and monitoring

Grand Valley State University – Partridge Lab

Developing novel detection techniques for hemlock woolly adelgid

Meg Sanders, Charlyn Partridge

Hemlock forests in eastern North America face a deadly threat: the invasive insect hemlock woolly adelgid, known as HWA, Adelges tsugae. Early detection of this pest remains a key focus to ensure rapid management responses to control and stop the spread of HWA.

Genetic approaches have been advancing as an affordable, efficient option to detect invasive species through methods such as environmental DNA techniques. Environmental DNA, or eDNA, refers to genetic material shed from organisms into their environment, such as water, soil or air. Invasive species managers can collect and analyze eDNA for the presence of targeted species. These techniques have been used for other invasive forest insects in the northeastern United States, such as the spotted lanternfly.

eDNA trap developed by GVSU researchers.

Researchers at Grand Valley State University's Annis Water Resources Institute developed an affordable, easy-to-use trap compatible with airborne eDNA sampling techniques and assessed trap efficiency as a monitoring tool for HWA. Research from 2020 and 2021 suggests that the eDNA traps are highly efficient at capturing HWA, particularly during the mobile crawler stage of the insect. HWA capture rates (i.e., the number of adelgids captured) were related to the insects' distance from an infested hemlock tree. This suggests that the number of adelgids captured per trap may help pinpoint infested hemlock stands within an area. Because Michigan is host to several adelgid species, we also tested the traps' compatibility with genetic analysis to confirm the presence of HWA. We found that our molecular test could distinguish HWA from other adelgid species and therefore could be used to confirm the presence of HWA within an area.

One advantage of this technology is that eDNA monitoring, coupled with current visual surveys, could cover larger geographic areas or aid in monitoring areas that are remote or in difficult terrain. Incorporating eDNA analysis into current management efforts could help preserve valuable personnel and financial resources for eradication efforts across HWA's invasive range.

Michigan State University – McCullough Forest Entomology Lab

Early detection of nonnative forest insect pests of concern

Paige Payter, Deborah G. McCullough

Undergraduate student assistants Marshal Weimer and Ren McIntire prepare to deploy insect traps.

In 2021, we surveyed 45 locations across Michigan to detect potentially damaging nonnative forest insect species. Early detection of a new invasive forest pest is an essential aspect of protecting the health of forests. Most species targeted by this survey are not known to be established in the United States or not known to be present in Michigan.

Forest pests of concern include insects such as bark beetles and woodborers that feed on wood or phloem (inner bark), along with selected defoliators. This includes several moth species that feed on leaves of hardwood trees or needles of conifer trees as larvae (caterpillars) in Asia, Russia or Europe. Our project is a collaboration with the Michigan Department of Agriculture and Rural Development and the USDA's Animal and Plant Health Inspection Service.

At each site, we set up an array of different types of traps. Each trap is baited with pheromones that attract species of concern or with volatile compounds produced by host trees of the insect pest targeted by the survey. Trapping sites include forested campgrounds and parks where visitors may bring potentially infested firewood, along with a few sawmills or log decks. We also trap at numerous industrial sites where manufacturers import steel or other materials that arrive on wood pallets or crating. Wood pallets, crating and similar materials represent high-risk commodities that can introduce nonnative woodboring beetles.

Cross-vane panel traps capture woodboring beetles.

All traps were checked monthly during the growing season to replace lures and collect captured insects. Insects were returned to MSU campus, sorted into groups and identified by species, a labor-intensive process that requires months. In 2020, we monitored a total of 600 traps, which captured more than 7,000 beetles, metallic woodboring beetles and horntails, along with thousands of tiny bark beetles. Thankfully, none of the serious nonnative pests targeted by the survey were captured in 2020. An additional benefit of this project is that we acquire a substantial amount of information about the distribution, diversity and activity of native woodboring insects, many of which have not been well studied.

Black ash conditions at varying stages of the emerald ash borer invasion

Alexandra Lepeschkin-Noel, Deborah G. McCullough

Ren McIntyre of MSU measures a black ash tree.

