
Cornell
CALS
College of Agriculture
and Life Sciences
NEW YORK STATE HEMLOCK INITIATIVE
KEEPING THE LEGACY ALIVE
The Nature Conservancy
Protecting nature. Preserving life.
HEMLOCK RESTORATION INITIATIVE
TREE SPECIES
IN PERIL
Lingering Hemlock Project
A. Grace Haynes, New York State Hemlock Initiative

Presentation Flow

- Tree Species in Peril
- Hemlock trees
- Lingering Hemlock Project
  - Searching for Lingering Hemlocks
  - Hemlock Health Monitoring Plots

History of Invasive Forest Pests in North America

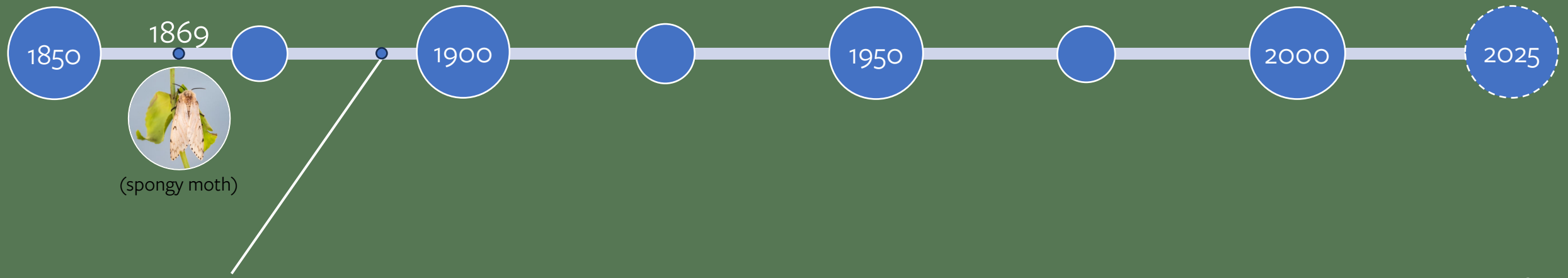
1869: Spongy moth escapes captivity in Boston.

Photo credit: Karla Salp, Washington State Dept. of Agriculture, Bugwood.org

Since 1920, spongy moth has defoliated over 95 million acres. Though it is an additional stressor to forests, it usually does not kill trees directly.

National Park Service 2023; Forest Service 2022

History of Invasive Forest Pests in North America



1890s: Beech bark disease (BBD) is detected in Nova Scotia, Canada.

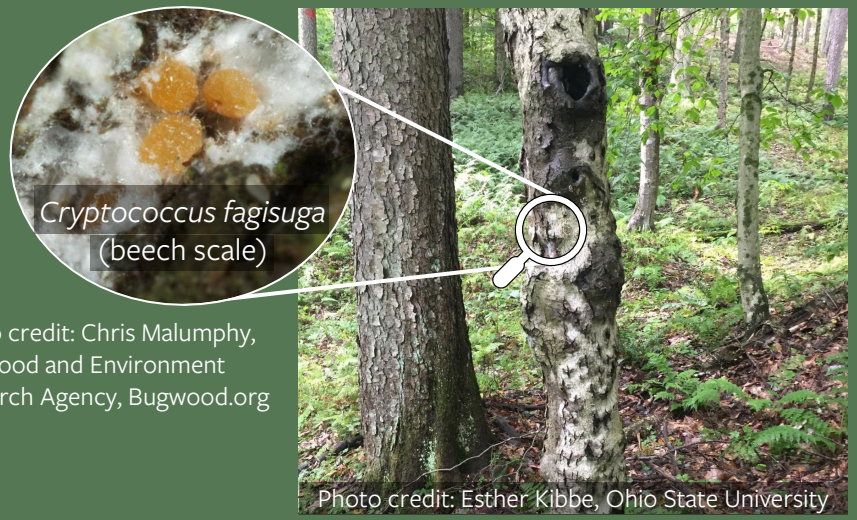
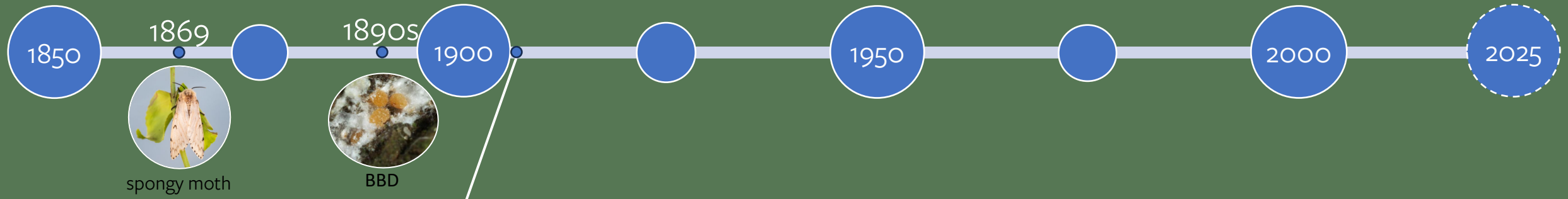


Photo credit: Chris Malumphy, The Food and Environment Research Agency, Bugwood.org

This disease complex typically kills about 50% of beech trees and severely cankers many more. Feeding by beech scale allows beech trees to be colonized by the fungus *Neonectria*, which is often the mortality agent.

Koch 2010; McCullough et al. 2005

History of Invasive Forest Pests in North America

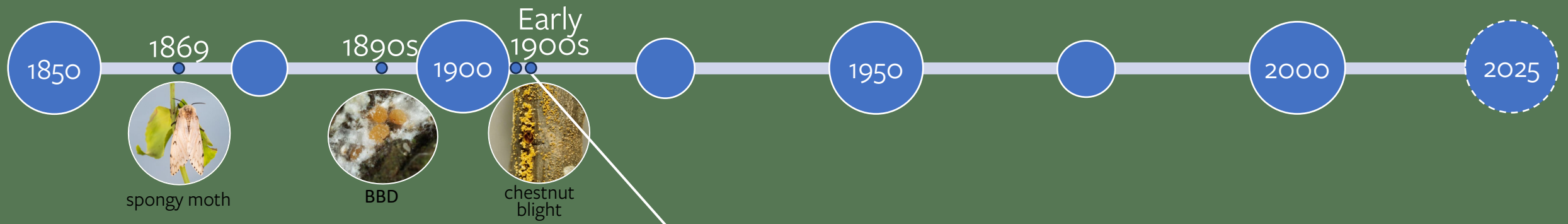


Early 1900s: Chestnut blight is introduced to the east coast of the United States.

An estimated 3.5 billion chestnut trees, once ubiquitous in the eastern United States, have been lost to this pathogen.

Fisher et al. 2012; Anagnostakis 1987

History of Invasive Forest Pests in North America



1908: Elongate hemlock scale (EHS) is first detected in New York.

In addition to hemlock this insect can feed on firs, cedars, spruces, and pines (though its impact on these other trees is negligible).

Venette et al. 2024

History of Invasive Forest Pests in North America

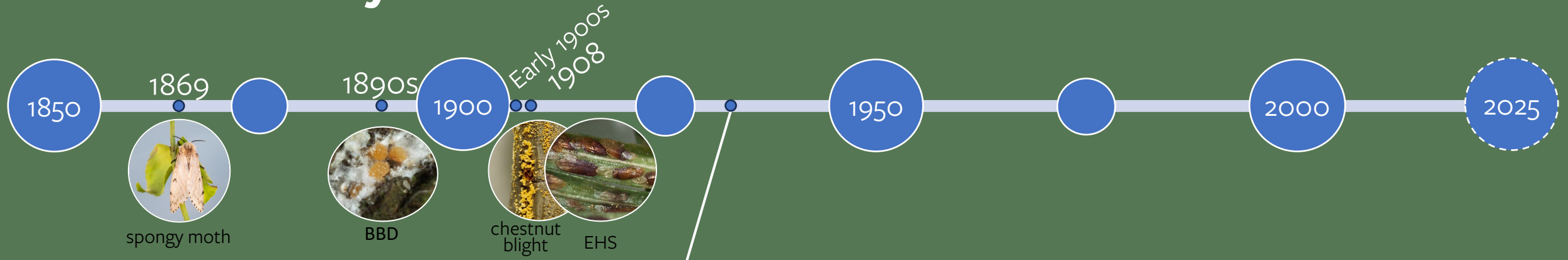


Photo credit: Pests and Diseases Image Library, Bugwood.org

Photo credit: Joseph Benzel, Screening Aids, USDA APHIS PPQ, Bugwood.org

Photo credit: C.J. D'Arcy

<u>1930s</u>: Dutch elm disease is introduced into the United States.

This disease complex has killed over 40 million elm trees.

D'Arcy 2000; Marcotrigiano 2016

History of Invasive Forest Pests in North America

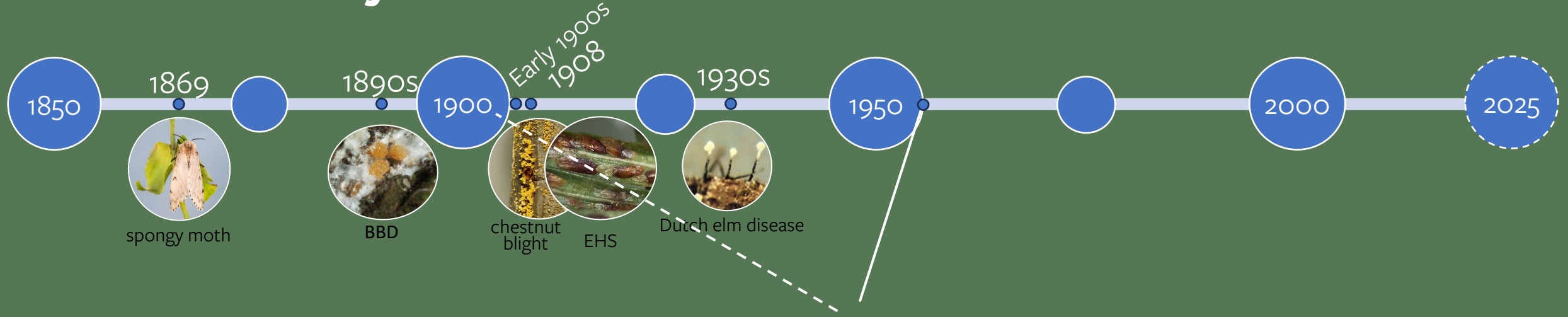


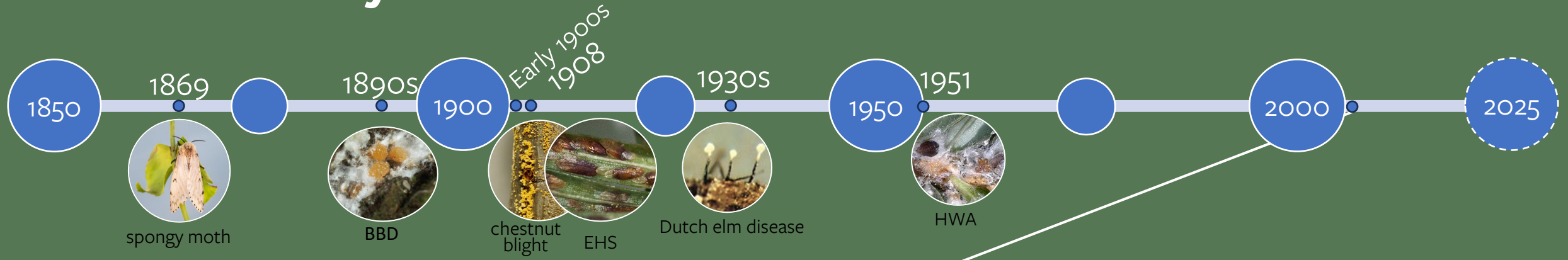
Photo credit: Chris Evans, University of Illinois, Bugwood.org

1951: The first hemlock woolly adelgid (HWA) is found in eastern North America. It was first introduced in the early 1900s but was not detected until 1951.

Hundreds of thousands of eastern hemlock trees have been killed by hemlock woolly adelgid.

