UNIVERSITY OF GEORGIA
Warnell School of Forestry & Natural Resources

WSFNR-20-71A

HEMLOCK WOOLLY ADELGID
PowerPoint Presentation

Elizabeth McCarty[1] and Lynne Womack[2]

[1] *Warnell School of Forestry and Natural Resources, University of Georgia*

[2] *Georgia Forestry Commission*

The text in this document corresponds with the slides in Warnell Outreach publication WSFNR-20-71A, available via a separate download as a PDF presentation.

Slide 1

Hemlock woolly adelgid, also known as HWA, is an invasive insect that is killing hemlock trees in eastern North America. However, steps can be taken to conserve hemlock resources.

Slide 2

This presentation will cover hemlock forests, HWA biology, and hemlock management.

Slide 3

First, for a wider perspective, here is a world map showing the nine hemlock, or Tsuga, species. Notice on the left side of the map that there are five hemlock species in Asia, and on the right side of the map there are four hemlock species in North America. Two hemlock species are located in western North America, and two species are located in eastern North America. The eastern hemlock range is indicated by blue, and Carolina hemlock, which has a much smaller range, is indicated by the small red area. HWA has native populations in Asia and Western North America. However, in eastern North American the HWA population was introduced from a Japanese HWA population. Eastern North America is the area we will focus on for the rest of the talk.

Slide 4

What is the threatened resource? The focus of this presentation will be on eastern hemlock, as its range is much larger and the impact from HWA is much greater. Eastern hemlock has an extensive range from Canada south to northern Alabama and Georgia. Eastern hemlock occupies a very distinctive ecological niche, especially as it is a slow growing, long-lived evergreen species and is shade tolerant. In a hemlock forest there are varying sized hemlock throughout the hemlock canopy, creating layers of foliage throughout. Because hemlock are shade tolerant, the smaller trees lower in the canopy are not shaded out like many other tree species, thus, the layers of hemlock trees are found throughout the canopy. Hemlock is a keystone species. It provides and conditions the habitat in which it lives. Hemlock is also a late successional species, which means that it does not colonize disturbed habitats, but rather comes later in the development of a forest. Seeds are only viable in the soil for 2-4 years, so there is not a long window of time for regeneration from seeds in the seedbank. Plants and animals depend on hemlocks – from the top of the canopy to the streams flowing through hemlock forests. Unfortunately, hemlock has an ecological role that cannot be replaced by another native evergreen tree species.

Slide 5

There is a forest health problem, and it is the invasive HWA. Again, the population in the eastern United States is native to Japan. It was likely introduced in the 1920s into a private garden in Virginia, however, HWA was not detected until the 1950s. It was known to be present for decades, but it did not become a forest problem until in the1980s. HWA is an ideal invader for many reasons. It has two generations per year, which means two chances for population increases each year. HWA are mostly female, so most of the offspring can reproduce /lay eggs. HWA only require females for reproduction, so nearly all of the offspring lay eggs, increasing population growth rates. Unfortunately, they do not have any native natural enemies in the eastern US that sufficiently reduce their populations. As a result, there has been widespread HWA population growth, range expansion, and hemlock mortality in eastern forests.

Slide 6

Remember we mentioned that HWA have two generations per year. This lifecycle figure shows the timing of each HWA generation. The sistens generation is represented in green, and the progrediens generation is represented in blue. The progrediens generations is a shorter generation that occurs from late-winter into early-summer. The sistens generation is a longer generation that starts in the summer and goes until the late-winter. Starting in late winter, on the bottom left of the figure, with the shorter progrediens generation hatching. Crawlers are the first HWA instar, or life stage, – see the top left of the figure for a crawler image. Crawlers are the only mobile phase of the HWA lifecycle. They will crawl to a favorable site (usually at the base of a needle), insert their long straw-like mouthpart into the plant, and begin to suck fluids from the tree. Progrediens will grow, produce wool, and later lay eggs all by late spring. In early-summer the sistens generation of crawlers will hatch and find a feeding site. The second instar will aestivate during warm months. This aestivation is a slowing down time, when HWA is not active. In the late fall, see the bottom right of the figure, HWA breaks aestivation and becomes active again. HWA sistens will feed, grow, and lay eggs for the progrediens generation. The cycle starts all over again in the late-winter.

