Management Strategies for Eastern Forests Threatened by Hemlock Woolly Adelgid *(Adelges tsugae)*

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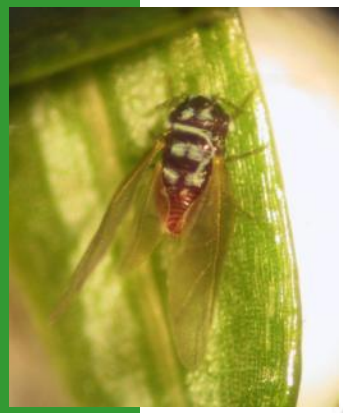
Introduced Threat: Hemlock woolly adelgid

Egg masses: Up to 300 eggs each

Biology and Life History

- Native to Asia and western North America
- HWA in eastern US originated from Japan
- First found in 1951 near Richmond, VA
- 2 generations/year
- 2 life forms: winged and non-winged
- Parthenogenetic (all females)
- Up to 300 eggs/female
- Active throughout the winter



Winter generation
Spring generation
HEMLOCK
SPRUCE
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
Aestivating Nymph
Nymphs 2,3,4
Adult
Eggs
Crawler
Adult
Nymphs 2,3,4
Crawler
Eggs
Winged Adult

Hemlock Woolly Adelgid

Winter generation hatching: Egg sacs and crawlers

Winter generation nymphs in summer aestivation

Sap sucking insect that feeds at the base of needles on the fluids in the xylem ray parenchyma cells

Making an informed decision about hemlock and the threat of HWA

Factors:

- Financial- What timber value might be lost?
- Ecological – Forest ecosystem function
- Wildlife habitat
- Liability- Risks from falling trees and branches
- Probability of infestation – How close is HWA?
- Stand vulnerability factors
- Management alternatives

Hemlock Stumpage Value

Example: $35 / Mbf

- Pure stand: 10-30 Mbf/acre; potential loss $350-$1,050 /acre
- Mixed stand: 0.5 – 10 Mbf / acre; potential loss $17 - $350 / acre

Ecosystem Function: Water Quality

- Hemlocks stabilize shallow soils and prevent erosion and sedimentation

- Hemlock forests maintain cool stream water temperatures*

***Critical for many aquatic insects and native brook trout (1-2.5°C cooler than hardwood forests)**

Wildlife Habitat

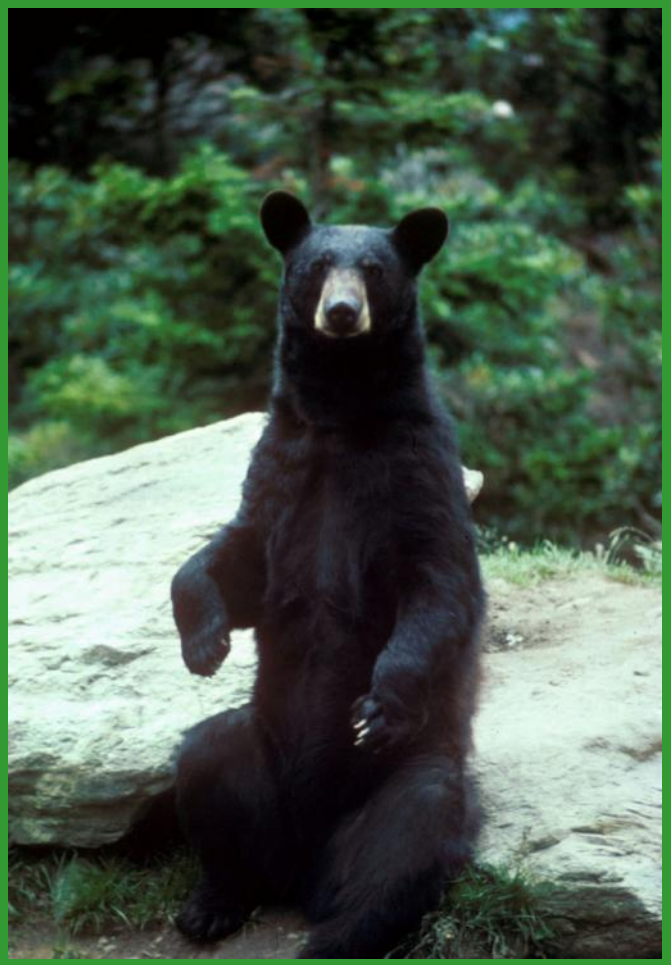
Hemlock forests provide critical habitat for neo-tropical migrant birds including:

Black-throated green and blackburnian warblers; Acadian flycatcher; and blue-headed vireo