Havill 2014; McCullough 2015

History of Invasive Forest Pests in North America



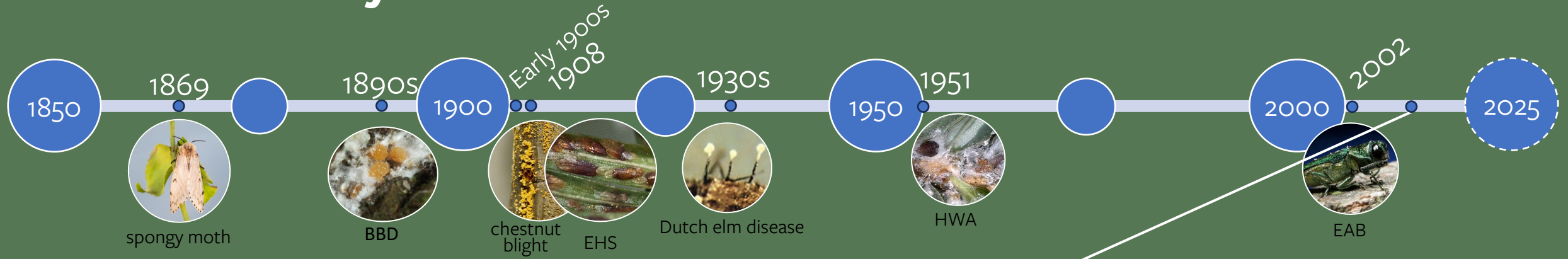
2002: Emerald ash borer (EAB) is detected in Michigan.

Photo credit: David Cappaert, Bugwood.org

This beetle has killed tens of millions of ash trees and is the costliest forest pest ever to invade North America.

Poland and McCullough 2006; Lovett 2022

History of Invasive Forest Pests in North America



Litylenchus crenatae mccannii (nematode subspecies that likely causes beech leaf disease)
Photo from Carta et al. 2020

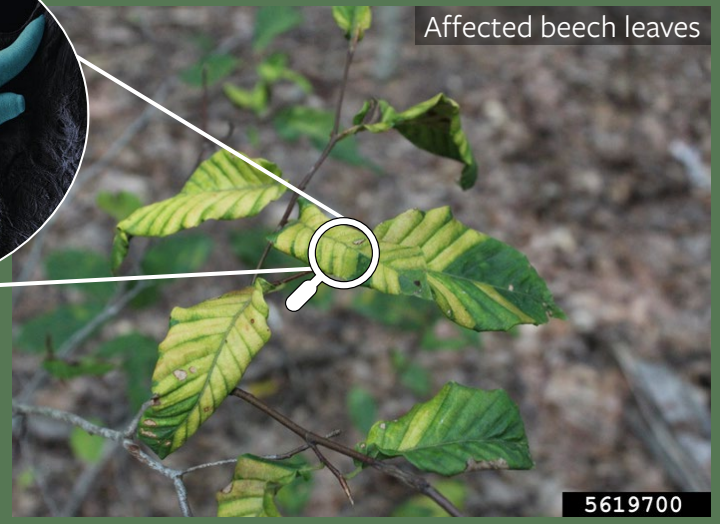


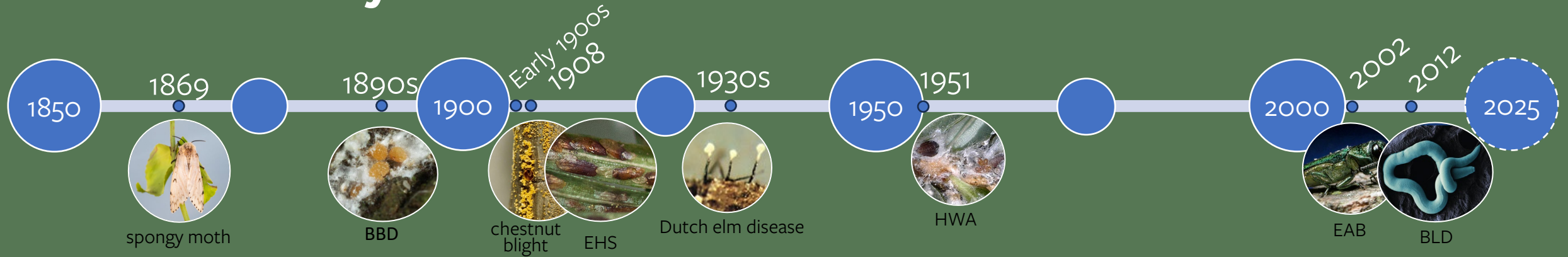
Photo credit: Kristen Wickert, USDA Forest Service, Bugwood.org

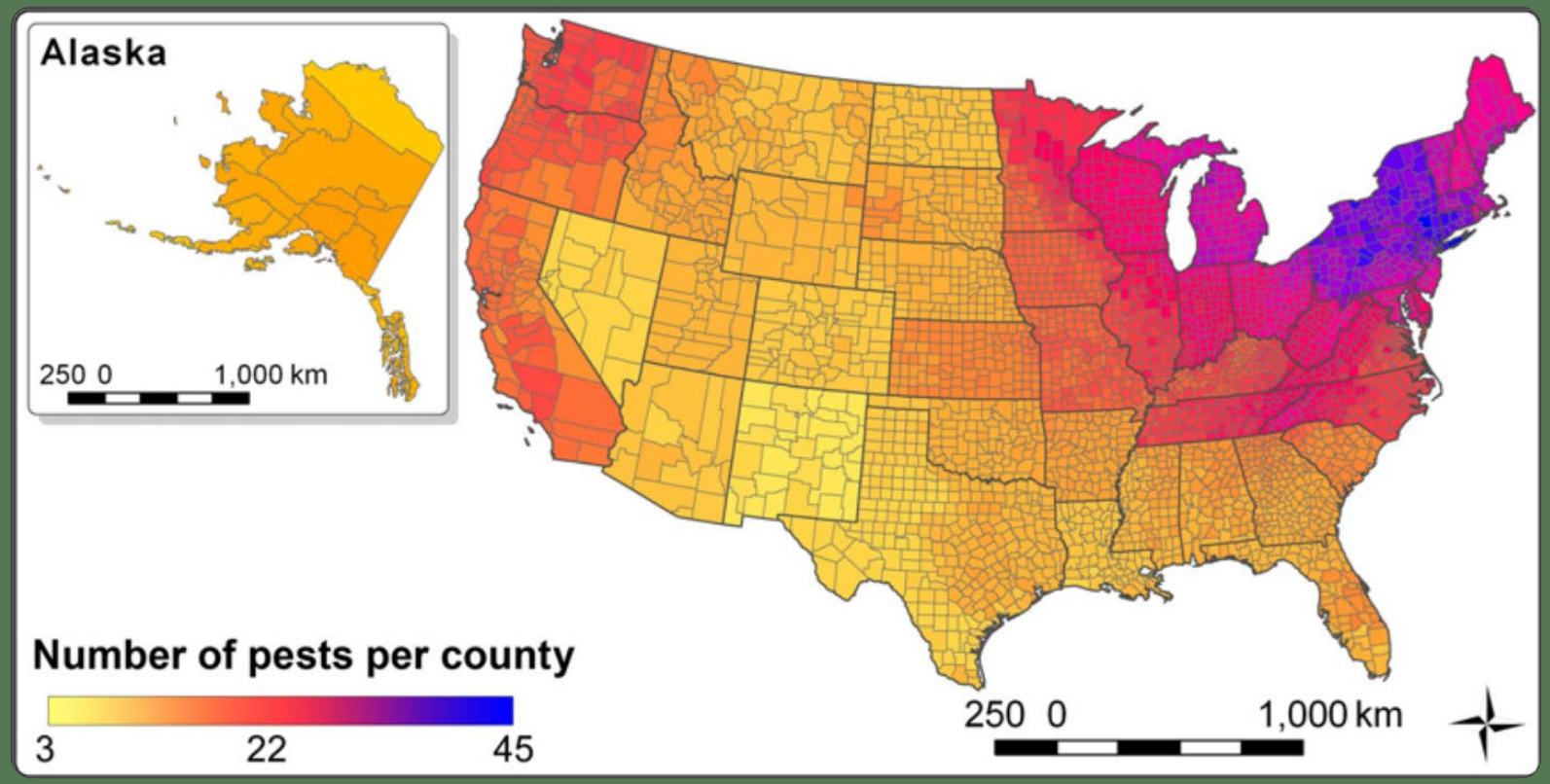
2012: Beech leaf disease (BLD) is first detected in the United States.

This disease adds additional stress to beeches, which are already threatened by beech bark disease.

Segall 2021; Carta et al. 2020

History of Invasive Forest Pests in North America





Liebhold et al. 2013

Tree Species in Peril

A The Nature Conservancy project to bolster genetic resistance to pests in vulnerable North American tree species.

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© New York State Hemlock Initiative

GREEN ASH

Fraxinus pennsylvanica

Emerald ash borer (EAB)

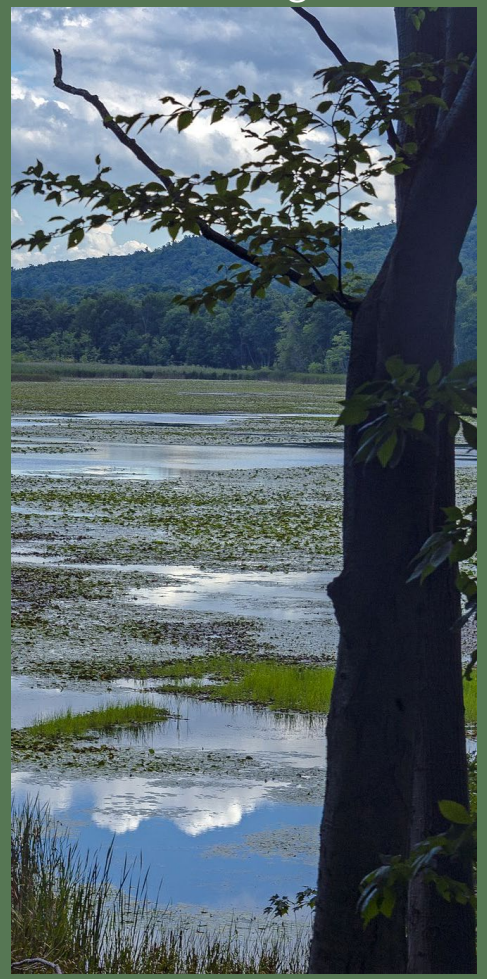
WHITE ASH

Fraxinus americana

Emerald ash borer (EAB)

BLACK ASH

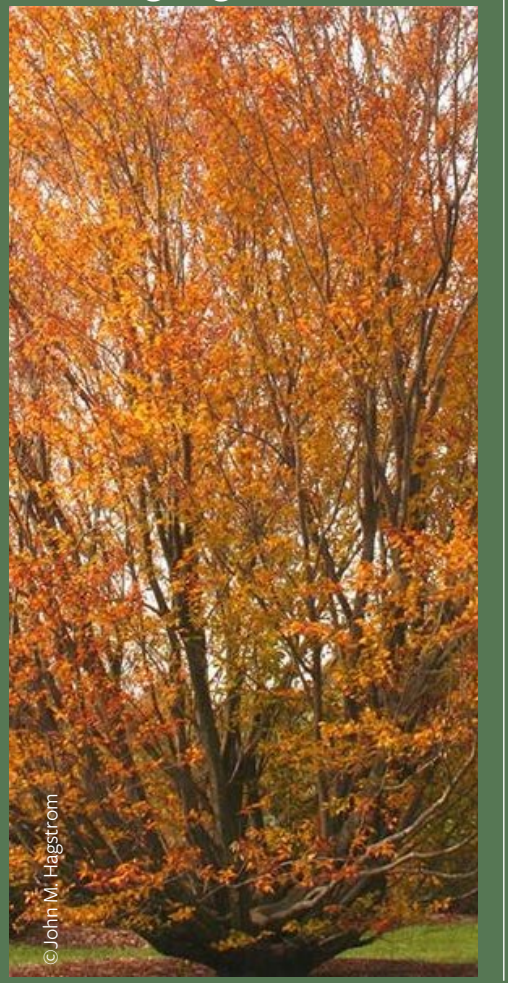
Fraxinus nigra



Emerald ash borer (EAB)

AMERICAN BEECH

Fagus grandifolia



Beech bark disease (BBD)
Beech leaf disease (BLD)

EASTERN HEMLOCK

Tsuga canadensis

Hemlock woolly adelgid (HWA)
Elongate hemlock scale (EHS)

GREEN ASH

Fraxinus pennsylvanica

Emerald ash borer (EAB)

