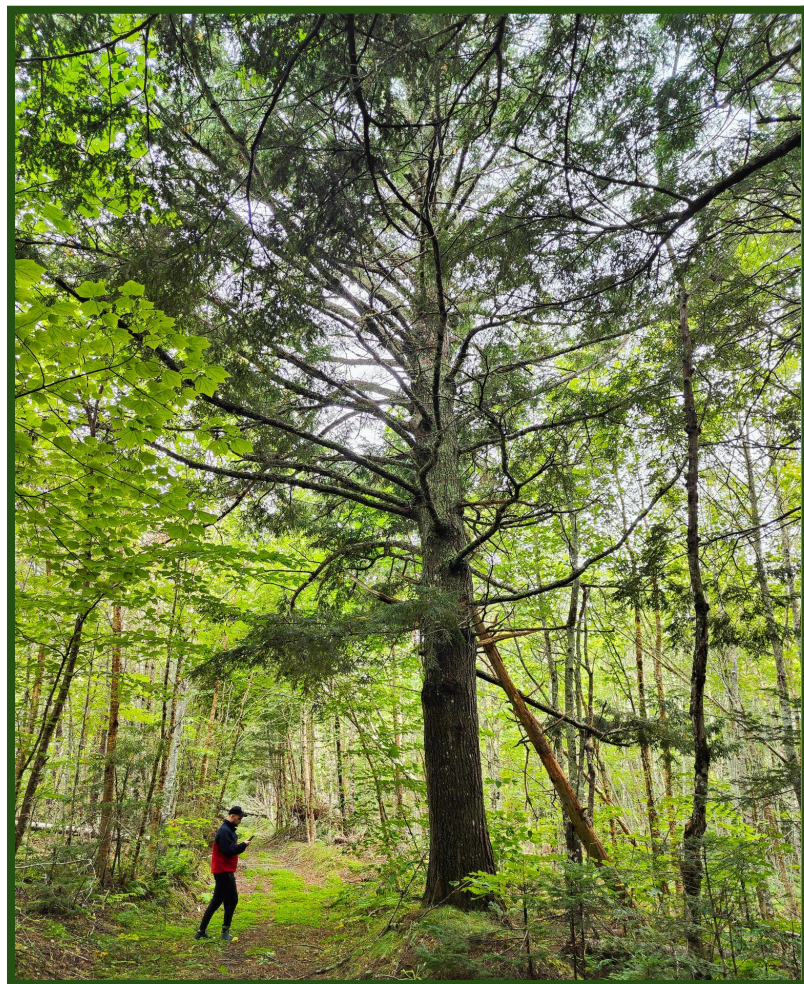


Woodlot Management in the Face of Hemlock Woolly Adelgid

A simplified survey protocol for woodlot owners.

Compiled and published by the PEI Invasive Species Council



This project was undertaken with the financial support of:

Ce projet a été réalisé avec l'appui financier de:



Environment and
Climate Change Canada

Environnement et
Changement climatique Canada



PRINCE EDWARD ISLAND
WILDLIFE
CONSERVATION FUND



Table of contents

What is hemlock woolly adelgid (HWA)?.....	2
What does the loss of Eastern hemlock mean for PEI?.....	2
How long do we have?.....	2
Hosts affected.....	2
General symptoms of HWA presence.....	3
Potential lookalikes.....	3
Other sources of Eastern hemlock stress.....	4
What can you do to help?.....	5
Visual survey, branch examination.....	6
Ball sampling.....	8
Preventative silvicultural controls.....	10
Reporting.....	11

What is hemlock woolly adelgid (HWA)?

- Very much like an aphid. This species sucks the sap out of hemlock twigs.
- Introduced from East Asia to Virginia in 1951 and has spread outward since.
- The insect's flighted stage cannot complete its life cycle in North America, so the adelgid relies on outside support to move it around.
- Pathways of movement include the wind, wood products, nursery stock, birds, and on people's equipment or vehicles.
- HWA is known to cause mortality in over 90% of infested Eastern hemlocks.

What does the loss of Eastern hemlock mean for PEI?

It means the loss of the positive ecosystem services that Eastern hemlock provides. These include:

- Loss of cool water and moist conditions.
 - Relied upon by many species including those at risk.
 - Salmonids, lichen, etc.
- Major changes in hydrology, sedimentation, species composition, etc.
- Loss of biodiversity.
- Loss of habitat for wildlife that depend on hemlock for shelter
- Loss of shady interior forest spaces that help prevent the spread of invasive species.
- Loss of a major source of nutrients for forest species.
- Loss of scenic beauty.