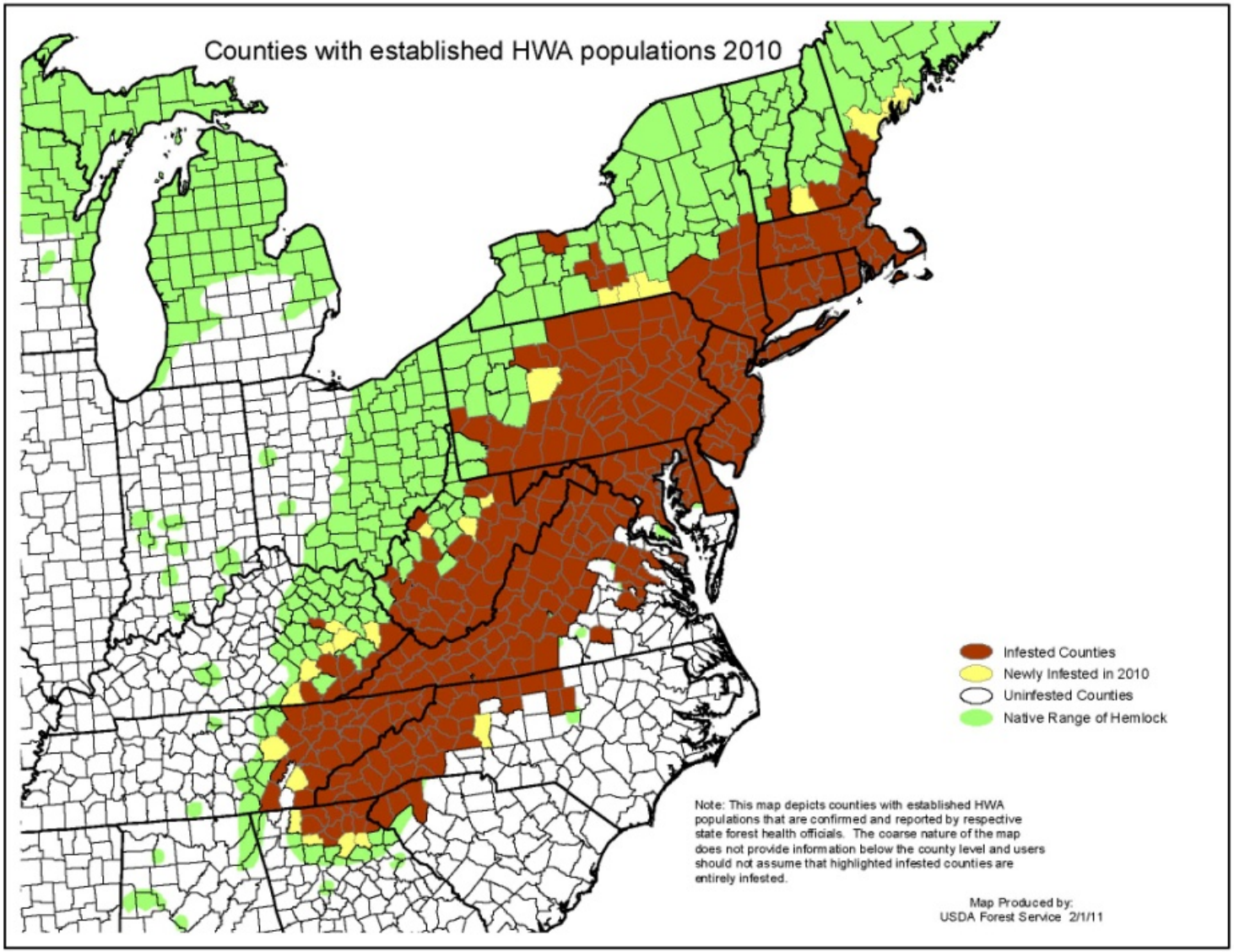
Wildlife Habitat

Hemlock forests provide winter shelter for many local wildlife species including:

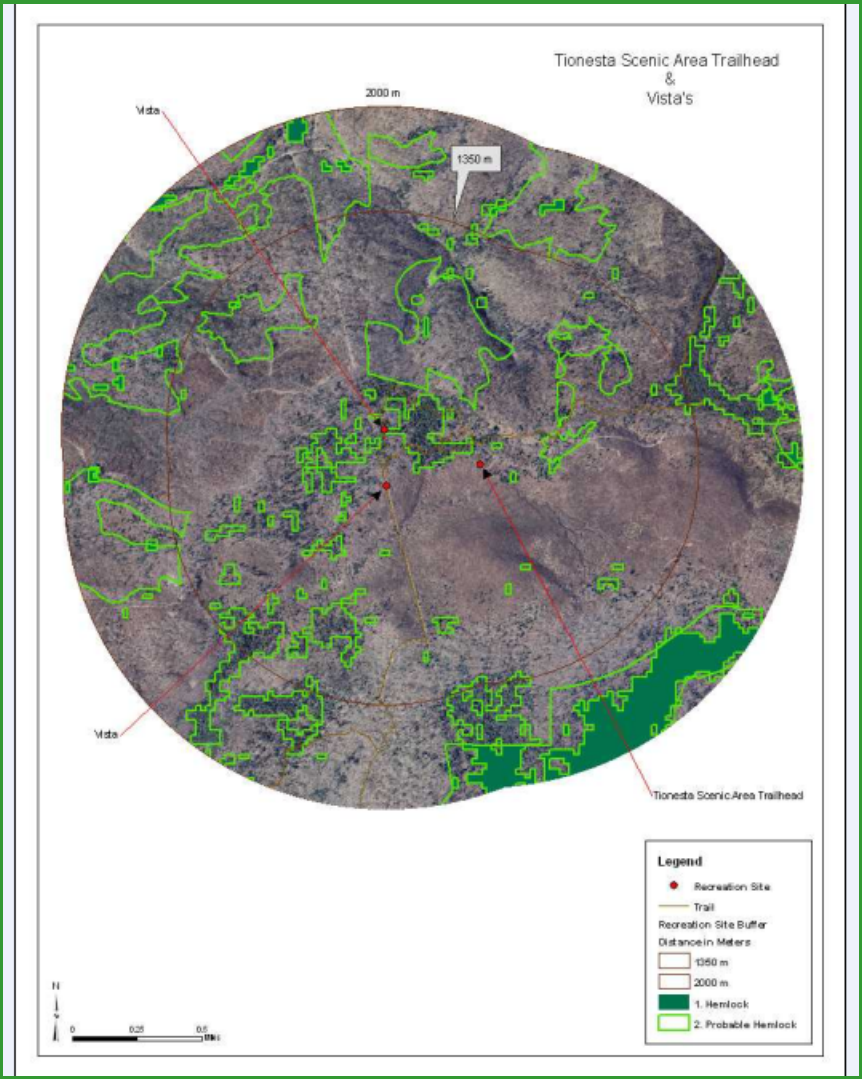
- ruffed grouse
- whitetail deer
- black bear
- numerous species of small mammals and birds



Infestation Risk - 2010



Hemlock's Future



- Review risk factors for HWA susceptibility and vulnerability
- Discuss stand and forest strategies to manage impact
- Review a few VERY recent brighter notes

Risk Factors

- All age classes of eastern and Carolina hemlock are vulnerable
- HWA is rapidly spreading to new areas (12-15 miles/year)
- HWA populations build quickly and are difficult to detect at low densities

Vulnerability Risk Factors

- Soil moisture – higher on sites with low mortality
- Winter temperature – Cold winters limit HWA population growth
- Foliar nutrients – High nitrogen in foliage might accelerate HWA population growth

Susceptibility Factors –

Proximity to:

- Nearest infestation (5, 10, 15 years)
- Major roads
- Streams
- Recreation destinations

USFS Forest Health Protection

Management Alternatives

- There are no effective native natural enemies of HWA in Eastern North America
- There are no parasites of adelgids
- Insecticide treatments limited to individual tree applications

Within-stand Risk

- Based on long-term monitoring, Delaware Water Gap: adelgid presence highest risk.
  - Intermediate trees 2.1 x more likely to develop decline than overtopped
  - Live crown ratio, crown density, DBH also influenced probability of decline

Rentch et. al. 2009. Biological Invasions

Silvicultural Options for Hemlock-dominated Forests (>30% BA)

