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Protecting Michigan's Hemlock Resource by Responding to Hemlock Woolly Adelgid

A Coordinated Statewide Strategy

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Drafted by the HWA Coordinating Committee

John Bedford, Pest Response Program Specialist
Robin Rosenbaum, Plant Industry Section Manager
Michigan Department of Agriculture and Rural Development (MDARD)

Sue Tangora, Forest Health Section Manager
Roger Mech, Forest Health Specialist
Michigan Department of Natural Resources (MDNR)

Deborah McCullough, Professor
Departments of Entomology and Forestry, Michigan State University

Melanie Manion, Natural Resource Management Supervisor
Ottawa County Parks and Recreation

Carol Young, Forest Silviculturist
USDA Forest Service, Huron-Manistee National Forest

Therese Poland, Research Entomologist
USDA Forest Service, Northern Research Station

Steven Katovich, Forest Entomologist
USDA Forest Service, State & Private Forestry

Executive Summary

Hemlock woolly adelgid (HWA; *Adelges tsugae* Annand) is an invasive insect that has destroyed eastern (*Tsuga canadensis* (L.) Carrière) and Carolina (*T. caroliniana* Engelmann) hemlocks in much of their North American range. Since the first detection of HWA in Virginia in the mid-1950's, HWA continues to spread into uninfested regions of New England, central New York, parts of the Southeast, and the upper Midwest. As of July 2017, HWA has been detected in four counties in western Michigan (Allegan, Muskegon, Oceana, and Ottawa) which poses a severe threat to the 173 million hemlocks across the state. There is still time to significantly slow the spread and locally eradicate HWA to ensure hemlock remains viable in Michigan. We propose a statewide coordinated response using a network of partners to prevent and detect HWA, manage and use field-collected data, implement insecticide treatments, conduct research, and establish long-term funding mechanisms to maintain hemlock in Michigan.

There are reasons to be optimistic; relative to infestations in the eastern U.S., Michigan's colder climate may help suppress HWA spread in northern Michigan. Insecticide treatments appear to work well, especially if coordinated in a strategic manner. Also relative to many parts of the hemlock range in the eastern U.S., hemlock makes up less of Michigan's forested landscapes than it did historically, all of which may reduce HWA spread.

Michigan's HWA infestation is an opportunity to advance creative solutions to optimize a coordinated response from government, non-profit, commercial organizations and the public. Michigan needs strong leadership to coordinate the many partners and activities that can collectively reduce the spread and impact from HWA. Private landowners are needed to help, demanding targeted public outreach, education, and engagement when implementing this plan. Additionally, research such as the development of models of state-wide hemlock occurrence, HWA spread, and the potential environmental and economic consequences of various management alternatives are needed to inform decision-making. The Michigan HWA Coordinating Committee recommends a state-wide response which will require an increase in resources such as staff and funding to be directed toward the problem. It is recommended that the Incident Command System (ICS) be applied as the governance structure for the network of partner organizations to help respond quickly and efficiently, and that the following key actions be implemented now:

- Prevent HWA by maintaining, enforcing, and updating as needed existing internal and external state quarantines that will limit the likelihood of moving infested nursery stock and cut hemlock materials;
- Detect HWA populations by developing and implementing a HWA survey plan, including designation of highest priority survey areas;
- Manage and use field data via a GIS-based HWA data management system that provides a common platform for data and information sharing, enhances work flow and decision-making and improves coordination and communication between partners;

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- Implement insecticide treatments of HWA to the greatest extent possible with highest priority to slowing the spread, regardless of land ownership;
- Conduct research via partnerships including hemlock models, climate-based HWA dispersal models, and consequences of treatment and restoration alternatives, including not coordinating treatments; and
- Establish long-term funding mechanisms adequate to achieve the goal and objectives of this plan.

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Introduction

Michigan forests have been profoundly altered by the introduction, establishment, and spread of invasive forest pests such as emerald ash borer (*Agrilus planipennis* Fairmaire) and the beech bark disease complex. The recent detections (2015-2017) of hemlock woolly adelgid (HWA; *Adelges tsugae* Annand) infestations represent another significant threat, this time to eastern hemlocks (*Tsuga canadensis* (L.) Carrière) throughout the state. Current HWA populations in Michigan encompass a relatively small area along the Lake Michigan shoreline in the southwest portion of the Lower Peninsula. As of May 2017, surveys have detected the pest in only four counties in western Michigan (Allegan, Muskegon, Oceana, Ottawa) on private and public land including the following state parks: Silver Lake, Duck Lake, Muskegon, P.J. Hoffmaster, and Holland. Treatment methods are available now to slow the spread of HWA, providing time to progressively improve management techniques, including the use of bio-control. Ensuring the persistence of hemlock in Michigan calls for a statewide response, using a network of partners to prevent and detect HWA, manage and use field-collected data, implement insecticide treatments, conduct research, and establish long-term funding mechanisms to maintain hemlock in Michigan.

