

# The Quest for Adelgid-Resistant Hemlocks

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Hemlock Camp Meeting  
24 Jun 2018





Ben Smith

Kelly Oten







Shenandoah National Park

Andy Whittier



Blue Ridge Parkway

Ben Smith







Great Smoky Mountains National Park

Will Blozan



David Lind



## Our Goal

- Produce genotypes resistant to or tolerant of adelgids
  - Short term: nursery and landscape industries
  - Long term: species restoration



## Our Strategies

- Host resistance
  - Find and exploit native resistance
  - Hybridize with resistant and tolerant exotic hemlocks



# Native resistance

- Search for native resistance
  - Eastern and Carolina hemlock



## Our goal

We aim to find and propagate naturally occurring eastern and Carolina hemlock trees that survive hemlock woolly adelgid (HWA) infestation. The hemlocks we identify will be bred to produce adelgid-resistant plants.

## Background

As HWA has spread throughout the eastern United States, massive mortality has occurred within eastern and Carolina hemlock stands following HWA infestation.

Occasionally, however, a few healthy-looking hemlock trees persist.

The Alliance for Saving Threatened Forests is interested in finding and evaluating these rare individuals for evidence of naturally occurring resistance to hemlock woolly adelgid.



*Close-up of  
HWA on  
hemlock*

The Alliance for Saving Threatened Forests has begun a project to identify and take cuttings from surviving eastern and Carolina hemlock trees to test their adelgid resistance.

**We need your help!**



*For Additional Information Contact:*

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**Have You Seen  
This Hemlock?**





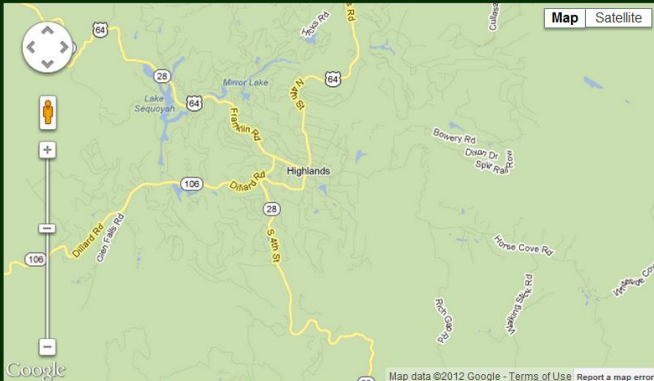
ASTF, Form to Submit lo... x

http://threatenedforests.org/locate/

### Step 1: Locate the "survivor" hemlock tree.

You can start by moving the pin below or entering an address (street name with city and state; a place, e.g. Nantahala National Forest; zip code) or a latitude & longitude pair (36.10, -81.46) & click on "locate". You should refine the location using the zoom controls located inside the map and also dragging the red push pin icon to the correct location. Switching to "Satellite" mode may help you locate the individual tree.

Start by entering an address or coordinates here:





Pick up the red marker and place that close to the area of the "survivor" and zoom in; once you are close, click on the "Satellite" button in the upper right so you can see trees and place the red marker on the actual tree. You can give extra details in the comments section below.

Latitude *\*required*

Longitude *\*required*

Map data ©2012 Google - Terms of Use Report a map error




**TreeSnap**  

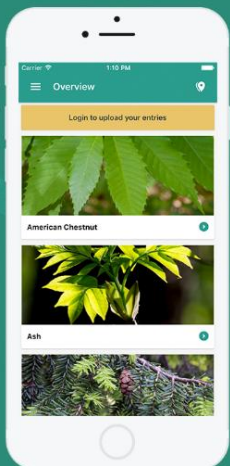
Home Map About Account

AVAILABLE NOW







## Help Our Nation's Trees!

Invasive diseases and pests threaten the health of America's forests. Scientists are working to understand what allows some individual trees to survive, but they need to find healthy, resilient trees in the forest to study. That's where concerned foresters, landowners, and citizens (you!) can help. Tag trees you find in your community, on your property, or out in the wild using TreeSnap! Scientists will use the data you collect to locate trees for research projects like studying the genetic diversity of tree species and building better tree breeding programs.