1. Do Nothing

2. Thinning targeting hemlock crop trees

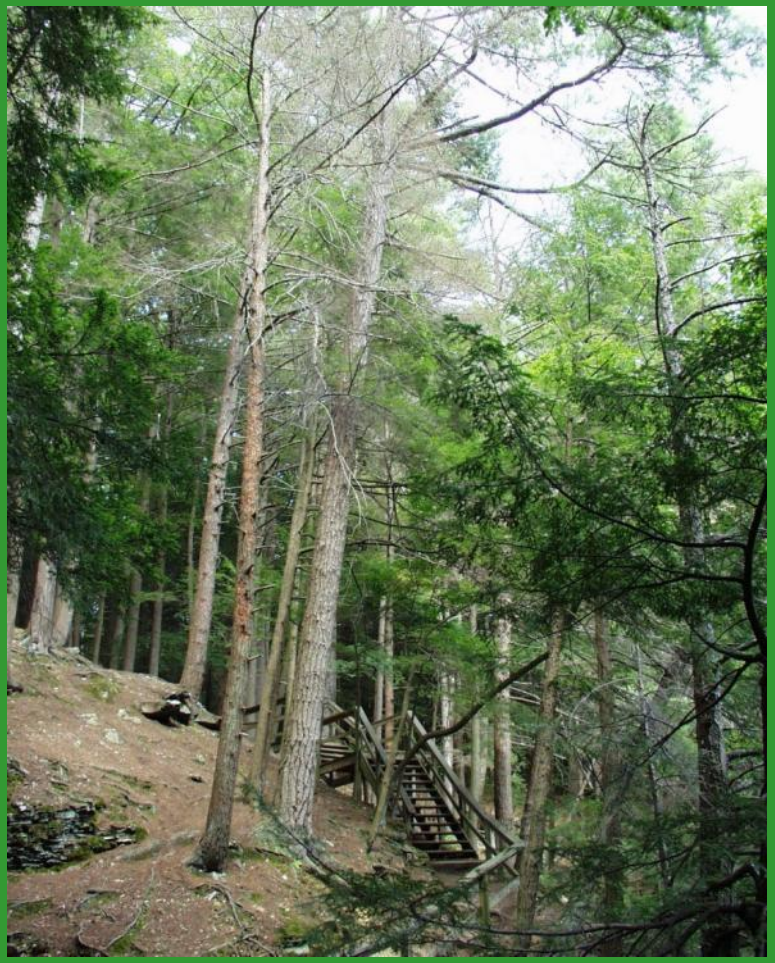
3. Shelterwood Cut – Regeneration

1. Do Nothing

- Infested hemlocks die in 4-15 years
- Light to forest floor increases
- Stimulates woody and herbaceous plants
- Habitat- Dead wood

Impacts at Delaware Water Gap NRA

- 1989: HWA first noted
- 1998: HWA widespread
- 2000: Hemlock decline and mortality first apparent
- 2009: 30% tree mortality

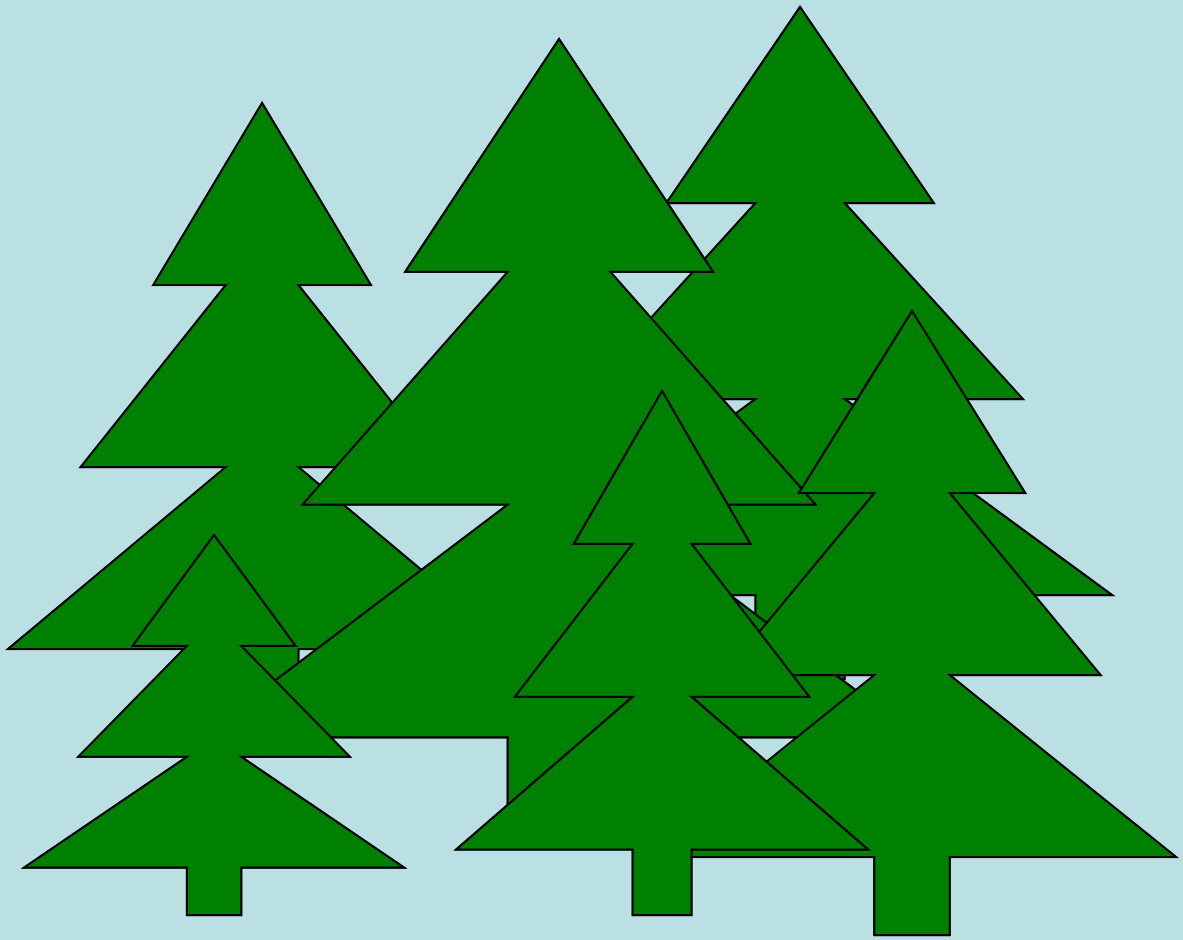


2. Thinning: Increase Hemlock Survivability in HWA -Threatened Stands

Objective: Reduce stand densities, reallocate resources (light, water and nutrients) increase hemlock vigor.


Objectives: Timber revenue and
Increase hemlock vigor

Silvicultural thinnings reallocate fixed site resources among fewer stems increasing the amount of light, water and nutrients per tree.