Partnerships must be created to leverage funding and expertise. Coordinating these partners will require leadership that is willing to work across jurisdictional boundaries to implement treatment strategies. The most effective response will require collective action, demanding targeted public outreach, education, and engagement when implementing this plan. Finally, research is needed to inform decision-making, such as the development of models of statewide hemlock occurrences, HWA spread, and the environmental and economic consequences of various management alternatives. Adequate leadership from the State will require increased resources in the form of staff and funding to be directed toward the problem.

This plan sets priorities within three phases of response. Phase 1 are urgent best practices to immediately coordinate the control of HWA, including prevention, detection, data management, treatments, critical population models, and establishing reliable funding. Phase 2 emphasizes long-term management of HWA by contributing to the advancement of bio-control. Phase 3 develops research to inform the long-term conservation of forests where hemlock is a foundation species.

The Resource at Risk

More than 173 million eastern hemlock trees grow in Michigan forests (USDA Forest Service, Forest Inventory and Analysis) and thousands more have been planted in landscapes throughout the state. While hemlock trees are most abundant in the forests of the northern Lower and Upper Peninsulas, they are locally common throughout the state in private woodlots, game management areas, and public parks and recreation areas. Hemlocks are some

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of the oldest living trees in Michigan's forests, with some individuals exceeding 300 years old. Old-growth hemlock trees are an important part of the forested landscape at several of Michigan's most iconic natural areas such as Tahquamenon Falls, Hartwick Pines, the Porcupine Mountains, and Sylvania Wilderness.

Dense hemlock canopies provide deep shade, critical winter cover, food and habitat for many bird, mammal and aquatic species. This includes white-tailed deer, migrating and nesting songbirds, and key habitat for some rare mammals such as fishers and pine martens.

In parts of Michigan, yards and landscapes often include hemlocks, especially in communities along the Lake Michigan and Lake Superior shorelines and in rural settings across the Upper and northern Lower Peninsula. Additionally, Michigan has an active hemlock nursery industry that will be heavily impacted by the damaging effects of HWA if action is not taken to slow its spread.

The Threat – Hemlock Woolly Adelgid

HWA is a tiny aphid-like insect native to Japan and has long been on Michigan's list of "most unwanted" invasive forest pests. HWA feed on needle-bearing shoots of eastern hemlock, damaging needles and stimulating a hypersensitive response that interferes with water translocation and photosynthesis, resulting in bud and needle mortality and generally death of the host tree within 4-10 years of infestation. Since HWA was reported in Virginia in 1951, hundreds of thousands of hemlock trees in the eastern U.S. have died.

Recent research has shown the economic costs of HWA in the U.S. amount to more than \$200 million annually, primarily due to decreased property values and costs of treating or replacing hemlock in landscapes. In the northeastern U.S, hemlock mortality following the HWA invasion has affected soil temperature and altered decomposition and nitrogen cycling, resulting in major changes in forest structure and dynamics. Dead trees in riparian areas where hemlock often grow result in increased erosion, higher water temperatures and reduced water quality, with subsequent changes in aquatic invertebrate communities and fisheries.

HWA has a complex life cycle that includes two generations per year. All individuals are female and reproduce by parthenogenesis. The ability to reproduce without finding mates facilitates HWA establishment and population growth. Each adelgid can produce an estimated 22-75 eggs to 49-300 eggs per female by the spring-feeding and winter-feeding generations, respectively. White waxy ovisacs (i.e., the 'wool') are secreted as the adelgids feed, providing protection from desiccation and natural enemies. No known parasitoids attack HWA and native predators have negligible effect on HWA populations in the eastern U.S. Biocontrol efforts began in 1995 with various non-native insect predators, however none have demonstrated measurable or consistent HWA suppression to date.

