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Managing Hemlock in Northern New England Forests Threatened by Hemlock Woolly Adelgid and Elongate Hemlock Scale

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Cover photo: Dave Orwig.

Pesticide Precautionary Statement

Pesticide products used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

Note: Pesticide restrictions vary from State to State. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

Contents

Managing Hemlock in Northern New England Forests Threatened by Hemlock Woolly Adelgid and Elongate Hemlock Scale

Hemlocks in northern New England are threatened by invasions of two exotic pests: hemlock woolly adelgid (HWA) and elongate hemlock scale (EHS). HWA is a forest pest that causes major damage throughout the native range of eastern hemlock. It has been spreading into northern New England since before 2000. EHS is a more recent invader.

Figure 1. Hemlock woolly adelgid wool. (USFS)

This document provides guidelines for managing threatened hemlock forests in the Northeast based on forest health specialists' current understanding of the interplay between HWA and EHS, our climate, and our forests. As with other invasive pests, this understanding, as well as available management techniques, can change quickly. Seek current information before making management decisions.

For more information about current distributions of these pests and available management techniques, contact your State's forest health office. Northern New England contacts are listed at the back of this guide.

Recognizing the Pests

Hemlock Woolly Adelgid

The most obvious sign of HWA is the covering of "wool" the insect makes from wax filaments as it matures (figure 1). The woolly masses range from 1/16 inch to 1/8 inch across. You can find them on branch tips, generally on the most recent hemlock growth.

Trees that have either been under attack for several years or have other significant stress will display off-color needles (often with a grayish cast) and thinning crowns as a result of losing needles.

HWA is most visible in the winter and early spring with snow cover on the ground that reflects the low winter sun. The reflected light highlights fresh, white wax that covers the insects at that time of year.

Common HWA Imposters

It is easy to confuse HWA with similar looking things on hemlock. A close look at the location, texture, and other characters can eliminate some of the imposters. Some frequently mistaken identities include conifer sap (figure 2), bird droppings, lichen, spider egg sacs (figure 3), spittlebugs (figure 4), caterpillar signs (figures 5 and 6), and tip blight (figure 7).

Figure 2. Pitch from other conifers is often mistaken for HWA. (NH DFL)

Figure 3. Spider egg sacs are silky or stretchy, and not firmly attached to the twigs. (Scott Costa)

Figure 4. Wet, frothy masses are created by spittlebugs, not HWA (note old HWA wool on twigs). (Beatriz Moisset)

Figure 5. Cocoons of Bucculatrix *sp. (skeletonizing caterpillars) on hemlock needles. (MFS)*

Figure 6. Brown needles tied together with silk indicate hemlock needleminer presence. (Ct. Ag. Expt. Sta., Bugwood.org)

Figure 7. Sirococcus shoot blight, caused by the fungus Sirococcus tsugae, *kills new hemlock growth starting at the tip. (USFS)*

Remember that you will only see HWA on hemlock (figure 8). Other clues include these:

- The dry, waxy "wool" is attached to the twig, not the needle.
- HWA cannot move when it is covered with wool.
- The wool is wispy like a cotton ball, not silky, stretchy, or like fabric.
- The wool does not look painted on (like pine sap) or leaf like (like lichen).

Figure 8. Hemlock twig heavily infested with HWA. (Mark Whitmore)

Elongate Hemlock Scale

Figure 9. This female EHS has a smooth, waxy covering. (USFS)

EHS attaches itself to the undersides of host needles. Hosts include hemlock, fir, spruce, and other conifers. EHS is an "armored scale"—a soft-bodied insect that creates a rigid cover as it develops. Female scales are covered by a variegated brown, smooth, waxy covering that has parallel sides (figure 9). You can see their covers year round, which often look like a wound. Male scales are most visible during the growing season (figure 10). At some stages they are covered by bright white fluffy or woolly material, so it's easier to see them. Both sexes are less than ⅛ inch long (figure 11).

The upper surfaces of affected needles will often be mottled with yellow spots that indicate where scales have fed on the undersides of the needles.

You may mistake several other armored scales for EHS (figures 12 and 13). They can infest the same conifer hosts; some are considered serious threats to tree health. If you see high populations of any armored scale on hemlock, report it to your State's forest health office.

Figure 10. Female (brown) and male (white) elongate hemlock scales on the undersides of hemlock needles. (MFS)

Figure 11. Male EHS are covered with wool in some stages. Females are covered by a brown, waxy coating. (MFS)

Figure 12. These pine needle scales are similar in size, location, and color to male EHS. The texture of their covers is smooth, whereas male EHS have fluffy, white coverings. (MFS)

Figure 13. Several species of scale, such as this circular scale, have a cast skin that stays near the middle of the insect when it settles. Although they can be pests, they have not been linked to severe forest decline. (Jen Weimer, NH DFL)

Survey and Monitoring

Once you are familiar with what HWA, EHS, and some of their imposters look like, you can survey for and monitor their populations. Review a publication by Ward and others (2004) for tips on developing survey and management priorities.

