



E. Appleton

HEMLOCK WOOLLY ADELGID

Survey Protocol

AT A GLANCE

- Hemlock woolly adelgid is a tiny sap-sucking insect that attacks and kills hemlock (*Tsuga* spp.)
- Prioritize inspection of host material in urban parks and green spaces, nurseries importing hemlock from infested or regulated areas and hemlock forests within 100 km of known infestations.
- Hemlock trees are inspected for the presence of cottony white egg sacs at the base of needles, twig dieback, discoloured foliage and tree decline

1. Background and Objectives

The hemlock woolly adelgid (HWA), *Adelges tsugae* Annand is a destructive pest of susceptible species of hemlock, *Tsuga* spp. and is native to India, Japan, Taiwan, and China. In 1919 HWA was first reported in North America in British Columbia and can now be found in Alaska, Washington, Oregon, Idaho, Montana and California occurring on both western, *T. heterophylla* (Raf.) Sarg. and mountain hemlock, *T. mertensiana* (Bong.). Damage on these two species is usually minor. HWA was first detected in the eastern United States in Virginia in 1951. Since this time it has steadily spread and is now established in Nova Scotia and 20 eastern states and the District of Columbia, where it has resulted in significant mortality of both eastern, *Tsuga canadensis* (L.) Carr. and Carolina, *Tsuga caroliniana* hemlocks. HWA is present in 5 townships in the Niagara region of Ontario, as well as in Grafton, on the north shore of Lake Ontario.

This survey supports plant health policy directive D-07-05, *Phytosanitary requirements to prevent the introduction and spread of the hemlock woolly adelgid (Adelges tsugae Annand) from the United States and within Canada*. This visual survey is aimed at early detection of the pest in areas where it is not known to be established.

2. Target Life Stages

HWA nymphs, adults, and white egg sacs through visual surveys.

HWA has a complex life cycle with two successful generations per year in North America (in its native range a third generation attacks spruce). From March through May, the immobile female adelgid (sisten) lays a single white cottony egg sac that contains up to 200 eggs. These egg sacs are deposited on the twigs and can remain on the tree for up to a year. Upon hatching, the nymphs (two types - progredien & sexuparae) crawl in search of a suitable site to settle, usually at the base of a needle where they remain, feed, and develop. The nymphs insert feeding stylets into plant tissue on the underside of the base of the hemlock needle and quickly develop through four instars.

In June and July, the progrediens that are now mature adelgids lay a 2nd generation of white cottony egg sacs on the branches of host trees. Upon hatching, the newly emerged nymphs (sistens), crawl to the base of host needles, feed for a short period and enter a period of inactivity called aestivation from July until October. In October, the young sistens become active, feeding upon the host throughout winter and develop into adults in spring. While feeding the adelgid produces its characteristic woolly covering.

Adelgid feeding at the base of hemlock needles causes needle desiccation (removal of moisture) and the tree tends to take on a grey cast. The resulting needle loss prevents the trees from producing new apical buds and can kill a tree in as little as 4 years. In North America, the sexupara group of adelgids that develop in the spring on hemlock can fly and leave host trees in June in search of a spruce (*Picea* spp.) host. These adelgids have not been successful in attacking spruce species occurring in North America and die without reproducing.