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Several HWA infestations were detected in 2015-2017 on predominantly private land near the Lake Michigan shoreline in Ottawa, Muskegon, Allegan and Oceana Counties. These infestations appear to have been initiated by hemlock nursery trees imported from infested eastern states prior to, or in violation of the external quarantine imposed by the state of Michigan in 2001.

The Likelihood of Success

Currently infested areas in Michigan are still relatively small with most of the hemlock range in the state still un-infested. However, slowing the spread of HWA becomes increasingly more difficult as populations spread unchecked. Viable treatment methods do exist and can be implemented over a broad scale within the known infested sites. Further, this insect appears to be susceptible to winter mortality and colder temperatures in Michigan. It is possible that some of Michigan's forests could be suboptimal for HWA survival.

Coordinated detection, treatment, and regulatory efforts should substantially slow the movement of HWA outside of the known infested counties. This would provide time for the evaluation of more long-term integrated management tactics such as biological control and the development of resistant or tolerant trees before HWA spreads further. It would also allow time to fully evaluate the threat HWA poses to hemlock trees in colder parts of the state and potential restoration alternatives.

Coordination

Hemlock trees are found growing on public, tribal, industrial and private lands in Michigan. The current infested sites are primarily located on private properties, but more extensive hemlock stands are present across Federal, Tribal, State and County lands, particularly in northern Lower and Upper Michigan. Therefore, a coordinated effort by many partners will be required to effectively limit the spread of HWA in Michigan.

Objective – Implement a coordinated local and statewide response effort against HWA.

- Identify, coordinate, and find efficiencies with all partners to expand prevention, detection, and treatment efforts to the greatest extent necessary.

Communication

Communication is critical for the successful implementation of this HWA Response Plan. Many agencies, partners and private citizens will be tasked with implementing this plan and the timely transfer of accurate information is vital. A solid awareness campaign will solicit support

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for the strategies outlined. Maintaining that support will depend on continued messaging and updates on progress.

Objective – Increase communication to more partners in a clear and coordinated fashion about all aspects of the HWA response effort including private residents, land managers, public officials and others.

- Apply Incident Command System as the governance structure for the network of partner organizations;
- increase staffing capacity, including establishing a full-time HWA coordinator;
- assemble a HWA communications team to coordinate key messages;
- develop a process for communicating to the network of partners;
- provide a clearing house on the internet for all information related to HWA response in Michigan;
- annually report on accomplishments of actions taken by the HWA Coordinating Committee and partners;
- increase outreach efforts beyond currently infested counties to increase participation in early detection and reporting; and
- develop press releases, talking points and briefing papers to communicate actions and highlight milestones.

Objective – Quantify and communicate the impacts from HWA, including economic and ecological, to a variety of audiences to raise awareness of the threat posed by HWA and the multiple values of hemlock trees.

- Collaborate with non-government organizations, units of government, academia and industry/trade groups to develop and target outreach to specific audiences;
- develop cost analysis of actions taken to address HWA versus no action;
- develop new and use existing outreach tools such as presentations, social media, displays, videos, and printed media;
- provide resources for teachers and non-formal educators to share with schools and youth groups; and
- develop metrics to track and measure success of outreach efforts.

Prevention

HWA can be moved into new locations via a variety of routes including infested nursery stock, cut hemlock boughs, and on the feet and feathers of birds. Some of these routes are more easily addressed than others. Natural spread of HWA is known to be about ten miles per year. Accelerated spread from people can be addressed by reducing movement of HWA by various pathways such as nursery stock, and landscaping activities.

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Objective – Prevent further movement of HWA to areas where it is limited or non-existent.

- Continue to maintain, enforce, and update as needed the existing external and internal state quarantines to prevent new introductions and movement of HWA in the state;
- maintain a nursery program that will allow growers and dealers of hemlock nursery stock within the quarantine area to continue to grow, sell and distribute hemlock nursery stock out of and within the quarantine area in a manner that prevents the spread of HWA;
- include information on HWA quarantines as a regular component of education and outreach activities;
- identify and immediately address additional pathways of spread;
- pursue listing HWA as a prohibited species in NREPA Act 451 of 1994, Section 324.41301.
- develop and distribute guidance on the best available options to prevent spread; and
- direct messaging on prevention at the most likely pathways.

Detection

In addition to preventing further spread of HWA, detailed information is required about where HWA already exists. Surveillance data must provide information that collaborators need to develop the best management alternatives for the current HWA distribution.