Download on the **App Store**  GET IT ON **Google Play**






**Observe** ?


-  **American Chestnut**  
*Castanea dentata* >
-  **Ash**  
*Fraxinus sp.* >
-  **Hemlock**  
*Tsuga sp.* >
-  **White Oak**  
*Quercus alba* >
-  **American Elm**  
*Ulmus americana* >
-  **Other**  
Other trees that aren't listed above >


**Hemlock** ?


ADD ENTRY INFORMATION


Images Add photos 


Woolly adelgids % Adelgid coverage 


Cones Please select 

Crown classification Please select 

Habitat Please select 

Trees nearby Please select 

Canopy health Please select 


Tree diameter Diameter 


Submit Entry Cancel




**Hemlock** ?

ADD ENTRY INFORMATION



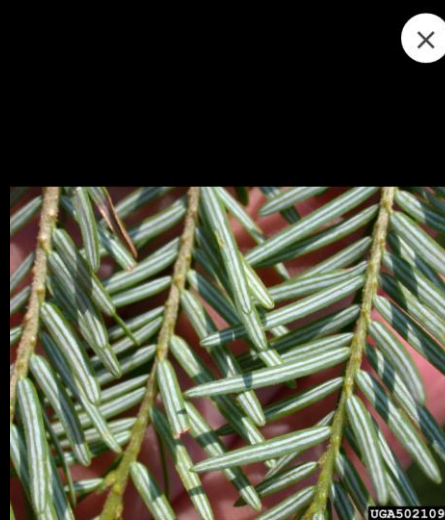
ID Photos 

Distribution Maps 

Species

Eastern hemlock (*Tsuga canadensis*)


Carolina hemlock (*Tsuga caroliniana*)



Hemlock needles are flattened, 1.5-2cm long, dark green on top and lighter on the underside with two white lines running the length of the needles.








Green cones:  
young,  
ripening,  
seeds in

**Hemlock  
cones**

Photo credit: Chris Evans,  
University of Illinois, Bugwood.org



Brown cones:  
Old, mature,  
seeds out

Photo credit: Bill Cook, Michigan  
State University, Bugwood.org




Photo credit: David  
Stephens, Bugwood.org

**Eastern  
hemlock**

**v**

**Carolina  
hemlock**

Carolina hemlock is...

- Less common, restricted to rocky hillsides of the southern Appalachians
- Smaller than Eastern hemlock
- Needles slightly longer than Eastern hemlock
- Needles spread at all angles (Eastern needles spread from sides)




Photo credit: USGS






Photo credit: William M. Ciesla,  
Forest Health Management  
International, Bugwood.org

Navigation icons: back, home, recent apps






*Tsuga canadensis*  
Eastern hemlock

500 0 500 1000 1500 Kilometers

USGS  
United States Geological Survey




*Tsuga caroliniana*  
Carolina hemlock

500 0 500 1000 1500 Kilometers

USGS  
United States Geological Survey

Navigation icons: back, home, recent apps



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Hemlock

?

ADD ENTRY

INFORMATION

Species

Eastern hemlock (*Tsuga canadensis*)

Carolina hemlock (*Tsuga caroliniana*)

Overview

American hemlock trees are being killed by hemlock woolly adelgids. Help fight these invasive insects by tagging health hemlock trees.

Description

Hemlock is an evergreen conifer. Its needles are 1.5-2 cm long, dark green on top and lighter on the underside with two white lines running the length of the needle. Hemlocks produce small distinctive cones. These trees prefer shade and are often found along creeks and streams in mature forests

There are two different hemlock species native to North America, Eastern hemlock and Carolina hemlock.

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Hemlock

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ADD ENTRY

INFORMATION

Hemlock woolly adelgid

This insect sucks the sap of hemlock trees, weakening trees, preventing new growth, and eventually killing trees. In addition, hemlock woolly adelgids are thought to inject a toxin when feeding that further damages hemlock trees by drying them out. Infested trees lose needles and branches and typically die 4-10 years after initial adelgid arrival unless treated.