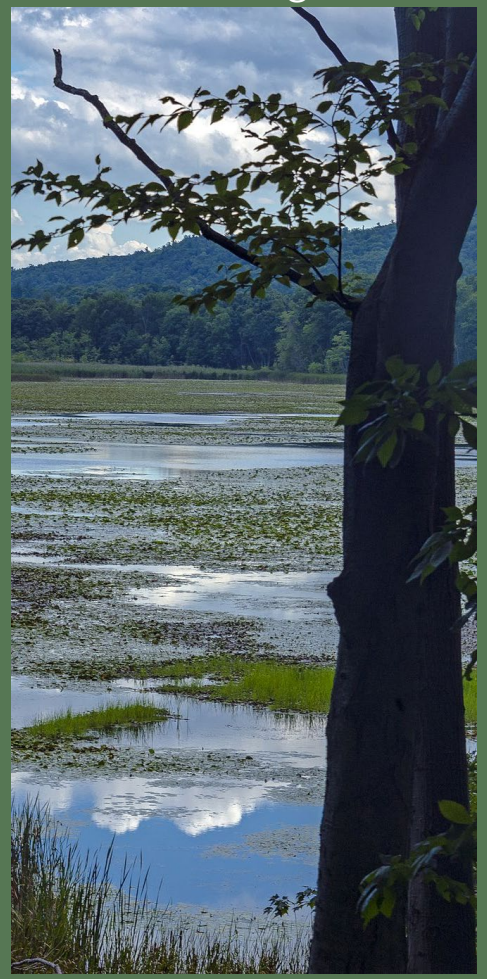
WHITE ASH

Fraxinus americana

Emerald ash borer (EAB)

BLACK ASH

Fraxinus nigra



Emerald ash borer (EAB)

AMERICAN BEECH

Fagus grandifolia

Beech bark disease (BBD)
Beech leaf disease (BLD)

EASTERN HEMLOCK

Tsuga canadensis

Hemlock woolly adelgid (HWA)
Elongate hemlock scale (EHS)


Bark
Rough
Furrowed
Brown
Foliage
Lacy
Feathery
Evergreen

Needles

Short and flat
Shiny, dark green color
Rounded tips
Opposite arrangement

Distinct white stripes underneath

Cones

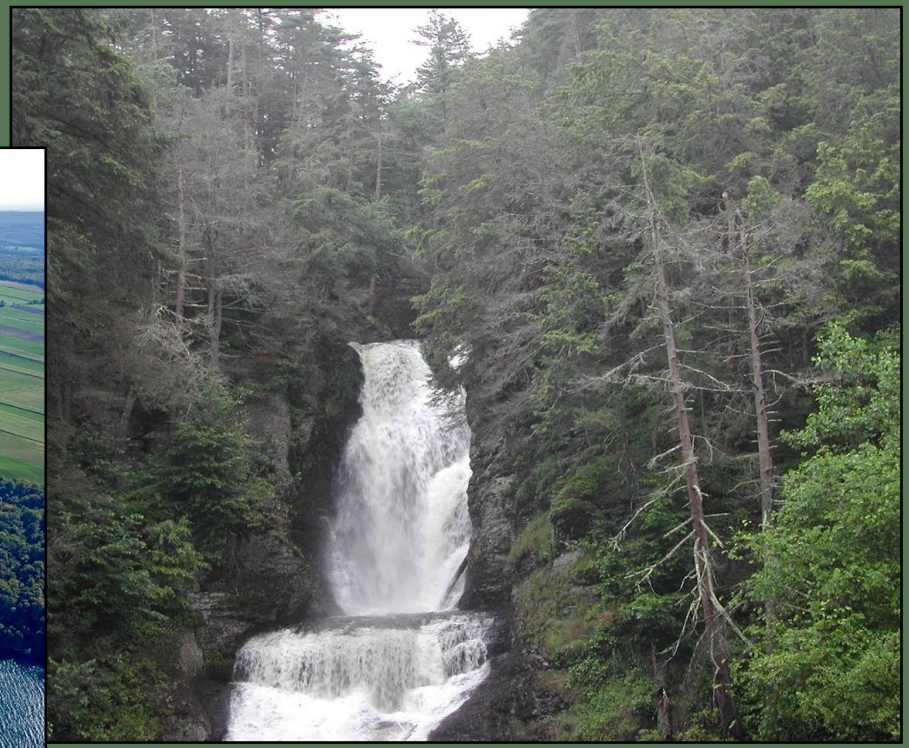
Small
Rounded scales
Brown (when mature)

Why hemlocks?

- Foundation *and* climax species

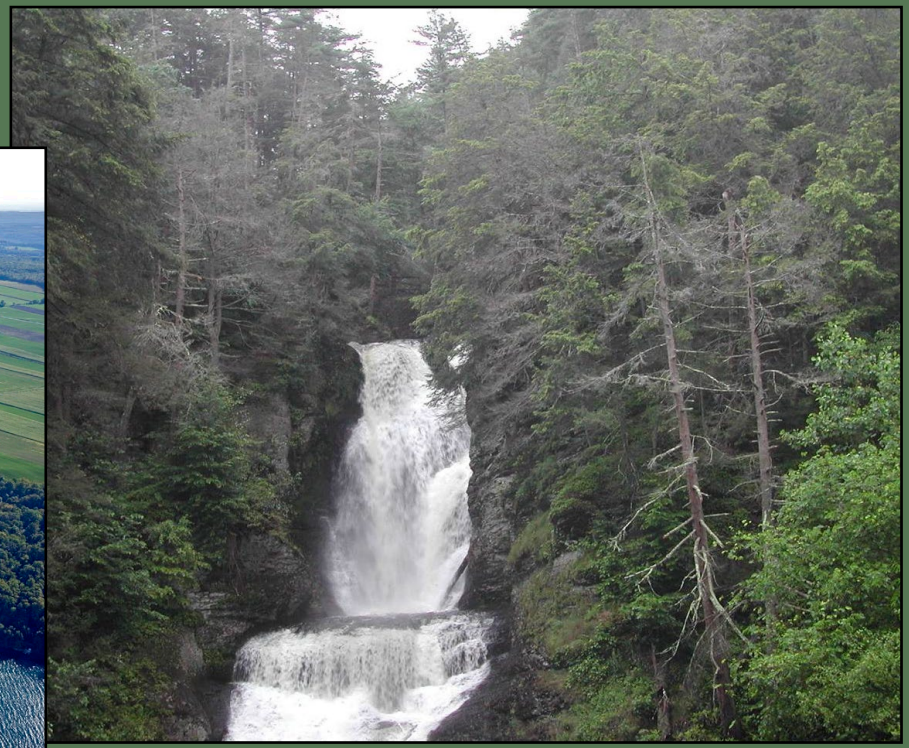
Why hemlocks?

- Foundation *and* climax species
- Prevent erosion and sedimentation



Why hemlocks?

- Foundation *and* climax species
- Prevent erosion and sedimentation
- Regulate water quality and temperature



Why hemlocks?

- Foundation *and* climax species
- Prevent erosion and sedimentati
- Regulate water quality and temp
- Provide habitat