Slide 7

The eggs, pictured on the upper left, are oval shaped and orange. The crawlers are pictured on the previous slide. They've settled at the base of needles and are now second instars in the picture on the upper right. The ring of white on the edge is the beginning of wool formation. On the bottom left is a picture where the woolly mass has been opened to expose the female and the eggs. On the bottom right is a picture of the female with her long mouthpart. She will sit in one location and draw up plant fluids from the tree, taking its carbohydrate resources, which ultimately causes hemlock death.

Slide 8

Perspective on hemlocks and hemlock management, due to hemlock's role in the forest ecosystems, is about more than just preserving a tree. Hemlock conservation is conservation of an entire forest ecosystem. This invasive insect feeds on trees and kills them. The picture on the far right is what the landscape looks like after HWA has caused wide-spread hemlock mortality. There is a cascade of ecological effects that happens as a result of hemlock loss in the forest.

Slide 9

The map shows both eastern hemlock and HWA ranges. The darker the color, the denser the hemlock occurrence in that area. Counties outlined in black indicate where HWA is already present. This map was produced in 2018, so numerous counties around the border would have been added by now, and HWA is currently present in Alabama on Lookout Mountain in the upper northeast corner of the state.

Slide 10

Many things happen in a hemlock forest after HWA-induced hemlock mortality has occurred. Canopy gaps open where hemlocks have died, which results in a rapid vegetation response. Changes in soil nutrients occur. The wildlife habitat is altered. Stream temperatures increase. Forest fire intensity can increase due to all of the dead wood in the forest. Forest fires can also be more likely to reach the canopy layer due to standing dead hemlocks. There can also be safety issues during wind storms and safety issues for campsites and hikers. In the south especially, there is increased rhododendron density, which decreases regeneration and diversity of other plant species.

Slide 11

Hemlock conservation is not about the conservation of one single tree, but conservation of an entire forest system and all of the animals and plants that depend on the presence of hemlocks. There must be a system-based perspective about the choices made for protecting hemlock forests, including both the positive and negative results of management tactics.

Slide 12

What is the goal for a state or federal agency or an individual who is going to manage HWA? Is it eradication, which means killing every single adelgid on the landscape? The likelihood of that being successful is very low. Suppression, which is reducing the populations of HWA? Suppression to what degree? The lowest possible HWA abundance - on a tree or in the whole forest? HWA populations low enough to maintain hemlock crown health, which means cone-bearing, reproducing hemlocks? Or maintaining HWA populations that are lower, but still high enough to support biocontrol predator complexes, which is a more complex option? Perhaps a property owner or land manager is not sure of what their goals should be. They may not be certain of which outcome they want and why those outcomes are desirable. The answers to these questions depend on how large the management program is – a yard with one tree or thousands of acres of public land – and many other factors.

Slide 13

Next is to understand the tools that are available. One option is to do nothing, and there are many reasons for choosing this option. It may be that someone does not think hemlock conservation is important. Possibly the financial resources are not available for treatment. Preserving every hemlock stand is not possible due to financial resources, timing, getting the resources to the field, regulatory limits, etc. If a stand is not preserved, it is not necessarily that a resource agency or individual landowner did not want to preserve it. Many financial and logistical issues are involved in these decisions. However, there are consequences to not treating a stand. The picture shows an area where a resource agency could not get hemlock trees treated in time. This was not an issue of not wanting to treat, but rather of not being able to treat. As a result, the agency will have to remove many dead trees to maintain safety for this roadway, which is costly. Safety issues like this help agencies prioritize where to make insecticide treatments.

Slide 14

When nothing is done there are cascading environmental effects. That also helps to prioritize conservation areas for critical habitat protection. Unfortunately, it is not possible to save every hemlock tree in the forest.