Early detection is the goal of doing a survey. It is difficult to find these insects when their populations are low. Although trees may survive for a long time after they are initially infested, the time between pest detection and significant tree decline may be short if you do not make targeted efforts to look for these pests.

Costa and Onken (2006) provide good guidelines for monitoring these pests after you find them. Consider recording either vigor class or overall tree health on sample trees each time you evaluate a stand.

Equipment

In addition to standard field equipment, bring a hand lens to help identify the insects, flagging and a GPS unit to record the location of suspect sites, zippered plastic bags to collect samples, and/or a camera to take pictures.

Timing

When possible, complete the survey from roughly August through February when there is a low risk of spreading HWA. HWA is most visible from December through June. This pest can be difficult to detect from late-July through mid- to late-October because of a lack of new wool (figure 14).

Figure 14. HWA can be difficult to detect in late summer and early fall. Use a hand lens to inspect the current-year growth for settled nymphs if you find suspect white material. (MFS)

If HWA is the primary target of your survey, the ideal time to look for it may be December through February. This is when the risk of spreading HWA is low, the insect is making new wool, light conditions tend to be ideal, and frozen water bodies can provide access to high-risk trees that would not otherwise be approachable.

EHS will be most visible from June through October because of the males' white coverings. The second half of October may be the best time to survey for both pests after HWA has resumed making its woolly covering.

Targeting Risk

Targeting sites that are at high risk for infestation when you survey will increase your likelihood of detecting these pests. Manager experience suggests that these areas include:

- Sites that concentrate or attract wildlife such as game trails; feeding stations (birds, deer, and other wildlife); and water sources, including vernal pools (figure 15).
- Sites that concentrate human activity such as trails, resting spots, and parking lots.
- Heat islands that reduce cold in the winter such as roadways, roofs, and large water bodies.

Figure 15. Target high-risk sites for your survey—trails, feeding stations, water sources, heat islands, ridges, and ravines. (VT DFPR)

- Features that may increase exposure to wind or birds such as edges, ridges, or hilltops; topography that funnels wind (ravines, gullies); and host trees that are dominant in the canopy.
- Sites that have many visitors or seasonal residences of people who also live in heavily infested areas.
- Areas with a lot of professional landscaping and grounds care.

Maximizing Chances of Detection

You may increase your chance of finding these pests by:

- Focusing on hish-risk areas as outlined above.
- Inspecting hemlock branches (HWA) and needles (EHS) up close.
- Using a hand lens to closely examine any suspect spots on needles and twigs that are the correct size, location, and color for HWA or EHS.
- Examining as many branches as possible throughout the survey area. At a minimum, try to look at 200 branches.
- Covering the area of concern to increase your likelihood of finding patchy, early infestations.
- Taking advantage of harvests, fallen trees, and clipped branches to check out upper canopy samples.

Expected Impacts on Hemlock Health

In extreme northern New England, it is not known if HWA and EHS will cause hemlock mortality or at what pace hemlocks may decline. Local site factors, native insects and diseases, precipitation and temperature patterns, and other factors can dramatically change the pace of impacts from these forest pests (see next section: Predisposing Factors).

Little is known about how EHS and HWA will interact in our forest. In general, premature needle loss and bud mortality lead to crown thinning and reduced growth. Managers in southern New England and New York report that tree decline appears to be more rapid when the two insects are found on the same tree.

HWA thrives on healthy trees. Once tree health declines, so do populations of HWA. When trees recover, HWA populations rebound. This cycle can repeat itself. While the ultimate outcome is tree mortality in the Southeastern United States, cold winters alter the balance in the Northeast. In central New England, extensive hemlock mortality was not observed for years after HWA was first detected, although it is now common.

A study in the Mid-Atlantic and Northeastern United States found that radial growth in codominant and dominant hemlocks did not begin to decline until fewer than 75% of the branches produced new growth, canopy transparency (as measured by a densiometer) was greater than 25%, fine twig dieback was greater than 10%, and live crown ratio was less than 60% (vigor classes Moderate Decline and Severe Decline as described in the following section) (Livingston and Pontius 2011, Pontius and others 2006) (figure 16). Similarly, in the Delaware Water Gap, researchers found decline was more likely in larger diameter trees and in trees with more light coming through the crowns. Intermediate crown class trees were more likely to decline than those that were codominant or overtopped (Rentch and others 2009).

In northern New England—given adequate monitoring for early detection, periodic cold winters, and decent growing conditions—managers should have many years to carry out treatments after hemlock woolly adelgid is found and before onset of severe decline.

Predisposing Factors

A tree or stand's ability to tolerate damage from HWA and EHS will be influenced by several factors other than adelgid and scale infestation levels.