How long do we have?

- It may already be here, it may take 25 years to arrive.
- First discovered in North America in Virginia in 1951, believed to have arrived on imported Japanese hemlocks.
- First discovered in Nova Scotia in 2017, likely present since 2007.
- The nearest observation was recorded in Halifax.

Hosts affected

- **Eastern hemlock, *Tsuga canadensis*** (native, regulated)
- Yeddo spruce, *Picea jezoensis hondoensis* (non-native, regulated)
- Tiger-tail spruce, *Picea polita* (non-native, regulated)

- Carolina hemlock, *Tsuga caroliniana*
- Chinese hemlock, *Tsuga chinensis*
- Japanese hemlock *Tsuga diversifolia*
- Western hemlock, *Tsuga heterophylla*
- Mountain hemlock, *Tsuga mertensiana*
- Southern Japanese hemlock, *Tsuga sieboldii*
- Himalayan hemlock, *Tsuga dumosa*

General symptoms of HWA presence

The following is a list of the most common symptoms of HWA infestation in Eastern hemlock:

- White woolly masses (ovisacs) fixed to twigs near the base of needles. These are either eggs, late-stage instars, or wingless adults. In fall these measure ~1mm across, growing to ~3-5mm by spring.
- Needles of affected trees develop a grayish tint.
- Discoloration of needles (chlorosis)
- Crown or branch dieback.
- Loss of needles.
- Aborted buds, lack of new growth.
- Crown thinning.
- Death of hemlock trees.
- Symptoms may be less apparent after a harsh winter, as most adelgids will be killed.

Potential lookalikes

- Commonly reported look-a-likes of HWA include
 - spider eggs,
 - other insects,
 - Balsam woolly adelgid, *Adelges piceae*
 - Pine bark adelgid, *Pineus strobi*
 - Spittlebugs (family Cercopidae)
 - Oak skeletonizer, *Buccatrix ainsliella*
 - Mealybugs (family Pseudococcidae)
 - fungus,
 - lichen,
 - spider mite injury,
 - drops of pine sap,
 - fake spider webs for Halloween, etc.
 - Lookalikes aside, any report is a good report. Reporting is important in any case, so if you are unsure, send detailed photos of your specimen to the PEIISC as soon as possible. Quick action may be key in preventing further spread.
- Before going into the field to monitor, it is important to refresh one's familiarity with the signs of HWA infestation before beginning a survey. Review photos and descriptions of HWA symptoms before heading out. Reach out to the PEIISC for support here.

Other sources of Eastern hemlock stress

Hemlock woolly adelgid, as you can imagine, is not the only species that feeds on Eastern hemlock. Signs of stress may be attributed to other insects, fungi, human activity, or environmental conditions.

- Desiccation and drought are prime sources of stress for Eastern hemlock, a tree that relies on moist conditions to thrive.
- Damping-off and root rot fungi of several species are highly damaging to young trees.
- Several species of rust fungi may cause distortion and damage to shoots and needles.
- Sapsuckers frequent Eastern hemlocks, which are quite resilient to their damages compared to some other species of trees.
- Mammals such as snowshoe hares and other rodents will feed on young trees.

Some key insect pests of Eastern hemlock (information sourced from Natural Resources Canada, United States Forest Service)

- Hemlock looper, *Lambdina fiscellaria*
 - Moth species.
 - Damage visible from late July to early August, caused by larvae feeding
 - Needles turn a reddish colour and drop off in the fall
 - Larvae only eat part of the needle, leaving the rest behind
- Pale winged grey, *Iridopsis ephyraria*
 - Not known to occur on PEI, but common in Nova Scotia.
 - Infestations begin in the understory in the first year, moving up to the crowns of mature trees thereafter.
 - May completely defoliate and kill a tree within 2 years
 - Missing or red needles are characteristic damage types.
 - Damage begins to appear in June when larvae hatch.
- Pine measuringworm moth
 - Little information is available, but the damage appears to resemble other moth infestations.
- Spongy moth
 - Eastern hemlock would not be a primary feeding target but may be defoliated when growing within heavily infested areas.
 - Tan spong-like egg masses seen on the surfaces of trees.
 - Severe defoliation may be seen.
 - Often, understory hemlocks will be killed.
- Spruce budworm
 - Although Eastern hemlock is not the primary food source of spruce budworm, defoliation will occur after primary food sources like balsam fir are exhausted.
- Pine spittlebug
 - Causes flagging and branch mortality when feeding damage prevents nutrient flow to areas of the tree.
 - Can cause death after several years of heavy infestation
 - Spittle is formed at feeding sites.
 - Damage is seen throughout the summertime.
- Spruce spider mite
 - First sign is a dusty substance on the needles.
 - Needles turn brown and drop off.