Slide 15

Contact insecticides are a HWA suppression option. The picture shows a horticultural oil application, but there are other contact insecticides that could be used. This option is not the best fit for most situations. There are the practical issues of getting high pressure hose equipment to the trees. In addition, contact insecticides must be applied to the crawler stage, which means applying once or twice a year. Contact sprays are really only an option for smaller trees and hedges in landscape settings, not for forests.

Slide 16

Biological control is not an easy, silver bullet option. The goal of biocontrol is to develop a suite of predator species in the landscape over time to suppress HWA populations. This is a long-term strategy, but it is not a quick fix.

Slide 17

To assist in thinking through how biocontrol works, a landscape view of a forest is pictured, and biocontrol organisms are going to be released in a few locations in this landscape. The HWA picture shows the potential pest density. These biocontrol organisms have to survive, find mates, reproduce, have populations that build up over time, and start to suppress HWA populations. This is a pretty tall order and will take time, patience, and knowledgeable resource managers. Biocontrol is a good option for state and federal agencies that use diverse management tactics on a landscape. Biocontrol is not a good option for a landowner who is trying to conserve individual trees or specific hemlock stands.

Slide 18

The last option listed is systemic neonicotinoid insecticides, which are the most commonly used management tactic. There are two different options – dinotefuran and imidacloprid. These are very complementary insecticides in hemlock systems.

Slide 19

Dinotefuran moves in to the hemlock canopy more quickly, while imidacloprid moves into the canopy more slowly. In a relatively healthy hemlock, dinotefuran can move into the canopy in effective concentrations to suppress HWA in about two - three weeks, whereas it takes imidacloprid three months.

Slide 20

Dinotefuran is only effective for 1 to 2 (at the most) years, and imidacloprid is effective for five to seven or more years.

Slide 21

Dinotefuran provides a quick but shorter-term reduction of HWA, whereas imidacloprid provides longer-term HWA suppression but takes longer to be effective.

Slide 22

Dinotefuran is best for heavy infestations, when it's a priority to get the insecticide in the canopy more quickly, and imidacloprid is best for light to moderate infestations.

Slide 23

Dinotefuran is a more expensive option, and imidacloprid is a less expensive option, since it is off patent. Imidacloprid is more commonly used due to the longer effectiveness, lower cost, and being a better option for light to moderate infestations. Whereas, the more expensive dinotefuran is prioritized for heavy infestations where time is more critical.

Slide 24

Dinotefuran can be applied by soil drench, soil injection, trunk injection, and bark spray.

Slide 25

Imidacloprid can be applied by soil drench, soil injection, trunk injection, bark spray, and CoreTect™ slow release pellets. CoreTect™ is great for situations where applicators are having to hike in long distances and/or water availability is an issue. Trunk injections are the most expensive option and are often used on hemlocks that are within 10 feet of a stream channel, lake, or wetland. There is no one best option for application method. It is about finding the best method that fits the management situation.

Slide 26

Insecticide application instructions for hemlocks are available online. Please be careful where you get HWA management recommendations. State and federal agencies and university extension sites are the best sources. Stick with sites that end with ".edu" or ".gov." Soil drench and soil injection guidance has been developed and published jointly by the Georgia Forestry Commission (GFC) and the University of Georgia (UGA). The GFC-UGA guidance has mixing instructions for both imidacloprid flowable and water soluble packet formulations.

Slide 27

For the water soluble packets, put one packet, which has 34 grams of imidacloprid active ingredient, in a Nalgene bottle that is marked for insecticide use and is only used for insecticide applications.

Slide 28

Pour water into the container to the 48 oz mark, so there should be 48 oz in the container with the water and the water soluble packet. Other methods will recommend different mixtures, and that is okay. The concentration of the suspension depends on which method you are following. Recommended insecticide suspension mix and application volume will determine the dose of active ingredient per diameter of the tree that is applied. The dose of insecticide will affect product effectiveness and longevity of the treatment, so please follow instructions carefully. Be sure to read the entire pesticide label before making applications and follow all safety precautions. The mix in the GFC-UGA guidance is for a 0.75 grams active ingredient per 1 inch diameter at breast height [4.5 feet above groundline] (DBH) dosage rate, which should effectively suppress HWA for 5 – 7 years.