Porcupine


Moose

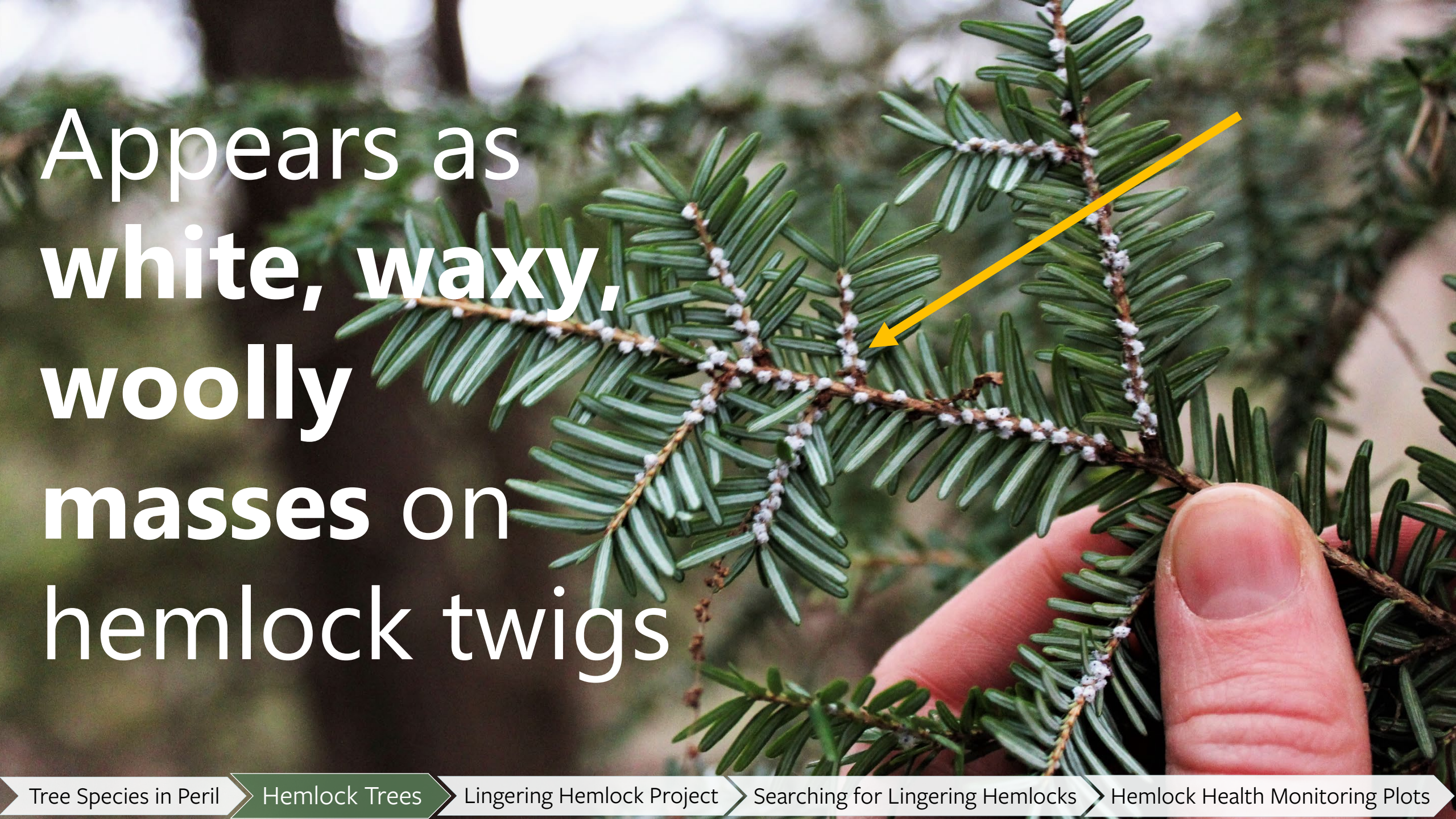

Brook trout


Black-throated green warbler


Blue-headed virio

Hemlock Woolly Adelgid

Invasive hemlock pest

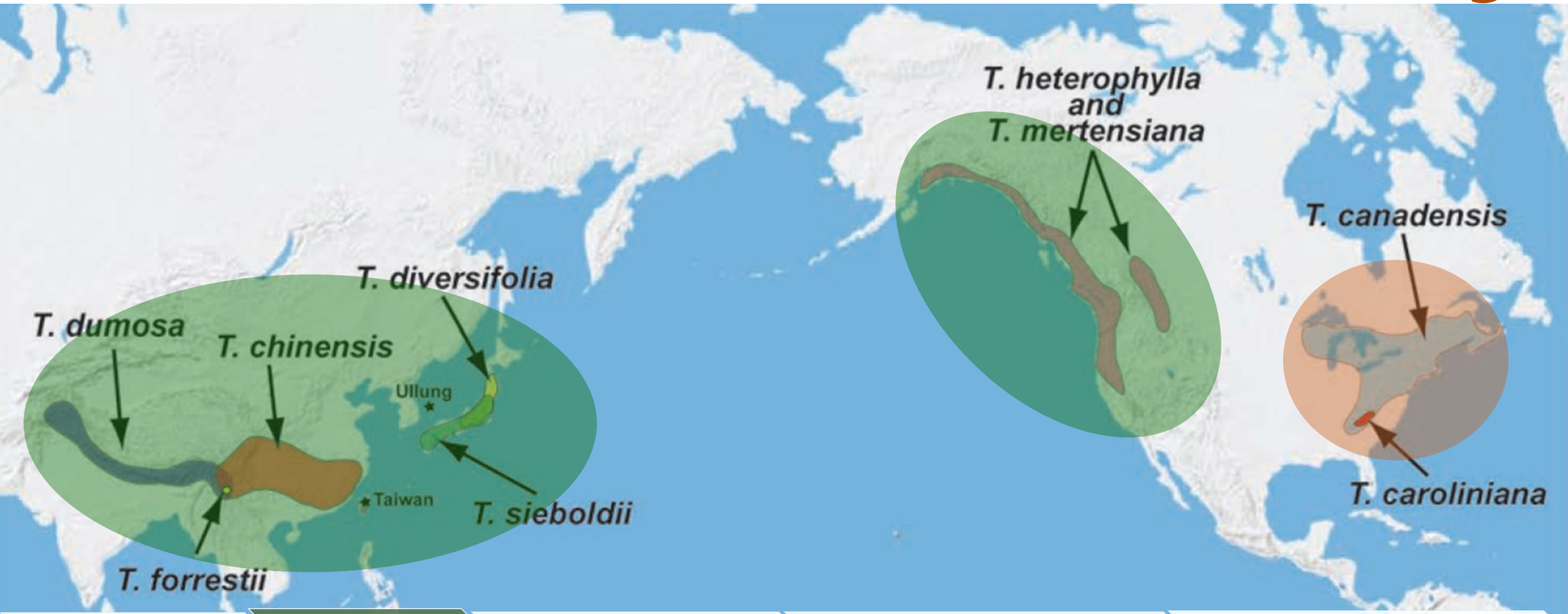

Appears as
white, waxy, woolly masses on
hemlock twigs

Feeding **damages** hemlock **twig tissue**


4-20
years to kill tree

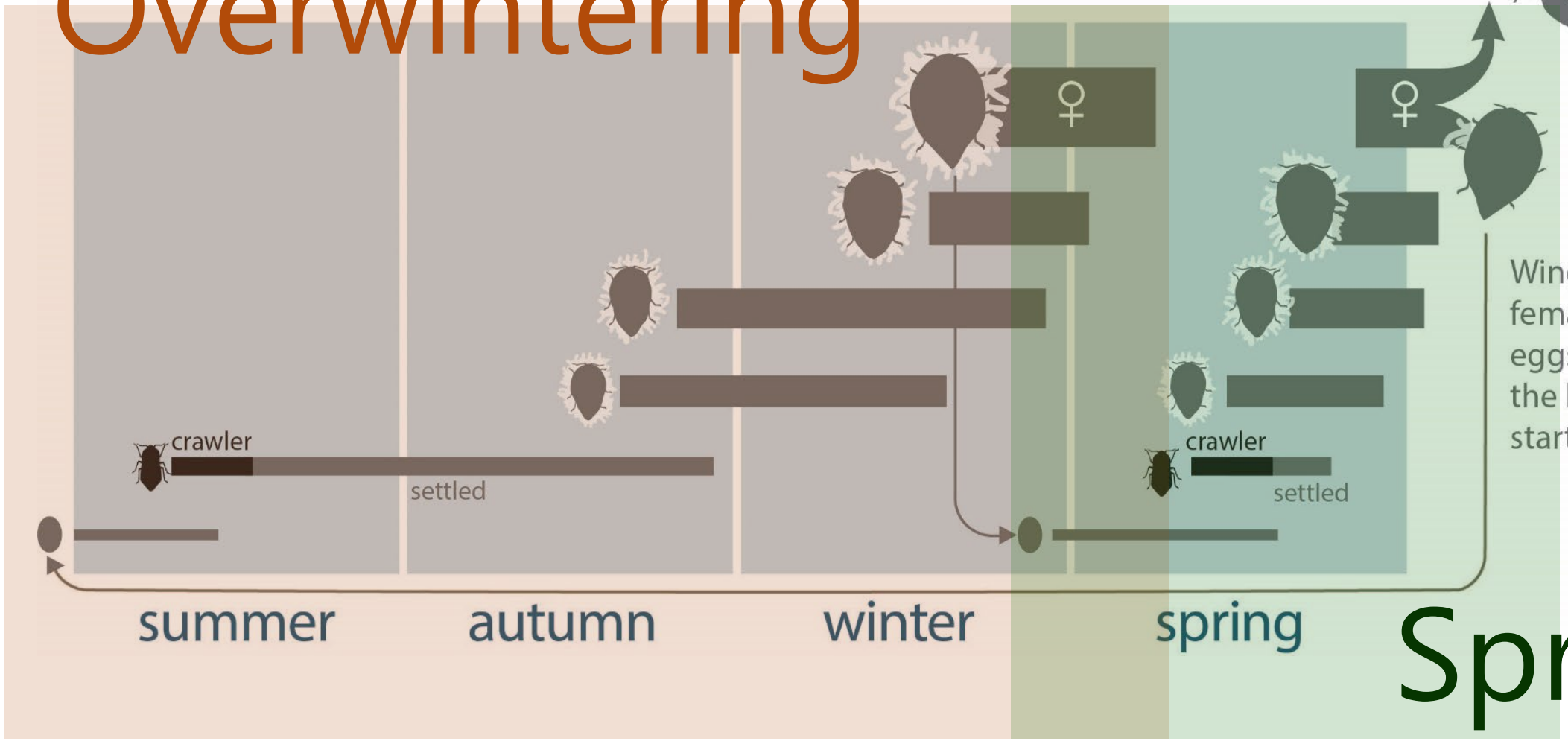
HWA Native Ranges

HWA Invasive Range



2 generations per year

Overwintering



Spring

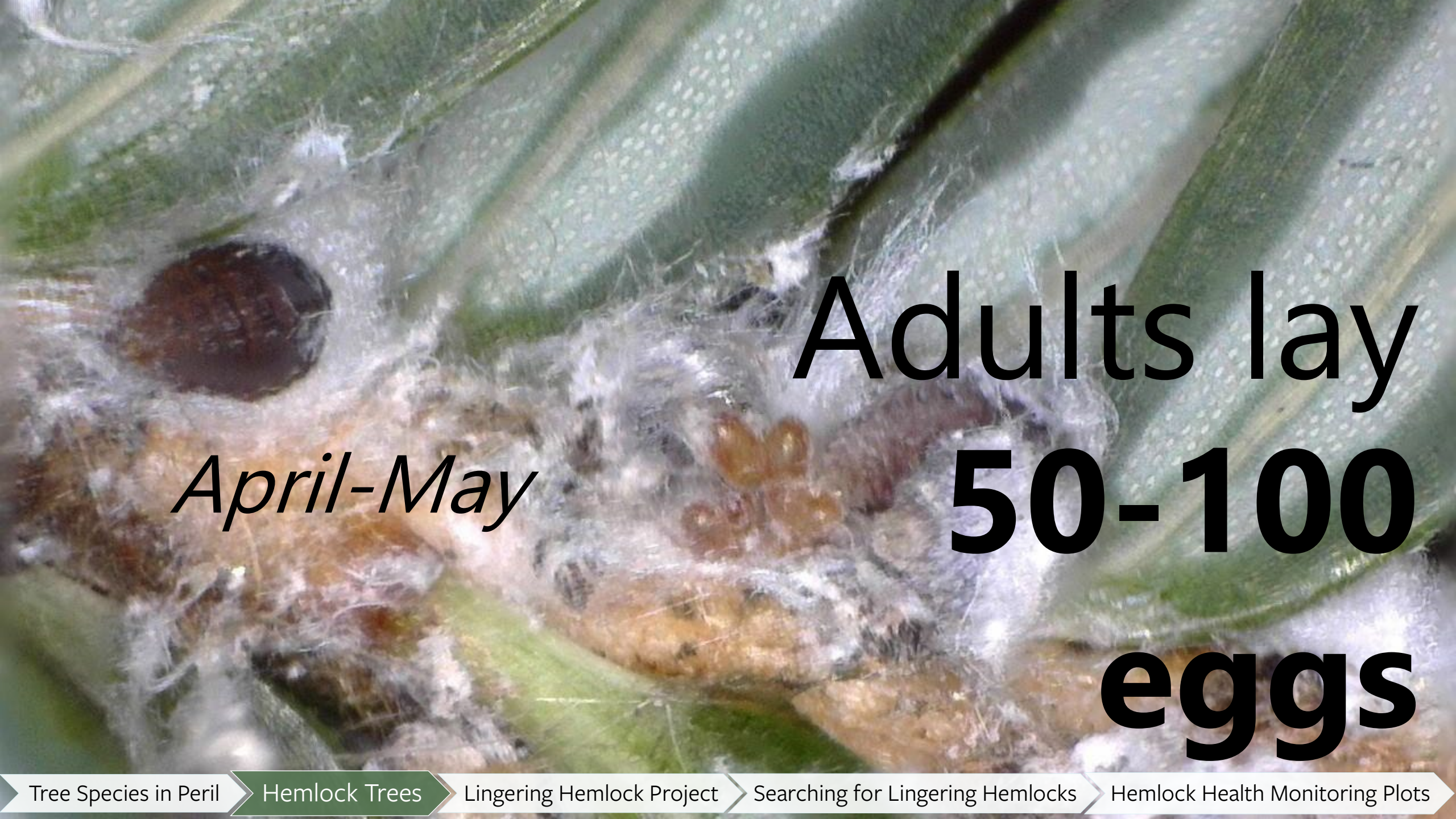
April-June

Only mobile stage!

Hatch from eggs into **crawler stage**


Crawlers settle on twigs and become **aestivating nymphs**
July-October
Overwintering only