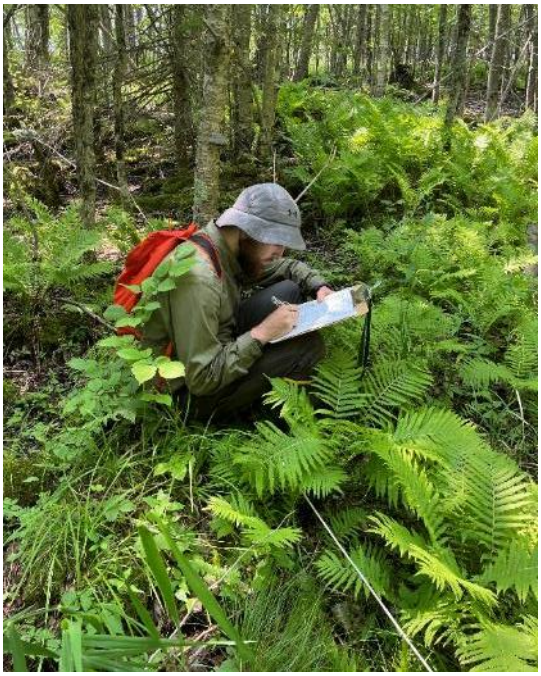
Black ash (Fraxinus nigra), most often found in northern swamps, bogs and riparian forests (those near lakes or rivers), is the most highly preferred and vulnerable host the emerald ash borer has encountered in North America. While timber value is minimal, black ash plays critically important ecological roles and is also a major cultural resource for many Native American and First Nation tribes.

This summer, we continued efforts to evaluate conditions in Michigan forests where black ash represented a dominant or codominant overstory species. More than 25 post-invasion forests in the Lower Peninsula were surveyed in 2020. In 2021, we focused on the Upper Peninsula. Ten black ash sites across nine counties were identified. We recorded size, density and condition (live, dead) of black ash and other overstory trees and density and species of regeneration (recruits, saplings, seedlings, stump sprouts) and quantified fallen logs and other coarse woody debris.

Virtually all black ash overstory trees examined in 2020 in the Lower Peninsula were dead, along with most overstory black ash in the eastern U.P. sites. However, in sites in the central and western Upper Peninsula, more than half of the black ash overstory trees were alive in 2021.

Many of the live black ash trees have healthy canopies, while others have been colonized by EAB and are declining. In the eastern Upper Peninsula, sites where most of the black ash overstory is dead, healthy black ash seedlings were present and often abundant. In contrast, black ash regeneration was generally low in sites where most black ash overstory trees are alive. A few sites had dense herbaceous vegetation that probably limited germination or survival of ash seeds. Herbaceous vegetation was generally comprised of native species, and we observed no evidence that invasive plant species had colonized sites.

We are continuing to collaborate with USDA Forest Service personnel in Minnesota and New Hampshire who are collecting similar data in newly invaded black ash forests or in areas where EAB densities are now peaking. Collectively, our results will provide valuable information on black ash ecosystems along a continuum of EAB invasion and the long-term prospects for this unique forest type.



Marshall Weimer of MSU records data at a black ash site.

Long-term impact of beech bark disease on forest conditions in Michigan

Nick Zoller, Deborah G. McCullough

Beech bark disease, BBD, is an invasive pest complex that includes a tiny, sap-feeding, beech-scale insect and a fungus that kills the phloem, or inner bark of the tree.

Beech scales feed by penetrating the outer bark with their mouthparts, then sucking nutrients from cells in the inner bark. While beech scale does not transmit the fungus, each scale creates a wound in the bark that provides an entry point for the fungus. Once trees are infected by the fungus, branches and eventually the trunk can be girdled and killed. Additionally, strong winds can cause live, but infected, trees to break, a condition known as beech snap.

Beech scale was detected in Michigan in 2000, near Ludington in the Lower Peninsula and north of Newberry in the Upper Peninsula. We established plots in 62 sites in 2002-2003 to monitor BBD progression and impacts over time. Only a portion of the sites had beech scale, and there was no evidence of BBD-related mortality in 2003. These sites were revisited in 2012, and beech scale had significantly spread in both the Upper and Lower peninsulas. Beech trees had begun to die in the U.P., but there was little mortality in lower Michigan. High densities of beech saplings, known as beech thickets and an unwanted side effect of BBD-related mortality in the northeastern U.S., were rare.

