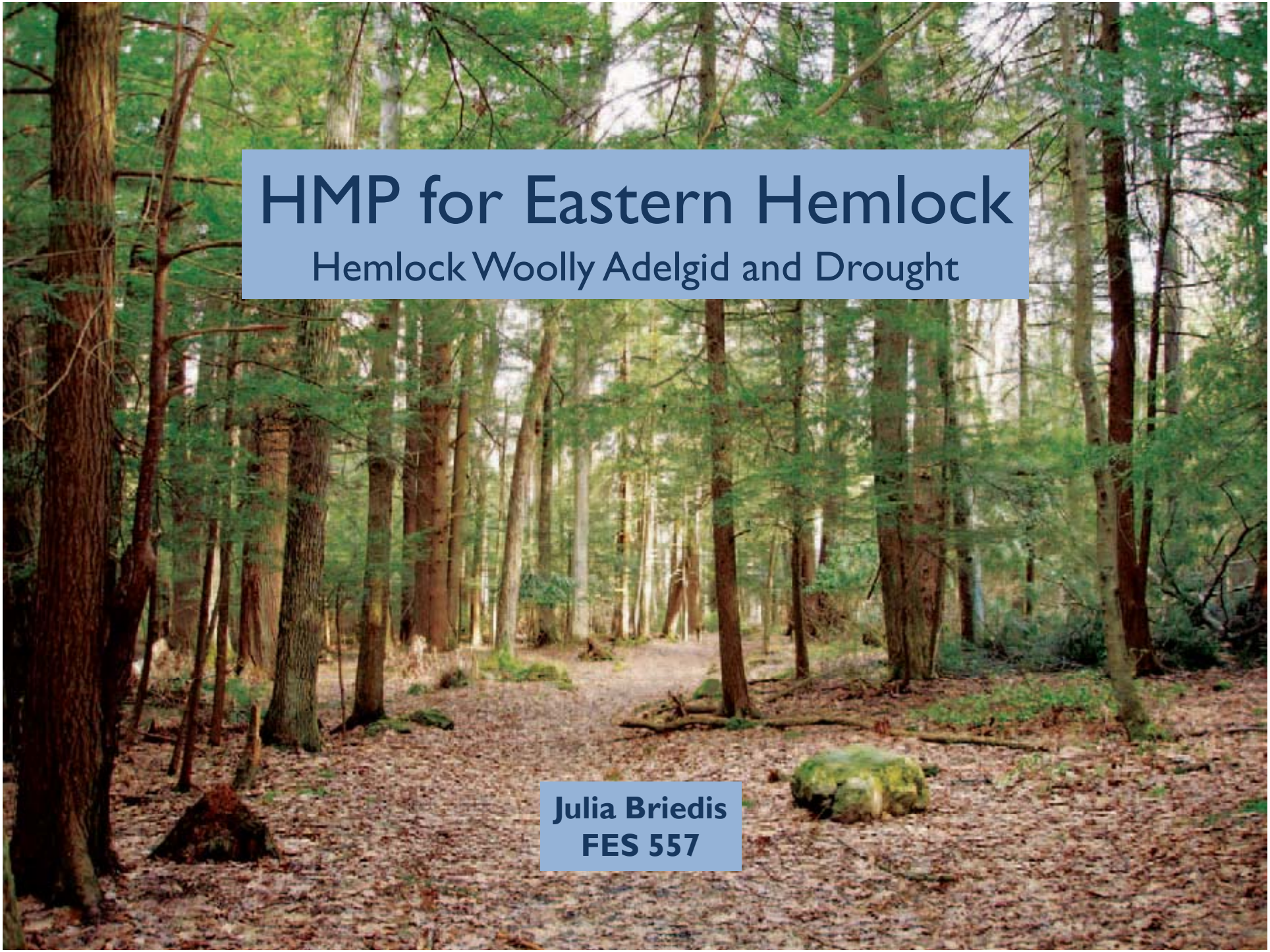


# HMP for Eastern Hemlock

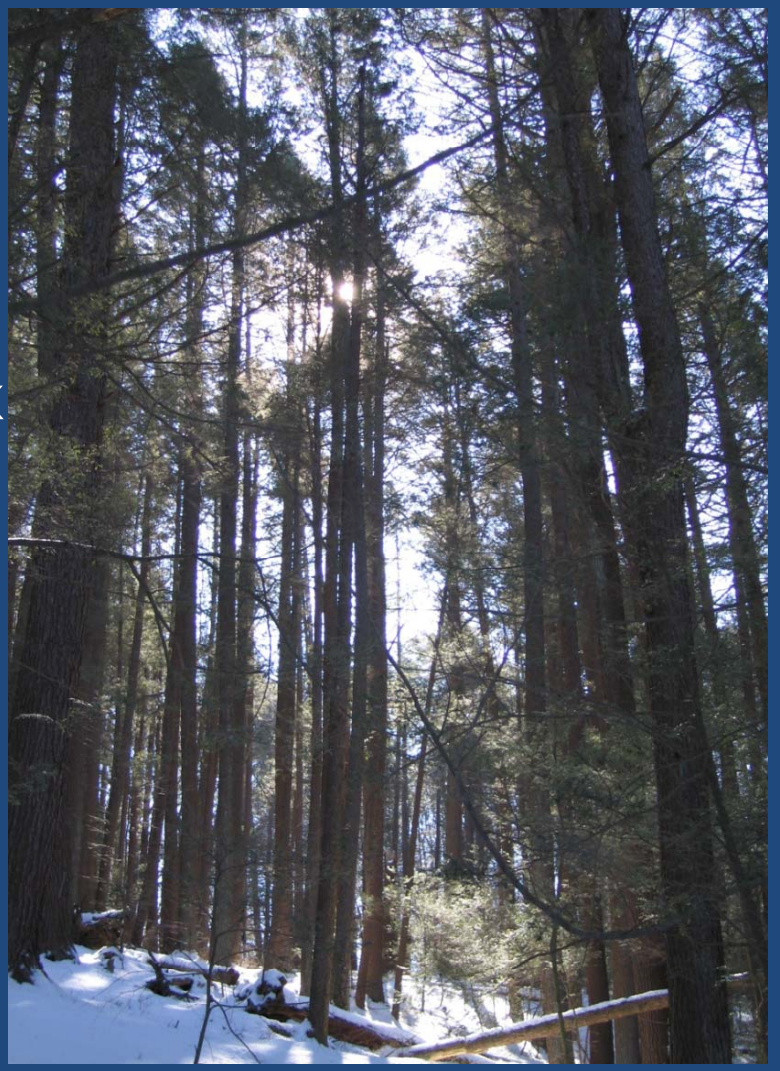
## Hemlock Woolly Adelgid and Drought

**Julia Briedis**
**FES 557**

# Overview

- Introduction
- Eastern Hemlock Adaptations
- Hemlock Woolly Adelgid Complex
- Drought Disease Complex
- Health Management Plan

  Recommendations
- Conclusions



# Introduction

- Hemlock is an ecologically important species
- Provides habitat for many plants and animals
- Low value as timber products
- Hemlock woolly adelgid (HWA) is threatening hemlock's survival
- Drought conditions could hasten its decline

