



PROTECTING ONTARIO'S EASTERN HEMLOCK (*TSUGA CANADENSIS*) FROM HEMLOCK WOOLLY ADELGID (HWA):

A Practical Guide for Practitioners, Landowners, and Land Managers



I wish we had treated more trees sooner in stands near the Annapolis Valley and in Kejimikujik National Park. As these last great hemlock forests decline faster than we can get them treated, we realize what will soon be lost forever, and at that point it's often too late to deploy pesticides.

Donna Crossland summarizing the sentiment from what she's witnessing on private woodlots and protected areas with HWA in Nova Scotia

When should I take action? As soon as possible.

Protecting Ontario's Eastern Hemlock From Hemlock Woolly Adelgid (HWA): A Practical Guide for Practitioners and Landowners

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PREFACE

The invasive insect hemlock woolly adelgid (*Adelges tsuga*) (HWA) poses a significant threat to Ontario's native eastern hemlock (*Tsuga canadensis*). Eastern hemlocks are slow-growing, long-lived species that play an important role in vast areas of Ontario's forest ecosystems. As of this writing, HWA has already infested much of the eastern United States and southwestern Nova Scotia. It has also been found in Ontario along eastern Lake Erie, the Niagara Region, Toronto, Grafton, and neighbouring municipalities. All eastern hemlocks in Ontario will likely be at risk of HWA infestation under projected best-case climate scenarios. Several decades of research and lived experience in the eastern USA and Nova Scotia have led to the development of effective strategies to reduce hemlock losses, as well as to the development of future positive programs, such as seed collection. As a species that serves unique and critical ecological functions, hemlock should be a high priority for protection. Any landowners or land managers with eastern hemlock present on their land can begin monitoring for HWA and taking active measures to promote hemlock conservation.

This Guide serves as a starting point for HWA education for practitioners and landowners and equips readers with approaches to monitoring and treatment to conserve hemlock. Key information, instructions, and external resources are provided to guide the reader through the entire process.



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— 1 —
INTRODUCTION

1.1 What is Hemlock Woolly Adelgid (HWA)?

Hemlock woolly adelgid (HWA) (*Adelges tsugae*) is an invasive aphid-like insect that causes mortality rates approaching 100% in eastern hemlock (hemlock) (*Tsuga canadensis*) and Carolina hemlock (*Tsuga caroliniana*) trees. Death typically occurs within four to ten years of infestation.¹ HWA feeds at the base of hemlock needles, intercepting nutrients destined for the tree, resulting in the death of the affected needles and branches. As infestation spreads and impedes the flow of nutrients from the needles to the tree, the tree can no longer produce sufficient energy and dies. Adelgids are closely related to aphids but are distinguished from their better-known relatives, as adelgids are specialist feeders on conifers only.² This guide concerns eastern hemlock, which is simply referred to as “hemlock” here.



Figure 1: HWA wool. From USDA hemlock Woolly adelgid³

1.2 About This Guide

The information in this Guide is intended to be applied on land where the presence of hemlock is confirmed and is at risk from HWA. It has been written for:

- Forestry Practitioners
- Pest exterminators
- Private landowners
- Environmental organizations, such as Conservation Authorities, Land Trusts, and Non-Profits,
- Any person(s) and/or group(s) that has a management responsibility for forested land(s)
- Students



Using the most up-to-date information and methods, this Guide provides information on:

1. Monitoring for HWA
2. Identifying and reporting HWA infestations
3. Deciding which management action(s) to take
4. Prioritizing trees and stands for management
5. Executing the chosen management action
6. Following a treatment plan into the future, monitoring for success

In addition, key external resources, advice on financing options, and relevant contacts are presented.

1.3 HWA in Eastern North America

HWA has native ranges in Japan and Western North America. Hemlocks in Japan and western North America have evolved with HWA and both have natural HWA predators and some level of genetic resistance. As a result, HWA does not cause meaningful hemlock death in hemlocks native to Japan and western North America. Natural predators and genetic resistance do not exist in eastern hemlock to any meaningful extent.

HWA was first detected in eastern North America in the 1950's near Richmond, Virginia USA⁴. Entry was most likely on live plant material from Japan. There was a first detection in Southern Ontario in 2012 in Etobicoke on infested imported nursery stock and Niagara Falls at Niagara Glen Park in 2013. Both instances were incinerated and deemed exterminated with no detections at those sites in monitoring since.⁵ In 2023 new infestation sites along the north shores of Lake Erie and Lake Ontario were reported and there have been additional reports since. These more recent detections have not been eradicated. The uptick and spread of infestation triggers a need for a management response.

For a list of all currently confirmed HWA detections and associated maps visit:

- Canadian Food Inspection Agency;
 - o [Hemlock Woolly Adelgid Page](#)⁶
 - o [Regulated Areas Map](#)⁷
- EDDMaps; [eddmaps.org](#)⁸
- iNaturalist; [inaturalist.org](#)⁹

The method of introduction to Ontario is uncertain, as there are many modes of HWA transmission and movement across the landscape. The primary dispersal methods are birds and wind.¹⁰ HWA can also be spread to other wildlife, hemlock nursery stock or greenery, clothing, equipment, and via water, animals, other insects, and hemlock wood products. Erratic dispersal is possible over long distances, making it difficult to predict where a viable population may be established next.

The invasive HWA established in eastern North America is native to Japan's southern temperate region. Analysis of microsatellite DNA markers and mitochondrial DNA confirms the Japanese lineage and identifies a single clone of HWA throughout the eastern USA, suggesting a single introduction event.¹¹ Mitochondrial testing of the **western** North American population shows that HWAs are of the same species but belong to different lineages, having separated during one of the last ice ages.¹¹ HWA native to western North America is a regulated pest and would also be considered invasive if introduced in eastern North America.⁶

HWA gets its name from a fibrous, white, and waxy substance that resembles ‘wool’ that is secreted as it feeds (flocculence). HWAs are half a millimetre to one and a half millimetres in length, resembling a small speck to the naked eye. In eastern North America, populations grow rapidly through parthenogenesis (asexual reproduction), producing offspring that are ‘clones’ of their mothers and reproducing twice a year (two generations).⁴ The two generations are: Progredian, the spring generation and Sistens, the summer and overwintering generation. In North America, only wingless females (progredientes) are able to lay eggs.⁴ There is a third, winged (sexuparae) lifecycle of the HWA. However, without the available host tree, tiger-tail spruce (*Picea torano*), they are unable to reproduce and die shortly after hatching.⁴

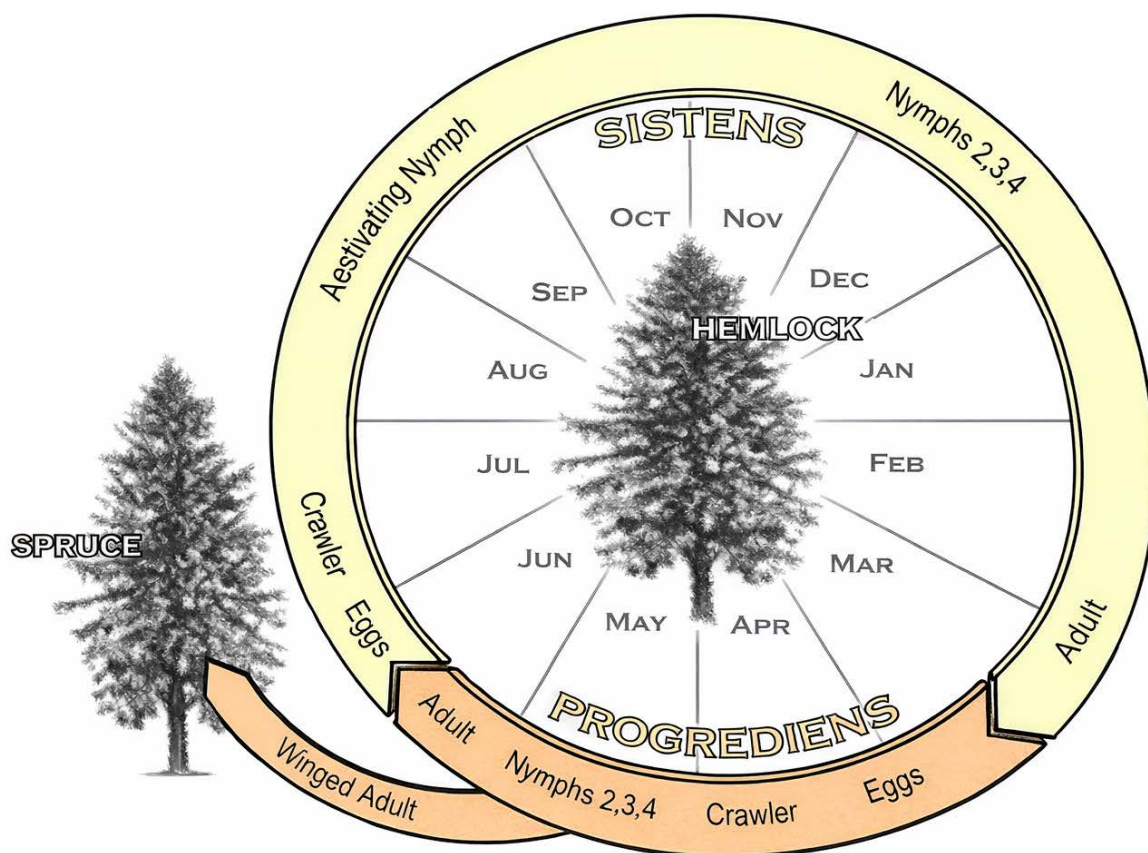


Figure 2: Hemlock woolly adelgid life stages. Note: Maine Department of Agriculture, Conservation and Forestry (n.d.). From Bugwood Network.¹²

The mature Sistens generation emerges from the protective ‘wool’ sacs in the spring along with their Progredian offspring who are in the nymph 1 or ‘crawler stage’. The spring generation can lay anywhere from 100-300 eggs on average per wingless female.¹³ The crawlers travel a short distance seeking a suitable place at the base of tender new needles. They will travel no further in their lifespan (sessile), moving only their mouthparts (stylets) to feed. The Progredian generation matures much more quickly than the Sistens generation, in only a few short months, laying eggs in late spring. This time they may lay fewer eggs, around 75, that hatch in the early summer (Sistens generation).¹³ It is during the crawler phase in July that movement and spread are most likely to occur.

The crawlers of the Sistens generation that hatch in early summer enter an aestivating phase (dormant) shortly after hatching and do not actively feed again until cooler temperatures arrive in the fall. This generation overwinters (winter diapause) in its woolly secretions, maturing more slowly and beginning the cycle again the following spring.⁴ A devastating effect of this otherwise incredible life cycle is that a single wingless female can trigger an outbreak, and populations can rebound quickly.



1.4 Why is it Important to Manage HWA?

Hemlock, a slow-growing and long-lived species, is an integral part of Ontario's forested ecosystems, providing many crucial ecosystem functions. Research in the eastern hemlock range has found that 96 bird species and 47 mammal species are associated with hemlock stands.¹⁴ This group of associates includes iconic species such as ruffed grouse, American marten, bobcat, black bear, northern goshawk, black-throated green warbler, blue-headed vireo, blackburnian warbler, Acadian flycatcher, and many more. It has also been found that at least 273 species of arthropods (insects, mites, spiders, etc.) are associated with hemlock.¹⁵

Hemlocks are often found on steep slopes and in riparian areas, including brooks, creeks, rivers, lakes, vernal pools, and ravines. The dense shade cast by hemlock stands has a cooling effect that helps regulate water temperature and loss. Hemlock's presence in these areas controls erosion, slope slumpage and filters rainwater runoff, positively impacting water quality locally and downstream. The shade from these stands also slows the melt of the spring snowpack, allowing for an extended release of cold water into streams. All of this maintains the integrity of aquatic habitat for sensitive cold-water fish species, such as brook trout, which require water temperatures below 15°C.

Dense hemlock canopies provide thermal cover against harsh weather and can create areas of shallower snow that facilitate winter wildlife movement. This is particularly beneficial to wild turkey, deer, and moose, who may yard up in such areas through the winter and feed on hemlock shoots. If HWA spreads unchecked through Ontario, these ecosystem services will be dramatically reduced, and many species will be adversely affected, harming Ontario's forests and wildlife.

Hemlock has direct economic value. Its average annual harvest in Ontario is 20,430 cubic meters, with twenty-two mills generating hemlock wood products.¹⁶ Additionally, given the value of hemlock to wildlife, the outdoor tourism industry, including wildlife tourism, ecotourism, hunting and fishing, will also be negatively impacted by the loss of hemlock. Finally, landowners will be impacted by the loss of forest cover and may need to remove hazardous dead trees, which could be at a significant expense.

The death of hemlock trees will reduce overall forest health and may increase vulnerability to other invasive species that colonize disturbed areas, such as dog-strangling vine, garlic mustard, and glossy buckthorn, which could potentially increase vulnerability to other disturbances and degradation. The loss of hemlock due to HWA will forever alter the structure and function of Ontario's forests.

1.5 Areas of Ontario at Risk

There are no natural predators of HWA and no known genetic resistance in eastern hemlock to HWA. The only natural limiting factor for HWA in eastern North America is suitable habitat. For HWA, suitable habitat means the presence of hemlock and suitable temperatures and moisture levels. HWA is native to temperate climates and is susceptible to both extremely high and low temperatures.

Winter mortality begins at -20°C to -25°C, with mortality increasing to 90% when temperatures drop below -30 °C.¹⁷ A mortality rate of 90% is required to keep HWA populations static. However, the timing and length of a cold snap within the season also impact mortality rates.¹⁸ The decreasing frequency of extreme cold and increase in annual winter temperatures due to climate change could aid in the northward spread of HWA into areas where it previously could not survive.

The trend toward higher summer temperatures above 30°C is associated with increased HWA mortality.¹⁷ Direct sunlight exposure can also increase mortality.¹⁹ The timing of these higher temperatures and the

number of days that sustain them affect mortality rates.

Extreme rain events have been shown to cause HWA mortality by making conditions favourable for fungal pathogens that can kill HWA.²⁰ Further research is needed on the relationship between rainfall and HWA mortality to draw definitive conclusions.

These environmental factors may limit HWA spread or success, but HWA can often rebound or could even adapt to new conditions. Furthermore, climate change could expand the range of suitable climates for HWA in Ontario.

Research from the University of Toronto suggests that HWA-suitable climate will expand in the future. Figures 3 and 4 use climatic averages from 1970-2000 overlaid on Ontario’s historic townships and current hemlock locations to evaluate HWA risk. Risk was determined by correlating the proportion of host abundance (eastern hemlock forest cover) and HWA habitat suitability (temperatures) under historic climate conditions.²¹ Hemlock abundance was equally split into the three categories: low, medium, and high, based on the percentage of hemlock in the total forest cover. HWA habitat suitability is based on set temperature thresholds. At present, habitat suitability already extends beyond the area of infestation in Ontario. As a result of climate change, even in the most conservative low emissions scenario (See Figure 4), it is predicted that by mid-century the entire range of Ontario’s hemlock will be within suitable temperature ranges for the survival of HWA. In late-century projections and in higher-emissions scenarios, the entire range of hemlock and beyond is highly suitable for HWA.