The hemlock woolly adelgid's name comes from the insect's egg sacs, which hang from the undersides of branches at certain times of year and look like small woolly tufts. These insects are invasive in North America, introduced from Japan.

Our hope is that this reporting app will let members of the public identify hemlock trees that have some natural resistance to hemlock woolly adelgid. We will then collect seeds from these trees and add them to tree breeding programs to try and propagate resistant trees to use in forest restoration.

<

Hemlock

?

ADD ENTRY

INFORMATION

Im

What is the height of the crown of this tree relative to others in the stand?

☐ Dominant. This tree's crown extends above others in the area.

☐ Codominant. This tree's crown is level with or slightly below other nearby trees.

☐ Overtopped. This tree's crown is entirely below other trees nearby.

☐ Not applicable (Tree is isolated)

☐ I'm not sure.

CANCEL

Tree diameter

Diameter

Submit Entry

Cancel

<

Hemlock

?

ADD ENTRY

INFORMATION

Im

What is the health of this tree's canopy?

SHOW EXAMPLES

☐ 1 - Healthy

☐ 2 - Thinning

☐ 3 - Some dead branches (less than 50%)

☐ 4 - Many dead branches (more than 50%)

☐ 5 - Completely dead

☐ I'm not sure

CANCEL

Tree diameter

Diameter

Submit Entry

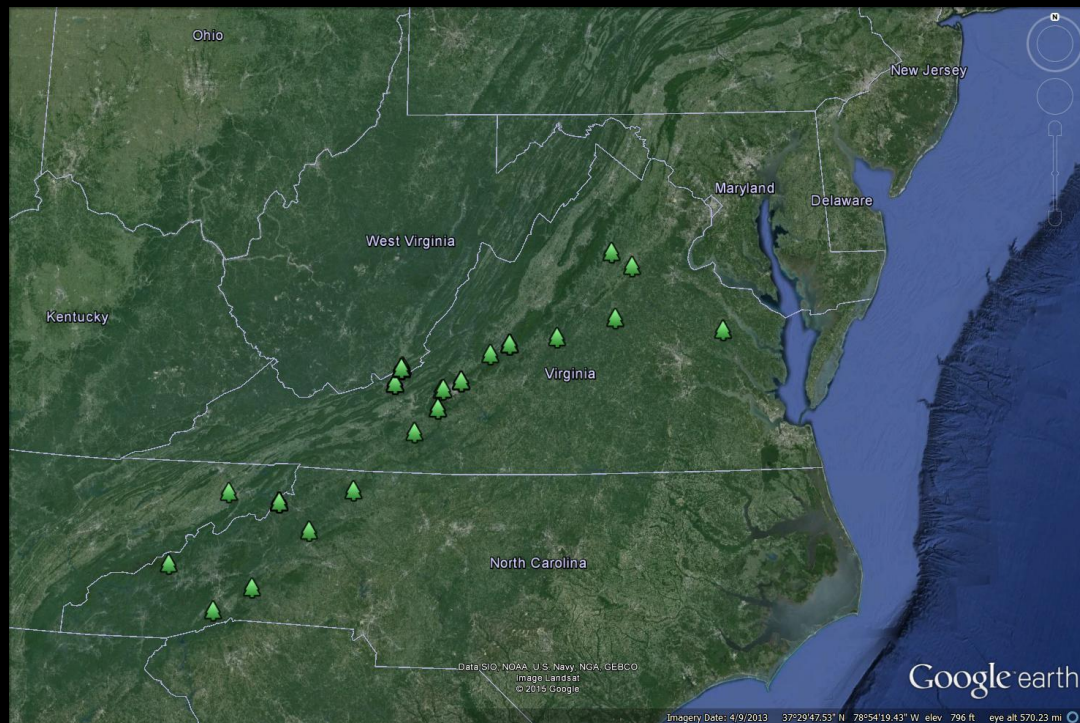
Cancel





# Native resistance

- Search for native resistance
  - Eastern and Carolina hemlock
  - Plan to begin screening ornamental cultivars as well
- Screening process
  - Site visit
  - Collect cuttings