# Eastern Hemlock Adaptations

*Tsuga canadensis*

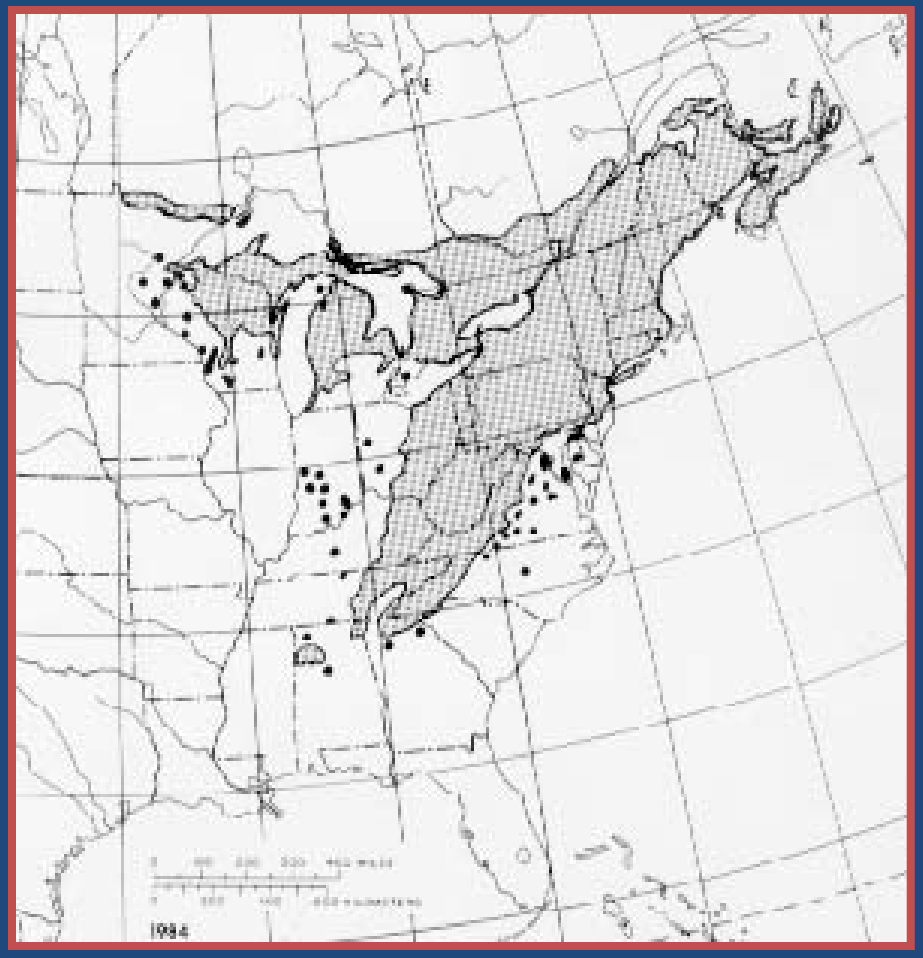
- Long lived species
  - up to 800 years
- Diameter up to 40 in.
- Height up to100+ ft.
- Very shade tolerant

Associated Stand Types

- Pure dense hemlock stands
- Dominant species component (white pine-hemlock, hemlock-yellow birch)
- Scattered throughout other forest types