A researcher measures and collects data on a beech tree.

In June 2021, we began revisiting these same 62 sites to assess current stand conditions. We surveyed 19 of the original 28 sites in the Lower Peninsula. Beech scale was present in 18 of the 19 sites in 2021, compared to nine sites in 2003 and 15 sites in 2013. We assessed beech scale presence and density, recorded overstory trees by species and condition, and quantified regeneration and coarse woody debris. There was no evidence of BBD-related beech mortality. We expect to encounter substantial beech mortality and perhaps relatively fresh down beech logs, especially in the U.P., when we survey the remaining 43 sites in 2022.

Managing emerging insect pests of chestnut in Michigan

Max Ferguson, Deborah G. McCullough

A long-nosed female chestnut weevil perches on a nut husk.

Chestnuts, which are eaten fresh and processed into products such as gluten-free flour, are a high-value specialty crop. While most chestnuts consumed in the United States are imported from Asia and Europe, Michigan is the largest producer of chestnuts in North America. Additionally, many landowners have planted chestnuts as a source of hard mast for wildlife. Unfortunately, as chestnut acreage expands, so do pest-related problems.

Chestnut weevil is a native insect with larvae that feed inside of and destroy chestnuts. The small, whitish grubs emerge from nuts in fall and burrow into the soil, where they may spend one to three years before pupating and emerging as adults, either in spring or in late summer when chestnut burrs are growing. Adult females insert their long snouts into burrs, feed on a nut, then turn around and lay up to six eggs in the developing kernel. If infested nuts are harvested and sold, larvae are likely to emerge on countertops or in cabinets, leading to unhappy consumers.

A weevil larva emerges from a chestnut.

In 2021, we continued research to identify adult emergence from soil and behavior. We conducted trials in the lab to assess attraction of adult female and male weevils to specific volatile compounds associated with chestnuts. Lures with attractive compounds will be tested in traps in the field in 2022. We are continuing studies to identify post-harvest treatments to kill young weevil larvae without damaging nut quality. The standard treatment, which involves submerging nuts in water heated to 120 degrees Fahrenheit for 20 minutes, substantially reduced larval survival, but about 15% of the larvae still emerged in 2020 trials. We are also evaluating use of entomopathogenic nematodes, or tiny worms that can kill larger insects, that could potentially act as a biocontrol for immature larvae in soil. Lab and field studies will continue in 2022.

We continued tracking the spread of the invasive Asian chestnut gall wasp, first detected in 2015 in Berrien County. High densities of galls can substantially reduce chestnut yields and tree growth. Sticky cards to capture tiny adult wasps and visual surveys indicate the wasp is now established in nine counties. Gall dissections indicate a highly effective introduced parasitoid of wasp larvae is also spreading, but more slowly than the wasp itself. Monitoring will continue in 2022.

Post-treatment assessment of hemlock trees following insecticide treatment to control hemlock woolly adelgid

Justin Keyzer, Deborah G. McCullough

Major efforts to control and contain hemlock woolly adelgid infestations continue in the western Lower Peninsula, where this invasive, tree-killing pest was first detected in 2010. Systemic insecticides, primarily imidacloprid applied via soil drench, have been widely used in the eastern United States for years to protect hemlock trees, forests and entire watersheds. We established studies in 2016/2017 and 2018/2019 to assess rate, level and persistence of HWA control resulting from imidacloprid, dinotefuran or a mix of both products applied with trunk injection or basal trunk sprays.

Canopy condition of 140 trees, including untreated controls, was visually assessed in December and June from 2018 to 2021. Results indicate dinotefuran controlled HWA within two to three months of application. Imidacloprid treatments, however, had little effect on HWA until at least eight to nine months post-treatment. Canopy condition of most imidacloprid and control trees declined substantially in 2018-2019, but many trees appeared to be recovering in 2020.

Light meters used to measure forest sunlight levels.