- Silk threads on twigs are another sign of infestation
- Shake a branch over a white piece of paper and see if tiny spider-like creatures fall. They are fast-moving.
- Multiple generations per year can cause waves of damage.
- Damage begins in the lower crown and moves upwards.

Some key fungal diseases of Eastern hemlock

- Hemlock-blueberry rust, *Naohidemyces vaccinii*
 - Damage usually does not lead to significant stress.
 - Damage appears when needles become yellowed and gain raised bumps.
 - Yellowing proceeds from the twig to the tip of the needles.
- Pinicola brown crumbly rot, *Fomitopsis pinicola*
 - Causes heartwood rot of living trees.
 - Usually occurs from an existing wound.
 - Discolouration of the wood with a pale yellow or brownish hue is the initial symptom. This is followed by the formation of red fruiting bodies in strips around the infected area. These turn grey and wrinkled with age.
- Brown Cubical sap rot
 - Causes sapwood and some heartwood rot.
 - Yellow or yellowish-brown pockets of discolouration will appear in the sapwood and outer heartwood.
 - Usually occurs from an existing wound.

What can you do to help?

- Let us know where your hemlocks are. Report Eastern hemlock presence to the PEIISC.
 - This information will be used to determine the true extent of a future infestation as efficiently as possible.
 - Encourage your friends to tell us too!
 - Share information about your hemlocks at: peiinvasives@gmail.com
- Monitor hemlocks on your property.
- Conduct monitoring on Eastern hemlock trees on your property.
- Do not move firewood, hemlock wood, or live hemlock trees from off-island back to PEI.
- Promote the health of individual hemlocks in your stand.
- Collect cones.
- Talk to your friends and neighbours about Eastern hemlock and HWA.

Monitoring techniques

- Monitoring techniques vary in their efficacy and ease of execution
- Monitoring techniques include:
 - **Visual sampling (considered below)**
 - **Ball sampling (considered below)**
 - Interception traps
 - eDNA traps

Visual survey, branch examination

- This technique involves the examination of branches in the outer canopy of hemlock trees using a hand lens and the naked eye for the presence of HWA signs & symptoms.
- A benefit of this technique is that it can be done by anyone with the ability to identify with essentially no expense.
- *Materials required:*
 - Bleach bath (if within or nearby an infested area)
 - Lint roller (if within or nearby an infested area)
 - Smartphone or GPS and logbook
 - Hand lens
 - HWA can sometimes be seen with the naked eye, but a hand lens helps especially for earlier stages of the life cycle.
 - Additional useful gear:
 - PEIISC datasheets
 - Zip-lock bags and sealable dishes for specimen collection.
 - Pruning shears
 - Pole pruners
 - Knife
 - Digital camera
 - Tree identification guide
 - HB pencils
 - Permanent markers
 - Paper labels
 - GPS unit & Compass
 - Maps (including forest cover or municipal forest inventory)
 - Field book with waterproof paper
 - Flagging tape
 - Measuring tape
 - Protective footwear (Safety boots)
 - Reflective vest
 - Sunglasses
 - Hat
 - Sunscreen
- *Target life stages:*
 - **Eggs**, adults, late-stage nymphs/larvae coated in woolly masses.
 - Eggs/ovisacs are the most obvious life stage.
- *Timing:*
 - General: November-June
 - Optimal: March-May
 - Nymphs/larvae: November-February
 - Eggs & adults: March-May (crawlers also present during this period)
 - If monitoring outside the recommended monitoring period, a hand lens should be used to view aestivating HWA.
 - Avoid surveying when snow may be on the branches.
 - Ideally visual surveying should be done twice per year, around the beginning and end of daylight savings time.
- *Procedure:*