Hemlocks can show growth increase to thinning regardless of age as long as live crown ratio >30%

Stand Structure: Overstocked (basal areas ≥200 ft^2/a)

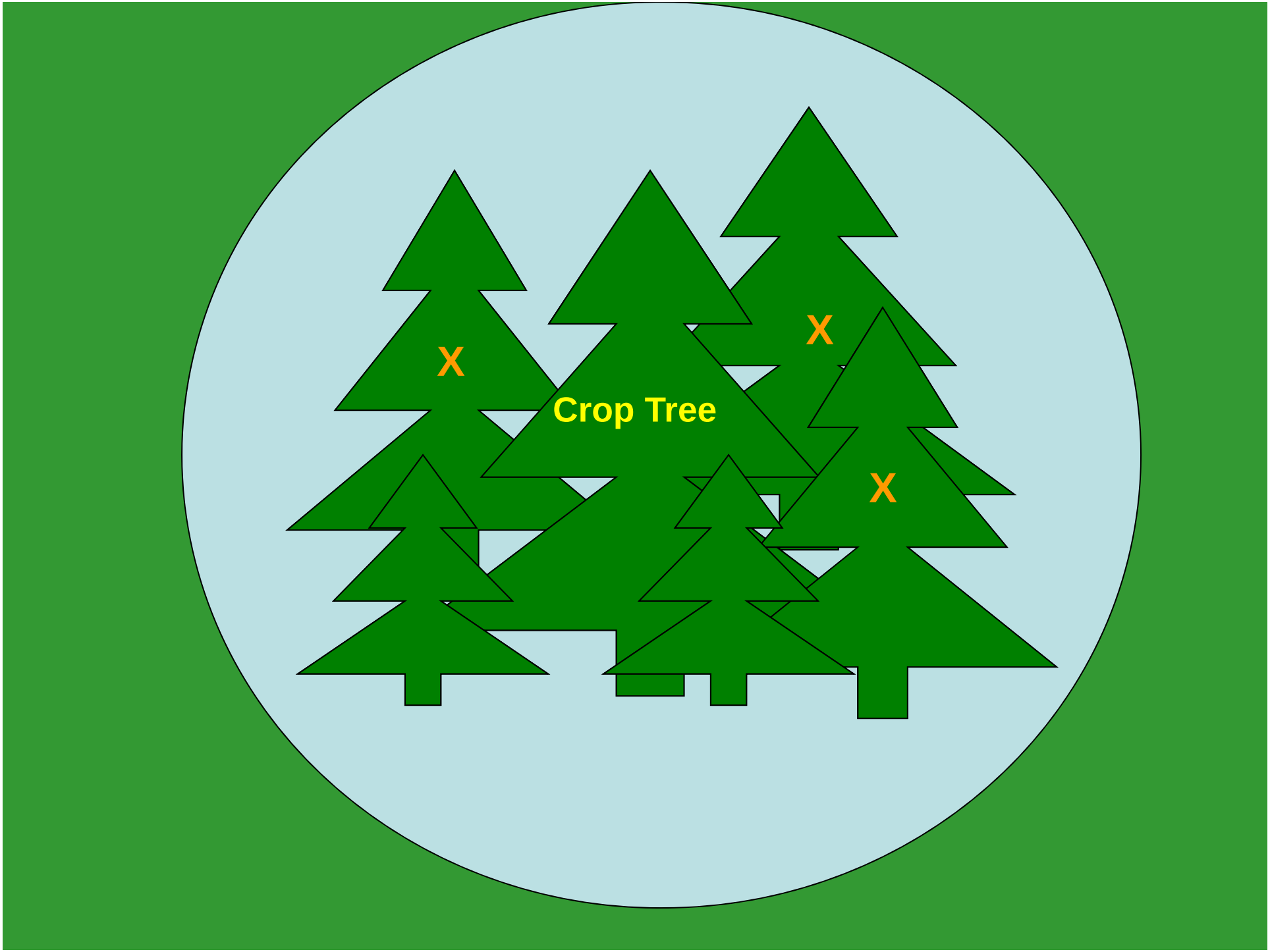
- Mixed upland Hardwoods
  - **Black cherry**
  - **Hemlock (50-70 ft^2/a)**
- Oak/hardwood transition
  - **Oak and red maple**
  - **Hemlock (30-50 ft^2/a)**

Marking a Thinning
Reduce relative density 30-40%

Guidelines: Crown / low thinning

- **BA <150 reduce to 80 ft^2/a**
- **BA 150-200 reduce to100**
- **BA >200 reduce to 130**