Trees treated with dinotefuran sustained less HWA injury and recovered more quickly than imidacloprid-treated trees. Trees exposed to full or nearly full sunlight also appear to be recovering better than fully shaded trees.

Insecticide residues in needle and twig samples collected in 2020 from the 140 trees were quantified by collaborators with the USDA Animal and Plant Health Inspection Service's Plant Protection and Quarantine program using enzyme-linked immunosorbent assays, or ELISA. Analysis is ongoing, but preliminary results show imidacloprid accumulates in foliage, while residues are consistently much lower in woody twigs. Imidacloprid residues appear to persist at levels sufficient to control HWA for at least four years, but dinotefuran residues were very low two years post-treatment. Residues in the same samples were also quantified using high-performance liquid chromatography/mass spectrometry.

Evaluation of these results will enable us to assess persistence of imidacloprid parent material and specific secondary metabolites that have insecticidal properties.

Michigan State University – Sakalidis Forest Pathology Lab

Caliciopsis canker disease in Michigan's forests

Rebecca J. Harkness, Monique L. Sakalidis

Red cankers on white pine wood. Photo via Rebecca Harkness.

Best known as Michigan's state tree, eastern white pine is a substantial economic and ecological resource throughout its native range. Recent USDA Forest Service surveys indicate at least 109 million white pines grow in Michigan. However, this iconic tree can be found from Minnesota to Maine and southeastern Canada to Georgia.

The white pine is a valuable timber species and an integral component of many forest cover types, contributing to biodiversity and wildlife habitat. In the last several decades, there have been increasing reports of declining white pines throughout its native range. Lower branch death, needle browning and even mortality in saplings have been observed. Many of these symptoms are characteristic of Caliciopsis canker disease.

Caliciopsis pinea causes this disease, known as CCD, on eastern white pine. It is considered a native fungal pathogen that is thought to be emerging due to chronic stressors impacting forest trees.

This fungal pathogen infects white pines through natural and artificial openings in the tree, causing sunken red cankers to form on the trunk and branches, pitching and profuse resin bleeding, and flagging that can evolve into complete crown dieback. The pathogen forms distinctive fruiting bodies that assist with field identification. Surveys by the Sakalidis lab have identified *C.* pinea fruiting bodies on white pines in 21 out of 28 surveyed counties in the state, in both the Lower and Upper peninsulas. These findings suggest a fairly ubiquitous distribution of the pathogen, with disease occurring more often on poor-quality or stressed sites.

Caliciopsis fruiting body at 50 times magnification. Photo via Rebecca Harkness.

Current research at MSU is focused on determining the timing of C. pinea sporulation, or when it forms spores. Spore traps were deployed in nine field sites across five states, and samples were collected weekly to determine the temporal and environmental factors influencing spore release. This can help inform management practices.

We also have discovered Caliciopsis-like fruiting bodies and small cankers on additional softwood and hardwood hosts. Work is ongoing to identify these fungal species and assess the risk they pose to our forest trees.

Oak wilt – stump colonization and root transmission

Pedro Pablo Parra, Monique L. Sakalidis

Bretziella fagacearum is the fungal pathogen responsible for the oak wilt disease. It is present in 61 Michigan counties and kills thousands of oaks every year. The pathogen spreads with the help of sap-feeding beetles and through the root system when nearby oaks are root-grafted.

An endoconidial suspension of Bretziella fagacearum was applied to the stump.

Root transmission of the oak wilt pathogen makes up about 95% of new tree infections in existing disease epicenters. This is not only the most important short-range pathway of spread, but also the stage of the infection cycle where management strategies would be most efficient in stopping the pathogen from spreading. Currently, management strategies focus on disrupting the root system and limiting the movement of the pathogen within disease epicenters, but implementing these strategies still presents limitations.