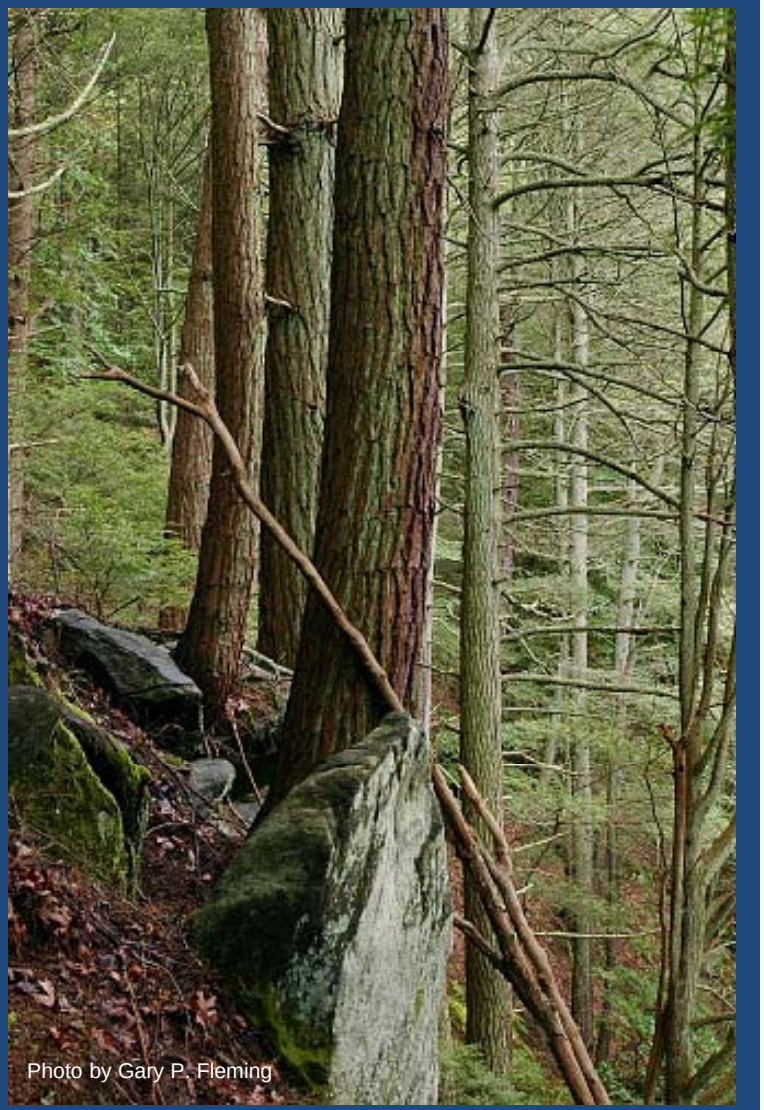
# Geographic Range

- Canadian Maritimes, west to lake states, south along the Appalachian range to northern Georgia and Alabama
- Cool and humid climate
- Adequate precipitation, 29 – 50 inches annually



# More Adaptations

- Well drained soils able to retain moisture
- In northeast: shallow loams and slit loams
- Preferred sites are benches, flats, and swamp edges, and northern and eastern facing slopes
- Can grow on variety of sites
- Shallow root system



# Importance to Ecosystem

- Regulate stream flow and water temperature
- Winter habitat for deer, moose, porcupine, snowshoe hare, small rodents

Karen Felton, USDA Forest Service

- 90 species of birds
  - Black-throated green warbler
  - Acadian flycatcher


©Mike Hopiak, Cornell Laboratory of Ornithology

# Hemlock Woolly Adelgid Disease Complex

# Hemlock Woolly Adelgid

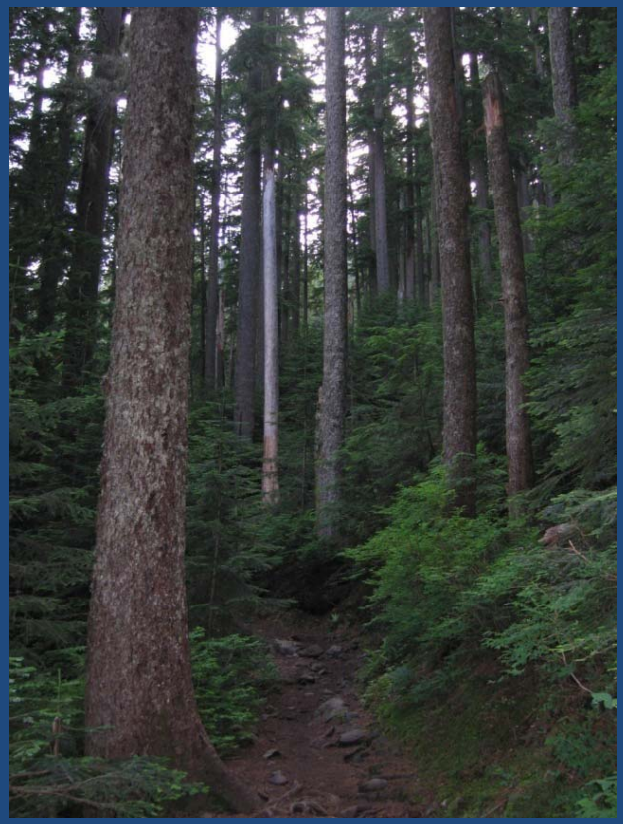
## *Adelges tsugae*

- Homoptera order of insects
- <1.5 mm long (1/16$^{th}$ inch)
- Covers itself with wool-like wax filaments to protect from desiccation
- Native to Japan and China


Mike Montgomery, USDA Forest Service

# Complex Components

## Hemlock



Susceptible species

- Eastern Hemlock and Carolina Hemlock (*Tsuga caroliniana*)