Figure 16. In general, radial growth will be normal as long as >75% of branches produce new growth, canopy transparency is <25%, twig dieback is <10%, and live crown ratio is >60%. (VT DFPR)

Temperature

USDA Plant Hardiness Zones (PHZ) provide a useful summary of winter climate (USDA 2012). HWA is sensitive to cold winter temperatures, and most detected infestations of HWA in the Eastern United States are confined to PHZ 5a and warmer (figure 17). One regional model suggests that adelgid- related hemlock decline will coincide with an area that roughly coincides with PHZ 5b and warmer (Livingston and Pontius 2011). However, HWA populations have shown an ability to adapt to colder winter temperatures. Less is understood about temperature impacts on EHS.

Moisture

HWA feeding damage may increase hemlock's vulnerability to dry conditions (Rivera and others 2010). More rapid decline has been noted on south- and west-facing slopes than east- and north-facing slopes (Rentch and others 2009). Expect more damage on drier and wetter soils than on soils with adequate but not excessive moisture.

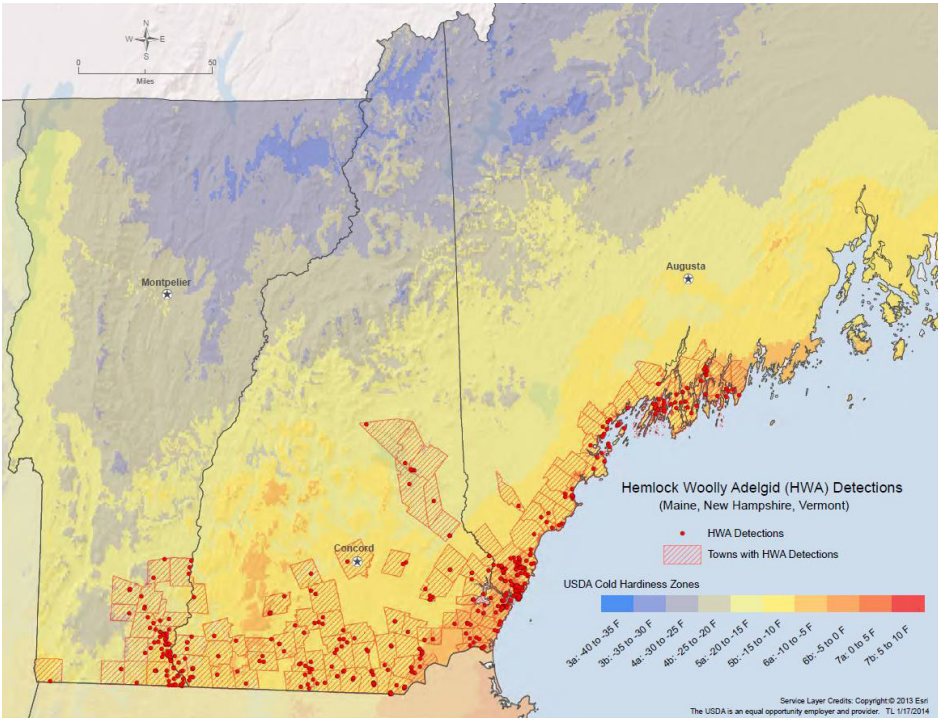


Figure 17. Detected infestations of HWA in the Eastern United States are confined to Plant Hardiness Zone 5a and warmer as of 2014. (Map: Tom Luther, USFS, Northeastern Area State and Private Forestry)

A Combination of Factors

Trees are likely to decline more rapidly if HWA and EHS are found together or if other stressors such as drought or defoliation are combined with one or both exotic insects. In a long-term study in the Mid-Atlantic States, warm winter temperature and summer drought were important factors in mortality of infested hemlocks (Eschtruth and others 2013).

When you evaluate a tree or stand's likely future, be aware of the expected recurrence of drought, hemlock looper outbreaks, and other stressors. Contact your State's forest health organization for more information on these factors. The U.S. Forest Service Forest Health Portal (http://foresthealth.fs.usda.gov/portal) also provides information for some of these stressors (figure 18).