Partners also need the most cost-effective and coordinated surveillance methodology. Field surveys can be made most efficient and statistically sound by modelling where hemlock is located and how HWA is likely to spread under various scenarios. Finally, survey plans must be dynamic and adaptable as additional information becomes available.

Objective - Develop a stratified, risk-based approach to conducting HWA early detection surveys. Use this to identify high priority survey areas.

- Form a survey unit within the planning section of the ICS structure that will develop a stratified risk-based HWA survey plan that can be adjusted based on the evolving HWA situation in Michigan. Designate high priority areas for HWA survey.

Objective – Develop HWA early detection survey protocols that can be shared with partners and easily implemented in the field.

- Develop survey protocols and provide training on the protocols to partners and cooperators.

Objective - Identify and train partners who can assist in conducting HWA surveys both in the high priority areas and throughout the state.

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- Develop and implement a survey program that can include participation from a variety of partners and cooperating agencies.

Data Collection and Management

A large amount of information on HWA surveys and treatments will be generated by partners in the coming years. To track progress, make strategic decisions, and establish transparency in decision-making, this information must be organized and made widely available. Metrics should be established and progress tracked to keep partners in agreement and to retain accountability. Monitoring of progress allows necessary adjustments to be made and enables appropriate changes to priorities and objectives as situations change.

Objective – Develop and maintain a GIS-based HWA data management system that provides a common platform for data and information sharing, enhances work flow and decision-making and improves awareness, coordination and communication between partners.

- Identify a HWA data liaison for each partner agency as the point of contact for interagency data communications;
- expand the Midwest Invasive Species Information Network (MISIN) to accommodate both HWA detection and absence, as well as a hemlock health assessment survey; and
- coordinate with the DNR Resource Assessment Section (RAS) to:
 - develop and maintain spatial data layers associated with HWA surveys, treatment tracking and other activities, including accessibility through the DNR’s online Open Data Portal;
 - develop standardized map templates to display local, county and statewide HWA survey, treatment, and quarantine status;
 - develop an ArcGIS Online (AGOL) data collector app for field surveys, treatment activities; and
 - include QA/QC mechanisms to ensure data integrity (e.g. reports from trained observers vs. untrained observers).
- Work with MISIN and DNR RAS to ensure that all HWA data meet spatial data standards for GIS;
- coordinate HWA training activities between cooperators to ensure proper data collection protocols and procedures are included; and
- disseminate information appropriately to all stakeholders.

Insecticide Treatments

Known HWA infestation locations vary in intensity from those with a few lightly-infested trees to those with dozens of trees that are heavily-infested. HWA is capable of rapid population

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increases if left untreated, increasing the likelihood that HWA will expand. Viable insecticide treatment options are available and are described in MSU Extension Bulletin E-3349. Insecticide treatments should be directed where they will most likely result in slowing the spread in Michigan.

Objective - Keep infested areas as small and isolated as possible for as long as possible with an initial focus on strategic areas.

- Coordinate insecticide treatments to most effectively slow the spread in Michigan by working with all landowners necessary. If funding resources are available, treat all known infested trees as well as trees in surrounding buffer zones.
- update priority areas for treatment on a regular basis and as needed to accommodate newly detected sites;
- develop and distribute guidance for treatment to licensed pesticide application businesses and landowners who desire to conduct their own treatments;
- provide training opportunities for those conducting treatments;
- develop a 'Frequently Asked Questions' document regarding the potential side effects of HWA insecticides;
- collect and manage treatment data as outlined above in the Data Collection and Management section; and
- communicate with impacted property owners, both private and public, to encourage participation in local control efforts. Keep landowners apprised of the local status of HWA.

Objective – Evaluate and report on treatment successes or failures.

With a variety of treatment options available for HWA it will be important to gauge the relative effectiveness of the compounds used and application methods employed. The results of this analysis should be communicated to those conducting or considering treatments so that treatment protocols can be altered as needed to improve effectiveness, efficiency and environmental impact.

- A systematic sampling of trees treated with various compounds, combination of compounds, various application methods, various rates of application at various times of the year should take place to better determine what works the best;
- consideration should be given to identifying the most effective, least expensive and operationally efficient treatments;
- preference should be given to those application methods that minimize exposure to the environment of the compounds applied; and
- host condition and recovery as a result of treatment should be evaluated as part of any long-term treatment strategy.