Wilkes County, North Carolina



Blue Ridge Parkway







Google

June 2009



April 2015

Blue Ridge Parkway



New Jersey "Bulletproof Stand"

Mark Mayer







# Native resistance

- Search for native resistance
  - Eastern and Carolina hemlock
  - Plan to begin screening ornamental cultivars as well
- Screening process
  - Collect cuttings
  - Propagate
  - Infest
  - Evaluate
    - Assess plant and adelgid health











## Native resistance

- Currently propagating rooted cuttings from over 130 potentially resistant/tolerant trees
- Genotypes screened as resistant/tolerant will be crossed, and the full-sib as well as additional OP progeny will be tested
- University of Rhode Island has tested rooted cuttings from several “Bulletproof stand” trees and has now established field studies with the most promising genotypes (began searching in 2005)
  - One field study location is in western NC



## Interspecific hybrids

- Non-native/exotic hemlock species we are working with:
  - Chinese (*Tsuga chinensis*) – Resistant



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## Interspecific hybrids

- Non-native/exotic hemlock species we are working with:
  - Chinese (*Tsuga chinensis*) – Resistant
  - Northern Japanese (*T. diversifolia*) – Resistant/tolerant



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## Interspecific hybrids

- Non-native/exotic hemlock species we are working with:
  - Chinese (*Tsuga chinensis*) – Resistant
  - Northern Japanese (*T. diversifolia*) – Resistant/tolerant
  - Southern Japanese (*T. sieboldii*) – Tolerant (native HWA host)



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## Interspecific hybrids

- Grow viable seed and screen progeny
- Backcross with native hemlock to decrease proportion of Asian hemlock genes
- Some crossing barriers appear to exist
  - Most successful hybrid is *T. caroliniana* x *chinensis*
  - *T. caroliniana* more closely related to Asian hemlocks than to *T. canadensis*



*T. chinensis* x *caroliniana*



## Interspecific hybrids

- U.S. National Arboretum has been working to breed hybrids since the early 1990s
- We are cooperating on a test of hybrid hemlocks at the Upper Mountain Research Station in Laurel Springs



Establishing field trial for US National Arboretum hybrids, October 2011







## Somatic embryogenesis

- We are working the Merkle Lab at the University of Georgia on somatic embryogenesis (SE)
- SE may be able to help overcome crossing barriers through embryo rescue
  - Could be instrumental in producing hybrids with eastern hemlock
- Currently testing plants produced to verify hybrid status using DNA fingerprinting



## SE applications for hemlock resistance

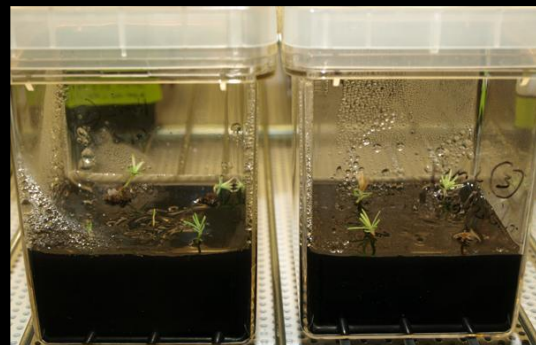
- Propagate hybrids with resistant Asian species for clonal testing
- Propagate clones derived from seeds of surviving, potentially resistant or tolerant native hemlocks for testing
- Rapidly bulk up numbers of selected clones from cryostored cultures for distribution







Germinating Carolina hemlock somatic embryos



*T. Caroliniana x chinensis* emblings



Scott Merkle





*T. caroliniana x chinensis* and *T. caroliniana x sieboldii* clones



## Future work

- Develop high throughput screening pipeline
- Continue attempting novel hybrid crosses
- Shorten generation times
  - Stimulate pollen and cone production (floral induction)
- Develop more rapid assessment for resistance





# Thanks

- Hemlock Restoration Initiative
- NCDA&CS Mountain Research Station
- Joey Borders
- Josh Pratt
- Justin Kearse
- Fred Hain
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- Great Smoky Mountains Conservation Association
- NC Nursery and Landscape Association
- Hemlock Restoration Initiative
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