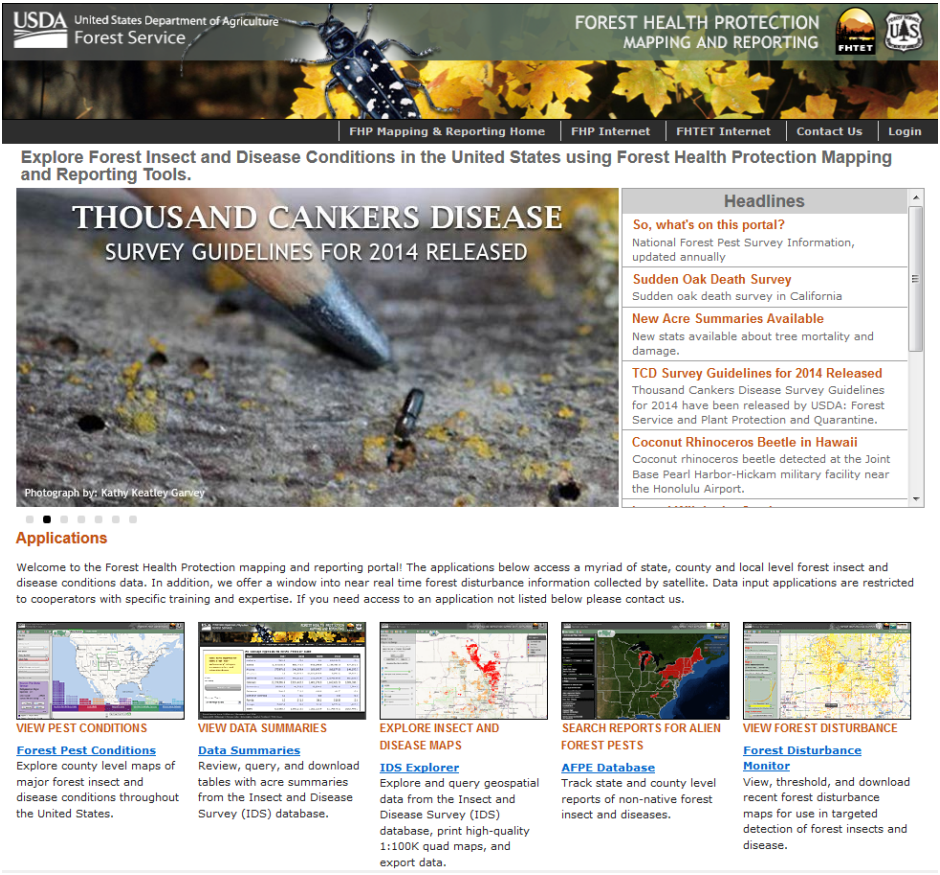
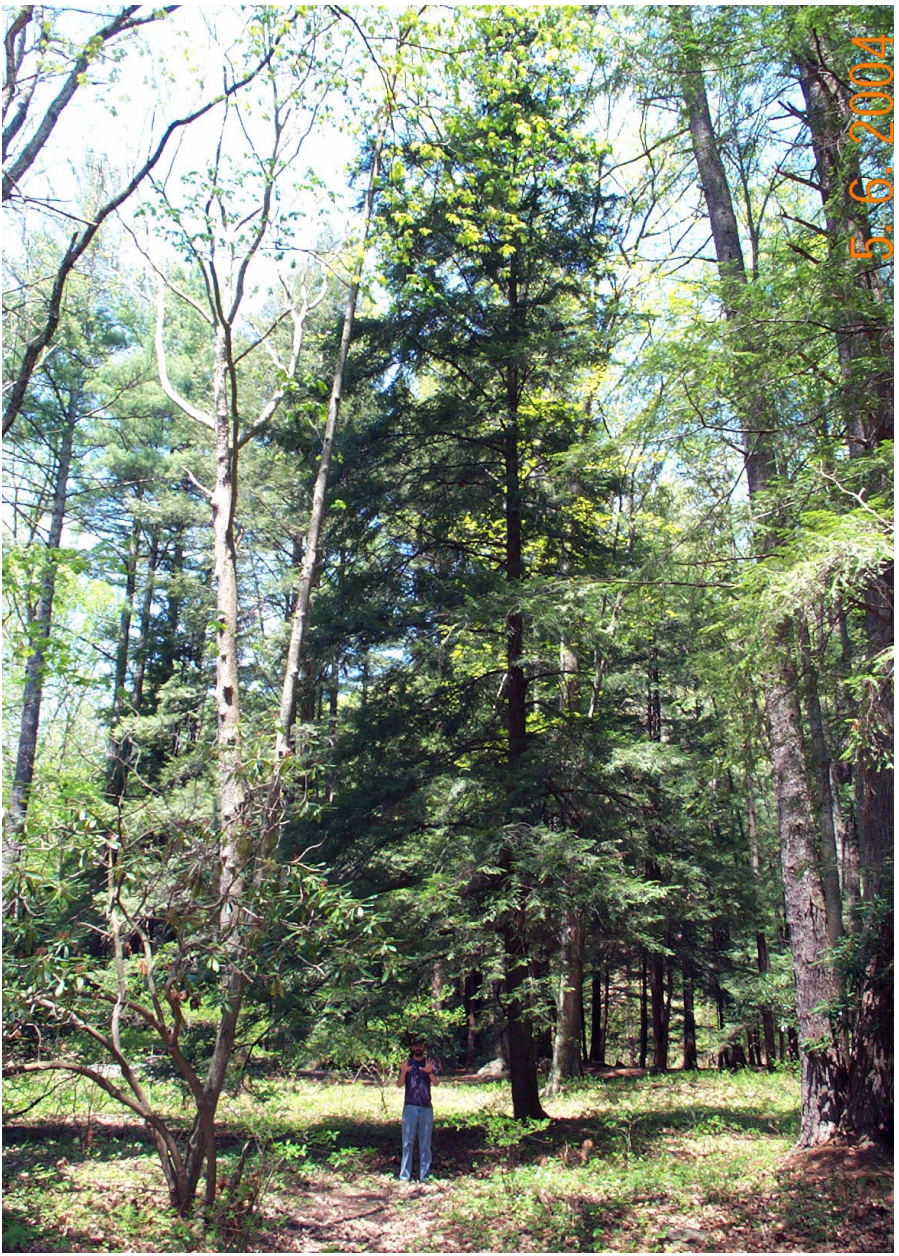