Resistant

- Mountain hemlock (*Tsuga mertensiana*) and western hemlock (*Tsuga heterophylla*)

# Symptoms

- Crown turns greenish-gray
- Needles fall off and branch tips dieback
- Low needle density and high crown transparency



- Reduction in apical bud formation and new shoot growth
- Several years before symptoms show

# Impacts to Tree

Tissues affected

- Xylem ray parenchyma cells

Tree functions affected

- Reduced growth
- Tree dies within 4-15 years


Photo by Steven Baskauf

Landscape scale effects

- Elimination of hemlock
- Replaced by black birch (*Betula lenta*)
- Maple, oak, and WP likely replace in northern NE

# Signs

- White woolly masses on underside of hemlock needles
- Between October and mid July

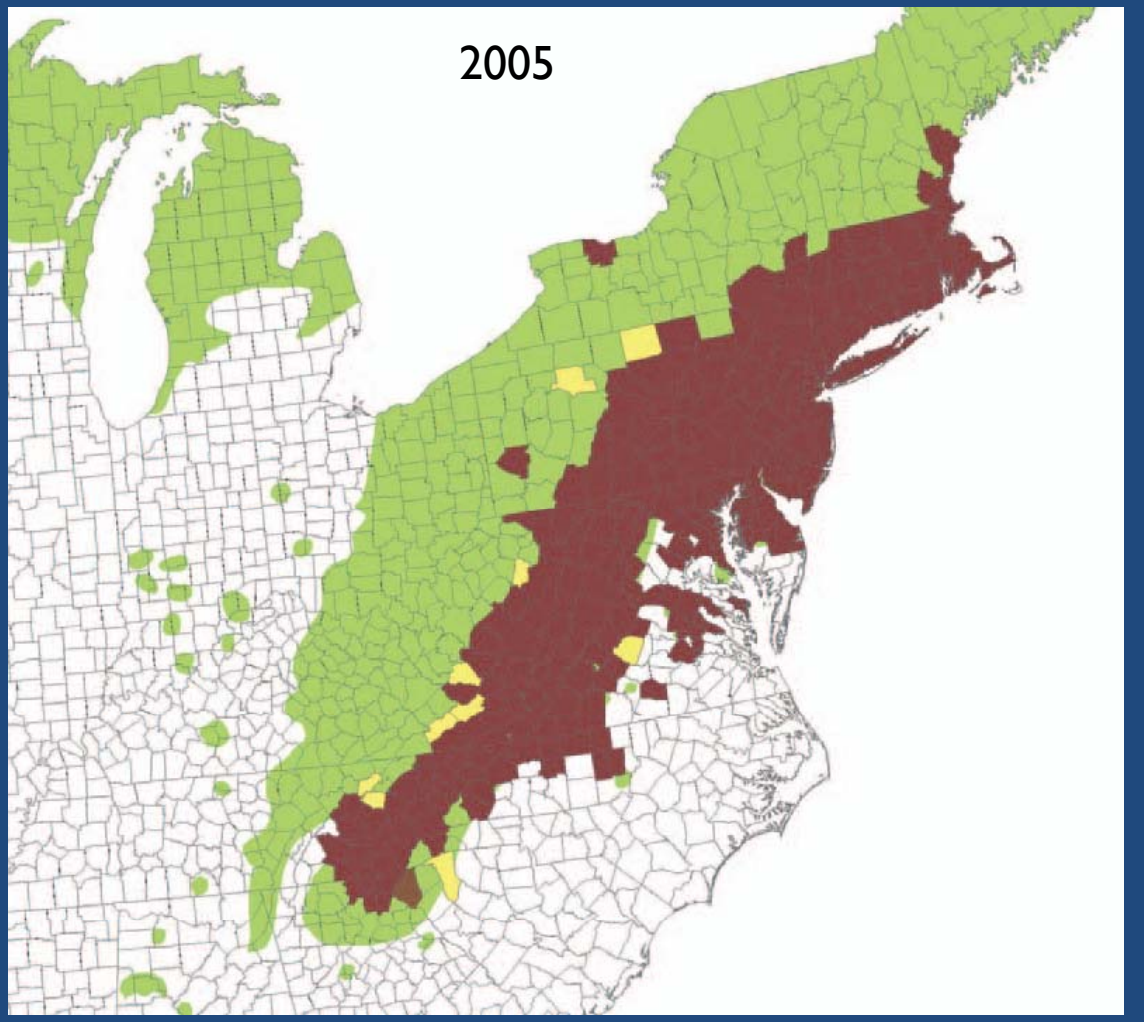
Mike Montgomery, USDA Forest Service

Mike Montgomery, Forest Service

- Dormant during the summer months, difficult to see

# Environment

- 1950's first discovered in eastern US in Richmond, VA
- Now it is found in 16 states from Maine to Georgia
- Spreads 10-20 mi per year
- Tolerates temps down to -20 deg. F