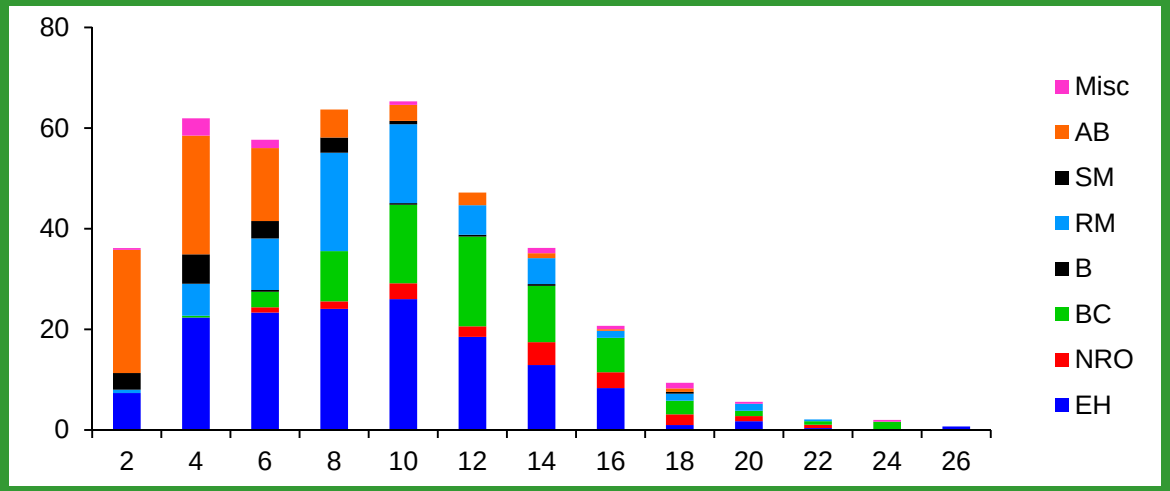
Release midstory and understory hemlock


X
X
X
Crop Tree

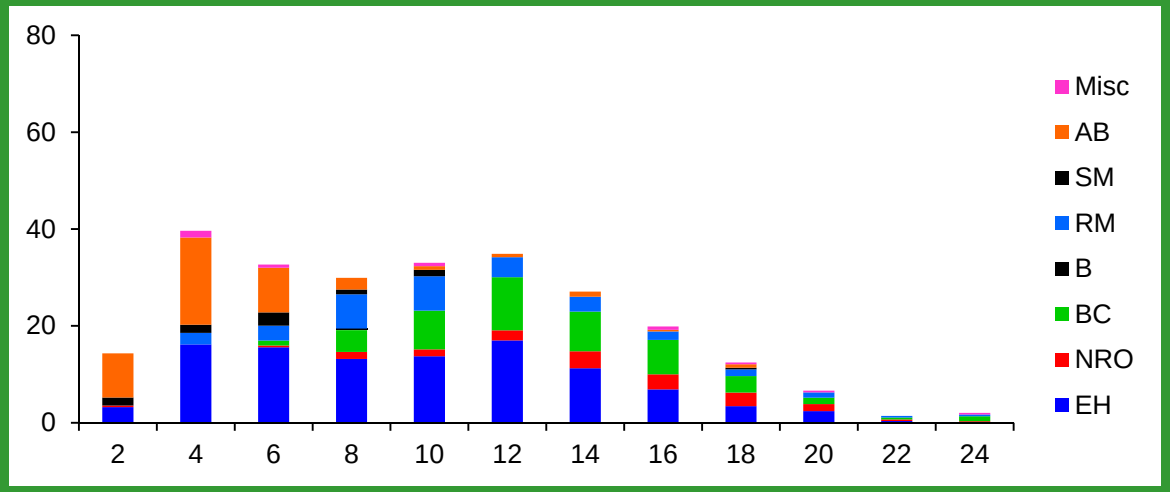
Beech poles and birch marked to release understory hemlock

Stand 1: Diameter Distribution

Pre- Harvest 2005



Post harvest 2011

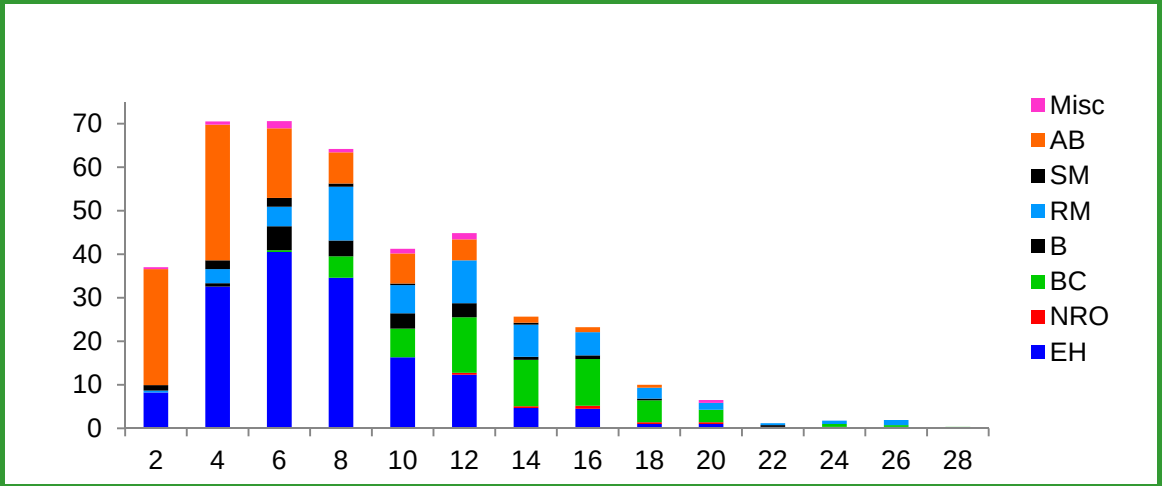


Trees/ A

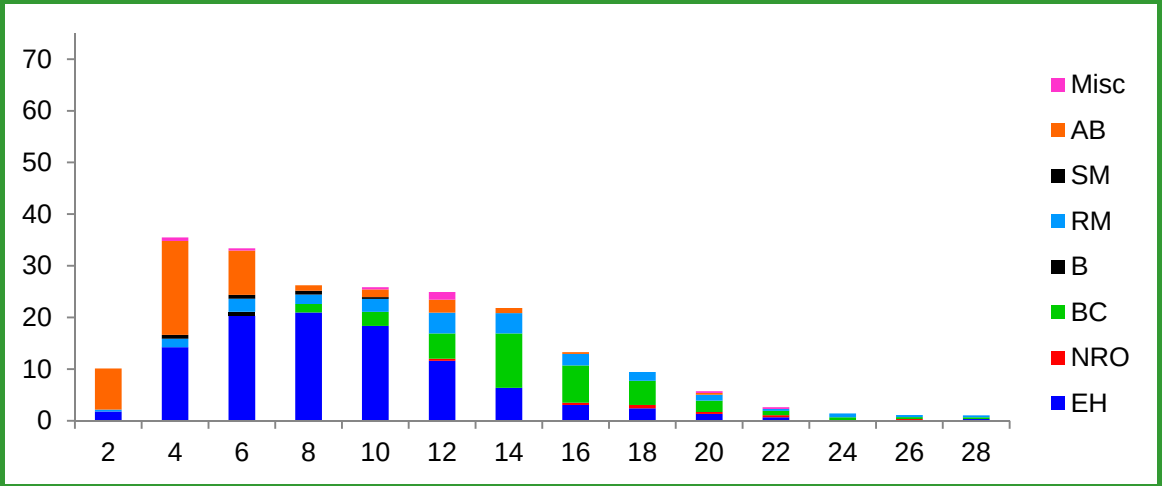
Diameter (inches)

