



HEMLOCK RESTORATION INITIATIVE



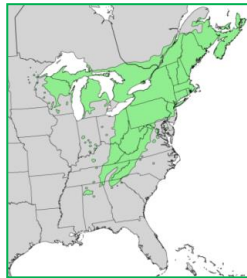
The **eastern hemlock** (*Tsuga canadensis*) is a vital part of mature forests throughout eastern North America, including much of western North Carolina. This slow growing, long-lived tree may take 250-300 years to reach maturity and may live over 800 years.

Hemlocks are significant because of their ability to grow in shade. Once a hemlock forest becomes established, it will renew itself until the cycle of new hemlocks replacing old is interrupted.

www.conifers.org

The stability of hemlock forests has created much of the character and habitat quality of western NC. The Carolina hemlock occupies xeric habitats in the Southern Appalachians and is important ecologically for those landscapes.

<http://esp.cr.usgs.gov/data/little>



BEETLES SAVE NEEDLES

Hemlock woolly adelgid (*Adelges tsugae*) was found in NC ~1995. It was reported in the Pacific Northwest in 1924 and in Virginia, 1954. Now established through most of the range of eastern hemlock, this prolific pest threatens the climax forests of eastern North America.



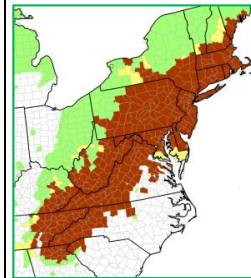
Adult HWA and eggs
Symbiont Biological Pest Mgt.

The HWA is a very small, burgundy colored, aphid-like insect with two generations per year, with no local, natural enemies. Once the insect settles at the base of a needle, it inserts its feeding tube and sucks the juices out. This causes bud mortality, twig dieback, and defoliation and, under high infestation rates, death of the tree in as few as 4-7 years.

4-7 years.

HWA can be easily seen from late fall through early spring with the presence of white cottony masses at the base of the hemlock needles.

2012 infested counties in brown
www.na.fs.fed.us/fhp/hwa



Control Options

Control options for HWA require retreatment over time, for control not eradication. The high cost means treating forested areas is not feasible and limits use to landscape and high value trees.

Chemical controls are applied by stem injection, soil drench or injection, and foliar or basal spray, with residual lasting 1-8 years depending on pesticide used. The pesticides are known to affect multiple insects, wildlife and fish (imidicloprid and dinotefuran).

Least toxic controls have much shorter residual. Insecticidal soap or oil, as a foliar spray, is limited to smaller trees or the lower portions of larger trees but can help reduce HWA population levels. Applied during the dormant season; they work until dry.

The bioinsecticide, Azadirachtin, is made from neem tree seeds and injected into the tree. Its residual is about 4 months.

Wild collected predator beetles from western U.S.

Since HWA is native to the Pacific Northwest, it has native predators there that hold it in check. One such predator is *Laricobius nigrinus* which has been released in NC since 2003. The majority of the beetles in NC have been either collected from the Pacific Northwest, or collected in NC from established beetle populations.

Unlike most predator beetles of HWA, Lari is a winter feeder. This tiny (2-3mm) beetle has adapted to NC and both the adult and the larvae feed on HWA from October to May. The adults can eat 6 or more adelgids per day before laying 200-400 eggs singly in HWA egg sacs. Each larva can consume 200-250 HWA eggs or crawlers before they pupate in June.

Beetles are not inexpensive but they breed and spread once introduced.

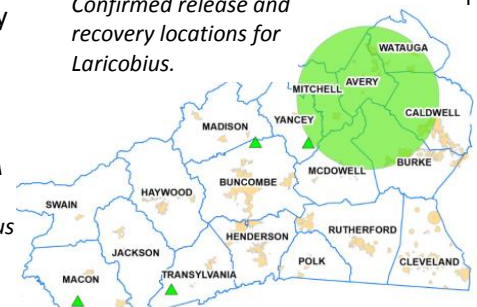


www.nps.gov



Laricobius larva feeding on HWA eggs.
www.na.fs.fed.us

Confirmed release and recovery locations for *Laricobius*.