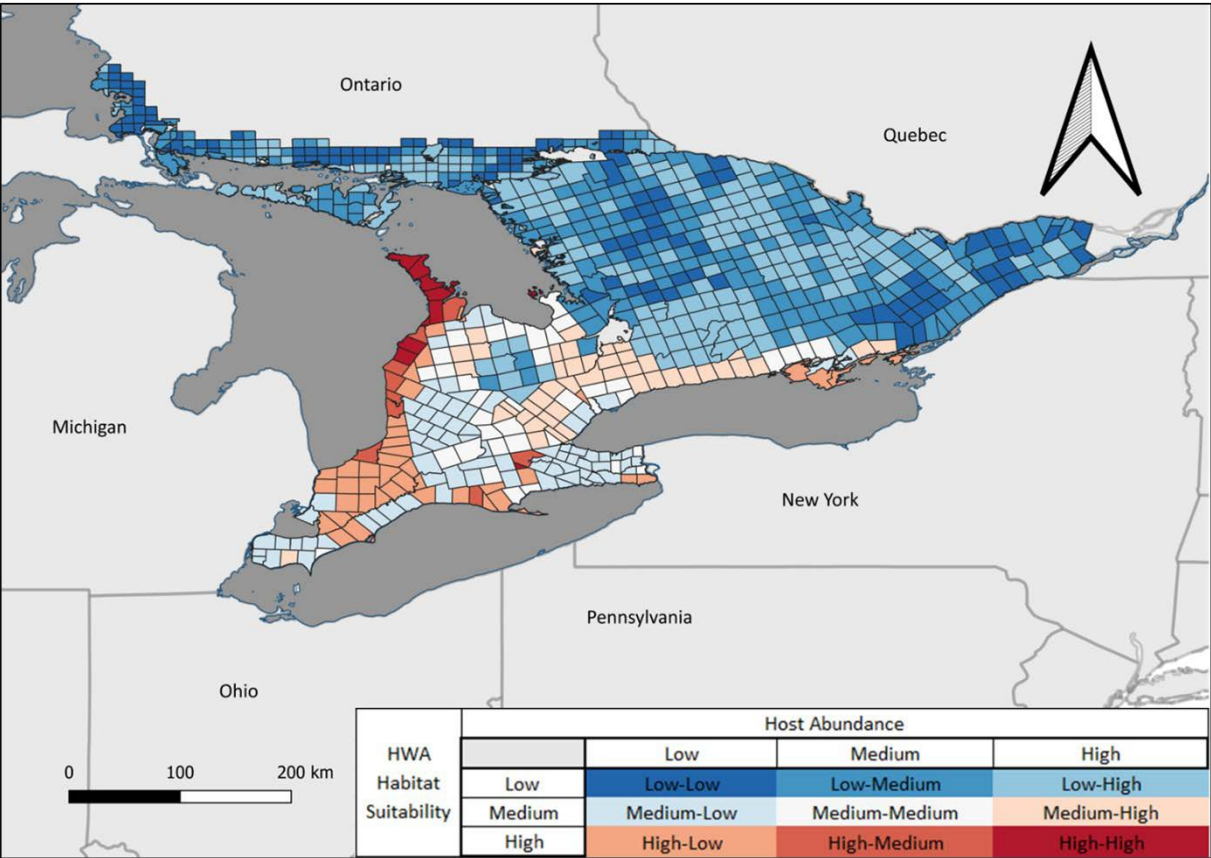


Figure 3 Present HWA habitat suitability map under historic climate conditions. From Cornelsen et al. 2024²¹



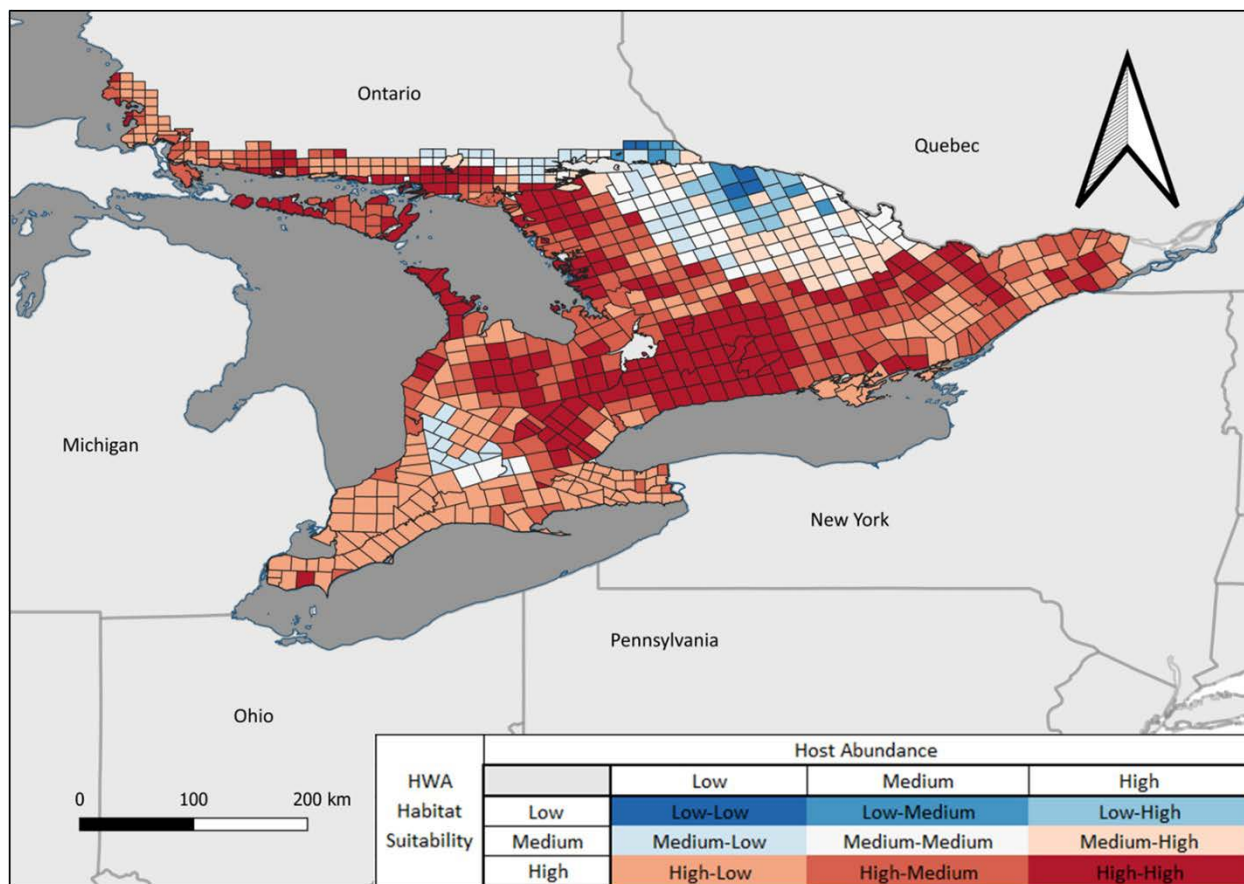


Figure 4 Low emissions 2041-2060 predicted HWA habitat suitability map and HWA habitat suitability (susceptibility) under a “best case” SSP 126 climate change scenario. From Cornelsen et al. 2024²¹

1.6 What Can be Done?

1.6.1 Education

Education is a valuable tool for empowering the development of knowledge and skills in forest owners and managers. This Guide aims to provide sufficient, up-to-date information to help make the best decisions when managing HWA.

Owners and managers will need to assess their land based on available treatment methods and the potential impacts of HWA. From these findings, a treatment plan can be devised that best suits the current situation. If the forest or woodlot does not have a forest management plan, now is a good time to prepare one and incorporate appropriate hemlock management strategies. The plan should include a good property map, a repeatable forest inventory including species composition, size, structure, and health; confirmation of hemlock locations; confirmation of the presence or absence of other preferred tree species; presence of invasives; and notes on any potential future risks or opportunities. It should also identify priority actions. This information will help to prioritize stand treatment, increase treatment efficacy and efficiency, and support possible funding opportunities for HWA treatment.

The details around how to complete this sort of management plan and inventory are beyond the scope of this Guide, but a reputable forest service provider can complete or support these activities. Furthermore, joining an organization like the Ontario Woodlot Association (OWA) will help keep landowners and land managers informed about HWA management opportunities, new science, and

support further educational work, such as this Guide. Local Conservation Authorities, City, Municipal and County Forest Managers are also knowledgeable resources.

Finally, the more familiar the landowner or forest manager is with the forested property, the more efficient and effective management will be. This means making sure the entire management team (owners, friends, family, and anyone who will be involved in treatment) is familiar with the property boundaries, access, goals and objectives, and hemlock locations.

1.6.2 Action

After a landowner or land manager has educated themselves, there are some specific actions they can take. These are briefly summarized below and discussed in greater detail throughout the rest of the guide. These actions include:

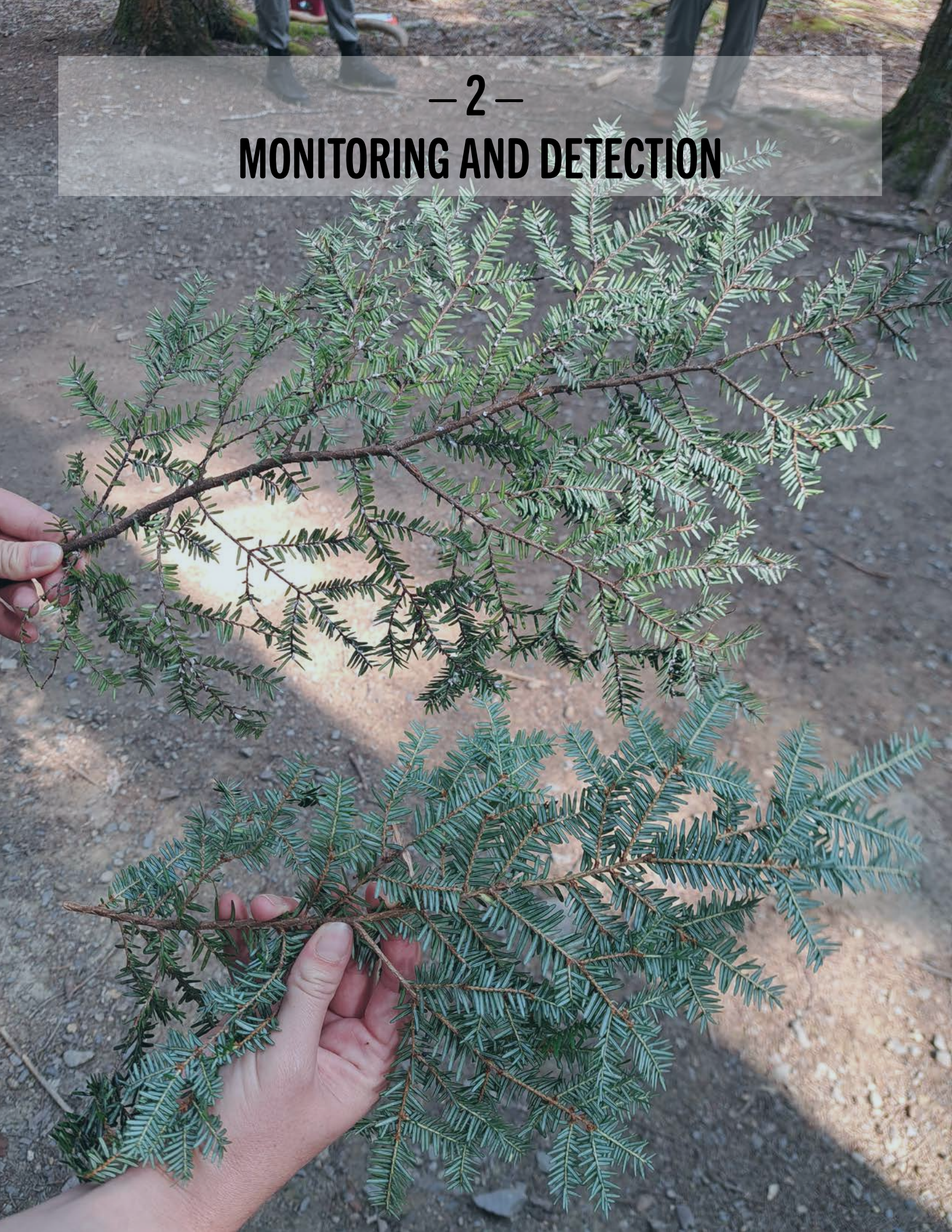
1. Monitoring for HWA
2. Taking no action and allowing HWA to spread in the stand
3. Implementing silvicultural activities to improve stand health
4. Applying chemical insecticides to protect trees against HWA.

Biocontrol is a management tool that uses living organisms, such as predators, parasites, parasitoids, and pathogens like bacteria and fungi, to target and control undesired species. Nova Scotia and several U.S. States have implemented a rigorous, science-based biocontrol program to control HWA. The intent is to introduce HWA's natural predators from western North America to eastern North America, in hopes that they will reduce HWA population to non-lethal levels. This will alleviate the pressures of the chemical treatment regime that landowners and forest managers are now facing. There is no biocontrol program in Ontario at this time.



— 2 —

MONITORING AND DETECTION



This section provides information on how to monitor for HWA, including what to look for to detect it when present.

2.1 Existing Efforts

In Ontario, the federal and provincial governments, conservation authorities, private organizations, individuals, and municipalities have begun regular monitoring for HWA. There are four main methods being used to monitor for HWA:

1. Visual surveying: Inspecting crown density, examining hemlock branches at eye level, trimming high branches, or looking at newly fallen branches from wind or squirrels (this is the method most landowners will use).
2. Ball sampling: A Velcro-coated ball is propelled into the hemlock canopy using a slingshot and checked for adelgid “wool”. YouTube – [Invasive Species Center ‘HOW TO: Ball Sampling for Hemlock Woolly Adelgid’](#)²²
3. Sticky trapping: Small cards coated in an adhesive film are left face-up in the understory of hemlocks for five to seven days and then inspected with a hand lens or microscope for HWA crawlers.
4. Environmental DNA (eDNA): Sticky traps are set near hemlocks, then collected and analyzed for HWA DNA in a lab.

There is an HWA monitoring network in Ontario coordinated by the Invasive Species Centre (ISC), in partnership with Natural Resources Canada (NRCan) and the Canadian Food Inspection Agency (CFIA). Through a volunteer landowner network, they monitor for HWA using eDNA traps in various locations across southern Ontario. Landowners interested in participating in this monitoring network can contact the Invasive Species Centre or register on their website.²³ Participating in this monitoring network is voluntary, and landowners and land managers can always survey on their own.