Stand 2: Diameter Distribution

Pre- Harvest 2005



Post harvest 2011

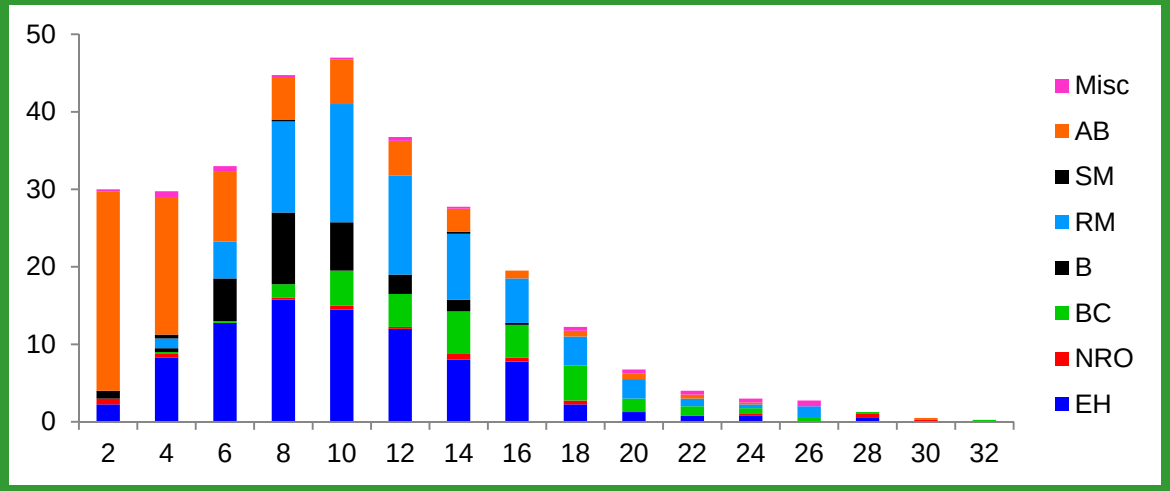


Trees/ A

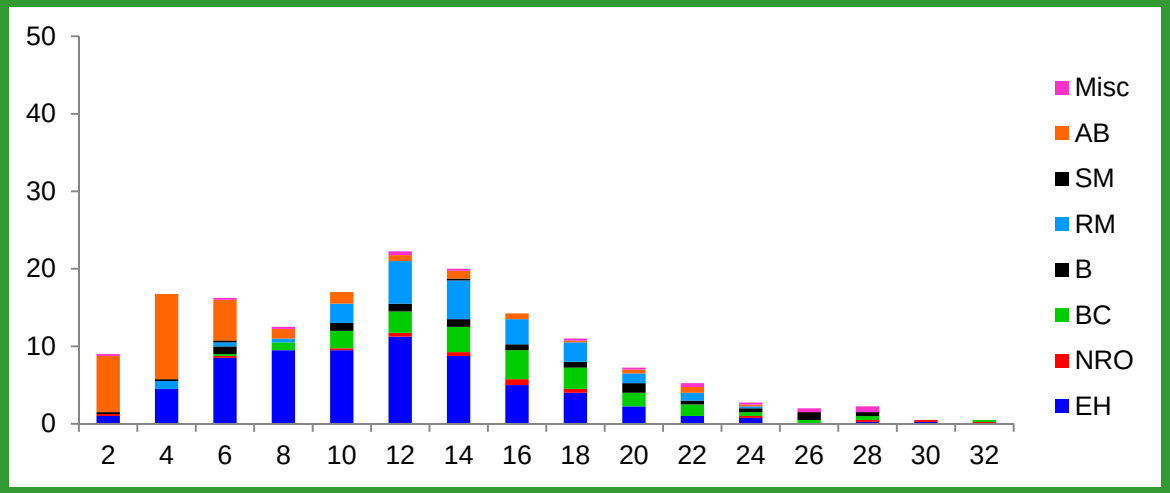
Diameter (inches)

Stand 3: Diameter Distribution

Pre- Harvest 2005



Post harvest 2011



Trees/ A

Diameter (inches)