Predator Beetle Collection

In NC, established *Laricobius nigrinus* beetles can be collected and redistributed locally from mid-Oct. through March.

The goal of the local NC collection/release is to redistribute *L. nigrinus* beetles into every western North Carolina watershed with HWA-infested hemlocks. Releases, since 2003, and natural dispersion have established the *L. nigrinus* beetle in a 20,000 square mile area; roughly 70+ miles in every direction from Grandfather Mountain, and spreading at a rate of 2+ miles, on all fronts, each year. By coordinating local collection/release efforts to introduce *L. nigrinus* beetles throughout western NC, the timeframe for spread and establishment could be reduced and local hemlocks preserved.

HOW to Collect Predator Beetles

Any collections **MUST** involve landowner permission. **NO TRESSPASSING.** Workshops or organized collection events are planned with permission. Random or unapproved collection on any private property is not advised. You must also ensure that your local release site will allow for future access for population tracking and collection.

[See page 6 for **Equipment Required** for collection/release.]



Collect on warmer sunny days from mid-October through March. Do not attempt to collect under adverse weather conditions (e.g. heavy wind, rain, or temperatures below freezing). Sunny days with temperatures above 45°F, between 10am and 4pm are the best times to collect. Target branches that are in open areas receiving sun and are infested with HWA; this is usually where the beetles are. Keep your collection equipment cool and in the shade at all times.

Indications of sun access and sufficient open space include living branches with needles present on the lower trunk.

Step 1 – Prepare collection materials



Prior to beetle collecting, place HWA-infested food in pint **paper** cartons, and also in the plastic vial with the aspirator. Make sure there is adequate HWA on twigs in the carton. You must soften the impact of the beetles when you aspirate. If you can hear beetles hitting the bottom of the vial, then add more twigs to soften their impact. **NOTE: Do NOT use plastic cartons.** They allow moisture to build so beetles get stuck to the wet sides, increasing beetle mortality significantly.



Step 2 – Beating the branches



Beetle on beat sheet

Focus on branches with HWA. Put the beat sheet or umbrella under the limb to catch any falling beetles. Tap the limb briskly, but not too hard from one direction, starting from the center of the branch and moving to the tip, and back) about five times, keeping the beat sheet/umbrella directly under the limb. The impact of the pole on the limb will cause any beetles present to be dislodged and fall to the sheet.



Larvae with HWA egg sac above

Step 3 – Selecting the beetles

Scan twigs and needles on the beat sheet as beetles often crawl on/under needles, hiding in the debris. Use the aspirator to collect **ONLY** *L. nigrinus*, counting with the thumb counter. Collect 50 - 100 beetles per aspirator vial and empty the vial into a pint paper carton with the HWA-infested hemlock twigs for food during transport to the release site. Don't crowd the beetles, put no more than 300 beetles in each container. Dump the debris and other insects at the base of tree. **Keep the aspirator COOL, and OUT of direct sunlight to avoid cooking the beetles in the plastic vial!** Keep your cooler in the shade too.



Step 4 – Securing for transport



Once a carton has ~300 beetles, seal the lid tightly. Use rubber bands to secure it in place. Label the lid with the date, place, and number of beetles collected. Store the paper carton in the cooler, making sure not to freeze the beetles. Depending on the cooler size, place 2 freezer packs covered with newspaper on the bottom of the cooler, packing the containers snugly without displacing the lids. You may transport beetles safely in the pint paper cartons for up to 24 hours if there are adequate HWA-infested twigs in the carton and the temperature is between 50°F and 39°F.



HOW to Release Predator Beetles

Ideally *Laricobius* beetles should be released Oct/Nov when the HWA wool becomes noticeable, and weather is still relatively warm. In late winter, release beetles as soon as HWA begin laying eggs, usually by late January. Collecting and releasing beetles at this time, when the Lari females are also ready to lay eggs can provide quicker population increase, post-release.