To determine whether the oak wilt pathogen can colonize the roots of stumped trees and spread to adjacent healthy trees, we set up an experiment in fall 2021. Trees were felled, and a 20- to 60-centimeter stump was left. Subsequently, the exposed tissue was inoculated using different endoconidia counts of the pathogen (1 million, 100,000 and 100 endoconidia per 100 milliliters). Stumped trees that were inoculated and control trees were sampled, and adjacent trees were monitored for the development of oak wilt symptoms every two weeks. Through November 2021, the pathogen has not been recovered from sampled tissue. Sampling will resume in spring 2022, and it will inform whether the pathogen was able to colonize the exposed tissue and to move to adjacent trees. Additional and ongoing oak wilt research in the Sakalidis lab includes refining overland spread risk periods and evaluating the effectiveness of alternative tactics for root disruption to reduce the expansion of oak wilt infection. We are also studying how growth regulators may induce anatomical changes that can be used as a prophylactic treatment to protect healthy trees near newly infected oaks.

Two core samples were taken per stump and transported to the lab, surface-disinfected and plated.

Michigan Technological University – Bal Forest Health Lab

Beech bark disease resistance and experimental plantings

Andrea L. Meyers, Tara L. Bal

Beech bark disease, known as BBD, is an invasive disease complex that continues to significantly impact beech trees in Michigan. Actions to mitigate BBD focus largely on the production of scale-resistant trees through breeding and grafting programs, with many agencies in Michigan involved in efforts to increase production of resistant seed.

Michigan Technological University began work to establish a grafting program in 2017 in collaboration with the National Park Service at Pictured Rocks National Lakeshore and Sleeping Bear Dunes National Lakeshore in Michigan.

We are working to increase rates of production of grafted BBD-resistant beech through multiple lines of inquiry. By exploring transplanting wild beech regeneration, we aim to support a more consistent raw material supply (young trees for rootstock), and optimum modes of planting out grafted trees. Successful transplant methods and rates of survival for American beech are not well documented in modern scientific literature.

Wild beech seedlings for an experimental planting.

We've successfully maintained wild young beech trees as containerized seedlings. An experimental planting trial was established in 2021 at the Ford Forest in Alberta, Michigan, to explore the conditions optimal for interplanting American beech directly within northern hardwood forests as seed orchards, rather than on more open fields. These trees are transplanted from wild origin and display similar vigor and survival rates as bare-root, orchard-originated trees.

Trees will be planted at different times of the year, and varying levels of site prep will be evaluated. The results of this trial will inform planting and site prep activities for restoration using BBD-resistant American beech. This is slated to occur in the national lakeshore properties over the next few years.

Northern oak wilt monitoring

Tara L. Bal, Sharon Reed – Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry

Forest health expert Simeon Wright demonstrates finding an oak wilt pressure pad to students in Dr. Bal's forest health

The current range of oak wilt stops near the 46th parallel in Michigan, Wisconsin and Minnesota, although infected trees were first detected in the 1980s along the Wisconsin-Michigan border. Since then, confirmed oak wilt has not expanded across the Upper Peninsula despite local wood movement, presence of native vectors and host trees. Susceptible hosts and vectors are also in northern Ontario, where the disease has not yet been detected.

The lack of northern expansion may indicate poor overlap between timing of host/pathogen/vector life cycles. Environmental factors controlling timing are being impacted by climate change, potentially increasing the risk of oak wilt expansion farther north.

During the spring and summer of 2021, a multiyear project was begun to evaluate timing and relationships between hosts and vectors (nitidulid beetles) potentially limiting northern expansion of oak wilt, with one known oak wilt site near Crystal Falls and uninfected sites across the Upper Peninsula (near Twin Lakes, Gwinn and Naubinway), Ontario (Sault Ste. Marie, Toronto and Guelph), New Brunswick (Fredericton) and Manitoba (Winnipeg).

Weather stations were installed in oak stands to monitor air and soil temperature and moisture variables. Sites were visited on a rotational basis to trap and monitor nitidulid beetles using pheromone baits and bread-dough traps, as well as beetles visiting to artificially wounded oak trees. In Michigan in 2021, we captured 672 nitidulids representing 15 species. In one season of data thus far, all Michigan sites had nitidulids in traps and in wounds. Canada, which also ran a trap comparison study, had more than 16,000 beetles representing 27 species. Not all Canadian locations had beetles visit wounds. The study will be repeated next year. Continued data analysis and future research will allow us to evaluate nitidulid species' wound use and relationships between temperature and other environmental variables in oak stands further north than the current range of oak wilt, to better predict future spread risk.