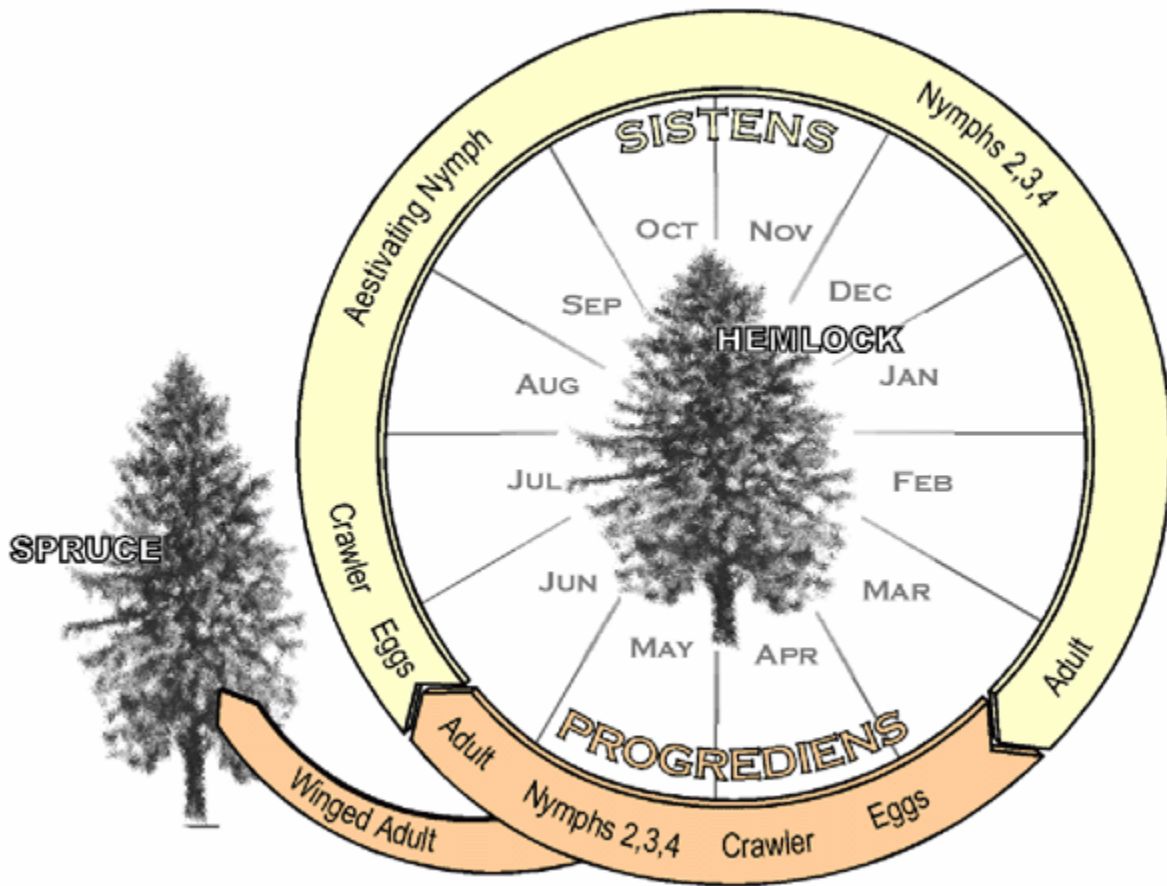


Figure 1. Lifecycle of hemlock woolly adelgid (From Cheah et al. 2004).

3. Target Hosts

All species of hemlock (*Tsuga* spp.)

4. Timing and Duration

Biologically, the optimal survey period is from March to May, within an overall survey period running from November to June. **Plan to complete this survey in April and May.**

Visual surveys for HWA are best conducted when obvious woolly masses are present. Although egg sacs can remain on a host tree for up to a year, searching in the summer is not recommended as only remnants of the previous generation’s egg masses may be present. If surveys fall outside the recommended time, a hand lens must be used to closely examine shoots for signs of aestivating sistens in summer and fall.

Avoid surveying when snow may be present on the branches of host trees.

5. Target Areas and Site Selection

Given the known distribution of HWA, the primary means by which the pest could be introduced into non-infested areas of Canada is through the movement of infested nursery stock and natural spread by wind, birds, and small mammals. The overall rate of spread has been estimated to be up to 20 km per year in the US however this has been significantly slower in northern areas with an overall average of about 12.5 km/year.

Alabama	Idaho	New Hampshire	Rhode Island
Alaska	Kentucky	New Jersey	South Carolina
California	Maine	New York	Tennessee
Connecticut	Maryland	North Carolina	Vermont
Delaware	Massachusetts	Ohio	Virginia
District of Columbia	Michigan	Oregon	Washington
Georgia	Montana	Pennsylvania	West Virginia

Table 1. List of US states with known hemlock woolly adelgid infestations.

Urban Parks, Green Spaces, and Hemlock Forest Stands

The sole requirement when selecting sites for this survey is the presence of hemlock trees. However, stands of at least 4 hectares and a strong hemlock component are desired. Suitable sites can include natural areas, wooded parks, green belts, and riparian zones. Information regarding hemlock distribution can usually be obtained from provincial ministry of natural resources staff or municipal forest staff. Aerial photographs, forest inventory, and GIS information should be consulted. Wind patterns and migratory routes of birds should be considered in site selection as these both contribute to the spread of HWA. Hemlock forest stands within 100 km of the Canada/US Border should be given priority over other wild sites.

6. Survey Method

The following survey techniques include excerpts and adaptations from the USDA Forest Service publication *Standardizing Sampling for Detection and Monitoring of Hemlock Woolly Adelgid in Eastern Hemlock Forests* (Scott Costa & Bradley Onken, 2006).

Prior to beginning any type of survey, it is important for surveyors to refresh their search image for the most common signs and symptoms of HWA as it may appear in field.

Surveyors should develop a search image for individual or small clusters of woolly masses (Fig. 2) instead of the massive infestations in typical photographs found in many publications.