DBH increase: Crop Trees

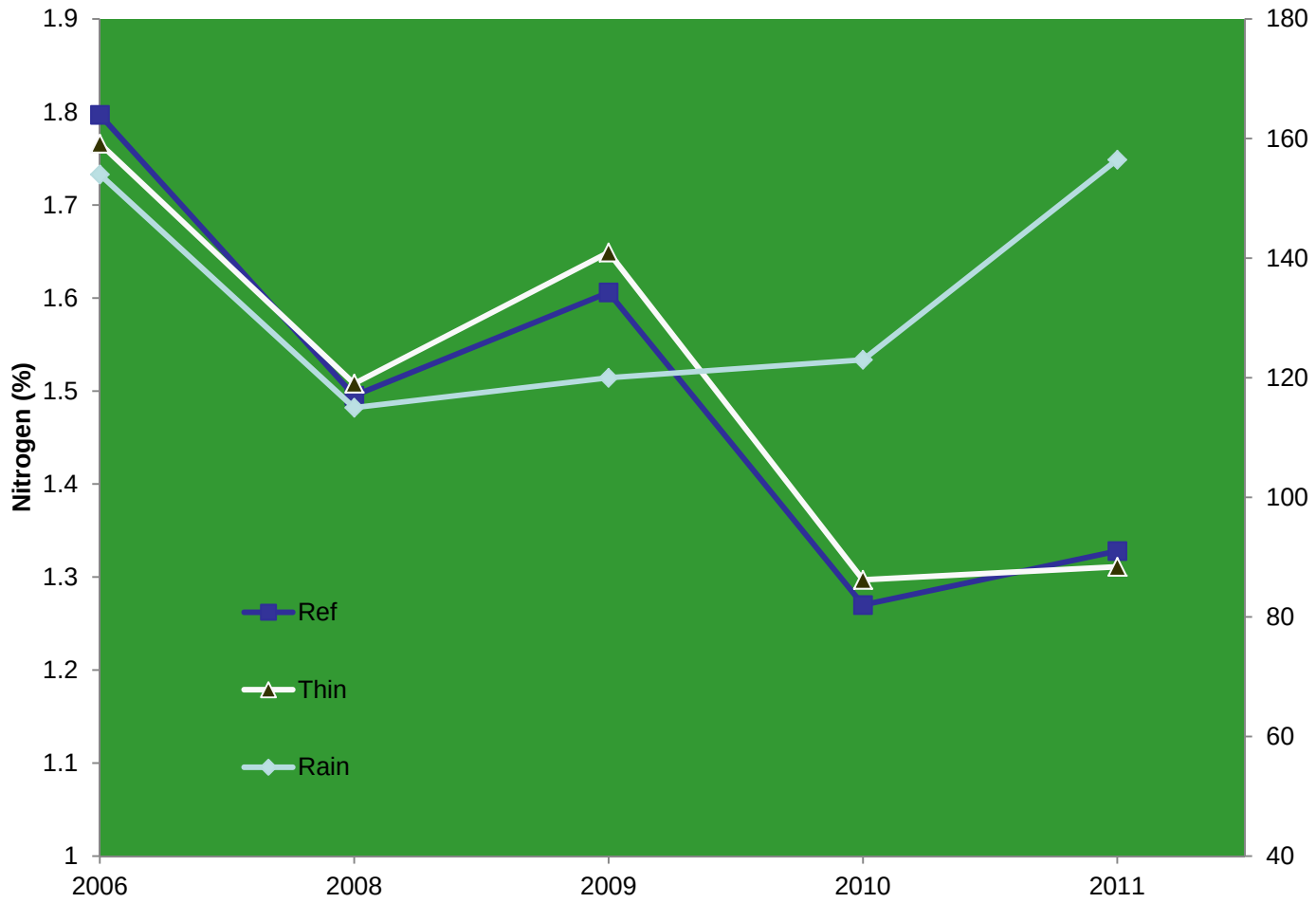
Thinned

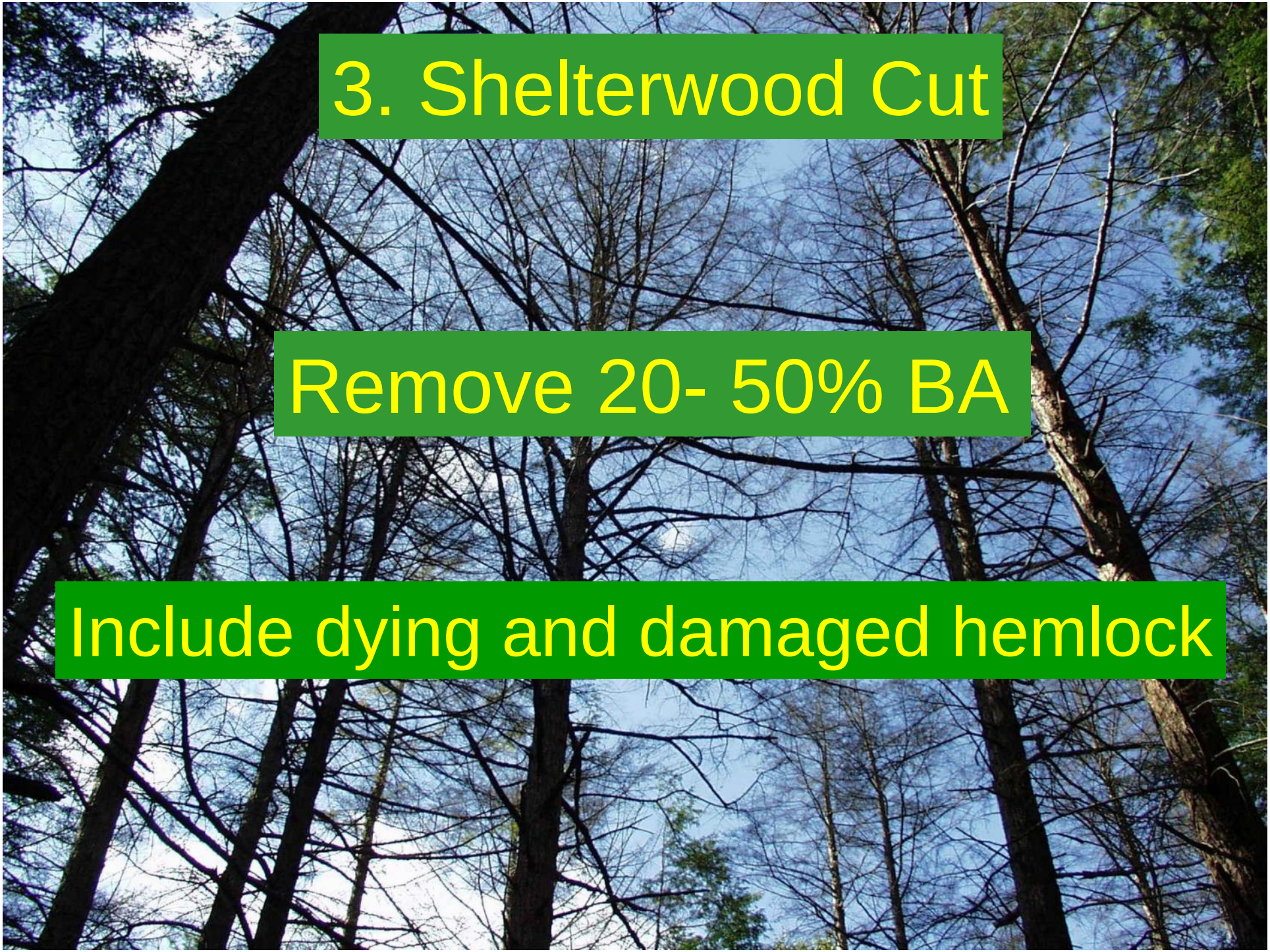
- Stand 1: 1.1”
- Stand 2: 1.6”
- Stand 3: 1.3”

Reference

- Stand1: 0.7”
- Stand 2: 0.9”
- Stand 3: 0.6”

Foliar Nitrogen Concentrations in Thinned and Reference Stands




3. Shelterwood Cut
Remove 20- 50% BA
Include dying and damaged hemlock


Regeneration


History:
-Large oaks removed in mid 1980s.
-Gaps favored white pine and hemlock regeneration after deer herd was controlled.
Goals:
Increase gap size


Basal area averages 169 ft2/a,
182 TPA,
QMD 13 “
63% hemlock
13% black birch
8% red maple


Harvest yield:
3,222 BF/a (1,859 BF hemlock)
4.6 cords/a
48 ft2/a basal area
64 TPA


Not Recommended:
Pre-emptive cutting or pre-salvage of uninfested forests

Biological Control

Approach:

Locate, identify, screen and evaluate HWA natural enemies in its home range

Goal: “Establish a complex of host specific natural enemies throughout the infested range and evaluate their effectiveness”

Biocontrol: HWA Predators being Released

- *Pseudoscymnus tsugae* (PT) was first and still most widely used
  - PA: 176,387 beetles released at 50 sites in 23 counties - recovered 642 beetles

- *Laricobius nigrinus* (Japan) 1,500 beetles (2003-2006)

- **Insect-killing Fungi**

Chemical Control Options

- **Foliar Applications**
  - Horticultural oils
  - Insecticidal soaps

- 2- 2 1/2% solutions
- Easy on beneficial insects
- Saturate tree to dripping
- Thorough coverage is necessary

Chemical Control Options

Systemic insecticides: Imidacloprid

- Application to soil by drench or injection
- **Application directly into tree by injection**

Chemical Control
Kioritz® Soil Injector

- **Advantages:**
  - Low volume (1 oz/inch dbh)
  - Easy use
  - 2+ years control
- **Disadvantages:**
  - Difficult to use in shallow/rocky soils
  - Not suitable in sandy soils, near open water or areas with a high water table

Tree Injection

Advantages:

- Use on trees near water
- Faster translocation

Disadvantages:

- Treatment timing more critical
- Good tree health
- More complicated
- More costly ($3-$5/inch dbh)