Canadian collaborators include J. Sweeney and C. Hughes (Natural Resources Canada, Canadian Forest Service, Atlantic Forest Center, Fredericton, New Brunswick), F. Ross (Manitoba Agriculture and Resource Development, Forestry Branch, Winnipeg, Manitoba) and J. Llewellyn (Ministry of Agriculture, Food and Rural Affairs, Economic Development Division, Guelph, Ontario). The Michigan Department of Natural Resources and American Forest Management, Inc. provided sites in Michigan.

Project funding from: USDA Forest Service Evaluation Monitoring Program, Michigan Technological University, SERG International, Canadian Food Inspection Agency, Natural Resources Canada, Manitoba Agriculture and Resource Development, and Ontario Northern Development, Mines, Natural Resources and Forestry.

Sugar maple dieback evaluation: 10-plus years later

Tara L. Bal

A European Lecanium scale insect found on a sugar maple twig.

Variable sugar maple dieback, crown loss, or decline levels continue to be reported across the upper Great Lakes region. In 2009-2012, we evaluated stands with dieback symptoms and found forest floor disturbance and associated impacts due to exotic invasive earthworms strongly correlated with sugar maple crown dieback.

We now are doing a follow-up study 10 years later to monitor changes in maple crown conditions over this time and to continue to understand factors associated with maple dieback/decline. Ultimately, our goal is to better characterize factors associated with maple dieback to develop tools to aid forest managers in making decisions to mitigate risk.

Previously, a network of 120 plots were established on public and private lands in northern Michigan, northern Wisconsin and eastern Minnesota. During the 2021 field season, 79 plots (about 65%) were revisited, with the remaining field sites planned for 2022.

Variables being measured include tree and canopy conditions, regeneration/herbaceous/invasive plant species abundance, browse impacts on understory, and potential biotic factors including sugar maple borer, cankers or diseases, defoliators, and European Lecanium scale, which has recently had outbreaks reported in maple hardwoods throughout the region. Earthworm species assemblages are being determined, along with rating their impacts to the condition of the forest floor.

Average sugar maple dieback continues to be variable, with a range of 1 % to 68 % in plots, averaging 11.8 %. Only 12 of 79 plots (15%) had no earthworms sampled or evidence of impacts to the forest floor. Generally low population levels of scale were seen, but Lecanium scale, cottony maple scale (Pulvinaria innumerabilis) or both were found in 55 of 79 plots (60%) surveyed so far. With the first of two planned seasons of field sampling completed, we will finish revisiting plots next year and work with collaborators to identify new areas of apparent sugar maple dieback or decline to evaluate.

If you have regions or stands with significant dieback that we may be able to investigate, please email tlbal@mtu.edu.

Graduate student Shelby Lane-Clark uses an arborist pole to sample a branch from a sugar maple canopy to survey for invasive scale insects.

Resources

Keeping up to date on the many issues affecting forest health can be difficult, but technology has made access to life-long learning much easier. Below is a list of resources for those interested in learning more about forest health or natural resource issues.

Further learning

1) **Michigan State University Extension Natural Resources Section**: Provides webinars, classes, articles and publications. Sign up for a newsletter to stay informed. MSU Cooperative Extension, or MSUE, has 75 additional subjects to learn about, including invasive species, fisheries and wildlife, water quality and youth activities.

2) **EAB University**: A resource for recorded and live webinars covering emerald ash borer-related topics and other invasive tree pests. Visit EAB University.

3) **Not MI Species**: The Michigan Department of Environment, Great Lakes, and Energy has partnered with the departments of Natural Resources and Agriculture and Rural Development to provide information on invasive species in Michigan. The NotMISpecies webinar series explores how organizations work together to protect Michigan's natural resources.

4) **Webinar portal**: The Forestry and Natural Resources Webinar Portal provides a look at issues affecting southern forests that potentially could affect forests in the Great Lakes region.