2.2 When Should Monitoring Begin?

Now that HWA has entered Ontario, all landowners and land managers with hemlock on their property should begin monitoring for HWA. Since HWA can disperse over long, sporadic distances carried by the wind or animals, there is potential for new infestations to occur far outside of currently infested areas. For landowners who are unfamiliar with hemlock, consult a field guide, a reputable website, a knowledgeable peer, or a forest practitioner for help with tree identification.

Ideally, monitoring should take place twice a year, but it can also be part of routine walks in the forest. It is very important not to rely on the sighting of HWA wool sacs alone for observational monitoring. By the time wool is visible on low branches, the infestation is considered heavy. Look for other signs of possible infestation in the ‘symptoms and signs of HWA’ later in this section to help determine possible infestation. Early detection can be difficult because HWA is small and often establishes high in the canopy, making visual detection difficult. Just because HWA is not detected, it does not mean HWA is not present in small numbers or out of sight.



Tool for Landscape Planning and Professionals

The University of Guelph has developed a landscape-level map that can be used to locate hemlock stands across Ontario and could be useful for strategic planning or for locating hemlock on large landholdings. Visit: <https://ee-bendv.projects.earthengine.app/view/eastern-hemlock-in-ontario-v1>.²⁴

2.3 Planning to Monitor

A landowner or land manager can perform basic visual surveys without external support. The following information and methods regarding monitoring are based on the Canadian Food Inspection Agency's protocol in the [Hemlock Woolly Adelgid Detection Survey Protocol](#).²⁵

2.4 Symptoms and Signs of HWA

There are two main ways that HWA is identified:

Sign 1: The visual impacts on hemlock are usually noticed first:

- Needle and branch dieback and “flagging” branches starting in the upper canopy
- Lack of new needle and twig growth
- As the infestation progresses, the above signs move lower in the tree
- Other dead hemlock in the area

Sign 2: The identification of the actual insect is often completed next:

- A small, compact, white ‘wool’ mass with defined edges at the base of hemlock needles that has a ‘cotton swab tip’ appearance and the adelgid appears as a speck in the middle
- Eggs, crawlers, and adults: Crawlers are reddish-brown in colour, which darkens to black. Adults are elongated oval shapes with rounded ends, flat, purplish-black and a slight white fringe around the edges of their bodies, giving a ‘halo’-like appearance.

These symptoms and signs are detailed below.

2.4.1 Sign 1: Visual Impact to Hemlock

Premature canopy thinning, discoloration, and dieback are usually the first signs of an infestation. Hemlocks are usually associated with dark, dense canopies. Feeding by HWA disrupts nutrient transport between needles and trees, causing needle death. Branch tips and twigs, normally full, will have noticeable gaps or ‘missing needles’ (See Figure 5). In advanced stages of infestation, swollen growths (gouting) can occur at the tips of twigs, and light green growth at the branch tips will be lost. ‘Grey hues’ on needles due to lost moisture are also present. This has given rise to the nickname ‘grey ghosts’ for hemlock in severe HWA decline, or for trees that have died.

Detection of Visual Impact

Crown density assessment is the primary and easiest method for assessing thinning, discoloration, and dieback in hemlock canopies. Use the crown density scorecard (See Figure 11) and give the canopy a score. Hemlocks usually have dark, closed canopies at 85%-95% closure. See section 2.5.2 Surveying Individual Trees Below for directions.

- Look for signs of ‘flagging’ branches with yellowish green in colour, usually higher in the canopy.
- ‘Grey ghosts’ are recently deceased hemlocks which give the once green and dark forest a grey, smoky hue.

An additional clue is changes to the understory vegetation. Increased light reaching the forest floor can indicate dieback and HWA feeding. Look for alterations in the understory communities due to changes in light levels. Examples include transition from moss to ferns, new raspberry populations, or other species including invasives that require higher light levels to establish.

If the signs above are present, it could indicate HWA in the tree or stand, and a more detailed inspection is warranted. A detailed monitoring system is detailed in the next section.

If the signs above are present, it could mean there is HWA in the tree or stand and a more detailed inspection for HWA is warranted. A detailed monitoring system is detailed in the next section.



Figure 5 Healthy hemlock branch showing full sets of needles and infested branch in decline. From Crossland et al. 2024²⁶ Hemlock crowns in Nova Scotia appearing grey due to moisture and needle loss. D. Crossland (personal communications, 2023)

2.4.2 Sign 2: HWA Presence

HWA secrete ‘wool’ while feeding, which is the most obvious developmental stage (adults). Ovisacs occur where the HWA settle to feed and grow at the base of the needles. The sacs can remain on the branches and twigs for up to a year. Ovisacs vary in density and size, and a light infestation may be difficult to detect, especially when it is high in the canopy. HWA wool sacs resemble small white cotton balls. Infestations tend to start from the top and work down the tree. Do not rely on detecting ovisacs alone. Be aware of HWA look-alikes that may initially appear to be HWA. See section 2.4.3 HWA Look-Alikes.



Detection of Wool:

‘Wool ovisacs’ sacs are formed from late spring to early summer and again in the fall but can persist for up to a year. To complete an inspection, examine the underside of branches and needles with a hand lens. Start at the newer terminal (tips) and lateral (down from tips) shoots of hemlock branches. Note the number of egg sacs to determine the level of infestation in Figure 5. For viewing high in the canopy, the use of a 2000-lumen light at twilight lights up the ‘woolly sacs’.



Low 1-5 sacs



Moderate 5-20 sacs



High 20+ sacs

Figure 6 Light infestation. S.Eggett (personal communication September 2025). Moderate infestation. A. Tonelli, 2012. From Wikimedia Commons.²⁷ Heavy infestation. From Insect Images by Connecticut Agricultural Experiment Station Archive, Wikimedia Commons²⁸

Detection of Eggs, Crawlers, and Adults:

Wool is not the only indicator of HWA. HWA complete a total of six stages of development: eggs, four nymphal instars and adults. Eggs hatch into nymphs known as “crawlers”. Crawlers are HWA’s only mobile phase and coincide with the peak of bird migration, increasing movement risk.⁴ Eggs and crawlers are reddish-brown in colour, which darkens to black as they develop through the four nymph life stages. In the latter nymphal instars, as they settle and begin to feed, the first ‘waxy’ secretions resemble a ‘halo’ around their oval-shaped bodies.⁴ Continued feeding by mature nymphs and adults develops into ‘wool’. Eggs, crawlers, and adults are very small (one millimetre in length at maturity) and difficult to detect. They will be on branch tips and lateral branches. From late **March to late April** and **early summer to November**, use a hand lens to inspect branches for HWA.



Figure 7 HWA eggs in ‘wool ovisac’. L. Grane, n.d., (© Bartlett Tree Experts) Bugwood Network²⁹. Mature HWA nymph instar viewed through a hand lens. From Whitmore, M. 2023³⁰

2.4.3 HWA Look-Alikes

There are HWA look-alikes that may initially appear like HWA feeding damage or HWA itself.

2.4.3.1 Feeding Damage Look-alike

There are several native and introduced species that can cause feeding damage similar to HWA and/or twig/branch dieback and mortality. Most of these species do not cause significant mortality in hemlock populations and are mainly associated with needle browning and loss. Extreme feeding damage from large populations of spongy moth or hemlock looper can lead to mortality. Armillaria root rot is also associated with mortality. These include:

- a) Sirococcus Shoot Blight (*Sirococcus conigenus*)
- b) Spongy Moth (*Lymantria dispar*) (invasive)
- c) Hemlock Looper (*Lambdina fiscellaria*)
- d) Hemlock Borer (*Phaenops fulvoguttata*)
- e) Armillaria root rot (*Armillaria* spp.)
- f) Needle rusts and blights (not pictured)
- g) Other Fungi (not pictured)



Hemlock Shoot Blight. From B. Watt, (n.d) University of Maine, from Bugwood Network.³¹



Spongy moth (*Lymantria dispar*) egg masses on tree bark, showing infestation. Note. Photograph by F. Lakatos, University of Sopron, from Bugwood Network.³²



Eastern hemlock looper (*Lambdina fiscellaria fiscellaria*) larva. Note. Photograph by Pennsylvania Department of Conservation and Natural Resources - Forestry, from Bugwood Network.³³



Hemlock borer (*Phaenops fulvoguttata*) observed in Greenwood, ME, USA. Note. Photograph by D. Nelson, 2023, from iNaturalist.³⁴



Armillaria root rot (*Armillaria mellea*) rhizomorphs. Note. Photograph by R. Anderson, USDA Forest Service, from Bugwood Network.³⁵



Armillaria root rot (*Armillaria mellea*) fruiting bodies. Note. Photograph by Dave Powell, USDA Forest Service (retired), from Bugwood Network (Image No. 0806035).³⁶

Figure 8 Feeding Damage Look-a-likes up close



The yellow-bellied sapsucker (*Sphyrapicus varius* L.) can cause feeding damage, which may lead to eventual dieback in hemlock. Feeding is in neat rows of vertical and horizontal holes. Extensive feeding can open pathways for pathogens and weaken tree health, leading to mortality. Increased feeding from other woodpeckers, such as pileated woodpecker galleries, can be a sign of a tree in poor health.



Figure 9 Woodpecker Feeding Damage

Yellow-bellied sapsucker (*Sphyrapicus varius*).

Note. Photograph by Melissa McMasters, 2015, Memphis, TN, USA, from Wikicommons.org³⁷

2.4.3.2 HWA Look-Alikes

There are HWA look-alikes (insects) that could easily be mistaken for HWA. Most are rarely associated with hemlocks, while others may cause minimal hemlock needle disturbance. Common look-alike insects include:

- a) 'Woolly aphids': There are several native aphids that produce wool similar to HWA. They can be found on American beech (*Fagus grandifolia*), Alder (*Alnus* spp), Apple (*Malus* spp) and some other tree and plant species. They are larger than HWA and are not limited to branch tips.
- b) Spider egg sacs
- c) Mealybugs
- d) Pine Spittlebug
- e) Brown Hemlock Needleminer

Figure 10 HWA Look-Alikes

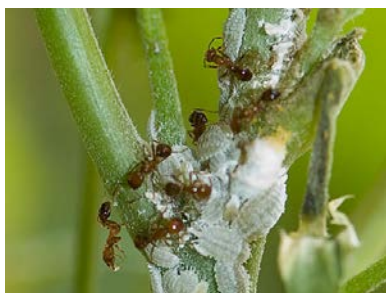


Woolly beech aphid (*Phyllaphis fagi*) on a leaf.

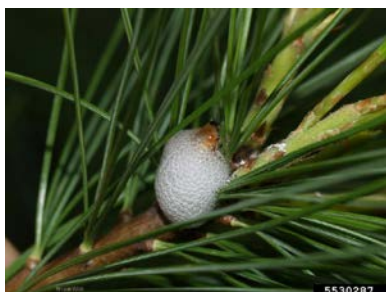
Note. Photograph by S. Rae, 21 June 2013, from Wikimedia Commons³⁸



Spider egg sac on a leaf. Photograph by K. Schulz (n.d), from Wikimedia Commons³⁹



Ants feeding on mealy bugs. V. Cavale, January 2007, from Wikimedia Commons .⁴⁰



Pine spittlebug (*Aphrophora cribrata*) nymph in spittle with abdomen exposed. Adapted from Bruce Watt, University of Maine, Bugwood.org (n.d., Image No. 5530287).⁴¹



Brown hemlock needleminer (*Coleotechnites macleodi*) larva(e). From Connecticut Agricultural Experiment Station, Bugwood.org (n.d., Image No. 1178010)⁴²

For a complete and up-to-date list of diseases, pests and pathogens affecting hemlocks in Ontario, refer to the Natural Resource Canada website on Hemlocks: <https://tidcf.nrcan.gc.ca/en/trees/factsheet/210>.⁴²



2.5 Completing a Survey

This section first details how to survey an individual tree, then how to apply this at the stand level to select which trees to survey within the stand. The procedures can be adjusted to suit the needs of the site, equipment, and number of surveyors.

2.5.1 Monitoring Supplies

These supplies will be needed or helpful when monitoring:

- Pole pruner (optional)
- Hand lens, binoculars
- Camera
- GPS unit or phone map
- Re-sealable bags
- Flagging tape
- Pencils, permanent markers
- Field book with waterproof paper, blank paper
- Protective footwear, safety glasses (optional)
- Cruising vest or carpenter's waist apron
- Knapsack
- Lint roller
- ArcGIS Survey 123 app (optional)
- 2000 lumen headlamp (optional)
- Monitoring and Tree Health Assessment Record (optional)

Control the Spread of HWA When Monitoring

Some biosecurity precautions are advised to prevent the spread of HWA if it is present at the survey site. Wear light coloured clothing to make HWA crawlers more apparent. Park vehicles away from the trees at the survey site. While surveying, avoid placing or hanging gear on hemlock trees and branches. Once finished surveying, exit the stand, lint-roll clothing and gear (or use sticky packing tape), and beat or lint-roll hats and packs to remove any crawlers. When back at the vehicle or house after this treatment, bag the field clothes in garbage bags and change into fresh clothes. Wash field clothing and then dry in a hot dryer. Decontaminate pets if present. If the survey is conducted during the crawler season (April-August), do not visit additional survey sites after visiting a positive or potentially positive site to avoid spreading HWA.

2.5.2 Surveying Individual Trees

The following is how an individual tree would be surveyed using the most basic and accessible methods.

1. Have a record-keeping system in place ahead of monitoring. This should include the date, tree location/ID, and begin a running tally for the number of trees examined.
 - a. See **Appendix B: Example Monitoring and Tree Health Assessment Record** for Monitoring and Tree Health Assessment Record
2. Observe the canopy condition and take note of any thinning, discoloration or dieback.
3. Stand at an arm's length away from the main bole (trunk) and determine a canopy density score (average between the two sides if needed). See the box below for instructions on completing a canopy density assessment.
4. Inspect branch tips further down the tree for signs of HWA; look for thinning needles, discoloration, and dieback.
5. When branches are within arm's reach, inspect branches directly.
6. When branches are too high for inspection, there are some options:
 - a. A pole pruner can be used to cut off some branches and twigs for inspection
 - b. Binoculars can be used to look into the canopy
 - c. Light from a high-powered 2000 lumen light can be directed into the canopy to make any HWA wool much more apparent. For best results, carry this out at twilight, as thinning needles may make it difficult to determine in sunlight.
 - d. Survey after a windstorm or ice storm when hemlock branches have been broken off the tree and onto the forest floor.
 - e. Inspect branches bitten off by squirrels.
7. Scan the underside of the branch for any evidence of ovisacs (HWA wool), or nymphs. If surveying in the summer, use a hand lens to look for the dormant nymphs. Focus the survey on the underside of the branch, at the base of the needles, towards the newest growth.
8. Repeat the process on the opposite side of the tree
9. Record results
10. Take photos of found and suspected infestations, as they are required for online reporting and are preferred over moving specimens.
11. If bagging a specimen for removal from the found location, do not move it off the property. Professionals should come to the site to assess the entire scope of the infestation.