Slide 29

Measure the diameter of the tree to be treated at . The technical term for this measurement is diameter at breast height (DBH), and use one ounce of suspension for every inch of hemlock diameter. For example, a 8 inch DBH hemlock will receive 8 oz of imidacloprid suspension that is mixed as specified in the GFC-UGA recommendations.

Slide 30

For a visualization, there's a water soluble packet in the Nalgene container in the photo to the left, and water is being added to the container to reach the final 48 oz volume in the picture on the right.

Slide 31

For a soil drench, it's very important to remove the duff layer before applying the imidacloprid suspension. The duff layer is the layer of organic material, such as leaves and small organic debris that is over the soil surface. Imidacloprid binds to organic matter, so it needs to be poured directly on the mineral soil around the roots of the hemlock tree rather than on top of the duff layer. Removing the duff layer will lightly expose some of the fine roots. These roots are prevalent in the first six or so inches of the soil, and this area with small roots is very active for absorption.

Slide 32

To do a soil drench application, pour the imidacloprid suspension on the soil around the base of the tree. The applications should be made on the soil within about 2 feet of the hemlock trunk. Check the volume to be sure the correct amount has been applied. It may be helpful to pour the exact volume you want to apply into a secondary container that has markings for every ounce for more straightforward measuring. Once the suspension has been absorbed into the soil, place the duff layer materials that were removed back over the exposed soil. This covers the area where insecticide was poured and is a way to protect against any unintended exposure to other organisms.

Slide 33

CoreTect™ slow release pellets are applied by a different method. Make holes in the soil around the base of the tree. The labeled rate is 2-3 pellets for every inch DBH. A 10 inch DBH tree would get 20 – 30 CoreTect™ pellets following the labeled rate. However, there are recommended dosage rates mentioned later in the presentation that specify lower pesticide use. Place the CoreTect™ pellets in the holes and cover everything back up again.

Slide 34

The GFC-UGA imidacloprid treatment document shared earlier is for a standard dosing rate. It is a good method for treating individual landscape trees or limited acreages. However, an optimized dosage rate has been developed to use less imidacloprid to treat hemlocks on a landscape level – Optimized Insecticide Dosage for Hemlock Woolly Adelgid Control in Hemlock Trees, published by the UGA Warnell School of Forestry and Natural Resources. Optimized dosage is a good option for management programs treating larger acreage. This is a way to use less insecticide on the landscape while still getting effective treatments.

Slide 35

As an example, here is a flyer that is a part of the optimized dosage document for CoreTect™ pellets. There are one-page printable flyers for CoreTect™, soil drench, and soil injection applications of imidacloprid. The flyers have mixing instructions and all other information needed for making the applications in the field, including maximum amount of insecticide per acre. The CoreTect™ flyer has the DBH of the tree and the number of CoreTect™ pellets to use for each size tree. For comparison, see the table on the right that has the DBH, the labeled rate for two and three CoreTect™ pellets for every inch DBH, and the new optimized dosage rate, which uses less insecticide. To date many state and federal agencies have treated and successfully protected over 150,000 hemlock trees with optimized dosage recommendations.

Slide 36

In addition, new United States Forest Service guidance has been published for integrating chemical and biological control. This is not a tactic for landowners treating individual trees or hemlock stands but for federal and state agencies managing HWA on a larger landscape scale. It's important to note these advances that are being made from integrating the latest science into management programs.

Slide 37

The University of Georgia and the Georgia Forestry Commission have partnered to develop a suite of hemlock resources for stakeholders. These include county agent trainings for county extension agents and federal and state agency employees working in hemlock management in Georgia; a jointly published HWA fact sheet; one-page soil drench and soil injection handouts; soil injectors available for checkout at GFC County offices across the hemlock range; soil drench kits available for checkout at county extension offices; and a YouTube video that shows how to make a soil drench insecticide application.