Research

While information on the biology of HWA and the best management practices in combating its spread have been collected in the eastern United States, little is known about how HWA will respond in Michigan's climate. Temperatures in some parts of Michigan are colder in the winter and temperatures remain lower for longer compared to infestations in the eastern states. This may impact HWA directly or impact the effectiveness of potential biocontrol agents.

Objective – Identify at a local scale where hemlock trees grow in Michigan forests and urban landscapes.

- Develop a comprehensive hemlock resource map.

Objective – Further develop research via partnerships related to HWA and hemlock management that are relevant to Michigan.

Research needs exist, including the following:

- Model HWA persistence and spread throughout Michigan's hemlock region, as well as the environmental and economic consequences of various management alternatives, including costs of not coordinating HWA treatments;
- develop research partnerships to test how silvicultural treatments in Michigan, including thinning, may serve to moderate adelgid populations and increase hemlock survival;
- Systemic neo-nicotinoid insecticides are highly effective, but their use is limited by annual per acre restrictions. Research on alternative products, chemistries and pest control tactics, including entomopathogens, is needed;
- there is a need to develop effective methods to distinguish hemlock trees and assess tree condition using remotely sensed data or overlays of remotely sensed data and other spatial data sets;
- support research into eastern hemlock and hybrid hemlocks that may show HWA resistance;
- monitor for potential HWA resistant or tolerant hemlock trees;
- support National, Regional and State efforts to develop and maintain a viable resistance screening program for eastern hemlock trees;
- evaluate the release, establishment, recovery and impacts of the biological control agents;
- locate facilities where field insectaries of HWA predators can be reared if needed, and establish and maintain hemlock hedges at these locations;
- if biocontrol proves to be feasible, establish field insectaries for rearing predators; and
- develop alternatives to restore eastern hemlock forests.

Funding Opportunities

There is a need for both short and long-term funding sources for work related to saving hemlock and combating HWA. A rapid response to the existing HWA populations will require funds for capacity including treatments, surveys, outreach, and staffing. Longer term, HWA will continue to threaten hemlock, necessitating the development and implementation of a more integrated management strategy using multiple tools. Partners and cooperators in this program should be encouraged to seek and coordinate funding to address the objectives listed in this strategy document.

Objective - Obtain funding to develop and maintain a viable comprehensive program that limits HWA presence and impact in Michigan.

The HWA Coordinating Committee will

- identify potential funding sources and assist and coordinate key cooperators in applying for funds; and
- create and annually update a list of priorities that can be used to target funding opportunities;

Prioritization

Priorities are directly tied to the objectives listed above. To accomplish these objectives, a rapid and coordinated response will be needed. Items that need immediate attention are listed under Phase 1. Phase 2 and 3 items are less timely, but should be addressed to develop a long-term management strategy that is targeted at meeting our goal of ensuring hemlock remains viable in Michigan.

Phase 1 – Partners implement the following activities as soon as possible to slow the spread of HWA and limit the extent and intensity of the known infestations.

- Prevent HWA by maintaining, enforcing, and updating as needed existing internal and external state quarantines that will limit the likelihood of moving infested hemlock nursery stock and cut hemlock materials;
- Detect HWA populations by developing and implementing a HWA survey plan, including designation of highest priority survey areas;
- Manage and use field data via GIS-based HWA data management system that provides a common platform for data and information sharing, enhances work flow and decision-making and improves coordination and communication between partners;

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- Implement insecticide treatments of HWA to the greatest extent possible with highest priority to slowing the spread, regardless of land ownership; and
- Conduct research via partnerships including hemlock models, climate-based HWA dispersal models, and consequences of treatment and restoration alternatives, including not coordinating treatments; and
- Establish long-term funding mechanisms adequate to achieve the goal and objectives of this plan.

Phase 2 – Partners pursue a more integrated hemlock management approach within areas infested by HWA.

- Locate facilities where field insectaries of HWA predators can be reared if needed, establish and maintain hemlock hedges at these locations; and
- if biocontrol proves to be feasible, establish field insectaries for rearing predators.

Phase 3 – Partners invest in additional long-term efforts targeted at maintaining hemlock as a viable tree species in Michigan forests.

- Monitor for potential HWA resistant or tolerant hemlock trees
- support National, Regional and State efforts to develop and maintain a viable resistance screening program for eastern hemlock trees; and
- develop strategies to restore eastern hemlock forests.