For selecting the appropriate release location, see **How to select a release site** on page 5. The site should be selected before the beetles have been collected or purchased. Once the site has been selected, take photos of the release site (including individual trees), to track change over time – try to pick a spot that you can find in future years to maintain the perspective and focus. Mark the trees with flagging (renew yearly) or a more permanent method like paint or tags, so they can be relocated easily each year. Record the GPS coordinates for the site no later than the release day.



Whether releasing beetles you have collected, or beetles that have been purchased, follow the same steps.

IMPORTANT

Release beetles as **early in the morning** as possible.

Do not release in adverse weather (e.g., storms, heavy wind, temps < 32°F). Light rain or drizzle is fine.

Once the beetles have arrived:

Step 1 – Release beetles in the field the day they arrive, or within 24 hours at the latest. Don't delay. If the release is delayed due to inclement weather, refrigerate them at 39-50°F, with sufficient food, until ready to release.

Step 2 – Release numbers per site

Plan for 300 or more beetles per site, depending upon availability, and release all beetles in the same general area. The greater the number of beetles released, the faster their population will build.

Step 3 – Release technique

Carefully open the container and remove and place the twigs onto the infested branches on the release tree. Inspect the container for loose beetles and gently use a painter's brush to place beetles on the tree.


Put all beetles in the same general area for quicker population buildup. A mix of conifers nearby, like pines, firs, and spruces will give the predators other adelgids to feed on during different times of the year, and assists the beetles to spread if the density of hemlocks in the area is low. Put all the beetles for a given tree on a single limb, centrally located so beetles can easily crawl to adelgid-infested twigs.



HOW to Report a Release Site

Step 1 – Keep records

Initial data collection should involve taking digital photos from multiple angles, so that the condition of the trees and release site are shown. A GPS location is recommended. This hemlock woolly adelgid biocontrol guidesheet and release form is available online to download at www.blueridgercd.org. While this form may be too complex for small releases, collecting some basic information is recommended.

| Pre-Release Data Form for HWA Predators | | | | |
|---|--------------------------------|----------------------------|---|---------|
| Release Location Information | Site Name: | |  | |
| | Site Address: | | | |
| GPS Coordinates (Decimal Degrees -NAD 83) | Latitude: | | | |
| | Longitude: | | | |
| Site Contacts | Name: | | | |
| | Phone Number: | | | |
| | Address: | | | |
| | Other: | | | |
| Releasers Contact Information | Name: | | | |
| | Phone Number: | | | |
| | Organization: | | | |
| | Address: | | | |
| Biological Control Agents Released | Species: | <i>Laricobius nigrinus</i> | | |
| | Number Released: | Eggs: | Eggs: | Eggs: |
| | | Larvae: | Larvae: | Larvae: |
| | | Adults: | Adults: | Adults: |
| | Source of Beetles | Lab- Reared Beetles | | |
| | Field- Collected Beetles | | | |
| Release Information | Date (m/d/y): | | Time of Release: | |
| | Temperature (C or F): | Cloud Cover: | Precipitation: | Wind: |
| | Method Release Area is Marked: | | | |

Step 2 – Data entry

Enter your release data here: <http://go.ncsu.edu/beetles.save.needles>. You do not need a password.

HOW to Track Success and Population Dynamics

Monitor release sites at least once a year for 3 consecutive years following the release. There are 2 primary monitoring times: October/November for emerging beetle adults and February to April for larvae and adults.

Conduct sampling on warmer sunny days during the cooler months, targeting branches that are exposed to the sun and are infested with HWA. Do not attempt to sample in adverse weather conditions (e.g. heavy wind, rain, or temperatures below freezing). Sunny days with temperatures above 45°F are ideal, between 10am and 4pm.

Step 1 – Identify monitoring areas

Return late-Oct to March the following fall after release to sample adult beetles. In the fall, beetles will be located where HWA is concentrated and receiving winter sunlight. Sampling can expand to neighboring trees in subsequent years.

Step 2 – Sampling protocol

Most beetles will dislodge easily from trees so avoid brushing or otherwise disturbing branches of the trees to be sampled until the beat sheet is in position to collect falling beetles. Focus on branches with healthy HWA, if possible, and tap the branch smartly with the stick 10 times above the beat sheet; enough to dislodge beetles, but not so hard that the branch bounces off the beat sheet. Sample 8 branches per tree (2 branches in each compass direction) whenever possible. If all the branches are on one side, then sample only those branches. Using the same protocol, sample at least 10 neighboring hemlock trees that have healthy HWA.