Figure 2. Individual woolly mass on hemlock twig. (Photo D. Holden)

6.1. Examining the Tree

- Trees are selected simply on the basis of having branches within reach without using a ladder or pole pruner.
- Select a branch with green foliage (needles)
- Scan the underside of that branch for any evidence of ovisacs, and nymphs focusing your examination along the stem on the outer 1 m of the branch
- If no woolly masses or nymphs are found on the first branch, a second branch on the opposite side of the tree is examined.
- Examine the lower portion of the bole for woolly masses or evidence of HWA before proceeding to the next tree (Fig. 3). While walking between selected trees, look on the ground for hemlock branches that may have broken off from the crown of trees. All shoots should be examined for signs and symptoms of HWA (Fig. 4).
- When walking along roads or open trails with lots of sunlight, use binoculars to periodically scan host trees for signs and symptoms of HWA.

Note: in mature stands where trees have no low branches, using a pole pruner, periodically remove two branches from the mid-upper canopy of selected trees particularly in high risk areas. Alternatively use binoculars as light permits or use the ball sampling technique as outlined in the CFS Technical Note 116.

http://publications.gc.ca/collections/collection_2016/rncan-nrcan/Fo123-1-116-eng.pdf

Mark suspect trees and follow-up with branch sampling to obtain an insect sample for lab confirmation. See section 8.



Figure 3. Evidence of HWA on the bole. (Photo E. Appleton)



Figure 4. Evidence of HWA on fallen twigs. (Photo E. Appleton)

6.2. Signs and Symptoms of Attack

6.2.1 Signs of HWA

Ovisacs: The white cottony egg sac is the most obvious stage to detect and can remain on the branches, stems and twigs for up to a year (unless they are rubbed or blown off).

Ovisacs occur at the base of the needles and resemble the tips of cotton swabs (Fig. 2).

Look along the underside of the terminal and lateral shoots of hemlock branches.

Nymphs and Adults: Nymphs (crawling and sessile) and adults of the hemlock woolly adelgid are very small and difficult to detect. Sessile nymphs are an elongate oval shape, flat, black and might have a slight white fringe around the edges of their bodies (Fig. 5).

Use a hand lens to view potential specimens.



Figure 5. HWA nymphs at the base of hemlock needles (Photo R. Neville)

6.2.2 Symptoms of HWA

Twig Dieback as well as Discoloring of Hemlock Needles: Feeding by HWA results in twig dieback and causes needles to lose their typically green colour. In advanced stages of the infestation, swollen growths (gouting) occur at the tips of twigs and there is no new formation of branches or twigs. The crown of heavily attacked trees changes in colour from dark to yellowish-green-grey and becomes transparent from needle loss.

6.2.3 Non-HWA Signs and Symptoms

The white woolly masses surrounding each insect are almost invariably located at the base of the hemlock needles. To the untrained observer, other things such as spittle bugs, caterpillar and spider webbing, scale insects, the two white lines on the underside of hemlock needles, and even sap and bird droppings might be mistaken for the adelgid. However, these can be readily distinguished because of their appearance, physical location, or both. Any specimens with questionable features should be bagged and later examined with a microscope or submitted to the Entomology lab for analysis.

6.3. Survey Methodology

6.3.1. Methodology: Urban Parks, Green Spaces, and Hemlock Forest Stands < 3 ha

For small urban parks and greens spaces, inspect all hemlock, to a maximum of 40 trees, or 2 hours per site.

Complete the Survey 123 Site Form (Appendix 1), recording the GPS reading for suspect trees and collect samples as per section 8.1.

6.3.3 Methodology: Urban Parks, Green Spaces, and Hemlock Forest Stands > 3 ha

The objective is to ensure that the trees that are examined are well distributed in the block or stand.

In cases where the hemlocks follow a stream or riparian zone, select a path that follows the edge of the waterbody.

Research has shown that HWA populations have a clumped distribution, as many insects do. This means that infested trees tend to be relatively close together in patches that extend across the forest stand or landscape. As more trees in the stand become infested the clumping diminishes. For the surveyor, this clumping tendency requires that the survey broadly covers the landscape to increase the chance of encountering an infested patch of hemlock trees. This is particularly important when attempting to detect low-level populations. Early infestations are often detected near roadsides or other travel corridors on individual or clumps of trees. An approach that includes both the edges and interior of stands is recommended.

Further research has shown that if no adelgids (woolly ovisacs or nymphs) are found after sampling 100 trees in a hemlock stand (as outlined below) then one can state with 75% reliability that the population of infested trees is less than 2 percent in that area.