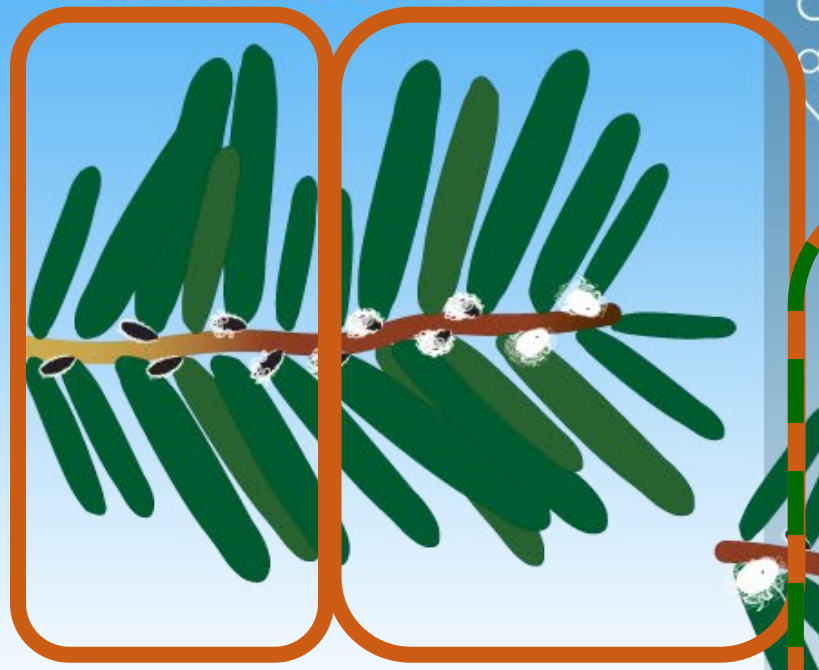

Nymphs
feed, grow,
and produce
wool
November-June


April-May
Adults lay
50-100
eggs

August-February

Overwintering Generation

Nymphs aestivate during summer, then go through 4 nymphal stages N1-N4



March-May

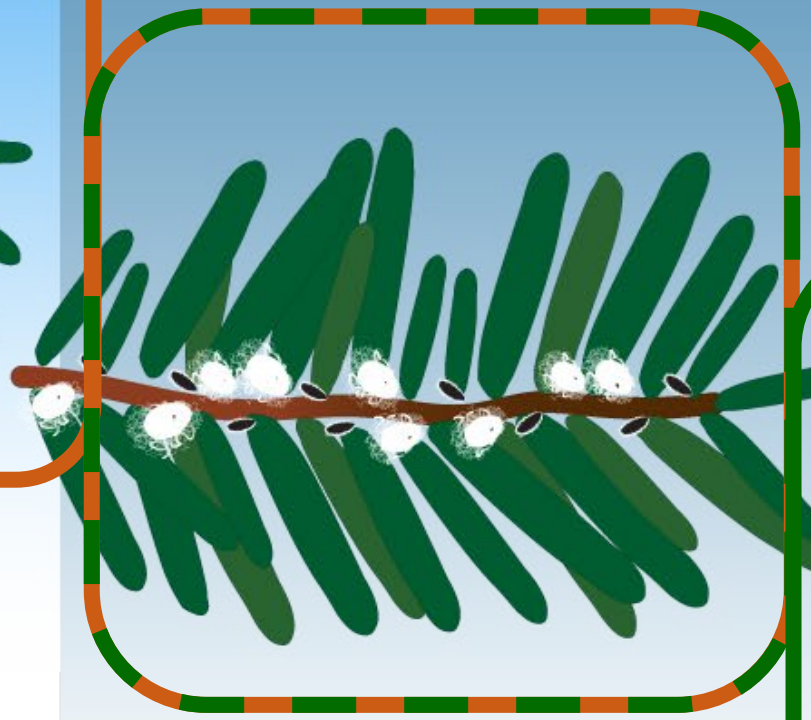
Overwintering Generation

Adults lay eggs

Spring Generation

Crawlers settle among sistens adults

N1-N4 to adulthood



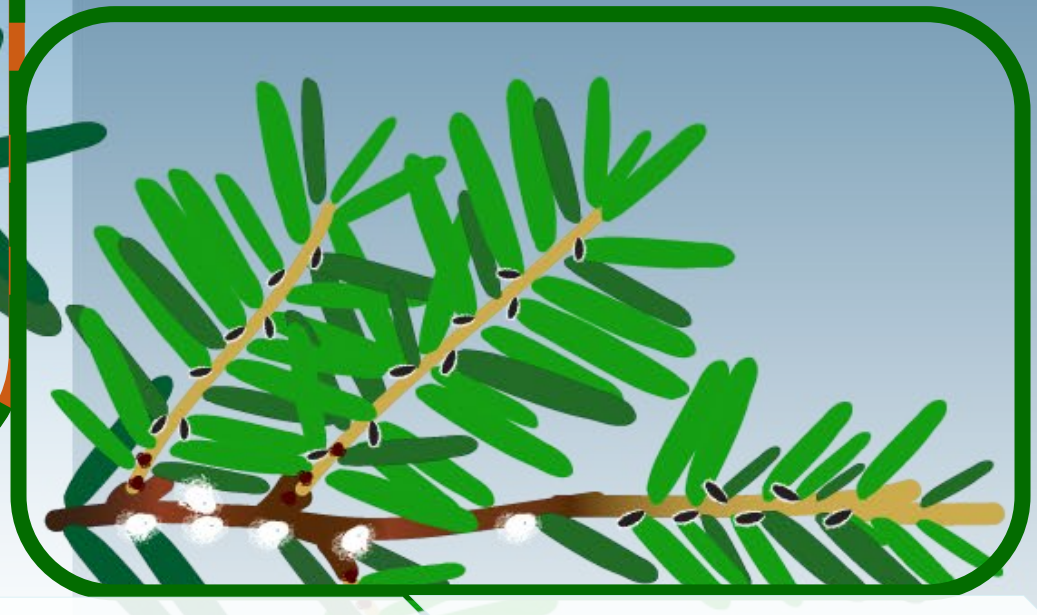
June-July

Spring Generation

Adults lay eggs

Next Overwintering Generation

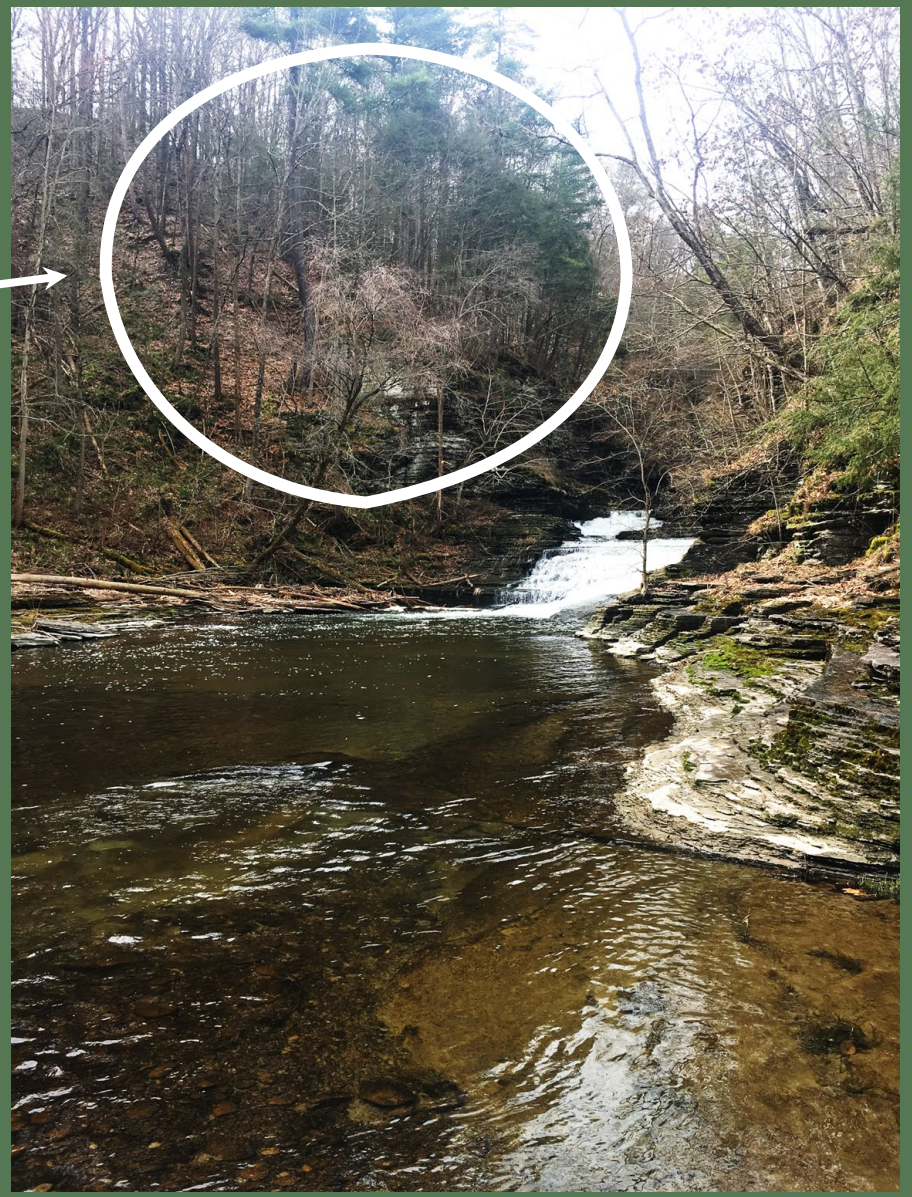
Crawlers settle on new growth



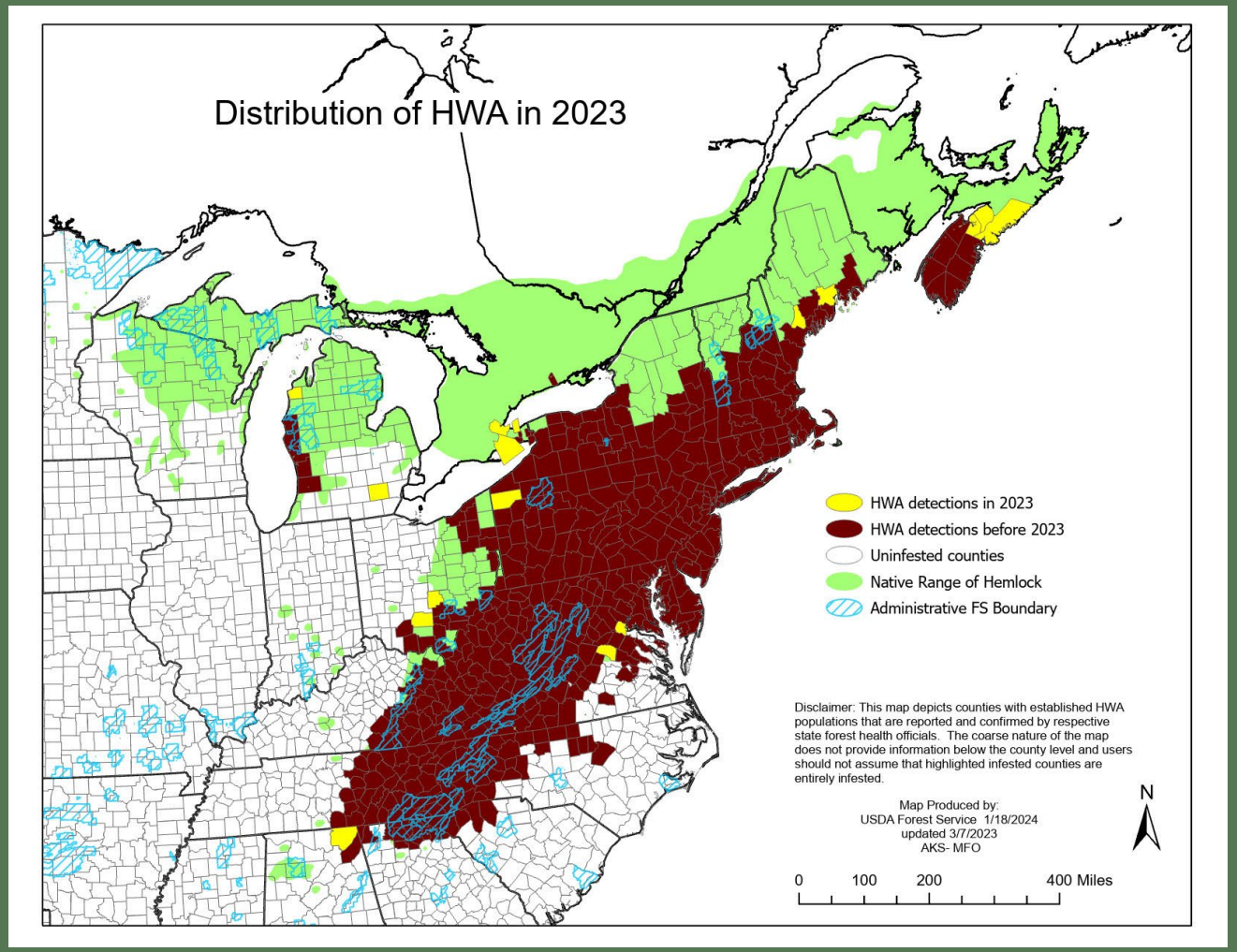
Elongate Hemlock Scale

Elongate hemlock scale (EHS) is an additional insect acting as a stressor to hemlocks.

This used to be a
dense stand of hemlocks



Mass mortality of both hemlock species has occurred in the southern range.



Ongoing control strategies

Ongoing control strategies

Chemical Treatment

Ongoing control strategies

Chemical Treatment

Biological Control

Biological control:

Ongoing control strategies

Chemical Treatment

Biological Control

Resistance Breeding

Ongoing control strategies

Chemical Treatment

Biological Control

Resistance Breeding

Enter: the Lingering Hemlock Project

The hemlock subset of “Tree Species in Peril”

Tree Species in Peril

A The Nature Conservancy project to bolster genetic resistance to pests in vulnerable North American tree species.

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Tree Species in Peril

A The Nature Conservancy project to bolster genetic resistance to pests in vulnerable North American tree species.