Determining Crown Density

Healthy hemlocks have dense, dark crowns. Assessing crown density with a canopy density scorecard can be used to assess canopy health. For ongoing monitoring, the use of a record system discussed in this Guide will show any decline over time. Live Crown Ratio should also be taken into consideration and be at least 50%, with a crown density of at least 65%, when assessing the trees' available resources to sustain and recover from a treatment regime. Hemlocks usually have closed, dark canopies with 85% or more crown closure.

To determine crown density:

- Hold the crown density scorecard (See Figure 11) overhead, while standing at an arm's length from the tree bole (trunk).
- Do not stand at the dripline (branch tips), as this will result in an inaccurate survey.
- Look straight up through the canopy.
- Look back and forth between the canopy and the density scorecard.
- Choose which score best reflects the observed density
- Take the density score from two sides of a tree if there are noticeable differences and average out the two scores
- Note that trees compete for light levels and do not have even crown distribution in tightly spaced forest canopies.

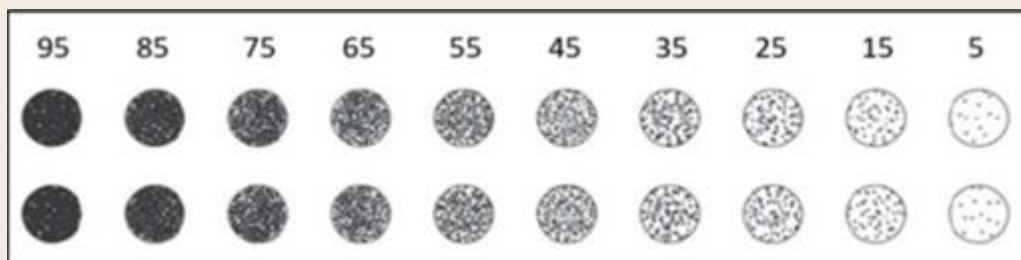


Figure 11 Canopy density Score. From Crossland et al. 2024²⁶

Live Crown Ratio (LCR) is measured by determining how many branches with live needles are present up the bole (trunk) of the tree. An LCR of 50% would mean that full healthy branches begin about halfway up the main bole to the tip of the canopy.

The higher the canopy density score, the healthier the tree; as HWA infestations progress, canopy density will decrease due to foliage thinning and needle drop. A low canopy density score (65 or less) alone does not indicate the presence of HWA. Look for ovisacs, nymphs and other signs to confirm.

A Must Read

Review Appendix A: Medway Community Forest Insecticide Treatment Key and Canopy Density Score to help determine which trees to treat with insecticide. This key was developed in Nova Scotia by Medway Community Forest Cooperative. It can also be found at: <https://www.medwaycommunityforest.com/hemlocks>.²⁶

****Note*** the above key is for the use of a single insecticide, imidacloprid, which was the only chemical available for use at the time of the key development.*



2.6 Monitoring and Surveying Hemlock at the Stand and Landscape Scale

2.6.1 Surveying Small Stands

In small stands where it is practical, either by virtue of the number of trees or by the time available to the inspector, inspect all hemlocks as per the suggested directions above. Have a map of the property with the hemlock trees located and stands clearly delineated. Maintain a good record-keeping system with written records and/or pictures.

2.6.2 Surveying Large Stands

In large stands, or where multiple stands must be inspected, and inspection of all trees is not practical or feasible, take a sample of trees. Below are points of guidance in developing a sampling methodology. The exact methodology and the number of trees inspected will be determined by both the individual site and the available time and resources.

1. Use a property or stand map to help plan the approach and ascertain the approximate boundaries of the area to be surveyed.
2. Obtain a general estimate of the size of the stand(s) to be surveyed. Larger stands can be broken down into blocks (halves, quarters) that are easier to manage based on topography such as trails, creeks, ridgelines, and other major features.
3. Develop a system for documenting the survey that includes the date, survey path, and number of trees examined. (See **Appendix B: Example Monitoring and Tree Health Assessment Record**)
4. Anticipate inspecting approximately one hundred trees per stand.
5. Consider the contour of the targeted stand so that the pattern covers stand edges and interior as well as high-risk areas.
6. HWA populations often have a clumped distribution, particularly during early stages of the infestation, meaning infested trees tend to be close together in patches. This clumping tendency requires that the survey cover a broad area to increase the chance of encountering an infested patch of hemlock trees.
7. Ensure that the trees selected for sampling are well distributed in the block or stand, while also placing a strategic focus on trees located in areas of highest probability for infestation, such as wildlife trails, stand edges, and bird routes (e.g. along streams, lakes, and fields).
8. Inspect all hemlocks showing discoloration, twig dieback or lack of new light green growth in late spring or early summer, regardless of whether they were on the inspection route
9. While walking between selected trees, inspect hemlock branches that have broken off and are on the ground.
10. If HWA is detected in the understory, know that the infestation has almost certainly originated from higher in the canopy, so the surrounding trees are also likely infested and should be inspected.

2.6.3 Passive Monitoring

Once familiar with monitoring protocols, landowners and land managers can monitor on a casual basis in addition to conducting formal annual surveys. Casual or passive monitoring is beneficial in finding HWA that went undetected during other surveys. This can be as simple as stopping to look at the canopy of hemlock trees, checking fallen branches, or looking at the underside of needles when walking by hemlock. These minor checks will help identify changes or declines in the health of hemlock and increase the chances of early detection. If a hemlock tree falls or is harvested, closely examine its crown. HWA infestations typically begin in the canopy and spread downwards.



Figure 12: Surveying a hemlock stand. Photo by O. Mehdi. (personal communication, 2024).

2.7 After Completing a Survey

If HWA is detected, it needs to be reported. Be prepared to provide the survey information recorded using the following procedure:

- Report via email to the Canadian Food Inspection Agency (CFIA) at cfia.surveillance-surveillance.acia@inspection.gc.ca. They will require photos, location, date, and contact information.
- Report online to the Canadian Food Inspection Agency (CFIA) at <https://inspection.canada.ca/en/plant-health/invasive-pests-and-plants/insects/hemlock-woolly-adelgid>⁶
- Report to the appropriate provincial agency and EDDMapS. Instructions for making these reports can be found at <https://www.invasivespeciescentre.ca/report-a-sighting/>⁴⁴
- Landowners within HWA-regulated areas do not need to report to the CFIA. They should report to the provincial agency.
 - o CFIA Regulated Areas⁷



- Provincial Reporting (as directed by the Invasive Species Centre)
 - o Report to: <https://www.eddmaps.org>⁸
 - o Invasive Species Hotline 1-800-563-7711
- Finally, share the information with neighbours, the Ontario Woodlot Association (OWA), the OWA local chapter, the local County Forester, and the Conservation Authority Forester.

If a survey was completed, but HWA **was not detected**, publicly reporting a survey is optional but highly beneficial and recommended. Citizen science surveys that assess hemlock health and detect the presence of HWA are vital for data collection, especially since many hemlocks are located on private land. Data submitted through online platforms like Survey123 help establish current baselines, support ongoing research, and contribute to monitoring and management efforts. The process is user-friendly; no long-in required and can be completed in a short amount of time.

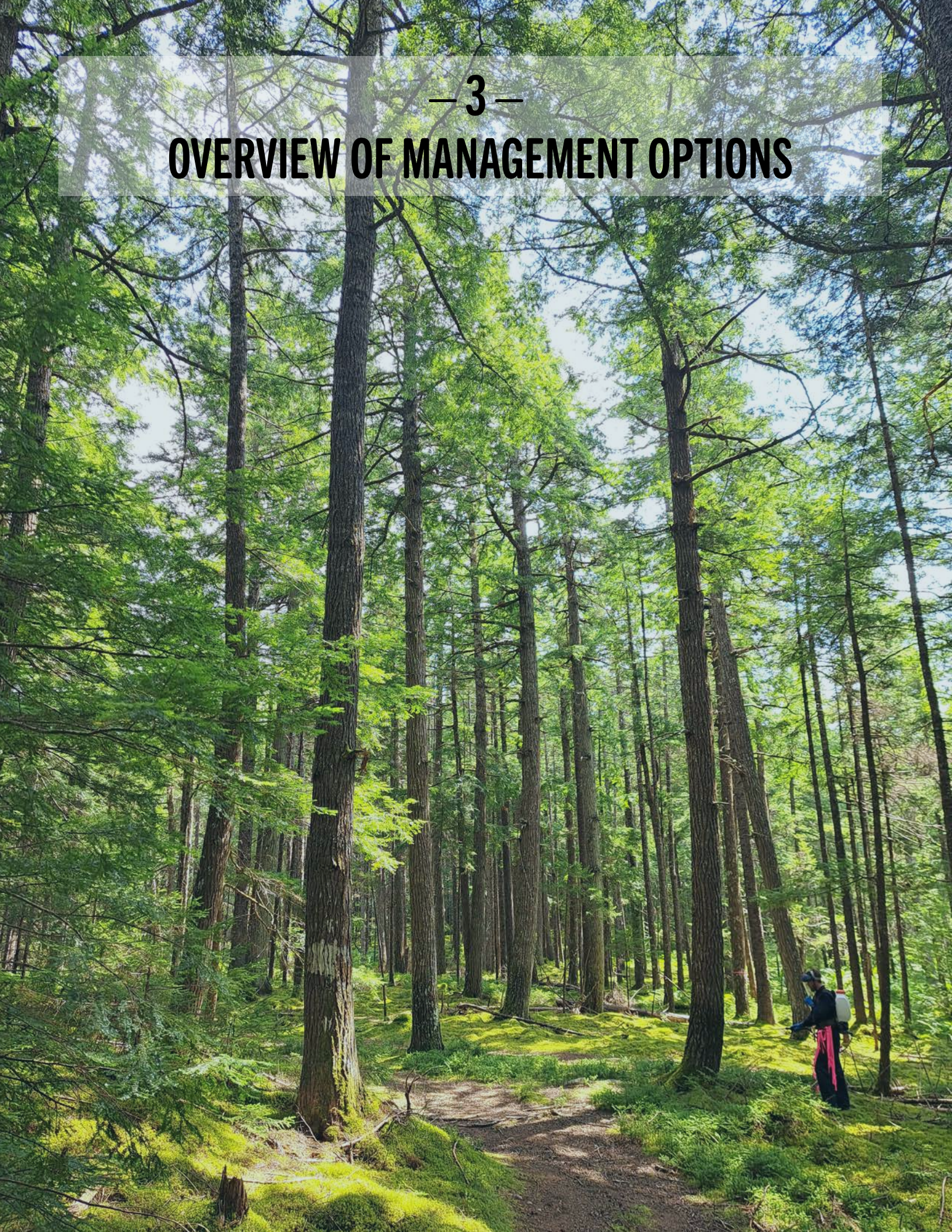
- To submit survey results online, visit: <https://arcg.is/1jLKbO0> and select “open in browser”.⁴⁵
- Alternatively, use a smartphone to download the free app ArcGIS Survey123, scan the QR code below and record and submit the survey results, which will be received by the CFIA. Both options are best completed while the survey is taking place.

Both options are best completed while the survey is taking place.



— 3 —

OVERVIEW OF MANAGEMENT OPTIONS



This section summarizes management options for HWA. The goal of this section is to inform readers about the available management options and when they can be used.

3.1 Management Options

Effective pest management uses a combination of actions. For HWA, there are currently three primary management actions available to landowners and land managers:

1. **Do Nothing and Let HWA Infest the Stand.** This approach can be used in situations such as:
 - a. Low priority stands where the cost of treatment is not warranted, and funds are better focused elsewhere
 - b. When the infestation is so far advanced that intervention will have limited or no positive impact
 - c. When conditions are too dangerous to work in (ex. many dead hemlocks or other snags, steep slopes, etc.)
2. **Implement Silvicultural Activities.** When applied well in advance of infestation, this approach can increase light exposure, improve residual hemlock tree health, and boost growth rates, all of which have the potential to increase hemlock resilience against HWA infestation and disfavour HWA productivity. Current experience is that silviculture alone will not prevent mortality but can prolong hemlock life expectancy in the face of HWA. Silviculture must be employed with care, under the direction of a Registered Professional Forester (RPF), and comply with any local tree-cutting bylaws. Silviculture is not meant to be used as an outright hemlock salvage-cutting system, but rather an attempt to improve the chances of hemlock survival ahead of HWA infestation and maintain other important forest values. Harvest revenues can be used to offset the costs of HWA management activities.
3. **Apply Chemical Pesticides.** Currently, chemical treatment offers the best chance of hemlock survival. Empirical evidence indicates that efficacy is quite high. Chemical treatment applies small, targeted doses of Insecticide to individual trees during the growing season. Landowners who want to ensure the survival of hemlock on their land are advised to use insecticides. To maintain local genetic diversity and viability, at least 100 individuals per square kilometre, or equivalent density, are required. This number should be considered when choosing how to allocate limited Insecticide application funds.

3.2 When Should Management Action Begin?

In general, the best answer to the question ‘when should I take action?’ is ‘as soon as possible’. Early action, even before infestation occurs, can improve HWA management outcomes. If considering silvicultural treatment, work is best carried out at least 10 years before the onset of HWA infestations. However, if applied in a known infestation, silviculture is believed to alleviate tree stress and provide more resources to affected hemlocks. If considering chemical treatments, there are options for protection pre-infestation, especially when HWA is nearby. If an infestation is found in a stand before chemical treatment has been applied, a rigorous chemical treatment should begin immediately if the trees are

still healthy enough (crown density, live crown ratio, good tree and stand health) to withstand the treatment cycle.

In practice, the lack of immediate threat to hemlock can lead to delays in treatment. However, proactive HWA management may be particularly well-suited to some woodlot owners and land managers and can be incorporated within existing management plans, or other management activities.⁴⁶ If action is delayed until signs of HWA are obvious, chances of positive management outcomes significantly decrease.

In addition to the recommendations of this Guide, implementing good forestry management practices is always a good idea, as a healthy forest is a resilient forest.

Take Note

Current experience is that virtually all hemlocks infested with HWA will die unless they are chemically treated with insecticides. Hopes of managing HWA by natural resistance of some hemlock trees are unlikely to materialize. Experience in the United States and Nova Scotia is that there is very little natural resistance to HWA in eastern and Carolinian hemlocks. Silviculture may extend hemlock lifespan against HWA, but more research is needed to determine how protective it can be and whether any trees treated with silviculture can withstand HWA and survive infestation. Landowners and land managers need to prepare for the possibility of mass hemlock mortality, as not all hemlocks will receive treatment due to the cost of treatment and/or the availability of contractors to complete the necessary work.