- Select a target hemlock stand located within 100 km of the Canada US Border or infested area in Nova Scotia, Ontario, or BC.
- Draw a quick sketch of the site to help you plan your survey approach
- Hemlocks along the edges of waterways should be prioritized and included in the search.
- Obtain a general estimate of the size of the stand. Larger stands can be broken down into blocks that are easier to manage (Fig. 6).
- Record a general assessment of the overall health of the stand. Trees showing decline near the edge of the stand should be examined first.
- Obtain and record a GPS reading for your starting point
- Examine the first tree (see 6.2) for HWA. Take 25 paces (2 steps per pace) along the planned general direction.
- After completing the 25 paces, examine the nearest suitable tree.
- Continue this process using a zig-zagging pattern (Figure 6) until about 100 trees (25 per block) have been examined. Consider the contour of the targeted stand such that your pattern maximizes coverage.
- Complete the Survey 123 Site Form (Appendix 1), record GPS reading for all suspect trees and collect samples (see 8.1).

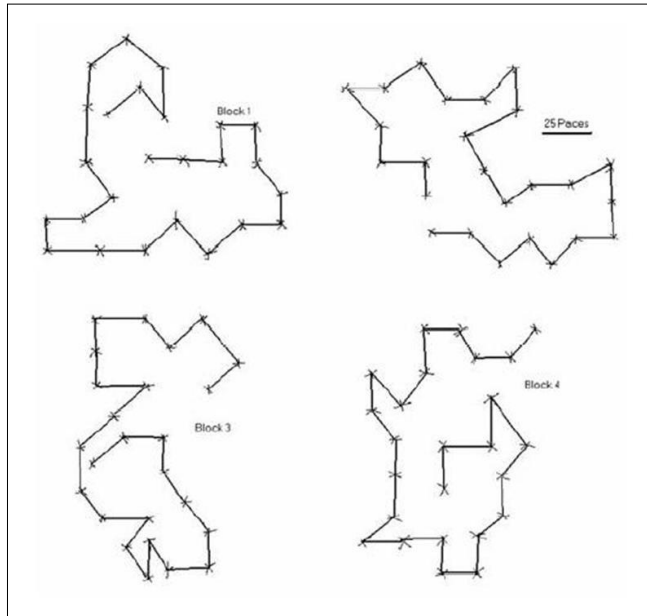


Figure 6. Example of zig-zagging pattern for use in larger hemlock parks, greenspaces, and stands that have been divided into four blocks.

7. Biosecurity Precautions

When visiting areas that are or could be infested with pests of significance, staff must take the necessary precautions to ensure that the risk of spread is mitigated.

- Light coloured clothing is recommended for this survey to make crawlers more apparent.
- Avoid placing gear on or near hemlock trees
- Remove potential crawlers from clothing using a lint roller once you have left the forest stand, before getting into your vehicle.
- Beat and/or lint roll hats and coats
- During the high risk period when crawlers are active (from March to Mid-August), ensure that you do not visit additional survey sites after visiting a positive or potentially positive site.
- Clothing should be laundered prior to visiting another site.
- Vehicles should be parked away from hemlock host trees.
- Clean pruners with a wipe or hand sanitizer prior to leaving each survey site.

8. Sample Handling and Laboratory Submission

8.1 Sampling Procedures

In the event that HWA signs are encountered during the survey, samples should be taken and prepared for submission to the CFIA lab in collaboration with CFIA inspection staff. A digital photograph of the egg sac or symptom should be taken. Contact your local CFIA office <http://www.inspection.gc.ca/about-the-cfia/offices/eng/1313255382836/1313256130232> or Area Survey Biologist cfia.surveillance-surveillance.acia@inspection.gc.ca. Suspect twigs or branches should be clipped at least 15 cm below the egg sac using pruning shears and placed in a plastic bag containing a piece of dry paper towel. Record the GPS coordinates in Latitude and Longitude in decimal degrees (NAD 83 datum) for the tree sampled, your name, comments about the site (estimated diameter of tree, health, etc.), the date, and other location information on a piece of paper and place this into the bag. A piece of flagging tape should be placed on the tree sampled as you will likely need to revisit the tree if the sample is positive.

8.2 Collaborative Data Management

Survey activities conducted for a regulated pest in accordance with the established CFIA survey protocol should be captured so that all collaborative efforts can be reported. An Excel spreadsheet containing latitude and longitude coordinates and address for the site surveyed, percent hemlock, organization details and coordinates for any suspect trees can be submitted to the CFIA cfia.surveillance-surveillance.acia@inspection.gc.ca by no later than September 1st each year so that all efforts can be mapped and reported Nationally. Possible suspects should always be reported in real time. Alternatively, data for each site can be entered in a new Survey 123 Site Form (Appendix 1).