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# Predisposing Factors

## Degree of Tree Adaptations to HWA

- Eastern hemlock has not evolved with HWA, so it lacks the resistance
- No natural predators, and highly susceptible hemlocks
- All sizes and all ages of hemlock are susceptible to infestation
- Youngest shoots are preferred, but will eat any available
- Both healthy and weakened trees are susceptible

# Predisposing Factors
## Hemlock Woolly Adelgid Life Cycle

- Two generations each year, both parthenogenetic

  Sistens
  - Winter generation
  - 8-9 months out of the year

  Progrediens (no wings) and sexuparae (winged)
  - Spring generation
  - 3-4 months of the year

# HWA Life Cycle

Summer dormancy (July to October)

Sistens nymphs emerge and find settling place (July)

Progrediens stay on host to produce ovisacs with ~ 20-75 eggs (June and July)

Sexuparae disperse from host looking for spruce, die with no offspring

Adults (June)

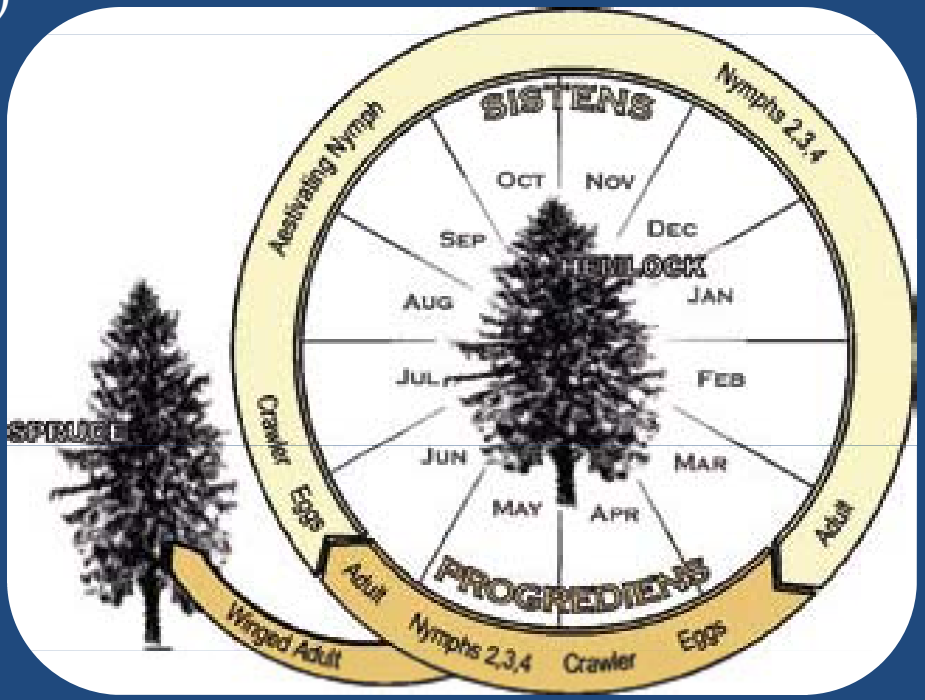
Instars (May)

Nymphs emerge, search for site, begin feeding (April)