3.3 Prioritization of Treatment for Stands and Trees

It may not be technically or economically possible, nor practically reasonable, to protect every hemlock stand or tree on the landscape using the tools currently available. The prioritization of stands for treatment is an important component of HWA management. When prioritizing, assign a relative value to hemlock stands and individual trees and use this to make treatment decisions. The size of the stand being managed and the abundance of hemlock will also affect the portion of hemlock that can be treated. Stands with fewer hemlock trees may see all trees being treated, while stands abundant in hemlocks will need to implement a triage system.

Stands and trees should be prioritized in terms of ecological value and resilience in the order shown in Table 1. Stands of high value and resilience are likely to respond more strongly and faster to silvicultural and chemical treatments, as is hemlock in ideal growing conditions: cool and damp, with deep, fertile soils, a continuous supply of soil moisture, and approximately 70% crown closure.

Table 1: Recommended stand and tree prioritization

Stands are prioritized by ecological value in this order	Individual trees are prioritized in this order
1. Riparian hemlock, hemlock along water courses. 2. Stands that mitigate erosion (steep slopes). 3. Old growth stands. 4. Older mature stands. 5. Important wildlife habitat and travel corridors. 6. Pure stands. 7. Larger stands where hemlock is dominant. 8. All other stands with hemlock that do not meet any of the above criteria Additional Consideration: • Stands of cultural and Indigenous cultural significance	1. Largest, healthiest-looking trees/crowns and future seed crop trees. 2. Hemlock along streams directly contributing to stream cover and temperature control. 3. Hemlock on slopes contributing to erosion control. 4. Hemlock with healthy canopies (LCR 50%+) and large DBH (50+ cm). 5. Hemlock with at least 65% crown density and signs of new hemlock shoot growth. 6. Other mature hemlock. 7. Smaller (younger) hemlocks that are not suppressed Additional Considerations: • Trees along high-occupancy trails may need to be treated with insecticides or removed for safety reasons • Trees that pose a risk to human life or infrastructure may need treatment

3.4 Choosing Management Options

Landowners and land managers will need to decide which management options to utilize. The prioritization exercise will help direct limited resources to the right place. The following guidelines are proposed for deciding which of the three management options to choose:

1. Assess the scope of treatment using the results from monitoring assessments and forest management planning. This means determining approximately how many hemlocks and/or hectares will require management.
2. Prioritize trees and areas for treatment using Table 1
3. Assess the likelihood of HWA entering the stand in the future, if it is not already there (how many kilometres away is a known infestation – look to section 1.3 HWA in Eastern North America for reported detections).
4. Evaluate the available resources relative to:
 - a. How many trees need to be treated?
 - b. How much money is available for treatment?
 - c. What help is available (foresters, forest technicians, insecticide applicators, loggers, family, friends, etc.)
5. Assess the suitability of the stand for silvicultural intervention by reviewing the silviculture section in this Guide and considering these questions:
 - a. Is a commercial harvest viable?
 - b. Would it target hemlock, other species, or both?
 - c. What are the desired outcomes? For example, mitigate the impact of invasive species moving in after hemlock mortality, stimulate the establishment or growth of desirable regeneration, and generate revenue to pay for additional HWA treatment activities.
6. Assess the suitability of chemical treatment. Use the key in Appendix A: Medway Community Forest Insecticide Treatment Key and Canopy Density Score and the table in Appendix B: Example Monitoring and Tree Health Assessment Record to determine which trees to treat. To maintain local genetic diversity and viability, at least 100 individuals per square kilometre, or an equivalent density, are needed. This number should be considered when deciding how to allocate limited insecticide-application funds.

Common management approaches would likely be some variation of the following:

- a) Do nothing in lower priority stands and stands without economic value.
- b) Treat mid-value stands with silviculture, using revenues to pay for non-economic but beneficial silvicultural activities and/or to pay for HWA insecticide treatments and management of other invasives present in the stand.
- c) Treat high priority stands and trees with pesticides, as funds allow.
- d) A combination of the above approaches, depending on available resources



— 4 —

IMPLEMENTING MANAGEMENT



Where the previous section introduced the management options, this section provides clear instructions on their implementation.

4.1 Silviculture

The desired outcome of silviculture in a hemlock stand is to create conditions that favour hemlock survival and decrease HWA productivity. It can also be used to control hemlock decline and reduce the impacts of sudden death to the stand, such as the invasion of other invasive species. Silviculture is most successful when employed well in advance of HWA infestation. Residual trees will have a greater share of available groundwater and more sunlight reaching their crowns, which can improve the health, growth, and resilience of hemlock. Higher light levels may increase HWA mortality, but further research is needed to confirm this. Silviculture can be followed by chemical treatments at the appropriate time if desired or if funds allow. Silvicultural practices will be most useful in mid- to low-value stands or in stands where insecticides will not be applied due to funding, access, or HWA infestation status.

Overall, hemlock silviculture aims to:

1. Improve the vigour of high-value hemlock
2. Reduce direct competition with dominant hemlocks
3. Remove unhealthy (unacceptable growing stock [UGS]) and suppressed hemlocks (unless they are wildlife trees).
4. Remove other UGS trees
5. Create a suboptimal microclimate for HWA.
6. Protect and promote the regeneration of other conifers and other desired species through silviculture and planting, if necessary.
7. Improve overall stand health and resilience

The current rate of HWA spread is believed to be between seven and twenty kilometres per year but may fall below or above this distance; dispersal is often unpredictable.¹⁸ Silvicultural interventions work best when performed at least 10 years before infestation, as recommended by researchers.⁴⁶ Based on the observed rate of spread, work should begin when HWA is within two hundred to three hundred kilometres of the property or further. During operations, be sure to prune back hemlock branches from footpaths and vehicle trails to prevent the spread of HWA to or from humans, pets, and vehicles. This is a good practice at any time to limit possible transmission from humans and pets to other locations.

To have silvicultural work or planning done, consult with a Registered Professional Forester (RPF). Special consideration should be made to ensure that any silvicultural plan conserves a stand's ecological function. Visit the Ontario Professional Foresters Association website: <https://opfa.ca/> or contact the Ontario Woodlot Association for assistance in locating an RPF.⁴⁷

Outright salvage or liquidation cutting of hemlock should not be undertaken. The window for successful treatment of HWA is relatively long compared with other invasive insects, and infested trees may still produce high-quality seeds and recover their health after chemical treatment.



A Must Read

Anyone considering silvicultural intervention should read *Hemlock Woolly Adelgid: Management Guidelines to Increase the Resilience of Ontario's Hemlock Resource to an Exotic, Invasive Insect* (2023)⁴⁶ and/or the related research article *Applying Three Decades of Research to Mitigate the Impacts of Hemlock Woolly Adelgid on Ontario's Forests* (2023).⁴⁸



Figure 13: A hemlock stand in Nova Scotia S. Eggett, 2024

Take Note

If there is a risk of HWA spread from silviculture work, work should be completed in summer, early fall, and over the winter.

4.1.1 Wood Movement Restrictions

Anyone harvesting in stands with HWA must be aware of the regulations and guidelines used to limit its spread. In Canada, the Canadian Food Inspection Agency (CFIA) is responsible for regulating the management of federally regulated invasive species, such as HWA. CFIA uses two main tools to manage how HWA and HWA-infested materials are allowed to move:

1. Infested Places Orders
2. Prohibitions of Movement

For an updated list and map of areas regulated by the Infested Places Orders in Ontario, visit the CFIA website - HWA [Regulated Areas](#).⁷ These regulatory tools prohibit the movement of hemlock plant material and firewood of all species (HWA-regulated articles) originating in an area under an *Infested Places Order or Prohibition of Movement*. Moving HWA-regulated articles out of one of these areas requires

CFIA approval and appropriate permits. In addition, the receiving mill generally needs to be approved by CFIA to process potentially HWA-infested materials.⁴⁹

For the full directives on these phytosanitary requirements, as well as information on permitting, refer to the Government of Canada document D-07-05 and contact the CFIA at 1-800-442-2342 for inquiries or clarification.⁴⁹

What is an *Infested Places Order* and *Prohibition of Movement*?

Infested Places Orders are used to reduce the spread of invasive species and usually apply to a Region, County, or Township. They restrict the movement of regulated materials (such as wood and related materials) out of an area. Landowners within these areas will not be made directly aware that they are subject to an Infested Places Order and will need to determine for themselves if they live in such an area by reviewing the CFIA list and the associated conditions of the *Infested Places Order*.

A *Prohibition of Movement* applies to single properties. A landowner subject to a *Prohibition of Movement* on their property will be served with a registered letter from CFIA. The letter states the restrictions on their property. *Prohibitions of Movement* are used for isolated populations of HWA or other invasive species.

4.2 Insecticides

The use of systemic insecticides is currently the most successful method for preventing HWA-driven mortality in hemlock trees. When insecticides are applied before HWA enters the stand, or when HWA levels are low, treated trees are likely to survive for the period during which insecticides remain active in the tree. Preventative treatment reduces the impact of new infestations. The longevity of some products means that up to a decade of protection can be provided through only two treatment cycles.

Insecticides used for HWA control are commercial products registered by Health Canada. In Ontario, IMA-jet, Starkle 20SG, Xytect 2F and TreeAzin are registered for use against HWA. IMA-jet and TreeAzin are administered as stem injections while Starkle 20SG and Xytect 2F are administered as basal bark sprays. Each insecticide has its own properties that must be considered when developing an insecticidal treatment plan. In general, the insecticides are classified in two ways:

1. Application Method: (a) stem injection versus (b) basal application
2. Speed and duration of protection: (a) fast-acting but short-lived versus (b) slow-acting but long-lived.

Table 2 & Table 3 have key information about the currently available insecticides.

Long-lasting, slow-acting products are used when HWA is not in the stand and is not anticipated to arrive within the next year. If HWA is in the stand or infestation is likely to occur within the year, then a fast-acting, short-lasting product is used in conjunction with a long-lasting, slow-acting product(s).

Starkle 20Sg and Xytect 2F can both be applied to the same tree to achieve rapid (Starkle 20SG) and long-lasting (Xytect 2F) protection. They can be applied separately or as a mix. While tank mixing for



basal bark applications is possible according to the product label, care should be taken to apply both products as directed on the label.

Based on efficacy research, these treatments can provide high levels of protection against hemlock mortality and are effective against HWA.^{50, 51}

4.2.1 Insecticide Product Information

Table 3 presents practical information on the currently available insecticides in Ontario. It is based on current published information and field experience and is intended for preliminary planning purposes. It is not definitive. All applications should be carried out in accordance with product labels and all applicable regulations. Those planning to apply should conduct due diligence before selecting a pesticide.

Currently available evidence suggests that any incidental impacts of insecticides on surrounding organisms are minor and are outweighed by the benefits of limiting impacts associated with mass hemlock mortality.⁵² More research is needed to verify this for all available insecticides and across additional application scenarios.

Table 2: Key Insecticide Properties and Common Use Cases

Product Trade Name and Application Method	Active Ingredient	Relative Key Properties	Common Use Case
IMA-jet 5 and IMA-jet 10 Stem Injection	Imidacloprid	• Long lasting, 4+ years • Long uptake time, 6-9 months • No water buffer required • Not subject to volume application limits • Slower application process (injection)	• HWA is not in stand and will not likely arrive within the next 12 months • Trees are within water buffer • Used to provide longer lasting protection
Xytect 2F Basal application	Imidacloprid	• Long lasting, 4+ years • Long uptake time 6-9 months • Water buffer required • Faster application process (basal spray) • Subject to volume application limits	• HWA is not in stand and will not likely arrive within the next 12 months • Trees are outside water buffer • Used to provide longer lasting protection
Starkle 20SG Basal application	Dinotefuran	• Short lasting, 1-2 years • Short uptake time, 3 weeks • Water buffer required • Faster application process (basal spray) • Subject to volume application limits	• HWA is present and fast acting product is needed • Trees are outside water buffer
TreeAzin Stem Injection	Azadirachtin	• Short lasting, 1-2 years • Short uptake time, less than 3 weeks • No water buffer required • Not subject to volume application limits • Slower application process (injection)	• HWA is present and fast acting product is needed • Trees are within water buffer • Classified for 'organic use'

Table 3: Available Insecticides as of this writing. Adapted from Nova Scotia hemlock Initiative (2023)⁵³

PMRA1 registration number	Product Trade Name	Active Ingredient	Registration Status	Approximate Cost of product ²	Product Application Rate Per cm DBH ³	Area-Based Label Product Application Limits ⁴	Approximate Total Diameter Treatable Within Limits (cm/ha/year) ⁵	Approximate Uptake Time ⁶	Approximate Years of Protection	Application Method
31375	IMA-jet 5	Imidacloprid	Fully registered	\$359/L	1.6-2.4 mL	No limit	No limit	6-9 months	4-5	Injection
31479	IMA-jet 10	Imidacloprid	Fully registered	\$640/L	0.8-1.2 mL	No limit	No limit	6-9 months	4-5	Injection
34596	Xytect 2F	Imidacloprid	Fully registered	\$45.88/L	1.16-2 mL	1.9 L/ha/year	950-1638 cm/ha/year	6-9 months	4-5	Basal bark spray
34653	Starkle 20SG	Dinotefuran	Emergency registration	\$100/kg	1.19-1.6 g	3025 g/ha/year	1890-2545 cm/ha/year	3 weeks	1-2	Basal bark spray
30559	TreeAzin	Azadirachtin	Fully registered	\$769/L	3 mL	No limit	No limit	Under 3 weeks	1-2	Injection

Table Notes:

1. [Health Canada Pest Management Regulatory Agency](#)⁵⁴
2. Prices may vary by supplier, shipping, customs dues, season, year, and USD-CAD exchange rate. Current experiences report costs to be nearly double what is listed at this present point in time.
3. DBH (Diameter at Breast Height) is measured at 1.35 meters above the ground.
4. DBH limit refers to the diameter sum that can be treated in a single year, once products have been diluted for application as per supplier instructions, based on the product limit per hectare.
5. Product limits refer to the maximum amount of Insecticide that can be applied in one year per hectare of land, expressed in the product's undiluted volume or undissolved mass
6. Uptake refers to the period before a product begins to take effect on HWA.

Note on watercourse buffers

Imidacloprid and Dinotefuran are acutely toxic to aquatic invertebrates. Adhere to the label to ensure proper buffers are in place around all waterbodies, watercourses, vernal pools, and wetlands that sustain life to prevent Insecticide from drifting into surface water. In this buffer, trees receiving treatment can only be treated via injection.

Additionally, it is recommended that mixing, pouring, and loading of insecticides should take place at least 30 meters from the water's edge in case of a spill.

4.2.2 Who Can Apply Pesticides?

Only provincially licensed exterminators can apply pesticides. A landowner can obtain a license and treat the trees on their own property. If the application is not completed by the landowner, additional licences and insurance are needed.



If silviculture was completed, stand prioritization, or planning work done by an RPF as advised, they may know a licensed exterminator, or may be licenced themselves. If not, look for a local forestry or extermination business with an insecticide operator license to apply insecticides.