9. Supplies

- Knife
- Hand lens
- Digital camera
- Tree identification guide
- Pruning shears
- Re-sealable bags
- HB pencils
- Permanent markers
- Paper labels
- GPS unit & Compass
- Maps (including forest cover or municipal forest inventory)
- Field book with waterproof paper
- Flagging tape
- Blank LSTS Report for Submission forms
- Measuring tape
- Protective footwear (Safety boots)

- Reflective vest
- Sunglasses
- Hat
- Sunscreen
- Lint roller
- Sanitizer
- Pole Pruner
- Binoculars. (Such as 10 x 42) Survey Site Form
- Tick Removal Kit (e.g., <https://canlyme.com/product/tick-removal-kit/>)

10. Supporting Documents and Additional Information

Pest Fact Sheet for *Adelges tsugae*, Hemlock Woolly Adelgid

<http://www.inspection.gc.ca/plants/plant-pests-invasive-species/insects/hemlock-woolly-adelgid/fact-sheet/eng/1325616708296/1325618964954>

Hemlock Woolly Adelgid Pest Card

General Information on Plant Health Surveys and Data Management and LSTS Entry Guidelines for Plant Health Surveys available on Merlin at:

<http://merlin/english/sci/pps/ppse.aspx>

Standardizing Sampling for detection and Monitoring of Hemlock Woolly Adelgid in Eastern Hemlock Forests (Scott Costa & Bradley Onken, 2006)

<http://www.fs.fed.us/foresthealth/technology/pdfs/HWASampling.pdf>

Natural Resources Canada – Canadian Forest Service Frontline Technical Note 116 - *Detection tools for an invasive adelgid*

<https://d1ied5g1xfgpx8.cloudfront.net/pdfs/36791.pdf>

Hemlock Woolly Adelgid Management Plan For Canada

<https://cfs.nrcan.gc.ca/publications?id=39158>

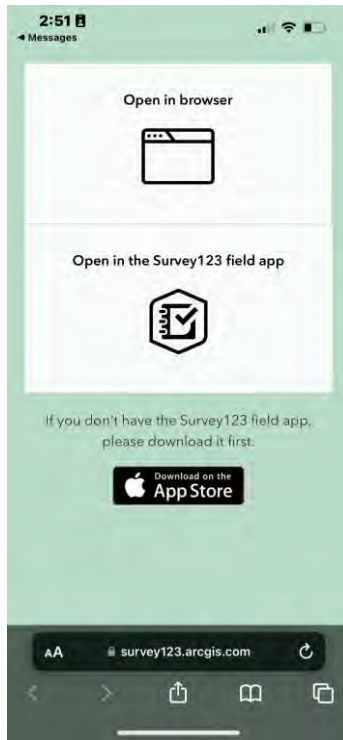
Hemlock Woolly Adelgid Fact sheet

<https://www.invasivespeciescentre.ca/invasive-species/meet-the-species/invasive-insects/hemlock-woolly-adelgid/>

Appendix 1: Survey 123 Guidelines for Hemlock Woolly Adelgid

Download the free ArcGIS Survey 123 app to your smartphone. Once downloaded, scan the following QR Code or click the link to open the Survey 123 form. You will not need an account to be able to access this form and the form will be accessible on the app home screen after first use.