Step 3 – Collection technique

Document the number of beetles and then dump the duff and insects at the base of the hemlock so they can return to their prior locations on the tree. Also track the numbers on the neighboring hemlocks with healthy HWA.

Step 4 – Data entry

Enter your sampling data here: <http://go.ncsu.edu/beetles.save.needles>. You do not need a password.

HOW to Select a Release Site

Finding an ideal release site is not trivial and takes **TIME and EFFORT** spent in the field.

Find places where hemlocks are still healthy, the HWA is heavy enough to attract beetles, and is also easy to visit for collection and later monitoring purposes.

Studies show that *L. nigrinus* releases do best where the site:

- 1) is undisturbed - The area will not be logged, sprayed, or have road/building construction
- 2) is south facing - coves or openings with infested hemlocks are ideal
- 3) has needle duff - good soil moisture and adequate needle duff for beetle larvae to drop to the soil and pupate



*Leaf litter or
needle duff are needed
for beetle larvae survival.*



South-facing openings are ideal release sites.

SELECTING A SITE FOR RELEASING PREDATOR BEETLES

- 1) Landowner outreach: contact the owners of the property and talk about the goals and objectives of the project. Ask for permission to access the project over multiple years and record all contact information.
- 2) Make sure the site will remain undisturbed for at least 5 years.
- 3) The best sites have winter sun exposure, i.e. south facing.
- 4) Look for trees with low growing hedge-like branches.
- 5) Look for sites with natural soil cover; duff/mulch is preferred over turf, for beetle larvae to pupate.
- 6) Surrounded by other hemlocks over a wide area, can also include a mix of pines, firs and spruces.

Once your predator beetle population becomes established (after 3 or more years), it may be possible to locally collect and release your beetles into less than ideal sites in surrounding areas. Time is needed for the beetle population to increase and spread to surrounding hemlock trees, and it will take several years for beetle populations to build to the point where HWA damage can be limited/reduced by consistent predator presence and feeding.

SELECTING A SITE FOR FUTURE COLLECTING (RECOLLECTION) IN MIND

- a) Mainly open-grown hemlocks or hedges
- b) Urban community interface, campground, school, cemetery, or similar
- c) Must have lower branches that can be easily accessed for future collecting

SELECTING THE RELEASE TREE(S)

- 1) Find the most heavily infested trees.
- 2) Trees should not be in significant decline, for example, if more than 50% of the branches show some new growth and less than 75% of the branches are infested with HWA.

- 3) Do not select trees that overhang roads, water or inhospitable terrain, since the larvae need duff and soil to pupate successfully.
- 4) Individual release trees must be close enough so that beetles can find each other and mate, within 1/3 mile.



High HWA infestation of 100%, with an adelgid at the base of every needle. A moderate infestation is 30% and a low infestation is 10%.



New growth visible on a hemlock twig.

Equipment Required for 1 Person Collection/Release

- 1) Long pole to tap hemlock branches
- 2) Large Cooler
- 3) Newspaper to insulate beetle containers from freezer packs
- 4) ~2 freezer packs (keep beetles cool, not frozen)
- 5) Data recording- sheets and maps
- 6) and 7) Marker and pen/pencil
- 8) Paint brush to transfer any leftover beetles from container
- 9) Clippers to cut hemlock twigs for aspirator and containers
- 10) Beat sheet or umbrella
- 11) Flagging tape to mark release trees
- 12) HWA-infested hemlock twigs for aspirator and containers
- 13) Pint **paper** cartons and rubber bands to hold lids in place
- 14) Aspirator and 10 dram vials with hemlock twigs inside
- 15) Camera/Cell phone to record release site and trees
- 16) Thumb counter to record number of beetles collected
- 17) Light gloves (optional)