Visit www.ontariopesticide.com for pesticide training and certification.⁵⁵ Visit Ontario.ca for information on licenses and permits; visit <https://www.ontario.ca/page/pesticide-licences-and-permits>.⁵⁶

4.2.3 Insecticide Treatment Planning

Treatment planning involves prioritizing stands and trees, marking trees for treatment, selecting the appropriate insecticide(s), purchasing insecticides and equipment, and applying insecticides to selected trees.

In all cases, it is advised that an RPF or a knowledgeable forestry practitioner create the treatment plan. This treatment plan can then be executed by a licensed exterminator. Anybody performing work related to treatment, or the treatment itself, should be trained in best forestry practices.

It is important to record when and where treatments occur, and whether future treatments are needed. This will prevent lapses in a tree's protection against HWA, which could allow for an infestation to advance. Continue to monitor the treated stand, and if any signs of tree health decline or an increase in HWA population are observed, plan a retreatment for the following year. If there is no observation of either condition, then plan a retreatment once the expected years of pesticide protection have elapsed.

Treatment productivity (how long it takes for a crew to apply insecticides) varies significantly depending on many factors such as the treatment methods being utilized (basal bark application or injection), the size of the crew, available equipment, landscape conditions such as space between trees, topography, weather conditions, and the experience of the crew.

A Must Watch

A series of 5 how-to videos on controlling HWA has been developed by Donna Crossland, former hemlock Conservation Project Coordinator at Medway Community Forest Coop. These videos can be found at Medway Community Forest Coop - [YouTube](#)⁵⁷ and are helpful for learning what is involved in site preparation, tree injection, and basal bark spray for those considering treatment.

4.2.4 Preparing and Implementing Chemical Treatment

The most important component of insecticidal treatment is selecting which trees to treat and marking them appropriately. Good knowledge of the stand, layout boundaries, and previous inventories will aid in this process. Having a plan in place ahead of time, including a property map, hemlock location-tracking systems, and a record-keeping system, will help save time. Consider the desired outcomes of treatment and what features are to be maintained, such as ecological function, aesthetics, erosion

control, protection of waterways, understory or overstory. All these factors will inform the best treatment options for the situation and assist in developing a budget.

Below is a suggested insecticidal application planning methodology that can be adapted to local conditions.

1. Create A Map

Many management plans already have a good map in place; if not, now is the time to make one. The map should clearly show where the hemlocks are located across the management area.

If treating more than one hectare, organize the map so that the treatment area is divided into one-hectare areas. Layout of hectare boundaries and shapes can be flexible (e.g., square, round, irregular). Creativity may be the difference between treating some or all hemlocks in one year. This hectare layout is to conform to the application limits for basal bark insecticides, which are calculated based on the volume of insecticide used per hectare. Injections have no hectare limits.

Layout boundaries need to be clearly marked on the map and visually delineated in the field for easy assessment and treatment. Label or name each hectare with a unique identifier to assist with record keeping. Delineate watercourse boundaries, as this impacts which insecticides can be used.

2. Develop an Inventory Record Keeping System

Good record keeping will be the basis for treatment. Whether treating a few or many, knowing when, where, and what treatment was employed is important, as insecticidal treatment is a multi-year process. A record of the locations and assessments of each hemlock to be treated is needed. This initial assessment record will give a baseline for future monitoring and treatment. See Appendix B: Example Monitoring and Tree Health Assessment Record for an example of a Monitoring and Tree Health Assessment Record.

Establish a numbering or coding system to track each tree as it is assessed. The following information for each tree to be treated (or anticipated to be treated, subject to insecticide application limits) will likely be needed:

- GPS coordinates
- Unique tree number including the block/hectare ID, DBH, the pesticide to be used, and the year of treatment. Do not restart tree numbers for each new hectare; continue increasing across the stands.
- Health assessment (optional)

3. Develop a Physical Tree Tagging and Flagging System.

Depending on the number of trees and the size of the treatment area, physical tags affixed to trees can be very helpful for visually indicating which trees have been assessed and/or treated. Tags will reflect the written record developed above and will remain with the tree until the next treatment (approximately 5 years). There are different tagging options, such as plastic or metal tags or, for smaller applications, tree paint. Choose something that is long-lasting and easy to add information to in subsequent treatment years.



While each tree will be tagged, it is also recommended that removable flagging tape be affixed to trees to be treated, with the DBH written on it. Different flag colours would denote different insecticidal applications. The DBH is used to determine the dosage; See Table 4 Converting DBH measurements to units of treatment per tree. Flags are then removed immediately after the tree is treated. This system allows insecticide application crews to easily identify which trees are to be treated and with which insecticide. It also eliminates the risk of trees being treated twice. Select distinct flag colours based on the treatment plan.

4. Complete Field Work and Assess and Tag Trees

- a) Walk through the stand and visually assess the trees, recording all needed information, as per above.
- b) Physically affix tags or apply tree paint. If possible, affix all markings on a consistent side of the tree (e.g., north side) for ease of locating them later.

5. Determine Insecticide Volumes Needed

Using the collected information and the delineated hectares, the required volumes of insecticides can be calculated. At this point, any volume limits per hectare for the products applied as basal spray can be determined. This information is needed to order sufficient insecticide and determine how many trees can be treated based on volume or financial limits. If application limits are reached via basal bark application, treatment can be planned for the following year to ensure maximum coverage in the stand. Alternatively, injection treatment can also be used, as there are no limiting diameters when the chemical is injected directly into the tree. Watercourses require buffers that may result in the need to use both methods of application in a treatment.

6. Affix the temporary flagging tape to the tree

With Step 5 complete, flagging tape can be affixed to the tree denoting the treatment it will receive. If volume limits are in effect, a system to determine when the application limits have been reached for a given hectare will be needed. This can be a simple tally based on the volume of pesticide legally applicable and the total DBH to be treated. Depending on the size and abilities of the crew implementing the treatment, Steps 5 and 6 may be combined.

7. Implement Treatment

Walk up to a tree with application equipment, read the tree DBH on the flag and determine the number of injection sites or spray time required; See Table 4: Converting DBH measurements to units of treatment per tree, for more information on determining spray times and the number of injection sites. Spray or inject the tree with insecticide. Remove the flagging tape and move to the next tree.



Figure 14 An example of a tree marking and flagging system, photo taken by OWA staff (personal communications, 2024)

Basal Bark Application of Insecticides

To apply the insecticide with a sprayer, read the DBH on the flagging tape, determine the application time based on DBH, then remove/rip the tape from the tree. The treatment zone of a tree is the trunk between ten and one hundred forty centimetres above the ground. Coat as much of this area as possible from top to bottom all around the circumference of the tree without spraying the ground and avoiding runoff. To count application timing as basal spray is applied, use a metronome or metronome app set to sixty beats per minute, keep time using a stopwatch, or have a partner keep time. Do not saturate the bark to the point of product runoff. If spraying must be stopped to step around or over an obstacle, pause counting until spraying is resumed. Spray until the application timing is complete.

When all spraying is complete, the tanks must be cleaned according to the label. Rinse water can be sprayed onto hemlock saplings, branches, or trees which were not treated to provide some protection against HWA.

Using a Handheld, Pump-Style sprayer

This process is only viable when treating a very small number of trees or may be better suited for hard-to-reach trees that require repelling. It uses a hand-pump sprayer to treat trees one at a time, refilling the bottle after each tree. First, the chemical is diluted as per the label. Then the sprayer is filled with the correct amount of chemical for the current tree being treated. The bottle is emptied of the contents on the tree and refilled with the correct amount of chemical for the next tree. This process is repeated for all hemlocks to be treated. This system is much slower than using a backpack sprayer and increases the risk of spilling pesticide.

Tree injection

Tree injection involves drilling holes into the tree's root flares, then administering the chemical directly into the tree using one of the available pressurized systems. The number of sites is determined by dividing the DBH by 5, and these sites are then distributed evenly around the tree. Tree injection takes longer to complete than basal applications and is generally used in two scenarios. First, where hemlocks are found within a water buffer area where basal applications cannot be completed. In most cases, a hemlock stand will need to be partially treated via injection due to water buffers. Second, injections carry no per hectare application limit so more trees can be treated in one year, if desired. There are several injection systems available from BioForest (Lallemand), Arborjet Ecologel, Rainbow Science and Chem Jet Tree Injector. Alternatively, some U.S based treatment programs have utilized chemical-rated hand-plunge syringes.

8. Follow-Up Treatments

It is essential that treated trees are marked and tracked to ensure they are re-treated appropriately at the retreatment window. DBH must be remeasured at the next treatment, as trees will likely have grown and could require more pesticide.

If HWA persists and spreads on a treated tree or if the tree shows persistent signs of decline, then treatment should occur the next year. Otherwise, use the guidance on the label and in this guide to determine when the next treatment is needed.



4.2.5 Additional Treatment Considerations

Planning Treatments According to Weather Conditions

Chemical treatment of trees should occur when the soil is moist and the trees are actively transpiring (moving fluids from the roots to the branch tips). Spring treatments are ideal and can begin as early as late March in some parts of Ontario. Treatment can continue all summer; however, soils need to be moist, and trees need to be actively translocating sap. Prolonged droughts will impede chemical uptake. Treatment can also continue into the fall and, for some parts of Ontario, into November, right up until the ground freezes.

Crew Organization

An ideal crew size depends on the number of trees being treated. For treating a smaller number of trees or a small area, an individual with all the required licenses and insurance may be able to complete treatment. In general, treatment areas greater than one hectare or with more difficult terrain may require more people.

Suggested Equipment

See **Appendix D: Suggested Equipment for Each Treatment Step**



Figure 15 An example of protected Insecticide application, photo taken by OWA staff (personal communications, 2024).

Backpack Sprayers

Backpack Sprayers are often used for basal applications. The stock nozzles on some backpack sprayer wands will need to be swapped for a 14.5 PSI control flow valve (CFV). If using a battery-operated sprayer, a CFV may not be required, as the sprayer may have flow settings.

All spray systems will need to be calibrated to ensure an appropriate and consistent volume of product is delivered. A suggested calibration method for a 14.5 PSI CFV would be as follows. Fill the tank with water, pressurize, and spray into a 2,000 mL graduated cylinder for fifteen seconds using a stopwatch to time. The goal is to deliver 200 mL in fifteen seconds. If it does not, check the air induction nozzle, filter, wand, hose, and constant flow valve for leaks, obstructions, or loose fittings. Clean or replace any parts as needed. If the correct volume is still not dispensed in fifteen seconds, replace the CFV nozzle and repeat the calibration.

Operators can always set their own flow rate and calculate the application time needed to deliver the correct volume per cm of DBH to achieve the dose as listed on the label.

Table 4: Converting DBH measurements to units of treatment per tree

IMA-jet 5 injection sites*	Xytect 2F application time**	Starkle 20SG or tank mix application time**
DBH/5= injections sites	DBH x 1= seconds of spray at low dose DBH x 1.67 = seconds of spray at 2 ml dose	DBH x 1.32= seconds of spray at 1.19 g dose DBH x 1.8 = seconds of spray at 1.6 g dose

**Injection calculations apply to 8 mL canisters at a 1.6 ml/cm dose rate*
***Basal bark spray calculations are based on a 13.3 ml/s calibrated spray rate.*
These formulas are based on 2024 labels; always ensure to use the most up-to-date information.

Mixing Pesticides

If both Xytect 2F and Starkle 20SG are being applied, a tank mix of the two may be used. Mixing involves properly diluting the products, either directly in a spray tank or separately, then transferring the solution into the spray tank. Take care to mix the appropriate concentrations and adhere to the per-hectare application limits. Note that these products have different application limits, which complicates application efficiency. To avoid this complexity, the two chemicals can be applied separately and successively, with time allowed for the first to dry.



Figure 16 Spill-safe EcoJect fill station, photo taken by OWA staff (personal communications, 2024)



4.2.6 Safety

All applications must adhere to regulations and label requirements regarding safe application and handling of insecticides. Table 4 is an example list of personal protective equipment (PPE) the OWA used as part of their treatment process. Different products require different PPE; check labels prior to use and adhere to all regulations.

Additionally, the following were on site:

- Hand and eye wash station must be available to flush eyes in the event of contamination, as per label instructions
- Wet wipes to help keep skin and surfaces clean of product contamination
- Contaminated water collection vessel
- Spill kit
- Clean-up kit
- Extra PPE
- First aid kit
- Product labels and SDS for each product being used
- A filled Health and Safety form (Appendix E)
- A chemical-rated spill berm/box as shown in Figure 14 to prevent environmental contamination.

Table 5: PPE that may be needed, or suit user preference.

Process	PPE	Optional additional PPE
Handling Pesticides	Safety glasses, nitrile gloves, long sleeves and pants, and boots	Tyvek suit, respirator/mask, face shield
Diluting Pesticides	Safety glasses, heavy-duty nitrile gloves, spill berm	Face shield, respirator/mask, Tyvek suit
Basal Bark Spraying	Safety glasses, nitrile gloves, Tyvek suit	Face shield, respirator/mask
Loading injections	Safety glasses, Tyvek suit, heavy-duty nitrile gloves, spill berm	Face shield, respirator/mask
Cleaning	Safety glasses, heavy-duty nitrile gloves	Tyvek suit, face shield, respirator/mask
Spills	Safety glasses, heavy-duty nitrile gloves, spill kit	Tyvek suit, face shield, respirator/mask

4.3 Insecticide Application Case Studies

Case Study 1: Basal Bark and Injection Treatments at Long Point Region Conservation Authority's (LPRCA) Jacques Tract

In a treatment trial conducted by LPRCA, OWA, and Trees Unlimited on a six-hectare stand, just over 500 hemlock trees with a mean DBH of 28.5 cm were treated. Treatment took place over three workdays by six workers. Prior to treatment, two teams of two people spent two full workdays selecting and marking trees for treatment. All treatment equipment was set up at a central location in the 6-hectare tract and revisited repeatedly for refills. The tract was generally flat, but movement was restricted by a series of deep vernal pools running east-west throughout the forest.

Treatment of the five hundred trees included both basal bark applications and stem injection applications with Imidacloprid-based products. Approximately 300 trees received a Xytect-2F basal bark spray over two full workdays, carried out by two workers. Approximately two hundred trees received IMA-jet 5 injections over three full workdays, carried out by a combination of three to four workers. Workers were all experienced in forestry work, and many had extensive experience in insecticide application and tree marking.

The OWA used Lallemand's EcoJect Microinjection System for injection treatments. This system uses reusable, refillable canisters that are pressurized on-site and then "plugged" into drilled holes in the tree. Based on this system, tasks can be organized as follows:

- One person drilling and placing nozzles.
- One person seating the nozzles firmly into the tree.
- One person placing canisters containing product onto nozzles.
- One person removing all application equipment pieces from trees.
- One person filling canisters at the central filling station located 30 m from water.