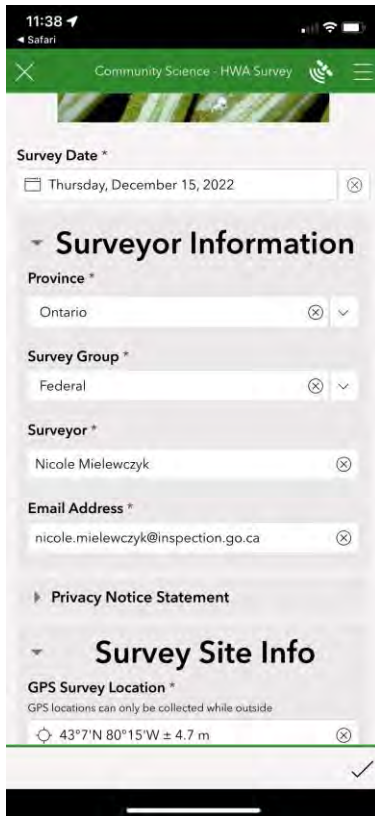
<https://arcg.is/1jLKbO0>



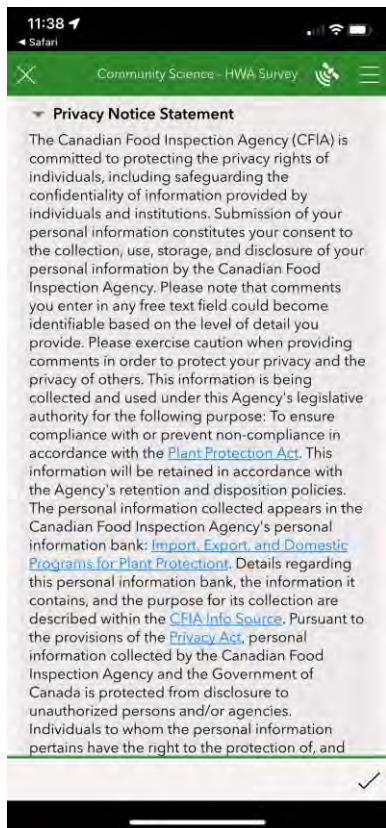
When using your smartphone, select *Open in the Survey 123 field app*.
 Browser version can also be used to track survey data, but field app is recommended. All steps remain the same, regardless of the platform used.



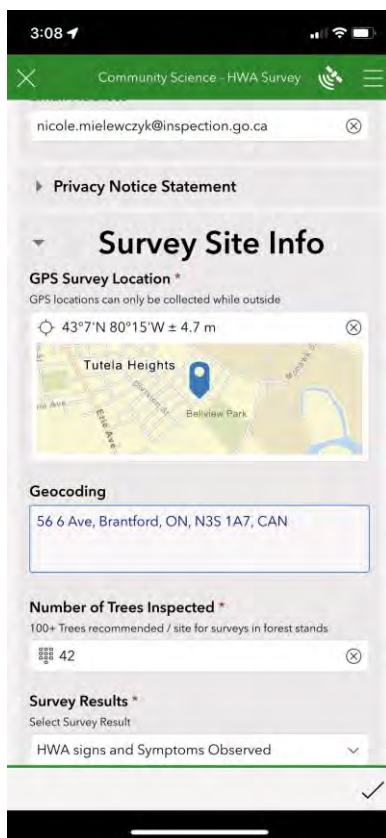
The *Survey Date* will be auto populated with the current date. This can be modified and backdated if required.



In the *Surveyor Information* section you will capture your information by first selecting the province and group you are part of from the pick list. Then type in your name and email address. These fields are required so that CFIA can contact you to follow up on signs/symptoms of HWA



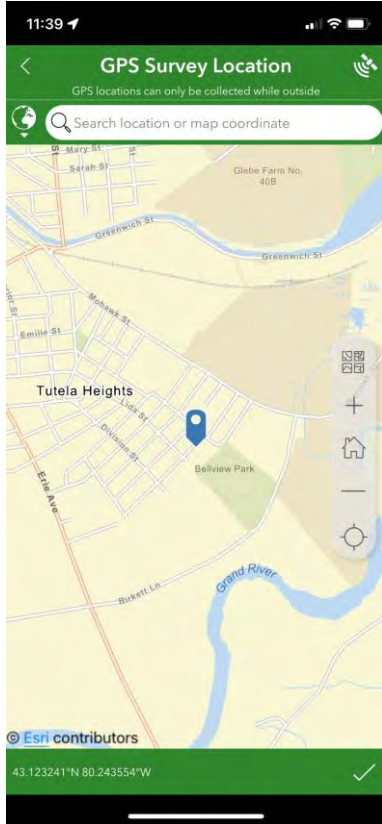
Select the *Privacy Notice Statement* tab to review details here.



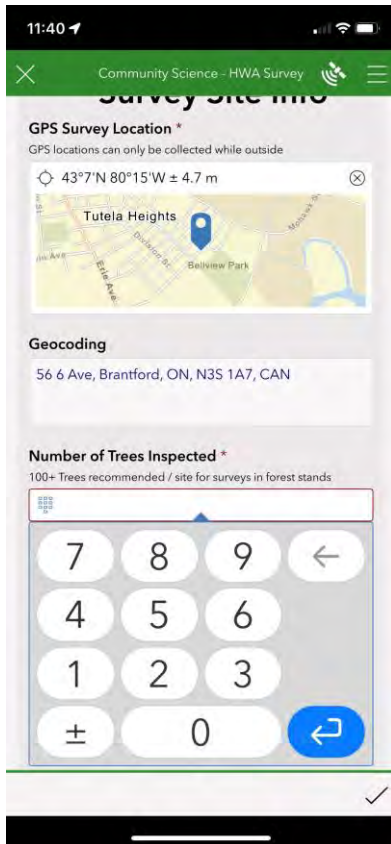
Then proceed to the Survey Site Info section.

In *GPS Survey Location* select the crosshairs icon or the map to capture the GPS. This will populate the *Geocoding field* with an address nearby.