Adult sistens produce ovisac with ~300 eggs (February to March)

Nymphs feed and Develop through instar stages (October to February)

Cool temperatures, Break dormancy (October)



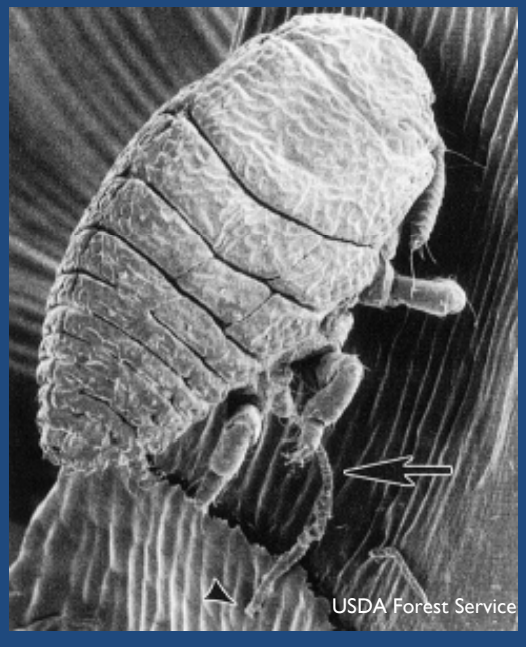
# Life Stages

## Eggs


Mike Montgomery, USDA Forest Service

## Nymphs

Carol Cheah, Conn. Agricultural Experimental Station




## Adult

Mike Montgomery, USDA Forest Service

Feeding nymph using long stylet bundle

# Vectors of Dispersal

- Wind
  - small hairs covering the crawlers
  - disperse up to 1350 m
  - strong spring winds coincide with progredien nymph life stage
- Birds
- Mammals
- Humans

USDA Forest Service

# Predation

- Native predators: some flies and lacewings
  - do little to control populations of HWA


- Active during winter when few generalist predators

# Virulent Pathogen

- Two generations each year
- Parthenogenetic adults
- Lay up to 300 eggs per adult
- Lack of natural predators of any consequence
- Tolerates large range of temperatures
- Many vectors, so it can travel far

# Inciting Factor

- Introduction of HWA into an area

# Contributing Factors

- Drought
- Elongate Hemlock scale (*Fiorinia externa*)

Penn. Dept. of Cons. And Natural Res.


Photo by Eric R. Day

- Hemlock borer (*Melanophila fulvogutta*)

Brad Onken, USDA Forest Service

# Control Options

## Chemical Control

- Horticultural oil and insecticidal soap
- Imiacloprid – soil or stem injection
  - High value trees
  - Protection areas


Great Smokey Mountains National Park Resource Management Archive


Richard Turcotte, USDA Forest Service

USDA Forest Service

# Control Options

Silvicultural Control

- Thinning ahead of leading edge (no more than 1/3rd of stand)
- Best to thin out intermediate and overtopped
- Salvage options
  - partial or intensive

Legal Control

- Quarantines

# Control Options

## Biological Control

- *Laricobius nigrinus* (Lari beetle)
- *Sasajiscymnus tsugae* (lady beetle)
  - feed on all life stages of HWA
  - feed exclusively on adelgids
- *Scymnus sinuanodulus* (Scymnus beetle)

Lynn Jones, USDA Forest Service

Lynn Jones, USDA Forest Service

# Drought Disease Complex

# Complex Components
## Hemlock

Symptoms

- Narrow growth rings the year following water stress
- Root tips first to die
- Foliar loss