Figure 18. The U.S. Forest Service Forest Health Portal provides a variety of forest health spatial information.

Guide to Hemlock Health

The following four vigor classes—Healthy, Light Decline, Moderate Decline, and Severe Decline—provide a qualitative rating of hemlock health. In general, trees in the first three vigor classes may respond to management aimed at improving tree health. Trees in the Severe Decline class are probably not candidates for restoration. (Photos by Gina Davis)



Healthy: Tree appears healthy with <10% branch mortality, twig mortality, or foliage discoloration of the crown.

Light Decline: Branch mortality, twig mortality, or foliage discoloration occurs on 10–25% of the crown.

Moderate Decline: Branch mortality, twig mortality, or foliage discoloration occurs on 26–50% of the crown.

Severe Decline: Branch mortality, twig mortality, or foliage discoloration occurs on more than 50% of the crown.

Management and Control Strategies

There are many strategies for managing hemlocks that are at risk due to the spread of HWA and EHS. To choose the best option, follow this three-step process. To maximize your options for management, be sure to conduct regular surveys to detect these pests as soon after their arrival as possible.

STEP 1: Assess key components of the infestation.

- Determine how much hemlock is present; what proportion of the forest it comprises; and how it affects forest structure, including age structure.
- Understand the health and vigor of the trees and suitability of the site to continued hemlock survival and growth.
- Evaluate accessibility of hemlocks in light of different management options.
- Determine the geographic proximity of the outbreaks. Are HWA and EHS already present or nearby?
- If hemlocks are infested, evaluate the severity of the infestation. Consider the whole stand, not just the most heavily infested branch.
- Determine the value of the hemlocks based on landowner goals and objectives, including timber and environmental values. Weigh this against the costs of management.

STEP 2: Decide on a management plan. Based on the information collected in STEP 1, review possible options outlined in the Management Options section that follows. Each option has associated costs and benefits.

STEP 3: Conduct post-treatment followup. Evaluate the effectiveness of previous management activities before pursuing further treatments or options, especially when pesticides were applied. Begin again at STEP 1 after determining effectiveness.

Management Options

Do Nothing

This option will not disturb the soil and existing regeneration as would alternatives that include cutting. Landowner goals, economic circumstances, or other factors may preclude other management options. The extent of the infestation may be too large, its severity too high, and/or the value of the hemlocks too low to make control worthwhile. Doing nothing may preserve genetic diversity, including any heritable resistance if it is present.

Cultural Control

If the extent of the infestation is small and the value of the infested trees is low, felling infested trees may slow the insect's dispersal by eliminating reservoirs of the pest. This is best done between August and February to avoid spreading the pest.

Figure 19. Before moving brush, chip and/or cover it. Adhere to quarantine requirements for your State. (VT DFPR)

Brush could be chipped, piled, and covered; piled and burned on site; or simply piled and allowed to dry. If brush will be moved, it is best to chip it first and cover it during transport (figure 19). Follow all quarantine requirements.

Silvicultural Options

General Silvicultural Guidelines

- Evaluate the current management plan in light of proximity of infestations, plant hardiness zone, hemlock health, and access. Hemlocks in cooler hardiness zones (4b and cooler) may not be greatly affected by either pest. Based on observations in northern New England, even in warmer zones, significant impacts are not likely to occur on good sites for a decade or more after initial infestation in the absence of other stressors.
- Evaluate strategies based on objectives and current stand conditions. Many infested trees will survive. Although their canopies will be reduced, they will continue to provide a backdrop for recreation, shelter wildlife, shade riparian areas, and protect watersheds. On the other hand, heavy infestations will limit timber production because diameter growth will be minimal. In recreation areas, declining and dead trees may impact aesthetics and safety.
- Minimize stress on residual trees with any stand entry. The shallow rooting pattern of hemlocks makes them more susceptible to root damage and decline when soils are disturbed. Consider harvesting approaches or equipment that will reduce soil disturbance around residual hemlocks (figure 20).