A key learning was that the site's topography will greatly influence the treatment rate. For example, a stand in a steep ravine may present significant challenges to access and movement. The main time constraints when treating are travelling on foot with equipment and the variable rates of injection uptake by the trees. Additionally, sufficient time must be allocated to the selection, marking, tallying, recording, and mapping of trees to be treated. This process takes much more time than traditional tree marking



Case Study 2: Treating the Old Growth Hemlocks of Sporting Lake Nature Reserve, Provided by Donna Crossland

In Nova Scotia, we have perfected the integration of volunteers into tree injection events to offset the high costs of treatment products and labour. In 2021, we did not yet have Xytect-2F available for hemlock treatments, and all trees needed to be injected. Even today, while basal bark treatments are much cheaper than tree injection, our local geology supports a picturesque network of rivers and lakes lined with hemlocks that require injection due to their proximity to water. How do we conserve those trees without breaking the bank?

We created a 'Hemlock Heroes' self-registration platform where people can find out about hemlock treatment events. These volunteers are motivated to help inject hemlocks for a range of reasons, from recognizing the inherent importance of conserving old-growth forests and combating a warming climate by maintaining healthy forests to sequester carbon, to conserving important salmon pools and trout spawning habitat.

We use the Ecoject injection system, which readily expands or contracts to the number of people available to carry out the work. Volunteers are safety-briefed, including a review of the insecticide label, wear proper safety apparel and follow instructions from a certified insecticide operator. They take on various tasks such as filling or carrying canisters, placing canisters and nozzles on trees, drilling trees, stripping injection gear from treated trees, and cleaning/packing out gear. Events are generally high-spirited and enjoyable. With a large team, it is possible to treat approximately 300 trees per day or over 10,000 centimetres of tree diameter.

We put the Ecoject system to its first test with a large number of volunteers at Sporting Lake Nature Reserve in 2021, where we received permission from the Provincial Protected Areas Branch to inject an entire stand of old-growth hemlock trees. Volunteers signed up on short notice to treat hemlocks (some being turned away due to limited camping space). The event involved a four-and-a-half-hour paddle and portage to reach one of the most remote sites in Nova Scotia. Volunteers, both young and old, learned how to inject trees. We injected a total of 2,168 hemlock trees (many of large diameter) in just ten-and-a-half days, covering 15.3 ha. We generally worked no more than six hours per day, and volunteers came and went over the near two-week period.

The success of treating old-growth hemlocks at Sporting Lake and its acceptance by Nova Scotians gave the provincial government the confidence to implement a government-led program to conserve hemlocks in provincially protected areas.

While I worked as the hemlock Project Coordinator with Parks Canada in 2020-21, I assisted the Canadian Forest Service (CFS) with early tree injection research trials on a couple of occasions. CFS injected thirty trees with TreeAzin using the Ecoject system, while my technician and I injected thirty trees with IMA-jet using the Quik-jet Air.

The Ecoject canister delivery system is most efficient when treating large numbers of trees, while the Quik-jet Air and other handheld injection devices are more portable, more readily transported over long distances on foot to remote forests, or more quickly deployed when only a few trees need to be injected. The key feature difference is whether one is using a system where the operator must remain at each individual injection site until the product is absorbed into the tree, such as Quick-jet, or a system where one can leave the tree until the product is eventually absorbed, while the worker is free to move about and tend to other trees until the process is completed, such as Ecoject.

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BIOCONTROL



HWA biocontrol involves introducing natural predators of HWA from HWA's native range in western North America. The goal of biocontrol is to establish predator populations that have minimal non-target impacts (do not feed on other insects) and can regulate HWA populations below levels that are fatal to hemlocks. Attacking both generations of HWA is an important feature of any biocontrol measure.

Biocontrol is viewed as a potential long-term solution for managing HWA and conserving hemlock. While very effective, insecticide treatments cannot realistically be carried out indefinitely and are considered a short- to medium-term measure to keep hemlocks alive until a more sustainable biocontrol solution is developed.

The vast majority of HWA biocontrol research has been conducted in the United States and has focused on eight predator species. A combination of *Laricobius* beetle species as well as *Leucotaraxis*, silver fly species, has shown potential for strong HWA predation, and together they can achieve predation of both HWA generations and are HWA specialists, meaning they only feed on HWA.⁴⁶ A major challenge in establishing biocontrol populations is the availability of predators for release. Collection from their home ranges is complicated, and rearing techniques take time to refine.¹⁶

It is hypothesized that the introduction of these species will create self-sustaining predator populations in HWA-infested areas, without negative non-target ecological consequences. However, ongoing research is required, and it may take up to two decades of releases for control agents to reach sufficient population sizes.⁴⁶

At the time of writing, biocontrol releases have occurred in Nova Scotia. There have been no releases in Ontario, nor are there any planned.



Figure 17 Adult *Laricobius nigrinus* beetle feeding on HWA. B. Mudder, September 20th, 2020. Wikimedia Commons⁵⁸

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INTEGRATION OF RESPONSES AND SEED COLLECTION



6.1 Why Genetic Diversity is Important

It is crucial to maintain the genetic diversity of any species to ensure healthy populations. Low genetic diversity leads to inbreeding. Such populations often remain suppressed, lack the capacity for adaptation, and may even die out. With greater genetic diversity, a species or a local population has a higher chance of adapting to changes and pressures. Phenotypically superior hemlocks (trees that appear visually superior) are more likely to survive and pass on good genetics to new seedlings. Trees that are phenotypically superior are more likely to have superior genes and to exhibit strong growth, seed production, resilience to environmental stressors, and some resistance to diseases and pests. By protecting as many phenotypically superior hemlocks as possible, the gene pool is likely to be conserved, and there is a greater chance of recovery from HWA infestations.

6.2 Identifying Superior Hemlock for Conservation

For hemlock, phenotypically superior trees will have crown densities greater than sixty-five percent, a live crown ratio over fifty percent, little to no yellowing of needles, an abundance of new growth, a straight trunk, a cone-shaped crown, and the presence of old seed cones or new developing cones. Large or older trees may also carry superior genes that confer traits that promote longevity.

To avoid treating trees that may be impacted or killed by stressors other than HWA, such as drought, it is important to focus on stands and trees that are phenotypically superior. Consideration should also be given to whether the tree is on a favourable growing site. Hemlock thrives on moist, cool, northern slopes, along the banks of streams and near swampy areas, and grows best in moist to very moist soils with good drainage. Shallow loams and silt loams are the preferred soils of hemlock⁵⁹.

6.3 Seed Collection

It is important to collect and preserve healthy and diverse hemlock seed so that populations can be restored or maintained in the future, both naturally and through planting. Seeds are necessary for natural regeneration and for nursery stock used in reforestation and restoration efforts. Growing stock from seed ensures greater genetic diversity than cloning, another common nursery practice.

Hemlock produces seed every two to three years with a forecasted seed collection window of late September to October. Collecting during this time frame increases the amount of viable seed collected. It is advised that seeds be collected from stands with over one hundred individuals per square kilometre, or equivalent density, to ensure sufficient genetic diversity, and that seeds be collected from at least fifteen to twenty individuals. This is also the minimum number of hemlocks that should be treated within a stand to retain genetic diversity. Note that the ecological function of the stand is unlikely to be retained unless the majority of the trees are treated.

Widespread hemlock seed collection should begin now. The current situation is unique because healthy hemlock stock is plentiful on the landscape. After collection, the desired seed can be stored for later use.

Collection should be performed in as many locations as possible and from as many trees as possible to retain regional, stand, and individual genetic diversity. In this regard, the involvement of landowners is important. If harvests happen to coincide with robust cone development, post-harvest seed collection is possible. Note that after silvicultural treatment, trees with increased access to sunlight may begin producing more seed.

Landowners or managers interested in participating in the seed collection effort should contact the Forest Gene Conservation Association (FGCA) for more information and assistance with collection.⁶⁰ By connecting with the FGCA, landowners may be able to contribute hemlock seed to seed banks. Seed collection should only be performed by trained or certified practitioners. The collection process is complicated, and if done at the wrong time, from the wrong tree, or is processed or stored incorrectly, the seed will go unused.

For more information on seed collection, tree genetics, or becoming a seed collector, see the FGCA website <https://fgca.net/>⁶⁰ for a copy of *Seeds of Ontario & Eastern Canada: A Manual for Tree and Shrub Forecasting and Collection* (2nd ED.).⁶¹



*Figure 18 An immature hemlock seed cone. From [Ontario.ca](https://ontario.ca/hemlock) hemlock*⁶²



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FINANCING

HWA control is expensive, and many forest owners or managers will need to secure additional funds to cover treatment costs. This section provides a summary of available funding opportunities.

7.1 Forest Management Business Costs

Landowners who manage their forest as a business or a farm woodlot can claim forest management costs, including HWA management, as business expenses. This can help reduce taxable income and alleviate some of the costs of HWA management.

7.2 Project Funding

As of 2026, no fund exists exclusively to support the treatment of HWA on private land; opportunities change regularly, and landowners should be proactive in seeking future funding. Other, more general funding sources that may cover HWA management costs are sometimes available. These sources come from the Federal, Provincial, and Local Governments, Conservation Authorities and associated agencies, as well as non-profit organizations. Below is a non-exhaustive list of possible agencies and organizations that may have funding for HWA treatment from time to time:

- a. Environment and Climate Change Canada (ECCC)
- b. Natural Resources Canada
- c. Local Federal social or economic development agencies
- d. Local Provincial social or economic development agencies
- e. Ontario's Ministry of Environment, Conservation, and Parks
- f. Ontario's Ministry of Natural Resources and Forestry
- g. Local Conservation Authority
- h. Invasive Species Centre
- i. Ontario Woodlot Association
- j. Local community foundations
- k. Local land trust
- l. Various environmental foundations
- m. Check the Bluebird Environmental Landowner Grant Tool below in the 8.2 Specific Contacts.

Funding specifically for Indigenous Peoples and organizations may also be available either through the above agencies or other specific funds. See ECCC's Indigenous Environmental Leadership, Funding, and Initiatives for more information.

When seeking funding for a project such as this, here are some helpful steps to prepare an application.⁶³



1. Define the activities involved.
2. Identify the ecosystem services it will generate.
3. Identify potential social, cultural, and economic benefits.
4. Identify who will benefit from the project (municipality, government, community, etc.).
5. Outline what the funding will cover (specific activities and equipment).
6. Estimate how much money is needed.

This information can then be used or adapted depending on program criteria to secure funding.

7.3 Conservation Finance

Conservation financing is most often focused on direct or indirect economic returns on initial investment. In Canada, conservation finance has yet to be widely adopted; however, organizations across the country are developing and promoting this pathway. For more information, resources, and contact with experts, refer to the Nature Investment Hub website.⁶⁴

— 8 —

USEFUL CONTACTS

HEMLOCK CRES.



Below are some useful contacts and organizations that may have resources to support HWA management.

8.1 General Contacts

Ontario Woodlot Association (OWA)	Support for woodlot owners, access to resources, connections to other organizations, and answers to questions related to this Guide.	(613) 713-1525 info@ontariowoodlot.com www.ontariowoodlot.com
Invasive Species Centre (ISC)	Information regarding HWA and other invasives, monitoring programs, Invasive Species Action Fund applications, and general inquiries.	(705) 541-5790 info@invasivespeciescentre.ca www.invasivespeciescentre.ca
Stewardship Resources Page (Formerly The LandOwner Resource Centre (LRC))	Forestry resources, referrals and redirection, access to environmental programs and services, and a resource library.	(613) 692-3571 info@lrconline.com https://www.rvca.ca/stewardship-grants/stewardship-resources
Ontario Professional Foresters Association (OPFA)	Find consultants and registered professional foresters and access to resources and research.	(905) 877-3679 opfa@opfa.ca https://opfa.ca/ ²¹
Ministry of Natural Resources (MNR)	Invasive species reporting and information, general inquiries, inquiry redirection, environmental news and updates.	1-800-387-7011 www.ontario.ca/page/ministry-natural-resources
Canadian Forestry Service (CFS)	Forestry resources and data, climate change information and tools, and updated research in many areas.	natural-resources.canada.ca/corporate/corporate-overview/canadian-forest-service