- Select a site with branches that can be easily reached.
- Focus on trees with signs of stress or noted symptoms of HWA presence. Focus on the outer 1m of branches for your search. Focus on the bases of the needles along the stem. Focus on branches with green foliage.
- If no branches are within reach at your site, look around on the ground for fallen branches or twigs, or use a pole pruner.
 - Collect branches from the ground as available and examine their undersides for wooly masses at the base of twigs.
- **Pruning:** If you have permission to do so, collect branches from the upper canopy of taller hemlocks using a pole pruner.
 - Prune a portion of the outer 1m of a branch. Select a and prune only branches with green foliage.
 - Pruning should not be used for all sampling, as it can cause damage to the trees and ultimately takes longer meaning fewer overall samples.
 - Ensure that you prune using proper technique to avoid injuring the tree.
 - Pruning in the fall or winter months can reduce the chances of a pruning wound attracting insects, as insects are largely inactive during this period.
 - As HWA often infests the upper canopy first, this practice can increase the chances of early detection compared with sampling from lower parts of the canopy.
- Examine the undersides of branches with a hand lens for wooly masses associated with later-stage nymphs, eggs, and adults. Examine trees for other symptoms of HWA infestation as described above.
- Examine the bole and bark for wooly masses or other signs of HWA.
- When surveying in areas >3ha
 - Ensure that the trees examined are well distributed throughout the survey area.
 - Where hemlock populations follow a watercourse or waterbody edge, prioritize these edge populations for surveying.
 - Survey both interior and edge trees where possible.
 - Survey branches from either side of the tree. At least two branches should be examined per tree until a suspect is found or 100 trees have been surveyed.
 - Record the survey starting point GPS coordinates.
 - After examining the first tree, take 25 paces (2 steps per pace) in the planned survey direction, and examine the nearest suitable tree.
 - Continue this process in a zig-zagging pattern until ~100 trees have been surveyed. Try to maximize coverage of the area during surveys.
 - Contact the PEIISC or CFIA with any suspect information.
- When surveying in areas <3ha
 - Inspect all hemlock to a maximum of 40 trees or two hours per site. If there are many trees on site, distribute your search throughout the area.
 - Address findings as needed. Contact the PEIISC or the CFIA with known suspect information.

- Survey branches from either side of the tree. At least two branches should be examined per tree.
 - If a suspect is found, fill out the suspect site form in Appendix 1 of the CFIA survey protocol as seen above.
- *Efficacy:*
 - **Low-Moderate**
 - Visual sampling is generally considered to be affordable and widely applicable, but is not always suitable for early detection.
 - Visual surveys without pruning are unlikely to provide early detection of HWA. This is because early infestations often begin high in the canopy of tall hemlocks where they catch windborne HWA.
 - Visual surveys with pruning cause damage to the tree which can result in stress or attracting pests to the area.
 - A benefit of visual surveys is that they can be done throughout the year, although summer surveying is not recommended.
 - If no HWA woolly masses are found after sampling 100 hemlock trees, one can state with 75% reliability that less than 2% of the hemlock trees are infested in that area.
- Information provided here is based on the Canadian Food Inspection Agency's Hemlock Woolly Adelgid Survey Protocol, Revision 2022-12-29: [Hemlock Woolly Adelgid \(invasivespeciescentre.ca\)](https://www.inspection.gc.ca/eng/food-safety-inspection/agriculture/pests-diseases/hemlock-woolly-adelgid/survey-protocol/revision-2022-12-29)

Ball sampling

- This technique uses velcro-coated racquetballs shot using a dog ball launcher to collect HWA woolly masses from the upper canopy of tall trees.
- *Materials required:*
 - **Slingshot/launcher:** [Hyper Pet™ Hyperdog Ball Launcher | Cabela's Canada \(cabelas.ca\)](https://www.cabelas.ca/hyper-pet-hyperdog-ball-launcher)
 - **The PEIISC has these launchers available to loan out to interested surveyors.** Reach out to the PEIISC at peiinvasives@gmail.com to inquire about availability. We have four launchers available and recommend working in pairs.
 - Launchers can be rented for one week, after which they must be returned. If there is nobody else waiting to use a launcher, you may renew your rental.
 - **Rental is free.** PEIISC staff will supply details for picking up the launcher from us once the rental is confirmed (pickup in Charlottetown).
 - In the event of damage to the launcher that renders it unusable, the renter will be responsible for replacing the launcher. A broken sling/cord is considered normal wear and tear, and users are not responsible for providing replacement slings.
 - Alternatively: [Notch Big Shot Throw Weight Launcher | Sherrilltree](https://www.sherrilltree.com/notch-big-shot-throw-weight-launcher)
 - **Racquetballs** of a highly noticeable colour (red preferred by CFS).
 - Cut a slit along the seam of the racquetball, and fill it with **wooden beads**.