Slide 38

Finally, here are some additional tips for homeowners and landowners for hemlock management. Avoid planting hemlock trees, unless you plan on treating them with insecticides for the life of the tree. Begin treating hemlocks with insecticide once you (or neighbors) detect HWA. Do not wait until the tree is in poor health. Avoid treating hemlocks with insecticide during the summer. Fall through spring are the best times to make applications. Do not use soil or spray applications within 10 feet of any water source or stream channel. Lastly, be sure to read and carefully follow all insecticide labels before using any kind of pesticide. And if you have any questions about application or mixing, please contact your local UGA Extension Agent or GFC Forester.

Slide 39

Thank you for your time, and thank you for efforts you may be making or plan on making to protect hemlock forest resources.

REFERENCES

Benton, E., and R. S. Cowles. 2017. Optimized insecticide dosage for hemlock woolly adelgid control in hemlock trees. University of Georgia, Warnell School of Forestry and Natural Resources, WSFNR-17-01.

Benton, E. P., J. F. Grant, R. S. Cowles, R. J. Webster, R. J. Nichols, R. S. Cowles, A.F.

Lagalante, and C. I. Coots. 2016. Assessing relationships between tree diameter and long-term persistence of imidacloprid and olefin to optimize imidacloprid treatments on eastern hemlock. Forest Ecology and Management 370: 12–21. doi.org/10.1016/j.foreco.2016.03.044

Benton, E. P., J. F. Grant, R. J. Webster, R. S. Cowles, A. F. Lagalante, R. J. Nichols, and C. I.

Coots. 2016. Hemlock woolly adelgid abundance and hemlock canopy health numerous years after imidacloprid basal drench treatments: Implications for management programs. Journal of Economic Entomology 109: 2125 – 2136.

Dilling, C., P. Lambdin, J. Grant, and R. Rhea. 2010. Spatial and temporal distribution

of imidacloprid in eastern hemlock in the southern Appalachians. Journal of Economic Entomology 103: 368–373.

Joseph, S. V., S. K. Braman, J. Quick, and J. L. Hanula. 2011b. The range and response of neonicotinoids on hemlock woolly adelgid, Adelges tsugae (Hemiptera: Adelgidae). Journal of Environmental Horticulture 29: 197–204.

McCarty, E. and K. M. Addesso. 2019. Hemlock woolly adelgid management in forest, landscape, and nursery production. Journal of Insect Science. 19: 24, 1 - 17. doi.org/10.1093/jisesa/iez031

McCarty, E. and L. Womack. 2019. Hemlock Woolly Adelgid Management in Georgia. Georgia Forestry Commission and University of Georgia Warnell Outreach Publication, 19-41.

McClure, M. S., S. M. Salom, and K. S. Shields. 2001. Hemlock woolly adelgid. USDA Forest Service, Forest Health Technology Enterprise Team, FHTET-2001-03, Morgantown, WV.

Onken, B. P., and R. C. Reardon. 2011. An overview and outlook for biological control of hemlock woolly adelgid, pp. 222–228. In B. Onken and R. Reardon (eds.), Implementation and status of biological control of the hemlock woolly adelgid. USDA Forest Service, Forest Health Technology Enterprise Team, FHTET-2011-04, Washington, D.C.

Orwig, D. A., and D. R. Foster. 1998. Forest response to the introduced hemlock woolly adelgid in southern New England, USA. Journal of the Torrey Botanical Society 125: 60–73.

Webster, J. R., K. Morkeski, C. A. Wojculewski, B. R. Niederlehner, E. F. Benfield, and K. J. Elliott. 2012. Effects of hemlock mortality on streams in the southern Appalachian mountains. American Midland Naturalist 168: 112–131.

SUGGESTED CITATION:

McCarty, E. and L. Womack. 2020. Hemlock Woolly Adelgid PowerPoint Presentation. University of Georgia Warnell School and Georgia Forestry Commission Outreach Publication WSFNR-20-71A. 39 Slides.