Figure 20. Use harvesting approaches or equipment that will reduce soil disturbance around residual hemlocks, such as removing trees in strips or groups. (VT DFPR)

- Delay entries in stands impacted by hemlock looper, drought, or other stressors. Conduct winter operations to reduce stress and spread of both the adelgid and scale (figure 21). As hemlocks are cut or die, anticipate a shift in species composition in the overstory and regeneration. Use appropriate silvicultural options to ensure adequate regeneration of desirable species, maintain productivity, and protect riparian areas and other sensitive sites. Monitor for invasive plants and treat as needed.
- Make sure management actions do not accelerate the spread of HWA and EHS:
  - Timing is important. Schedule operations from August to March.
  - Clean equipment, at least of green foliage, before leaving the site.
  - Know and obey quarantines (http://na.fs.fed.us/fhp/hwa/ quarantines/ quarantines.shtm).

Orwig and Kittredge (2005) provide a helpful overview of silvicultural options.

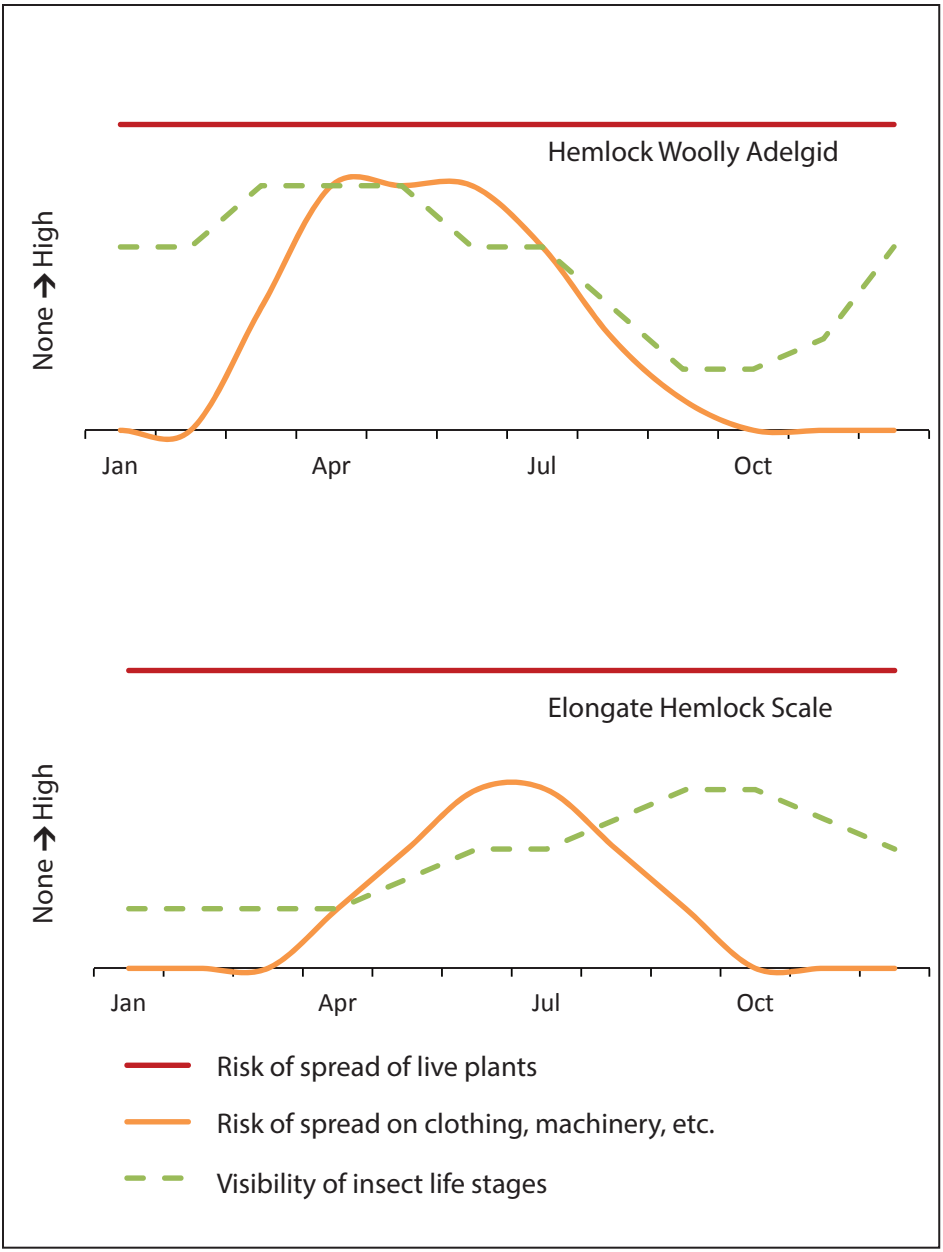


Figure 21. Risk of spread and visibility of hemlock woolly adelgid and elongate hemlock scale throughout the year.