- Wooden beads add weight to help the ball push through the canopy and reduce bouncing, making the ball easier to retrieve.
 - Glue the bead-filled racquetballs back together with **super glue**.
 - Surround the ball's seam with **velcro strips** (1cm wide) with adhesive backing. Do the same along the ball's opposite axis, creating x patterns at the top and bottom of the ball. Add additional velcro strips, one per each of the four empty spaces between the circumferential velcro strips. The resulting pattern looks like a basketball's seams.
 - Reinforce the edges of the velcro with **super glue** to keep them from peeling up.
- **Hard hat** and **eye protection** is required to keep surveyors safe.
- Wear **gloves**. Gloves should be fibre-free, rubberized, leather, or at least made with a dark material. This is to prevent fibers from light-coloured gloves from being caught on the velcro balls and confused with actual HWA wool.
- **Extra slings** pending breakage: [Hyper Pet™ Replacement Band/Pouch | Cabela's Canada \(cabelas.ca\)](https://www.cabelas.ca/hyper-pet-replacement-band-pouch)
- **Toothbrush** to clean debris from the velcro between samples.
- Bleach bath (if within or nearby an infested area)
- Lint roller (if within or nearby an infested area)
- Smartphone or GPS and logbook
- Hand lens
 - HWA can sometimes be seen with the naked eye, but a hand lens helps especially for earlier stages of the life cycle.
- Additional useful gear:
 - Zip-lock bags and sealable dishes for specimen collection.
 - Pruning shears
 - Knife
 - Digital camera
 - Tree identification guide
 - HB pencils
 - Permanent markers
 - Paper labels
 - GPS unit & Compass
 - Maps (including forest cover or municipal forest inventory)
 - Field book with waterproof paper
 - Flagging tape
 - Measuring tape
 - Protective footwear (Safety boots)
 - Reflective vest
 - Sunglasses
 - Hat
 - Sunscreen
- *Target life stages:*
 - **Eggs**, adults, late-stage nymphs/larvae coated in woolly masses (ovisacs).
 - Ovisacs are the most obvious form.
- *Timing:*
 - April-July, when wool is most abundant. May is ideal.

- If sampling before this time, ovisacs will be smaller and less likely to be collected, and after this period wool will become brittle and less likely to stick to the ball or be weathered away.
 - When sampling during June and July, be aware of the possibility of moving crawlers (the mobile life stage of HWA) around the survey area and away from the site. See biosecurity below for instructions on how to prevent this movement.
- *Procedure:*
 - Similar to archery.
 - Only recommended for trees greater than 15m tall, as the ball passes through the crown too quickly in smaller trees.
 - **NOTE:** be aware of your surroundings. Do not sling balls where there is a possibility that the ball will enter traffic, hit a bystander, or damage property.
 - Working in pairs, shoot balls from opposite sides of the trees and collect the ball from your partner's shot.
 - After loading your slingshot with a ball, "cock" the slingshot by pulling the ball back towards your chest
 - **NOTE:** Avoid pulling the ball towards your face initially. This is to avoid punching yourself in the face if the sling breaks.
 - After fully "cocking" the slingshot, bring it up to your face and aim it like you would a bow and arrow.
 - Aim for the outer 1m of the branches, as HWA congregates on branch tips most often.
 - Try to hit at least three branches in each shot to ensure the accuracy of sampling.
 - Collect the ball and examine it for wool from HWA.
 - Clear any debris from the velcro using a toothbrush between samples.
 - Collect 15 samples per tree for a complete survey. Experienced crews can conduct 4 samples per minute.
 - With each shot, try to hit a new part of the crown.
 - If wool is found, collect a specimen in a glass vial filled with 95% ethanol for later inspection by a trained professional. Contact the PEIISC for information on specimen submission. Specimens can be stored below freezing to prevent decay or escape.
 - Sampling issues:
 - Wool may become clarified and difficult to see after becoming wet, impeding detection. Be careful not to launch balls into the water where possible.
 - Wool may also be picked up from the forest floor after the ball falls, complicating the specific association of a particular tree with ball sampling results.
 - If a sample falls in water or becomes heavily embedded in dirt and debris, consider scrapping and repeating the sample.
- *Efficacy:*
 - **Moderate**
 - This method allows one to detect early infestations by accessing the upper canopy.
 - The user must create materials themselves.