FAQs: HWA and Ln

WHY HWA HAS BEEN SO HARD TO COMBAT

1. Non-native pest
...no local predators
...Eastern & Carolina hemlocks had never been exposed
2. Lots of available food
...forests of hemlock
...easy for HWA to spread from tree to tree
3. Prolific reproduction
... all HWA are female
...egg production six months of the year, mainly in the winter
4. Affects trees quickly
...high population
...year-round feeding ~10 months of the year
...already stressed trees succumb sooner

Native Predator Beetles

The search for HWA predators started in China and Japan where Asian predators keep HWA under control and those species have been reared and released in the eastern US. The discovery of predator beetles native to western North America made the use of native species became a possibility. A closely related beetle, *Laricobius rubidus*, is native to the east coast and feeds specifically on pine bark adelgid. These two *Laricobius* species can mate and reproduce, therefore they are the same species, just different biotypes. Studies show that the two biotypes occupy different niches: *L.rubidus*- pines, *L.nigrinus*- hemlocks.



L. nigrinus and *L. rubidus*

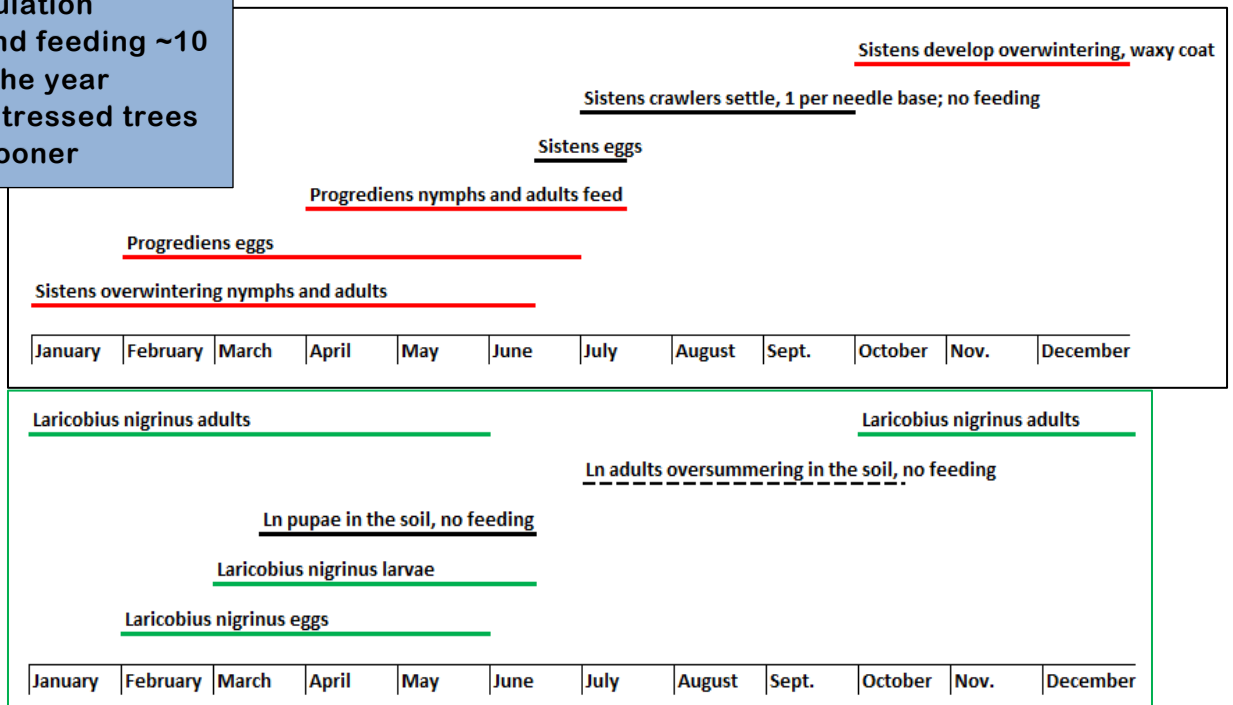
HWA Year Round Egg Production

On eastern hemlock, HWA produces two generations a year, an overwintering generation (sistens) and a spring generation (progreiens); these two generations overlap in the summer. The number of eggs in the sistens ovisacs can vary from 25-300, depending on temperature and elevation. The 'summer' progreiens generation lasts just over a month and lays only 12-25 eggs.