Note: When the GPS reading is plus or minus **more than 10 m** (+- 4.7m in example provided) a more accurate reading should be taken. Press on the map display and a new screen will open allowing a more precise site location to be specified.

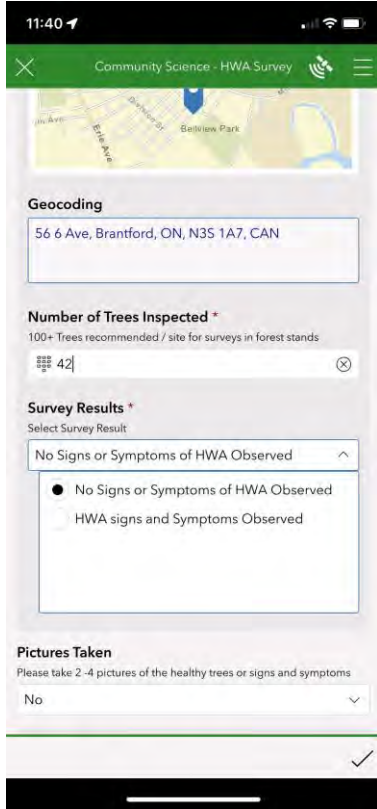


Position your location under the cross hairs zooming in as required. Press the check mark in the bottom right when satisfied.

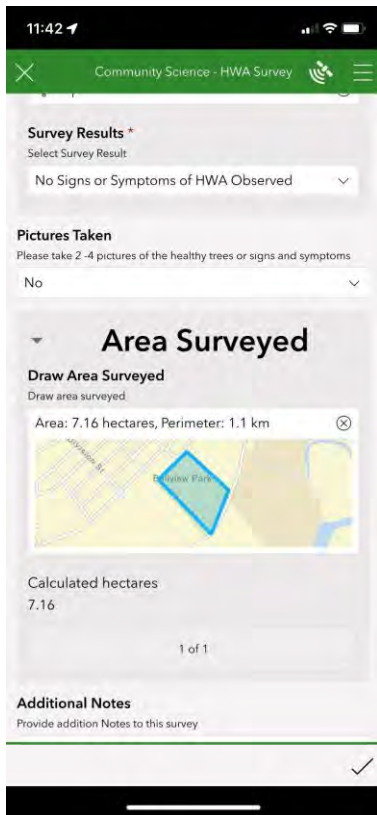


Enter the *Number of Trees Inspected*. Review Section 6.3 of Survey Protocol to determine optimal number of trees for the size of a site.

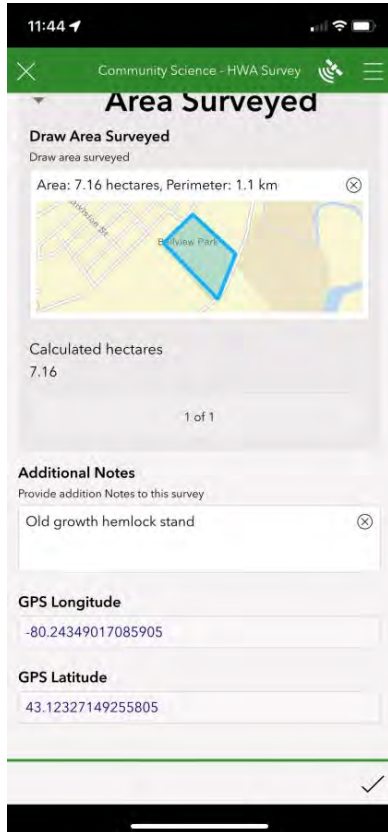
If unable to complete a full formal survey, even a small amount of trees inspected is helpful to support the early detection of HWA



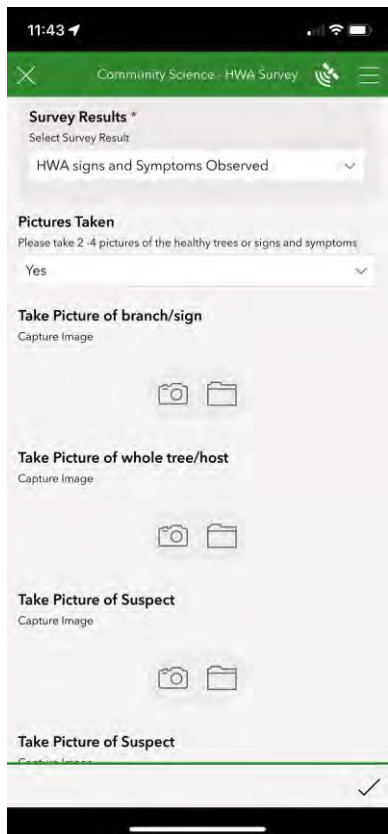
Select **No Signs or Symptoms of HWA Observed** when nothing is found.