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Enter: the Lingering Hemlock Project

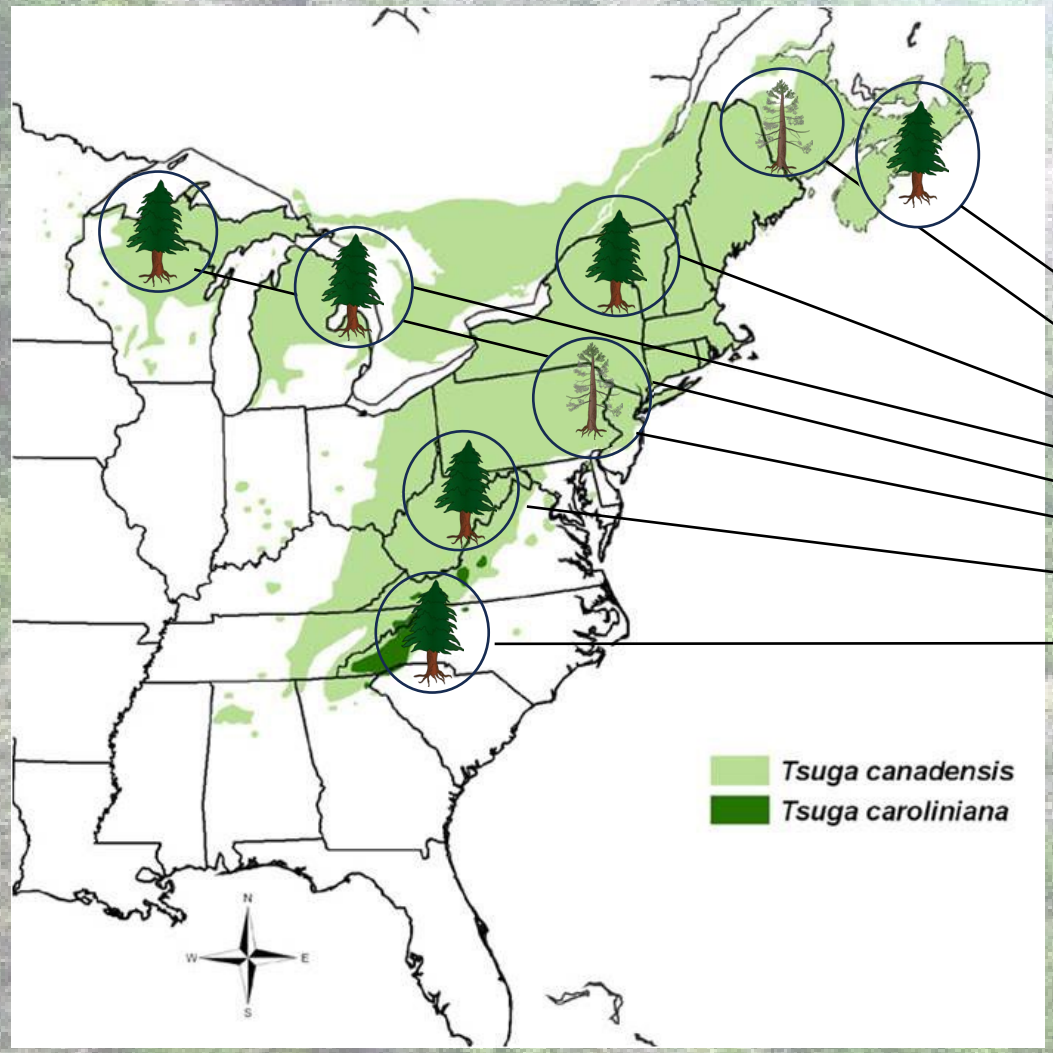
A “lingering hemlock” is a hemlock that remains alive when at least 80% of the hemlocks near it have died.

Enter: the Lingering Hemlock Project

A “lingering hemlock” is a hemlock that remains alive when at least 80% of the hemlocks near it have died.

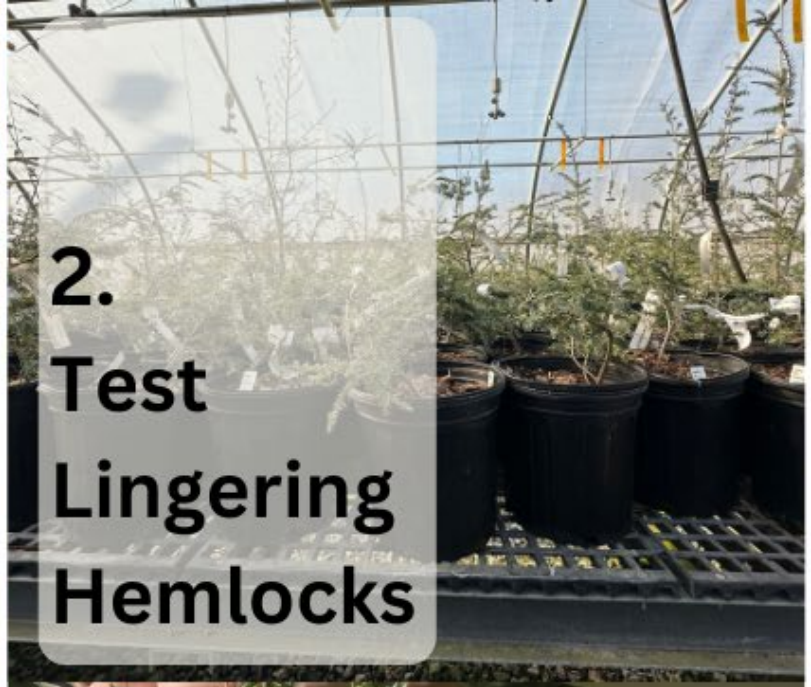
These “lingering” hemlocks may not be healthy, but they *are* still alive.

Enter: the Lingering Hemlock Project



The End Goal: breed robustly HWA-resistant hemlocks while maintaining genetic diversity.


1.
Find
Lingering
Hemlocks


2.
Test
Lingering
Hemlocks

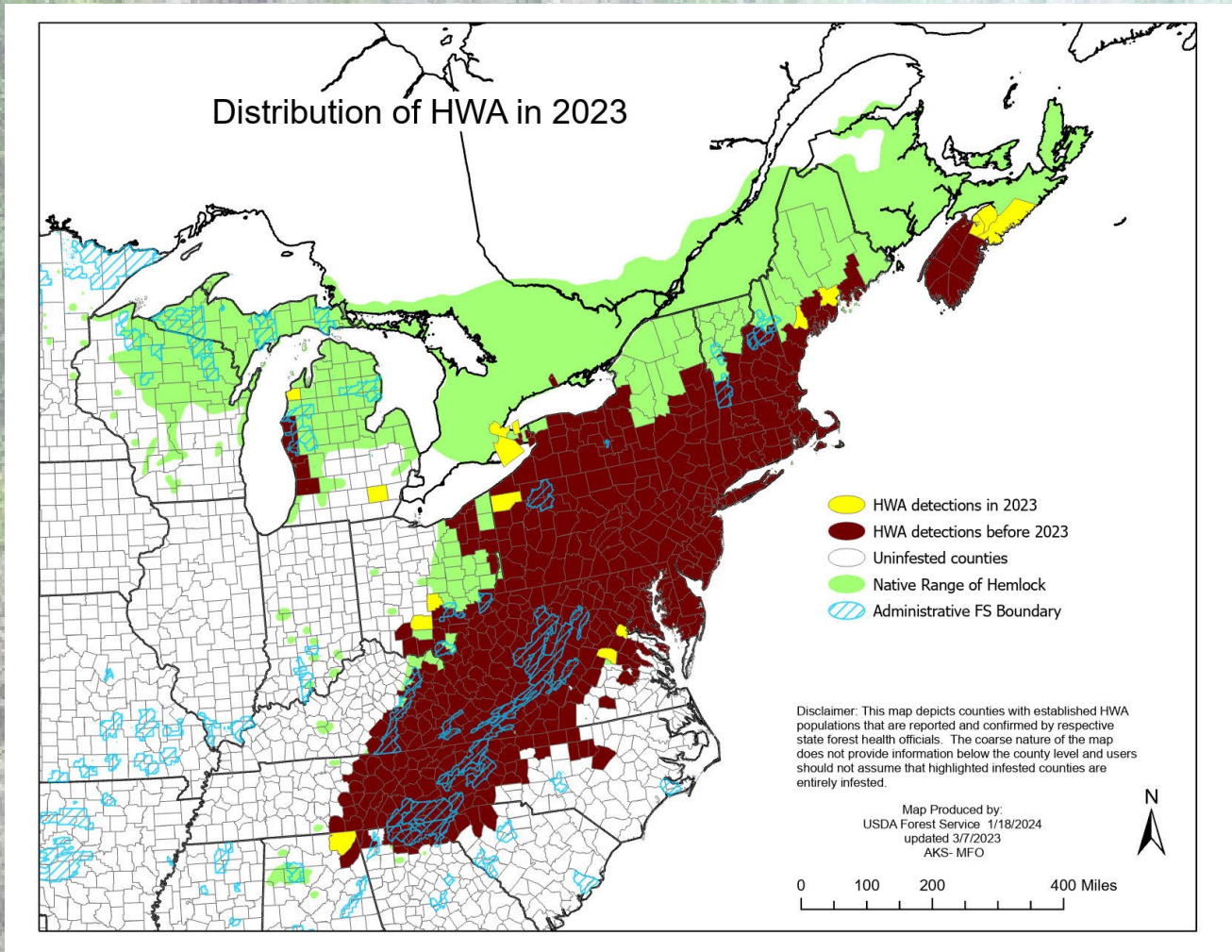

3.
Breed
Resistant
Hemlocks


4.
Plant
Resistant
Orchards


5.
Collect
Resistant
Seeds


6.
Restore
the
Forests

Enter: the Lingering Hemlock Project



Not all areas within HWA's spread have reached the 80% mortality threshold.

Two Different Protocols:

>80% Hemlock Mortality

Lingering Hemlock Protocol

<80% Hemlock Mortality

Hemlock Health Monitoring Protocol

Lingering Hemlock Protocol

For areas with >80% hemlock mortality

HEMLOCK RESTORATION INITIATIVE

How you can help find Lingering Hemlocks

Hemlock

US Units

Submitted By	Anonymous
ID	860859384
Cones	No
Tree Diameter	17 Inches
Habitat	Forest
Nearby Trees	No trees of this species nearby
Treated	Don't know
Comment	Upper reaches of Lower Ridge Trail. 30 feet west of trail. There are two similar hemlocks on the Park Ridge Trail just west of the standing Indian campground. Didn't have my phone to take pix etc.
Crown Position	Codominant, this tree's crown is level with or slightly below other nearby trees
Hemlock Crown Health	H = Healthy (>80% healthy crown; deep green, dense foliage; skylight is mostly blocked when you look at the tree)
Species	Eastern hemlock (Tsuga canadensis)
Hemlock Woolly Adelgid (HWA)	I'm not sure
Coordinates	35.060548888508194, -83.55557089981922
Location Accuracy	Within 5 miles radius
Date Collected	April 30, 2021 10:57 AM
Photos	See All Photos

Photos Map

Participants will use the TreeSnap app to record surviving hemlocks surrounded by dead or dying hemlocks.

HEMLOCK RESTORATION INITIATIVE

TreeSnap Data collected:

The Lingering Tree

- Species
- Size (DBH)
- Infestation

HEMLOCK RESTORATION INITIATIVE

TreeSnap Data collected:

The Lingering Tree

- Species
- Size (DBH)
- Infestation

The Surrounding Area

- Forest canopy
- Surrounding habitat type
- Health of nearby hemlocks

HEMLOCK RESTORATION INITIATIVE

Lingering Hemlock Qualities

- At least 4” (10cm) DBH
- Growing in a forested setting
- Where > 80% of surrounding hemlocks are dead and/or are dying
- Not been treated with pesticides or horticultural oils in the last 10-15 years
- Compared to surrounding hemlocks:
  - Deep green needles
  - Thick, full branches
  - Less sky visible when looking through tree canopy

Lingering Tree Search

TreeSnap

Home | Map | Scientific Partners | About | Login | Register

AVAILABLE NOW

Help Our Nation's Trees!

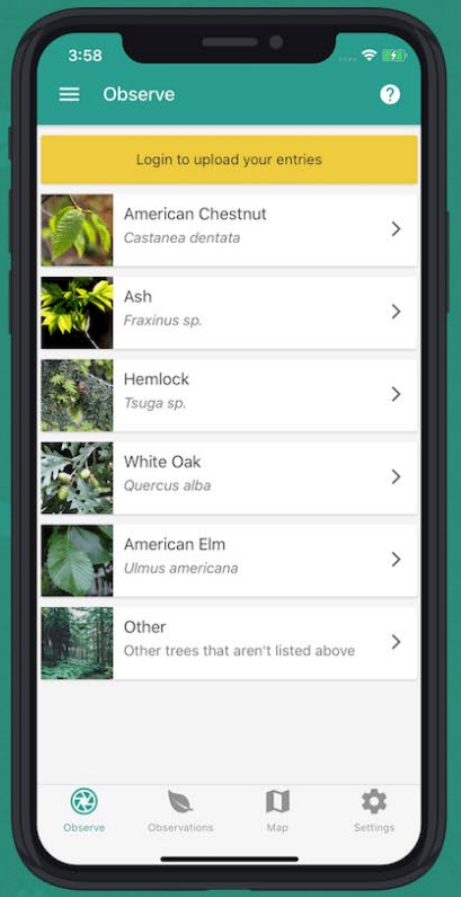
Invasive diseases and pests threaten the health of America's forests. Scientists are working to understand what allows some individual trees to survive, but they need to find healthy, resilient trees in the forest to study. That's where concerned foresters, landowners, and citizens (you!) can help. Tag 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.