5) The **Ohio State University Woodland Stewards Program** maintains a series of recorded forest health-related webinars of interest to the Great Lakes region. Check out Ohio Woodland Stewards Program webinars.

6) **Midwest Invasive Species Information Network**: This resource, hosted by Michigan State University and known as MISIN, is a regional effort to develop and provide early detection and response resources for invasive species. Professionals and community scientists can learn about invasive species and download an app to report sightings.

7) The **Michigan DNR forest health webpage** shares insect and disease threats to Michigan's forests. The DNR forest health webpage includes online interactive maps, the annual Forest Health Highlights report and a wealth of other information.

8) **The Michigan Department of Agriculture and Rural Development** establishes plant and pest quarantines to prevent movement of invasive species into Michigan and to or from affected counties.

Reporting

If you believe you've found an invasive species, please use one of the reporting options below:

Midwest Invasive Species Information Network

- Report sightings through the MISIN website or submit through the mobile application.

Michigan Department of Agriculture and Rural Development

- Email MDA-Info@Michigan.gov or call the MDARD Customer Service Center at 800-292-3939.

Michigan DNR Forest Health Team

- Email about suspected sightings, with photos, to DNR-FRD-Forest-Health@Michigan.gov.
- View and report oak wilt locations using our interactive oak wilt map.
- View and report Heterobasidion root disease locations using our interactive HRD map.

Contact and acknowledgements

Contact

Michigan Department of Natural Resources
Forest Resources Division, Forest Health Program
DNR-FRD-Forest-Health@Michigan.gov

U.S. Department of Agriculture
Forest Service
Eastern Region
State and Private Forestry
626 East Wisconsin Ave.
Milwaukee, WI 53202
FS.USDA.gov/naspf

Forest Health Protection
Eastern Region
State and Private Forestry
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Morgantown, WV 25305
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Scott Lint, center, with colleagues early in his career.

Scott Lint retires: The end of an era

"What would Scott do?" is a common catchphrase among the DNR's oak wilt management staff, a testament to forest health specialist Scott Lint's impact and devotion to passing on his knowledge of forest health issues to others.

Scott retired in 2021, completing a changing of the guard in the Michigan DNR's Forest Health Program, which began in 1979 with regional forest pest specialists Ron Murray and Bob Heyd. The program then added Frank Sapio and Roger Mech in the 1980s, followed by Scott in 2012.

Scott initially worked with the Forest Health Program in 1981 as a seasonal forest pest scout. He spent long hours battling deer flies and inclement weather while collecting data on jack and red pines, along with information on the impact of critters like the Saratoga spittlebug and jack pine budworm. This helped pave the way for the DNR's first comprehensive statewide forest regeneration database.

Scott, greatly influenced by Professor John Witter while attending the University of Michigan, was known as an excellent forest technician throughout his career. Scott was hired into the forest health program to assist with diverse projects including federal grants, forest management interaction and increasing demands to respond to new invasive forest pests. He quickly became a valued member of the team. His experience and reputation as a top-notch field forester, combined with his eagerness to learn, enhanced the program's interaction with field foresters and improved collaboration with Michigan's Forest Inventory Program. In 2018 Scott was promoted to forest health specialist, and he became a leader and mentor for new program staff.

Scott became well versed in prevention, detection, suppression and management of many forest health issues including oak wilt, hemlock woolly adelgid, Heterobasidion root disease, white pine decline, emerald ash borer, bark beetle damage and more. Over the years, many new confirmations of forest health issues occurred due to Scott's efforts. Scott was the program's primary aerial surveyor, logging countless hours in the airplane and coordinating mapping of forest damage across more than 20 million acres each year. He also assisted in hazard tree training, primarily for the DNR's Parks and Recreation Division and in state forest campgrounds.

The forest health program greatly appreciates Scott's many contributions and willingness to be the bridge between the old guard and new staff. Michigan's forests are better off due to his efforts, and his presence will be missed in years ahead.

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(1) Mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue SW, Washington, D.C. 20250-9410; or
(2) Fax: (833) 256-1665 or (202) 690-7442; or
(3) Email: program.intake@usda.gov.