Press on the map below **Area Surveyed** and a new screen will open allowing a polygon to be created to calculate the area surveyed.



Type in any *Additional Notes* and once you're satisfied with the data that's been entered, click the check mark in the bottom right to complete the Visual survey form.



If **HWA Signs or Symptoms Observed** please collect pictures showing the branch, overall tree and then close up shots showing the areas affected.

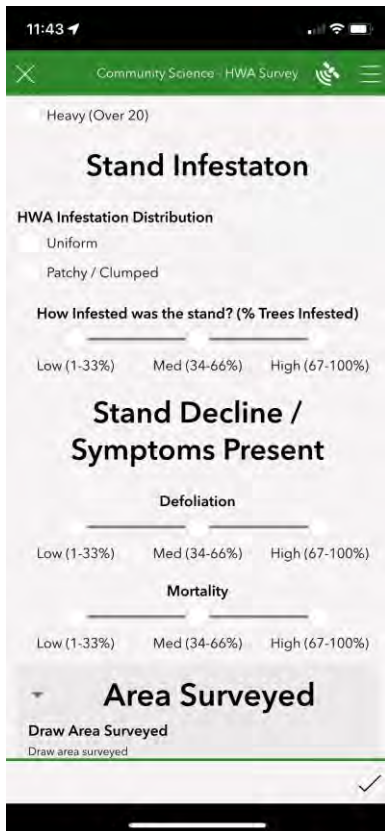
Note: Contact the Canadian Food Inspection Agency when Signs or Symptoms of HWA are observed.

cfia.surveillance-surveillance.acia@inspection.gc.ca

If more than one suspect specimen is identified in distinctly separate areas, submit an additional visual survey form for each specimen collected.

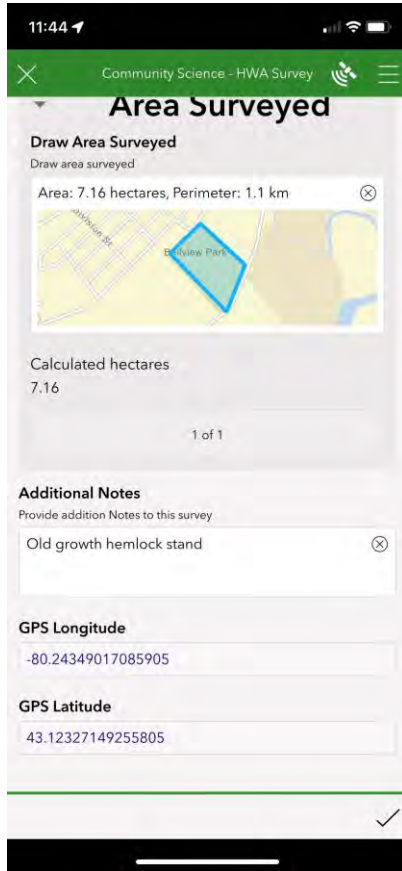


Record the *Signs Observed* and average level of *infestation of each infested tree*.



Record the *HWA Infestation Distribution* and the percentage of *Stand Infestation*.

Next record the percentage of *Stand Decline / Symptoms Present*.

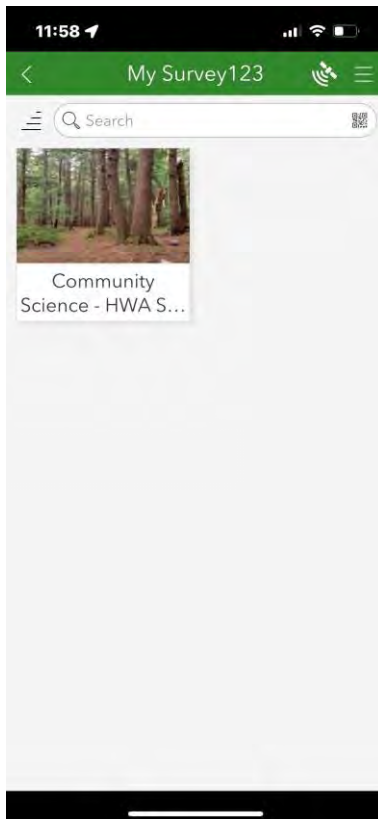


Press on the map below *Stand Area* and a new screen will open allowing a polygon to be created to calculate the area surveyed.

Type in any *Additional Notes* and once you're satisfied with the data that's been entered, click the check mark in the bottom right to complete visual survey form.



When using the field app for future data collection, select *Continue without signing in*.



The Community Science – HWA Survey form will be accessible on the home screen.