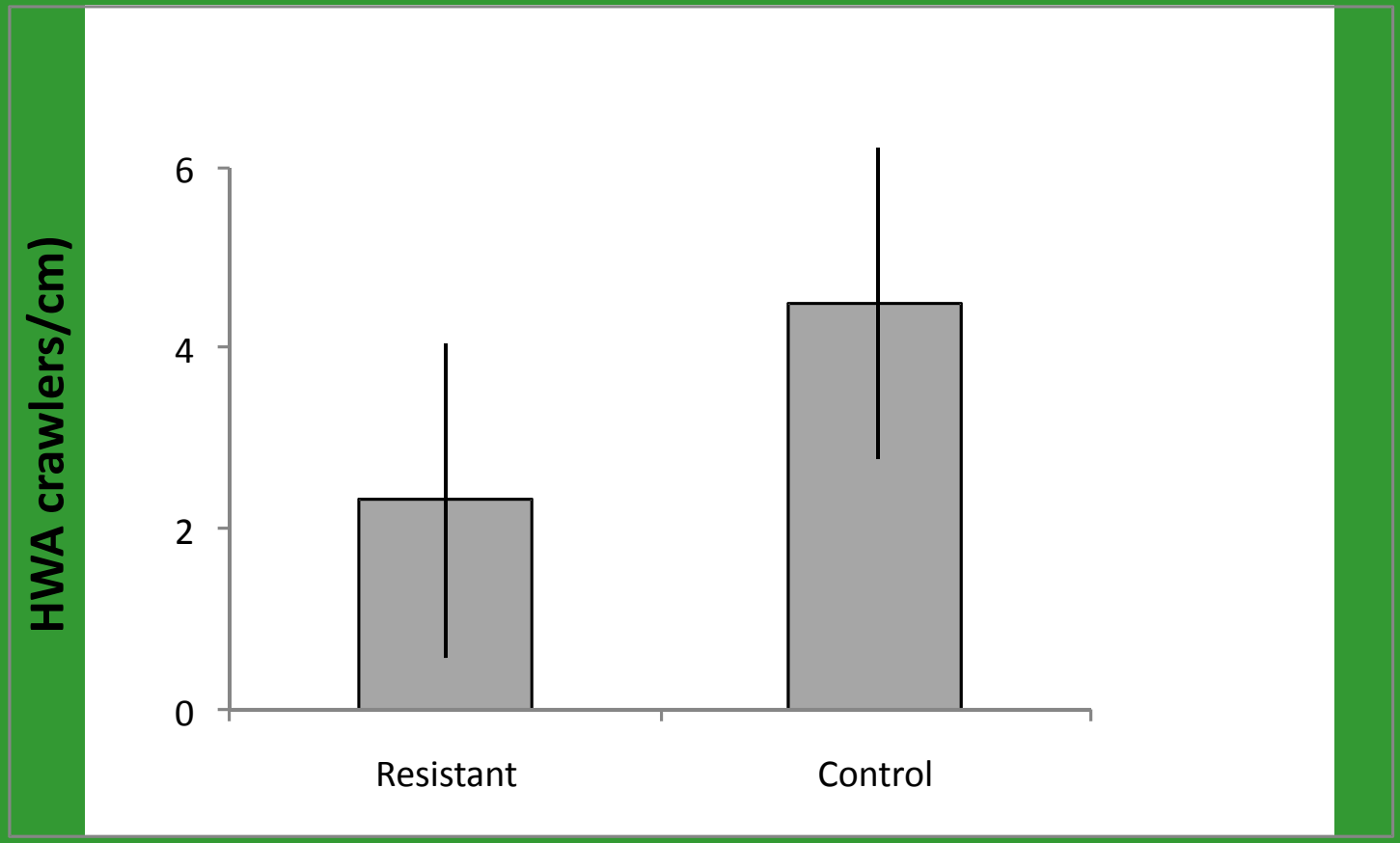
Future?

- Dr. Dick Cassagrande (U Rhode Island) and colleagues are testing “resistant” hemlocks
- Cuttings are rooted in nursery, then challenged with HWA

Resistant Hemlock?

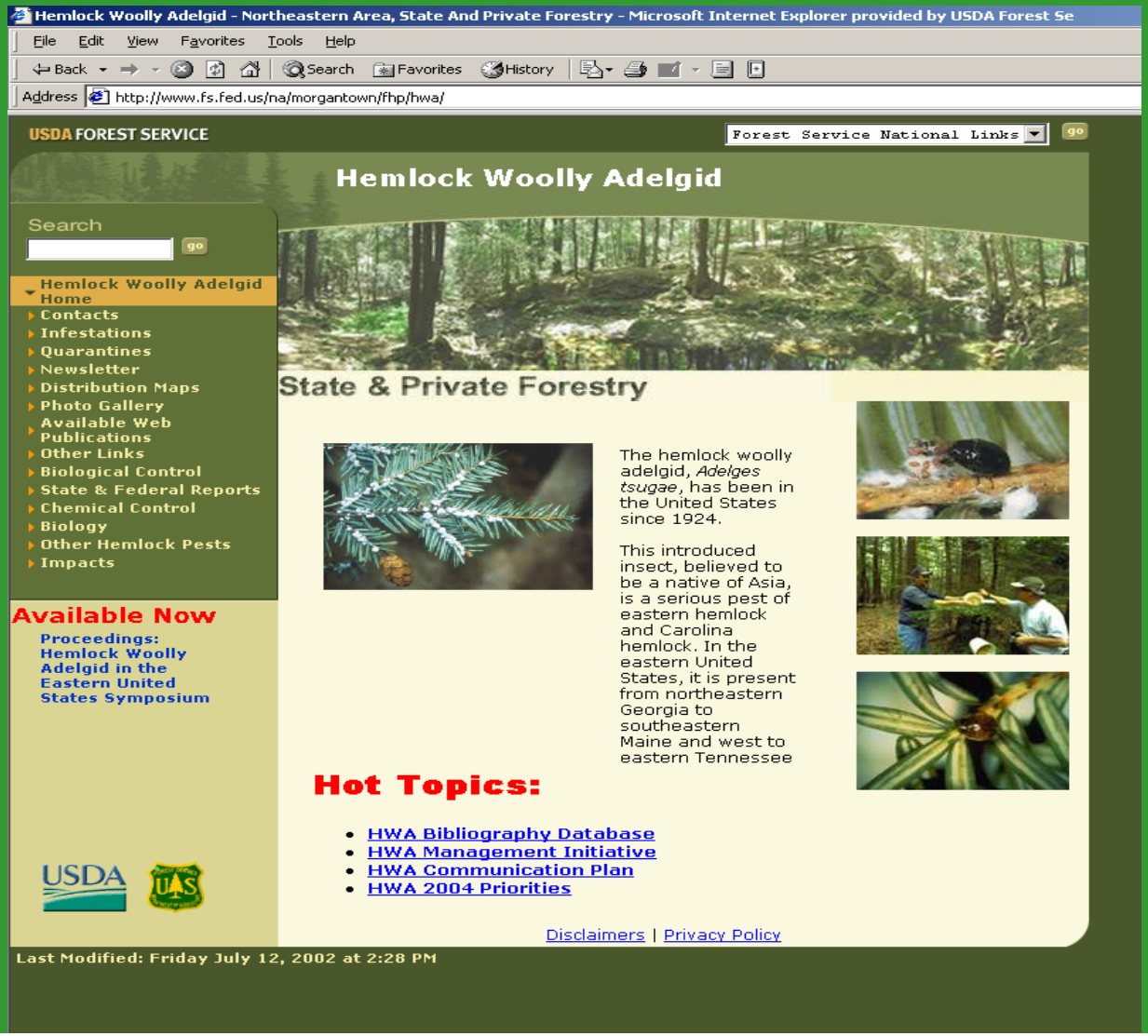
Photos from D. Cassagrande

2010 HWA inoculation results



Slide from R. Cassagrande

http://na.fs.fed.us/fhp/hwa




HELP!
I WANT TO GROW UP