Habitat Management Scenarios to Maintain Canopy Cover

Pre-Infestation:

- *Follow Existing Management Plan:* No change is needed if hemlocks are vigorous, the property is located in a cooler climate zone, or access is good.
- *Establish Regeneration where Hemlocks are Unhealthy:* Where no regeneration is established, remove unhealthy trees in groups to provide additional light on the forest floor. To maintain cover, limit the area of tree removals to what can be regenerated sustainably.

Figure 22. Hemlocks will continue to provide some value as cover as long as they are still alive. (VT DFPR)

Infested/Pre-Decline (Light Decline or better condition):

- *No Cutting:* Hemlocks will continue to provide some value as cover while still alive (figure 22). Avoid any disturbance, which could accelerate decline. Consider insecticide treatments and/or biological control.
- *Establish Regeneration:* Where no regeneration is established, remove unhealthy trees in groups to provide additional light on the forest floor. To maintain cover, limit the area of tree removals to what can be regenerated sustainably.

Infested/Post-Decline (Moderate Decline or worse condition):

- *No Cutting:* Hemlocks will continue to provide some value as cover while still alive. Avoid any disturbance, which could accelerate decline. Consider insecticide treatments.
- *Establish Regeneration:* Where hemlocks are declining, remove unhealthy trees in groups. Consider planting softwoods to continue functions that hemlock had provided. Some hemlock hybrids may be less vulnerable to HWA than native hemlocks.

Timber Management Scenarios

Pre-infestation:

- *Follow Existing Management Plan:* No change is needed if the timber is located in cooler climate zones or access is good.
- *Reduce Hemlock Stocking:* Where hemlocks are unhealthy or exceed 20% of basal area, reduce the hemlock component through appropriate silvicultural systems. The density of hemlock is often irregular within stands, so the percentage of residual hemlock can be locally higher.

Infested/Pre-decline (Light Decline or better condition):

- *Delay Cutting:* Lightly infested trees may continue to grow adequately. Unnecessary disturbance may put additional trees at risk.
- *Continue Cutting Schedule:* Use harvesting systems or equipment that minimize soil disturbance around residual trees, such as removing trees in strips or groups. Anticipate slower hemlock growth over the next cutting cycle.
- *Accelerate Cutting Schedule:* Re-evaluate diameter objectives given expectations of slower growth and reduce the hemlock component through appropriate silvicultural systems. Release advanced regeneration of desirable native species.

Infested/Post-Decline (Moderate Decline or worse condition):

- *Do Nothing:* Limited timber value may not justify stand disturbance.
- *Salvage:* Remove hemlocks, in groups, as they decline. Ensure regeneration of desirable species.
- *Species Conversion:* Remove all hemlocks. Ensure regeneration of desirable species.

Consider harvesting hemlocks between early August and late February to reduce the risk of spreading hemlock woolly adelgid.

Insecticide Treatments

When geographic extent is small and tree value is high, insecticides can be an effective option. Insecticide use is costly and is most often used at small scales on specimen trees or in special groves. Treatment costs are influenced by size and number of trees, product(s) used, and accessibility.

Insecticides should only be applied by those who have knowledge of State and Federal rules, possess the appropriate application equipment, and understand control methods. Insecticide applicators are required to have State pesticide applicator certification and proper safety equipment, and must follow all

instructions on the pesticide label.

Many pesticides should not be used near water or when nearby vegetation is in bloom. Be aware of per-acre label rates. It is easy to approach and exceed those rates if you do not take them into account.

Contact the organization responsible for pesticide licensing in your State for more information on Federal and State pesticide rules and regulations.

ME: http://www.maine.gov/dacf/php/pesticides/index.shtml

NH: : http://agriculture.nh.gov/divisions/pesticide-control/faq.htm

VT: http://agriculture.vermont.gov/pesticide_regulation

Figure 23. Foliar sprays of insecticidal soap or horticultural oil are effective when foliage can be thoroughly covered from all sides. (MFS)

Treat trees in Moderate Decline or better condition. No pesticide treatment will permanently protect your forest from future damage by HWA and/or EHS. Putting different color paint spots on trees can help differentiate treatment years and types of treatments. If you use pesticides, maintain records of which trees were treated, how and when they were treated, and notes on treatment effectiveness.

When determining efficacy of pesticide treatments, bear in mind that the white, cottony wool of HWA and the waxy scale covers of EHS may persist for over a year with no live insect inside. Examine samples under a microscope or high-powered hand lens to see if the insect is dead or alive.

Foliar sprays are effective when foliage is accessible from all directions. The foliar sprays with lower risk to non-target organisms are insecticidal soaps and horticultural oils. These products coat and suffocate the insect (figure 23).