The Importance of Predators

Laricobius nigrinus is an effective winter generation predator. Each adult beetle eats 6-8 HWA per day starting in mid-October. Female beetles lay 200-400 eggs, singly inside an HWA ovisac.

Upon hatching each *L. nigrinus* larva eats 200-250 HWA to reach their adult stage. The ingenious adults are able to space their eggs so that each larvae will have enough HWA eggs without competing with their siblings. But the timing of the life cycle and feeding for about 8 months of the year misses the second HWA "summer" generation (sistens), eggs and crawlers. In order to maintain year-round feeding pressure on HWA, additional summer predators are necessary and being pursued now.



Tracking the Effectiveness of Predator Beetles

The effectiveness of predatory beetles requires more than anecdotal observations. Claims need to be backed up by research that shows ‘operational type’ statistical significance that can be directly correlated to the activities of the beetles and corresponding regrowth of trees. When assessing the impact of predator beetles the traditional method has required extensive twig collection and dissection of HWA ovisacs to calculate the predation rates, through damage or the presences of predator frass (poop). This is necessary but would ultimately result in the loss of some predatory beetle larvae which were still feeding and would not then mature and lay their eggs.

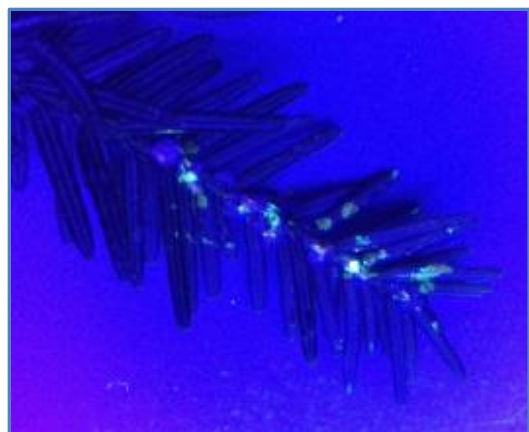
The discovery that ultra-violet-A light could indicate predator activity has provided an observation method by making activity visible to the naked eye. This method may ultimately be used to provide assistance in determining treatment needs, by assessing the degree of predator activity:

- UV-A 400-315nm wavelength (regular fluorescent black light poster light or urine detectors work well)

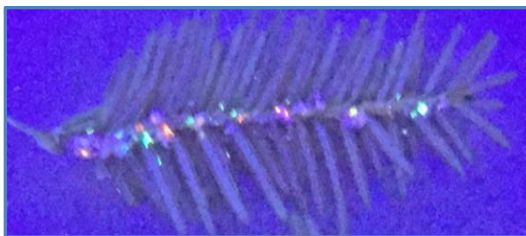
| OBSERVATION | COLOR |
|--|--|
| Undisturbed HWA adult honeydew | Bluish-white |
| Damaged HWA adult | Yellow-green (chartreuse) |
| Damaged HWA eggs | Bright yellow |
| <i>Laricobius nigrinus</i> and <i>Sasajiscymnus tsugae</i> frass | Bright orange fades to reddish pink over several weeks |



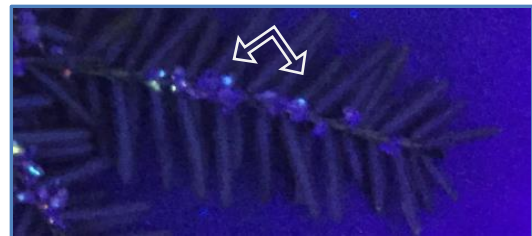
Yellow egg damage and orange frass



Chartreuse HWA adult damage



Adult and egg damage and frass



Undisturbed adults

This bulletin developed by Blue Ridge RC&D www.blueridgercd.org as part of the Hemlock Restoration Initiative, awarded by WNC Communities, 2014/15.



BLUE RIDGE
RESOURCE CONSERVATION & DEVELOPMENT

**Symbiont
Biological Pest
Management**

WNCCommunities



**USDA
APHS**



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