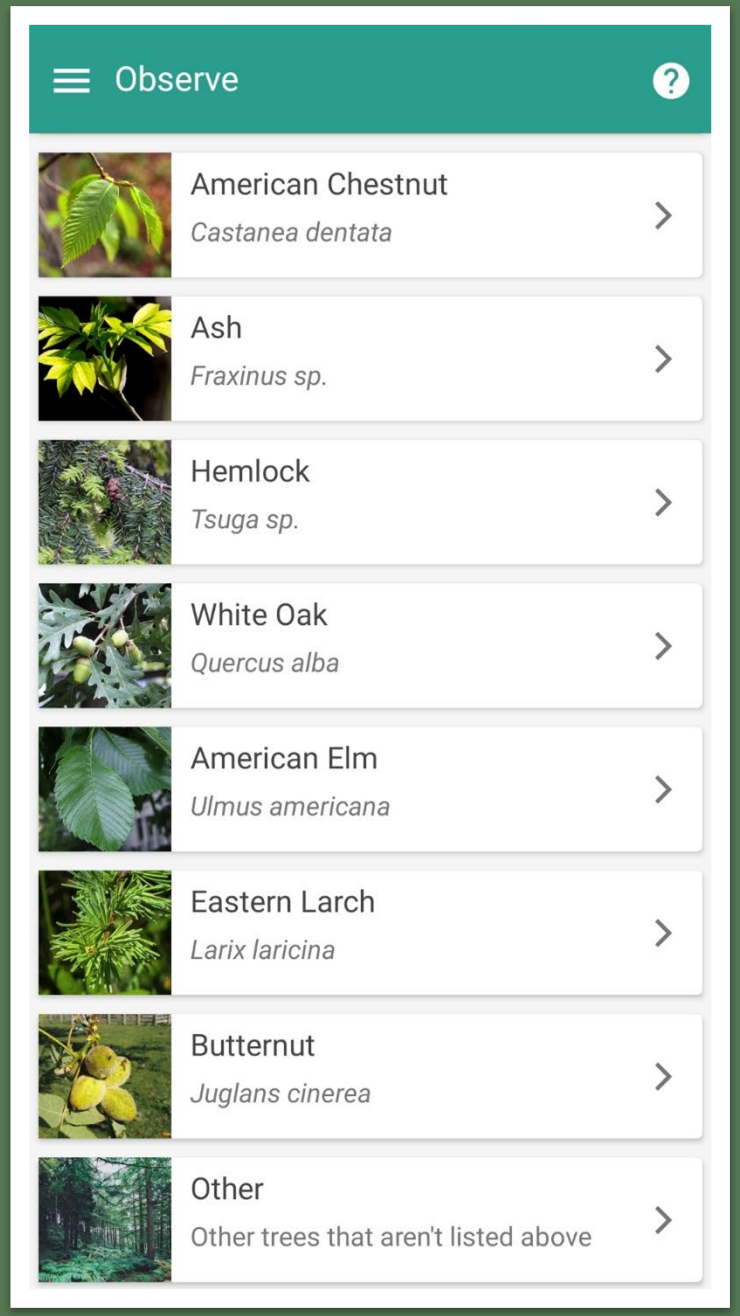
Meet the scientists that use TreeSnap data