While some oil sprays can be used throughout the growing season, be careful to follow the timing suggested on the product label to prevent damage to foliage. Other foliar sprays are also effective but more toxic to non-target and beneficial insects.

Systemic insecticides are those whose active ingredient is absorbed by and moved around within the tree. The insect is exposed to the insecticide through the sap or the needles and dies.

Figure 24. Soil injections use specialized equipment to deliver systemic pesticides to the root system. (NH DFL)

Two effective ingredients for managing HWA are imidacloprid and dinotefuran. Imidacloprid takes several months to take effect and does not control EHS, but typically provides about 5 years of HWA control. Dinotefuran can be effective within weeks of application. Consider using it on hemlocks with compromised health or where EHS is also present, which it will suppress. Dinotefuran protects trees from HWA for about 2 years.

Systemic insecticides can be applied via stem injections, soil applications, and basal bark sprays. Select an application method and insecticide(s) based on label specifications, tree condition, presence or absence of EHS, soil characteristics, and proximity to water.

- *Stem injections* require specialized injection equipment and training. Damage to the tree's cambium at the injection site is common, and uneven control within trees may occur. However, uptake by the tree can be quick, and there is low risk of runoff or drift. In general, reserve this method for treating trees very close to water.
- *Soil applications* are not appropriate on some soil types, especially very shallow or gravelly soils. Exposed bedrock is another factor that limits soil applications. Three soil-applied methods are available: injection, drench, and tablet (imidacloprid only).

Soil injections require specialized equipment but deliver pesticide directly to the root system and leave less pesticide exposed on the surface. Use shallow injections (2–4 inches deep) close to the base of the tree, if possible (figure 24).

Soil drenches are easy to apply. Mix the product in water and pour the mixture over the ground. There is a higher risk of human exposure and pesticide runoff with this method. Runoff risk can be reduced by pouring the solution in a shallow trench around the tree.

Imidacloprid also comes in a slow-release formula mixed with a fertilizer in tablet form. **Tablets** are placed in the root zone with a bulb planter or similar tool.

- *Basal sprays* are an efficient way to treat trees. Most sprayers are suitable for this use and application is easy; spray to thoroughly wet the bark from the root flare up to 4 feet. Spraying just to the point of saturation allows the tree to absorb the insecticide while minimizing soil contamination from runoff.

Caution: To protect both yourself and the environment, apply the pesticide only in strict accordance with label directions and precautions.

Biological Control

Over the long term, using the natural enemies of these pests as a biological control is likely to be important in maintaining a functioning hemlock forest.

People have located predators that feed on HWA in regions where the pest is native, and selected organisms have been reared in large numbers for release (figure 25). However, biological control is not economically possibile for most managers. State forest health staff sometimes receive predators through Federal partnerships and need suitable sites for releases. Contact your State forest health specialist to determine if predators are available and whether your stand has the characteristics that make it ideal for release.

Figure 25 The popular biological control beetle Laricobius nigrinus *(black arrows) is feeding on HWA. (USFS)*

In general, sites selected for biological control are forested and have some level of protection from conversion to non-forest land use. Ideally, biological control should be established when trees are still in healthy condition. Even with ideal timing, biological control agents may not be enough to preserve mature hemlock in infested stands.

A Federal permit is required to release non-native organisms, including HWA predators. A State permit may also be needed. You can find information about where hemlock woolly adelgid predators have been released in the Virginia Tech HWA Predator Release and Monitoring Database (http://hiro.ento.vt.edu/pdb/).

A Combination of Treatments

It is common to find HWA in a forested setting over a large geographic area where the goal is to reduce its population and neither cultural nor chemical treatment alone is a viable option. Examples include State parks or private campgrounds where hemlocks are valuable for aesthetics, privacy, wildlife, water quality, and much more.

These sites may require a variety of control measures. Consider targeted removal—cutting hemlocks in poor health and heavily infested trees. Target application of a systemic pesticide on high-value hemlocks. Re-evaluate trees for periodic removal and treatment.

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Abbreviations

EHS Elongate hemlock scale, *Fiorinia externa*

GPS Global positioning system

HWA Hemlock woolly adelgid, *Adelges tsugae*

MFS Maine Forest Service

NH DFL New Hampshire Division of Forests and Lands

PHZ Plant Hardiness Zone

USFS USDA Forest Service

VT DFPR Vermont Department of Forests, Parks and Recreation

State Forest Health Office Contacts

Maine: (207) 287–2431

http://www.maine.gov/dacf/mfs/forest_health/invasive_threats/

New Hampshire: (603) 464–3016

www.nhbugs.org/hemlock-woolly-adelgid

Vermont: (802) 879–5687

www.vtinvasives.org/invaders/hemlock-woolly-adelgid

USDA Forest Service Hemlock Woolly Adelgid Web Site

http://na.fs.fed.us/fhp/hwa/

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