- Materials are fairly affordable and easily accessible.
 - This method cannot provide accurate information on population density, although the number of positive samples may give some idea.
 - Can be difficult in rough terrain, deep leaf litter, and along waterways.
 - Only effective during certain times of year (spring and summer).
- [HOW TO: Ball Sampling for Hemlock Woolly Adelgid - YouTube](#)

Preventative silvicultural controls

Do you own or manage a woodlot with a large component of Eastern hemlock? Evidence suggests that certain silvicultural management strategies applied to at-risk stands of Eastern hemlock can improve Eastern hemlock fitness and resistance to HWA, and reduce HWA fitness. While extensive study of these techniques has yet to be completed in Canada, early evidence of their use is promising.

Silvicultural control is not enough to prevent infestation alone. Incorporate other methods of control simultaneously when under direct threat of invasion.

Preventative controls, pre-infestation and in lightly infested areas:

- **General promotion of hemlock health** and tolerance can help reduce or slow the effects of infestations.
- **Do not fertilize hemlocks with nitrogen.** This promotes HWA densities and reduces the likelihood of hemlock survival.
- **Make hemlocks unattractive to visiting wildlife** such as birds (remove feeders near hemlocks, etc.).
- **Increasing the level of direct sunlight hitting hemlock branches** by 30-50% can decrease the fitness of HWA, slowing hemlock mortality. This will, however, affect light levels and temperatures in the area (affecting other organisms that rely on normal conditions), and is not enough to stop the infestation's progress.
- **Thinning hemlock stands** can promote individual health and increase light levels, increasing the health of individual hemlocks and reducing the fitness of future HWA that may become established in the stand.
 - Removal of weak individuals, especially those with lower than 30% live crown ratio, can benefit remaining trees.
 - Thinning has heretofore implemented a reduction of 20-40% of less vigorous trees in an area. (Nova Scotia Hemlock Woolly Adelgid Management Plan, 2021)
 - This practice may accelerate hemlock loss when applied to heavily infested stands. (Nova Scotia Hemlock Woolly Adelgid Management Plan, 2021)
- **Salvage cutting in the face of an HWA infestation is not recommended.** The jarring shift in ecosystem character caused by the immediate loss of hemlock through harvesting will be much more harmful on local wildlife than the more gradual shift that would be experienced through HWA infestation. Salvage cutting may also remove resistant trees, stifling the future development of an HWA-resistant Eastern hemlock variety.
- **Improving species diversity** can increase the resilience of forested areas to disturbances such as that caused by invasive species.

- “Overall, our findings suggest that mixed forests are more resistant to natural disturbances that are relatively small-scale and selective in their effect. However, benefits provided by mixtures are less evident for larger-scale disturbances. Higher tree diversity translates into increased resistance to disturbances as a result of ecological trait complementarity among species, reduction of fuel and food resources for herbivores, enhancement of diversion or disruption processes, and multi-trophic interactions such as predation or symbiosis.” (Jactel et. al, 2017)

Reporting

- **Healthy hemlock stands** can be reported directly to the PEIISC at peiinvasives@gmail.com. This data will help the PEIISC monitor PEI's hemlocks for HWA and inform a response effort should HWA arrive on PEI. Include as much data on the stand as is available. Data may include:
 - Locations of Eastern hemlock trees and stands (as specific as possible, digital data preferred).
 - Sizes of Eastern hemlock trees. (DBH)
 - Percent Eastern hemlock coverage in an area.
 - Not all of this data is required, any available data will be helpful!
 - Reports of healthy hemlock stands or individuals can also be reported to this iNaturalist project: [Healthy Hemlock Forests of the Maritimes · iNaturalist Canada](#)
 - OR to this Google form: <https://forms.gle/Jr1Fx6KEsTHVGd2w7>
- **If you believe you have seen HWA or symptoms of its establishment on PEI, quick reporting is crucial.**
 - Report findings to the PEIISC at peiinvasives@gmail.com as soon as possible.
 - Include a description of your findings including the number of trees affected, detailed photos, the location of the find, your contact information, and the date of the find.
 - Where possible, include:
 - A description of the host tree(s).
 - The surrounding area.
 - Any other relevant information.
 - DO NOT move HWA out of the infested area or collect any specimens, and allow a CFIA representative to visit the site to confirm the observation.
- **Monitoring data for negative results (when you don't see HWA) should also be recorded.**
 - Data can be recorded digitally using the Survey123 form at the following link: <https://arcg.is/0OHGDf0>
 - NOTE: Install the app on your smartphone before clicking the link.
 - Alternatively, scan this QR code with your smartphone to access the Survey123 form.