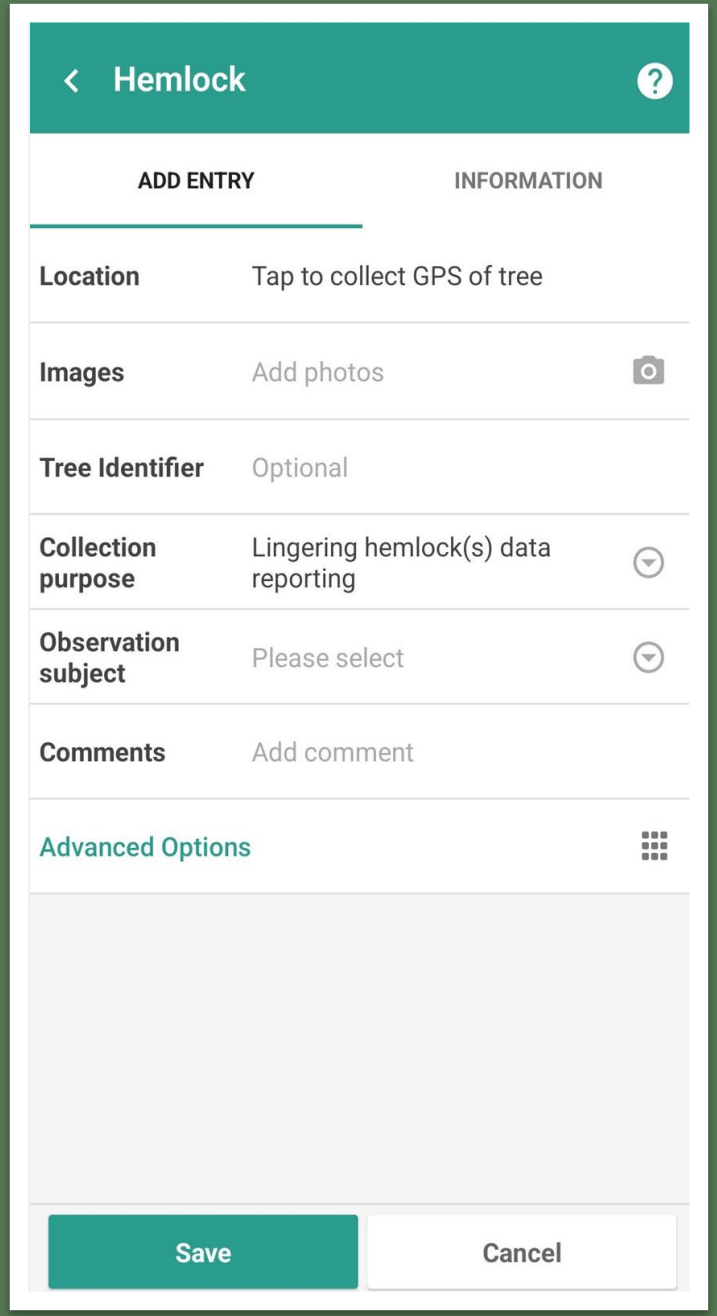
Tutorials available on YouTube

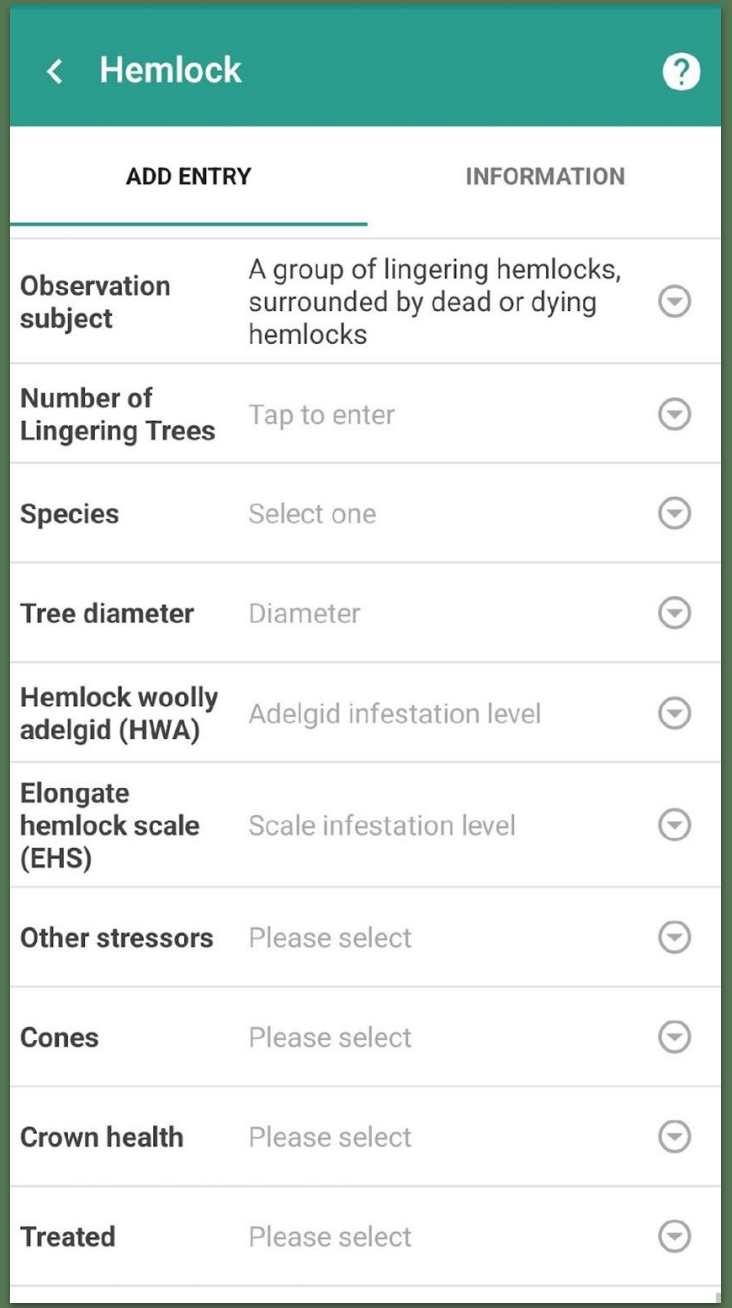
Download on the App Store

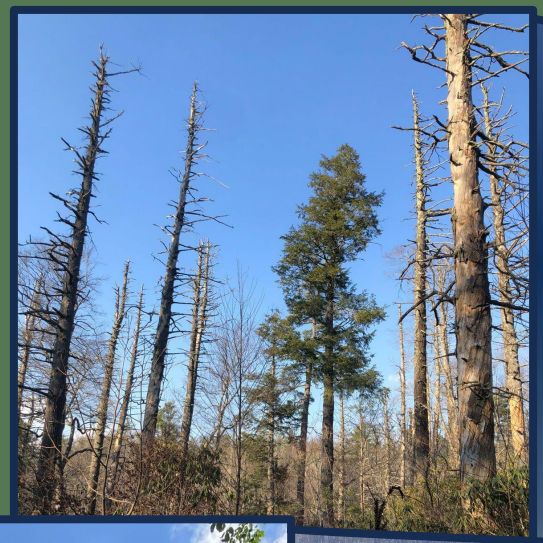
GET IT ON Google Play

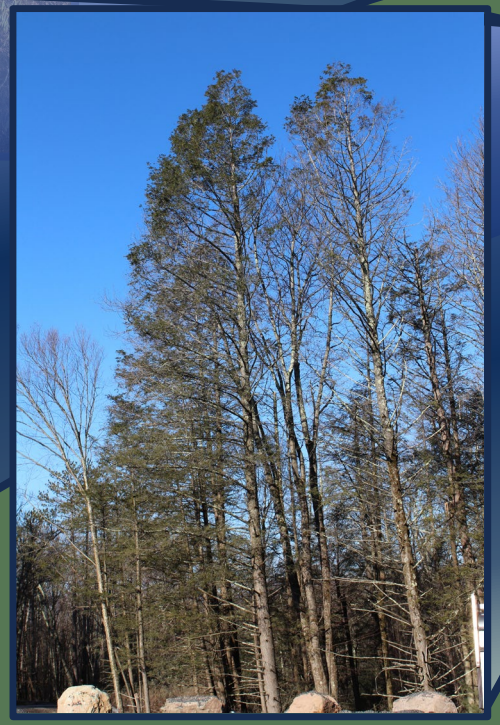


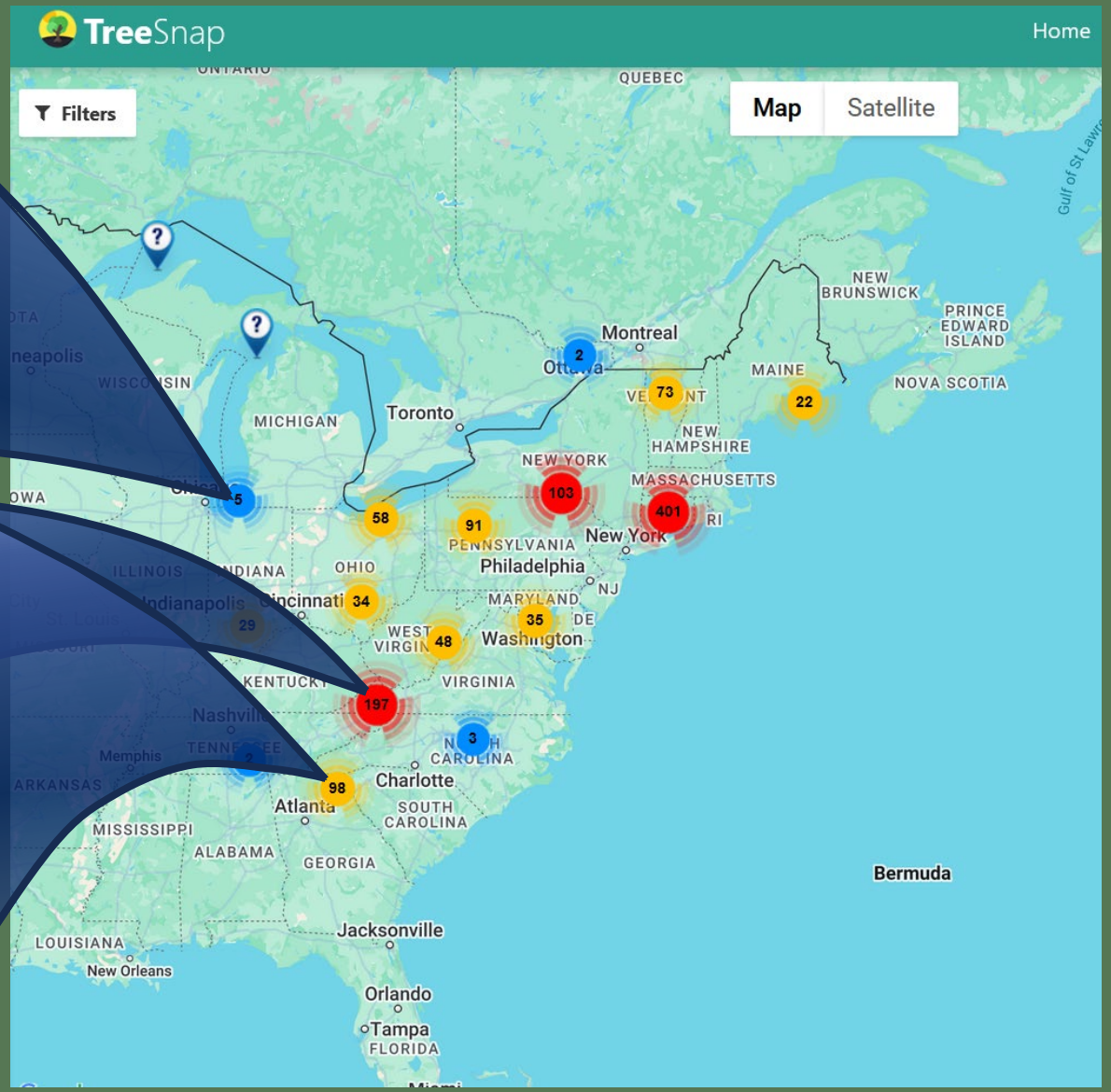

Observe
American Chestnut
Castanea dentata
Ash
Fraxinus sp.
Hemlock
Tsuga sp.
White Oak
Quercus alba
American Elm
Ulmus americana
Eastern Larch
Larix laricina
Butternut
Juglans cinerea
Other
Other trees that aren't listed above


Hemlock
ADD ENTRY
INFORMATION
Location
Tap to collect GPS of tree
Images
Add photos
Tree Identifier
Optional
Collection purpose
Lingering hemlock(s) data reporting
Observation subject
Please select
Comments
Add comment
Advanced Options
Save
Cancel


Hemlock
ADD ENTRY
INFORMATION
Observation subject
A group of lingering hemlocks, surrounded by dead or dying hemlocks
Number of Lingering Trees
Tap to enter
Species
Select one
Tree diameter
Diameter
Hemlock woolly adelgid (HWA)
Adelgid infestation level
Elongate hemlock scale (EHS)
Scale infestation level
Other stressors
Please select
Cones
Please select
Crown health
Please select
Treated
Please select






TreeSnap
Home
Filters
Map
Satellite
QUEBEC
Montreal
Ottawa
Toronto
MICHIGAN
NEW BRUNSWICK
PRINCE EDWARD ISLAND
NOVA SCOTIA
MAINE
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
New York
Philadelphia
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MISSISSIPPI
Memphis
LOUISIANA
New Orleans
Jacksonville
Orlando
Tampa
FLORIDA
Bermuda
Gulf of St Lawrence
2
73
22
5
58
91
103
401
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35
48
29
197
3
98

To Join the Search:

Contact Olivia Hall at the

Hemlock Restoration Initiative:

education@savehemlocks.org

HEMLOCK RESTORATION INITIATIVE

Download TreeSnap:

For Android

For Apple

Hemlock Health Monitoring Plots

For areas with <80% hemlock mortality

Hemlock Health Monitoring Plot Qualities

- An organization with capacity to conduct an annual survey
- 20-40 living hemlock trees near each other
- < 80% hemlock mortality
- Untreated in the last 15 years
    - Unlikely to be treated in the next 15 years

Monitoring Plot Establishment

1. Mark plot boundaries so they can easily be found in the future
2. Mark all trees to be monitored annually (>4” DBH)
3. Collect GPS coordinates on each tree alongside the number on its tree tag
4. Collect data on all dead trees in the plot
5. Collect first round of annual data!

Monitoring Plot Data Collection

Plot #	Tree Tag Number	Hemlock species (if incorrect)	DBH (inches to the tenth)	Found?	Alive?	HWA (H, M, L, No)	EHS (H, M, L, No)	How healthy is the crown of the tree? (H, I, S)	Canopy Position (Dom, Codom, Overtopped, N/A)	Treatment Status: Has the tree been treated with pesticides? (Y, N, ?)	Notes. Use this space to record any unique things about this tree (OPTIONAL)	Notes

Data Submission

Plot #	Tree Tag Number	Hemlock species (if incorrect)	DBH (inches to the tenth)	Found?	Alive?	HWA (H, M, L, No)	EHS (H, M, L, No)	How healthy is the crown of the tree? (H, I, S)	Canopy Position (Dom, Codom, Overtopped, N/A)	Treatment Status: Has the tree been treated with pesticides? (Y, N, ?)	Notes. Use this space to record any unique things about this tree (OPTIONAL)	Notes
1	24	eastern	7.8	Y	Y	M	L	H	Overtopped	N		
1	25	N/A	15	Y	Y	H	L	H	Codom	N	double trunk	
1	26	N/A	10	Y	N	H	No	S	Overtopped	N		dead but still standing
1	27	N/A	9.5	Y	N	H	No	S	Overtopped	N		dead, on ground
1	28	N/A	11.2	Y	Y	L	M	H	Overtopped	N		
1	29	N/A	11.1	Y	Y	M	L	I	Overtopped	N		
1	30	N/A	9.9	Y	Y	M	H	S	Overtopped	N		
1	31	eastern	14	Y	Y	H	No	I	Codom	N		

statonlabapps@gmail.com

Annual Tree Information

This information needs to be filled out annually for each tree in each plot.
Please create one row per tree per annual visit.
Dropdowns are bordered in blue. Please select from the options provided.
In subsequent years, please update from default is not found or no longer alive. (Column H)
Additional instructions can be found on the first tab.

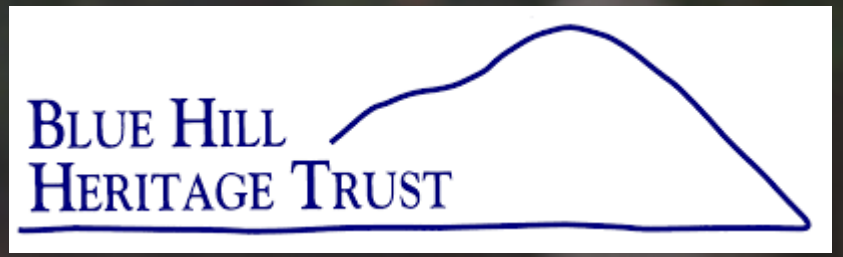
Plot Number	Tree Tag Number	Species	Date of data collection (MM-DD-YYYY)	Data Collector Name	Data Collector Email	DBH (inches to the tenth)	Was this tree found and alive?	HWA	E
1	24	Eastern hemlock (T	11/14/2024	Grace Haynes	gh447@cornell.e	7.8	Found and Alive	Yes, M = Mo	Y
1	25	Eastern hemlock (T	11/14/2024	Grace Haynes	gh447@cornell.e	15	Found and Alive	Yes, H = Hea	Y
1	26	Eastern hemlock (T	11/14/2024	Grace Haynes	gh447@cornell.e	10	Found and Dead	Yes, H = Hea	N
1	27	Eastern hemlock (T	11/14/2024	Grace Haynes	gh447@cornell.e	9.5	Found and Dead	Yes, H = Hea	N
1	28	Eastern hemlock (T	11/14/2024	Grace Haynes	gh447@cornell.e	11.2	Found and Alive	Yes, L = Light	Y
1	29	Eastern hemlock (T	11/14/2024	Grace Haynes	gh447@cornell.e	11.1	Found and Alive	Yes, M = Mo	Y
1	30	Eastern hemlock (T	11/14/2024	Grace Haynes	gh447@cornell.e	9.9	Found and Alive	Yes, M = Mo	Y
1	31	Eastern hemlock (T	11/14/2024	Grace Haynes	gh447@cornell.e	14	Found and Alive	Yes, H = Hea	N

To Set up a Plot:

Contact Grace Haynes (me) at the New York State Hemlock Initiative:

gh447@cornell.edu

Thank you to our many partners!



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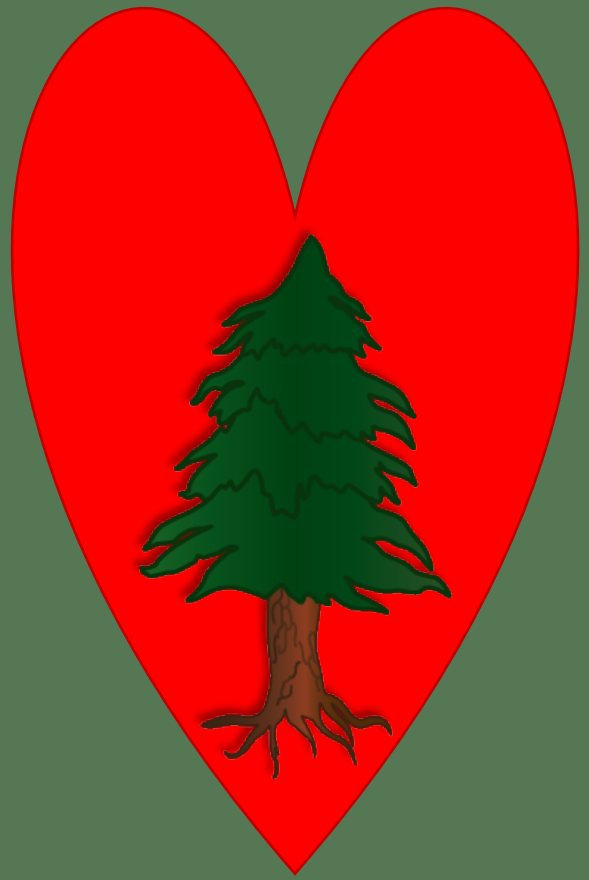

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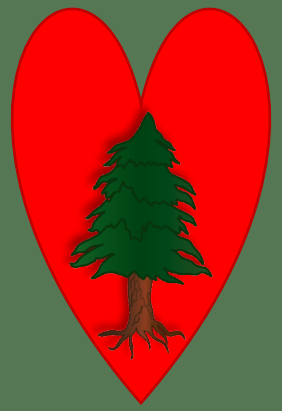

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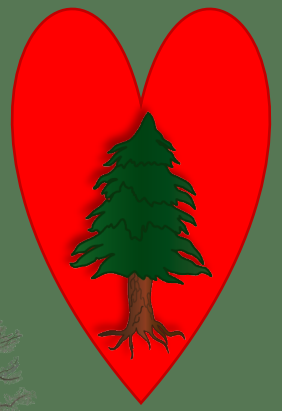

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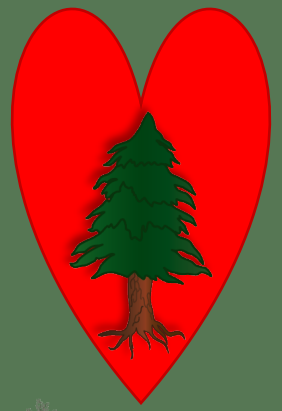

Do you own or have access to a hemlock stand you can monitor?
Reach out to us to schedule a training:

Grace Haynes (gh447@cornell.edu)

Hemlock Health Monitoring Plots in the NE United States

Olivia Hall (education@savehemlocksnc.org)

Lingering Hemlock Monitoring in the SE United States

QUESTIONS?

Grace Haynes (gh447@cornell.edu)
Olivia Hall (education@savehemlocksnc.org)

References:

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