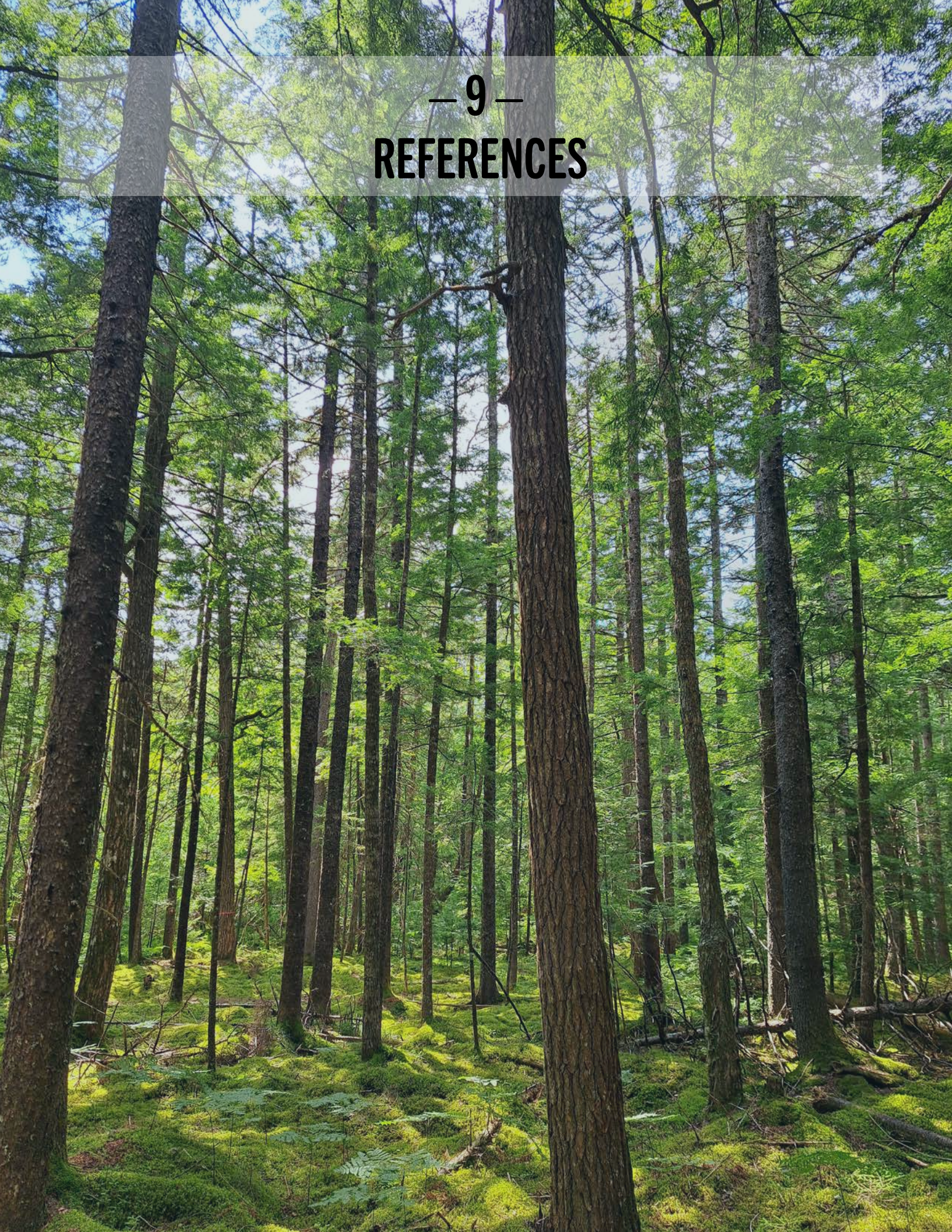
8.2 Specific Contacts

Forest Gene Conservation Association (FGCA)	Connect with seed collectors and seed collection information.	https://fgca.net/contact/
Canadian Food Inspection Agency (CFIA)	Updated list of verified HWA detections, reporting HWA infestations.	1-800-442-2342 cfia.surveillance-surveillance.acia@inspection.gc.ca https://inspection.canada.ca/en
Medway Community Forest Cooperative (MCFC)	HWA research, tree treatment decision key, newsletter, answering HWA treatment-related questions.	1-(902) 701-0505 info@medwaycommunityforest.com www.medwaycommunityforest.com/
Ontario Insecticide Training & Certification U of Guelph (OPT&C)	Information on Insecticide use requirements, obtaining Insecticide training.	1-888-620-9999 rcoptc@uoguelph.ca https://www.ontariopesticide.com
The Ministry of the Environment, Conservation and Parks and Client Services and Permissions Branch	Advice from Insecticide specialists, obtaining Insecticide licensing and permits.	1-800-461-6290 enviropermissions@ontario.ca Environmentalpermissions ontario.ca
Bluebird environmental	Landowner grants list for Ontario, Ecological project company and contractor list.	info@bluebirdenvironmental.ca bluebirdenvironmental.ca/landowner-grants
Local conservation authority	Reach out for information, advice, potential funding or grants, and conservation opportunities.	conservationontario.ca/conservation-authorities/find-a-conservation-authority

8.3 Supplier Contacts

Lallemand (BioForest)	TreeAzin, EcoJect system and parts	1-888-236-7378 https://lallemandplantcare.com/en/canada/
Arborjet	IMA-jet 5	781-935-9070 arborjet.com/about/
Rainbow Ecoscience	Xytect 2F	877-272-6747 www.rainbowecoscience.com/
Belchim	Starkle 20SG	519-826-7878 https://www.belchimcanada.com/
Rittenhouse	Control flow valves	1-800-461-1041 www.mkrittenhouse.com/ca/
TeeJet	Air induction nozzles	630-665-5000 https://www.teejet.com/
Husqvarna	Backpack sprayers	www.husqvarna.com/ca-en/
ULINE	Coloured Tyvek tags	1-800-295-5510 https://www.uline.ca/
ChemJet Tree Injector	Reusable, reloadable, microinjection syringe	https://chemjettreeinjector.com/





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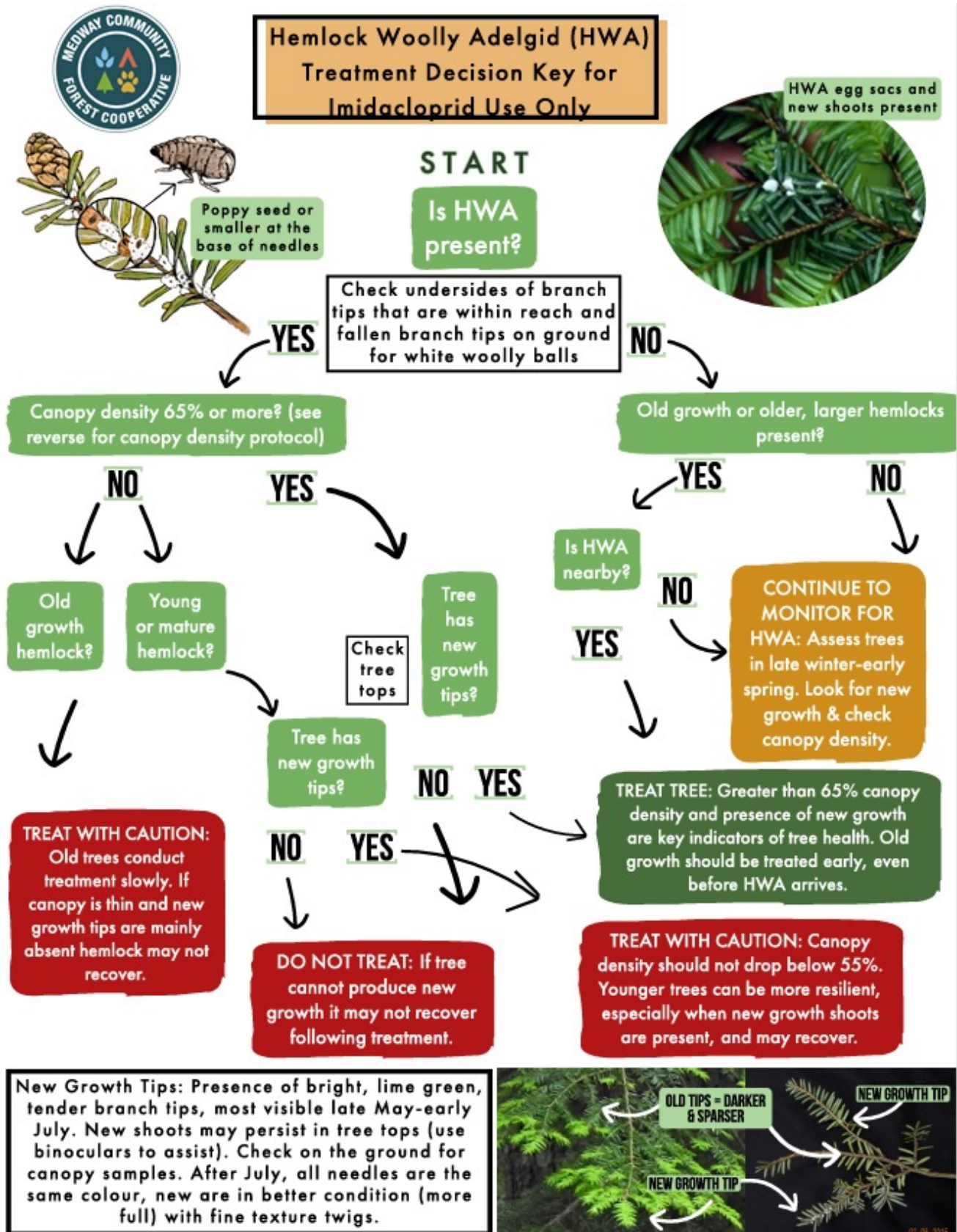


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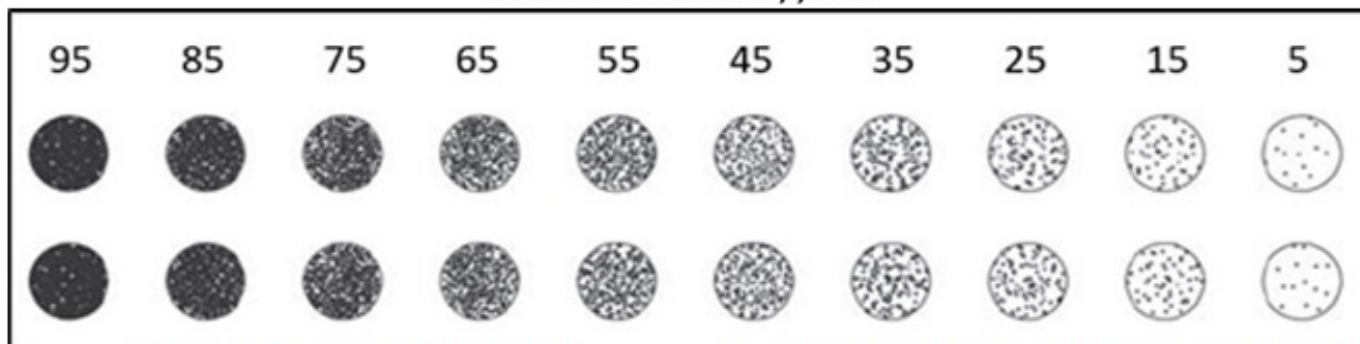
APPENDICES



10 APPENDIX A: MEDWAY COMMUNITY FOREST INSECTICIDE TREATMENT KEY AND CANOPY DENSITY SCORE



CANOPY DENSITY SCORE: Assess by standing at arm's length from tree & looking straight up through the canopy. Choose which best reflects the density you see.



1. TREE TREATMENT FACTS

1. Treatment using imidacloprid chemical is safely conducted inside tree sap wood.
2. There is little or no environmental exposure. Chemical amounts are small.
3. Treatments can last ~ 4-6 years.
4. Old growth should be treated early, even before HWA arrives.
5. The active product ingredient is the same used in some tick-flee medications.
6. The treatment is not toxic to birds or mammals.
7. Biocontrol agents are expected to control HWA in the long-term, but chemical treatment is presently essential or tree will die, likely within 3-5 years of infestation.

3. HWA INFESTATION LEVEL

Low Moderate High



1-4 sacs

5-20 sacs

>20 sacs

Why monitor your hemlocks for HWA 1-2 times annually? HWA can spread quickly by birds, people and pets. Infestations in the upper canopy may go undetected. Canopy decline (needle drop) may be sudden and go unnoticed. Watch for changes in canopy density and amounts of new shoots produced.

Cost Considerations:

- Costs of Hemlock removal near buildings and powerlines may exceed treatment costs.
- Hemlocks on stream banks protect bank erosion, road and bridge infrastructure from increased storm runoff events. Dead trees falling into waterways can cause blockages at culverts and flooding to homes downstream. Costs to repair infrastructure may exceed treatment costs.
- Supports for landowners are in place in some US states where HWA is present (e.g. tree injection kit rentals)

2. EXTRA CONSIDERATION FOR TREATMENT

High Value Trees:

Old growth hemlock is irreplaceable. If there is old growth hemlock on your land, you own something very rare that will be almost nonexistent in future unless you treat it.

HWA causes permanent loss of hemlock. Hemlocks that line stream banks are of high value to both forest and stream, shading, cooling, and sheltering many other species: trout, salmon, marten, fisher, moose, deer, and birds.

HWA Infestation Levels:

Check undersides of branch tips for HWA levels, examining several branches on opposite sides of the tree. Moderate to high HWA populations on branches will damage hemlock and eventually impede the tree from producing new shoots in spring. Treatment uptake is eventually impeded.

Branch Dieback:

HWA infestation severity can also be gauged by amount of fine branch dieback where needles have recently dropped. Note: Healthy hemlock normally feature broken and jagged coarse lower branches.

Percent Live Crown Ratio (LCR):

Is the % of total tree height that supports live foliage. For e.g.: if live branches reached from the top of the tree all the way to the ground, that tree has a LCR of 100%. A tree with no living branches anywhere on the tree would have an LCR of 0% (dead). If LCR declines to < 25 % from HWA, the tree is less able of conducting a treatment to the canopy.

Percent HWA infestation on new shoots:

Count the total number of new shoots (i.e., new branchlet tips) growing along a 30 cm branch tip. Next, count the number of new shoots with wool present on the underside of the branchlets. Divide number of woolly shoots by total number of shoots. HWA infestations present on > than 30 % of new shoots growing along the sample branch may indicate greatly impeded new growth in the following yr. Trees may not respond to chemical control.

KEEP UP-TO-DATE:

WWW.NSHEMLOCK.CA & WWW.MEDWAYCOMMUNITYFOREST.COM



11 APPENDIX B: EXAMPLE MONITORING AND TREE HEALTH ASSESSMENT RECORD

Date	Location (GPS)	Tree #	DBH	Crown Density Score	Foliage Dieback	Chlorotic Needles	New Growth Present	Ovisacs Present			Near Water	Priority Tree	
								L	M	H		Stand	Single-tree

12 APPENDIX C: EXAMPLE TREE MARKING FOR TREATMENT FIELD SHEET

Date: _____

Worker: _____

Location: _____

Hectare #: _____

Date	GPS	Tree #	DBH	Basal Bark Spray		Injection
				Xytect	Starkle	
			DBH Sum	DBH Sum	DBH Sum	

13 APPENDIX D: SUGGESTED EQUIPMENT FOR EACH TREATMENT STEP

Any reference to a specific product, producer, or supplier is provided for ease of locating products and does not constitute an endorsement by the OWA.

Step	Equipment	
For site preparation and marking	• DBH tape or tree callipers • 3–5 colours of flagging tape • Permanent marker • 3 colours of Uline Coloured Tyvek Tags (forestry tag). • 1.5-inch aluminum nails • Hammer • GPS • 7-meter rope or measuring tape • Red tree marking paint • Field sheets (Appendix C)	
For injection (EcoJect)	• 3L EcoJect injection kit with nozzles and 8 mL canisters • 125-150 PSI Air compressor and power source • Compressor hose and coupler • Battery-operated drill • Spare battery • 15/64-inch drill bits • Small hammer • 20 mm wrench socket • Spill berm • Folding table or work surface • Polyethylene storage tote • EcoJect cleaner solution or 99% isopropyl alcohol • 6x5 L buckets • 2 sealable plastic containers for cleaning nozzles and canisters • Shallow cardboard box for drying cleaned nozzles • Freezer bags for storing cleaned parts	
For basal bark spray	• Spill berm • Mixing paddle • Paint strainer • Large funnel • Husqvarna backpack sprayer + harness, • Sprayerdepot AI8003VS AI TeeJet Air Induction Flat nozzle • Rittenhouse 14.5 PSI Constant flow valves • Plumbing tape • 2000 mL graduated cylinder • Clean water source or tank • Metronome or metronome app. • Scoop and scale if using Starkle 20SG.	
For handheld basal bark spray	• Xytect 2F or Starkle 20SG • Spill berm • Large stir rod • Large mixing bucket • Funnel • Handheld pressure sprayer • 2 L Nalgene bottles • Water supply • 1000-2000 mL graduated cylinder	
Personal Protective Equipment (PPE) and safety gear	• Whistle • Safety glasses • Face shield • Tyvek coveralls • Hi-vis vest • N95 face mask or respirator • Heavy-duty nitrile gloves • Regular nitrile gloves • Field eye wash station • Field hand wash station • Contaminated “grey-water” collection • Spill kit (shovel, absorbent litter, clear garbage bags, towels) • Medical first aid kit • Cleaning kit (wipes, garbage bags, paper towels) • Safety Data Sheets and Labels for products in use • Paper or digital health and safety information with a list of emergency numbers and contacts (See Appendix E)	