Impaired plant functions

- Stomata close causing reduction in photosynthesis
- Root loss weakens tree

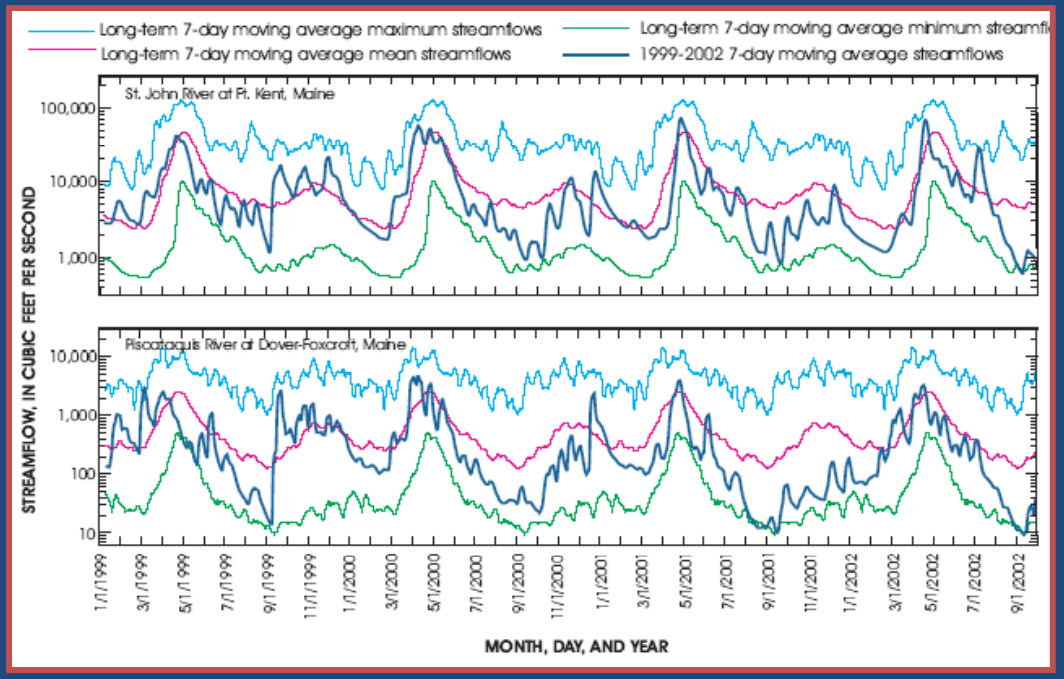
# Complex Components

## Drought

Signs

- Low streamflow rates
- Low precipitation

Southern Maine, August 2001

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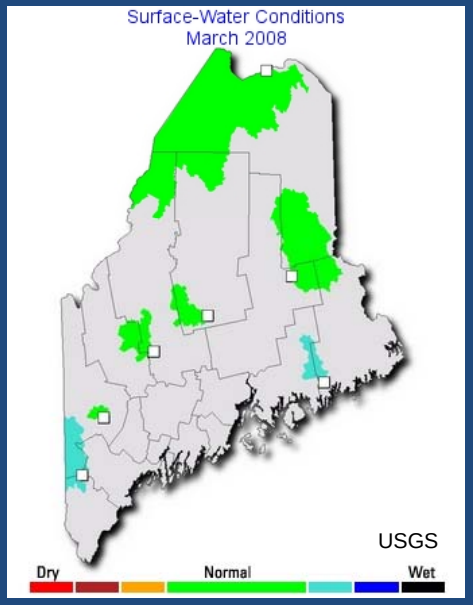


# Environment

- Southern and western slopes
- Ridges
- Shallow soil layer

NH Division of Forests and Land

# Predisposing Factors

- Shallow rooting system
  - Top layer of soil dries quickest
  - Seedlings are most affected because of smaller root system
  - Well established hemlocks can better survive water stress
- Dense stands
  - Competition for water

# Inciting Factors

- Dry, hot summer weather
- Only initiates disease in seedlings
- Drought merely predispose mature trees to other inciting factors

# Contributing Factors

- Other insect pests
- Drought contributing to HWA

# Control Options

- Water ornamental hemlocks
- Silviculturally thin
- Management hemlocks on sites to which they are best adapted
- If planting hemlocks, plant on well drained soils, in partial shade

# Health Management Plan Recommendations

# Pre-emptive Measures

- Most effective on sites where hemlock are well adapted

- Thin hemlock stands of the least vigorous trees
  - Won't stop HWA, but it slows the rate of mortality

- Avoid timber harvests in infested areas during early spring and mid summer

# Monitor and Survey

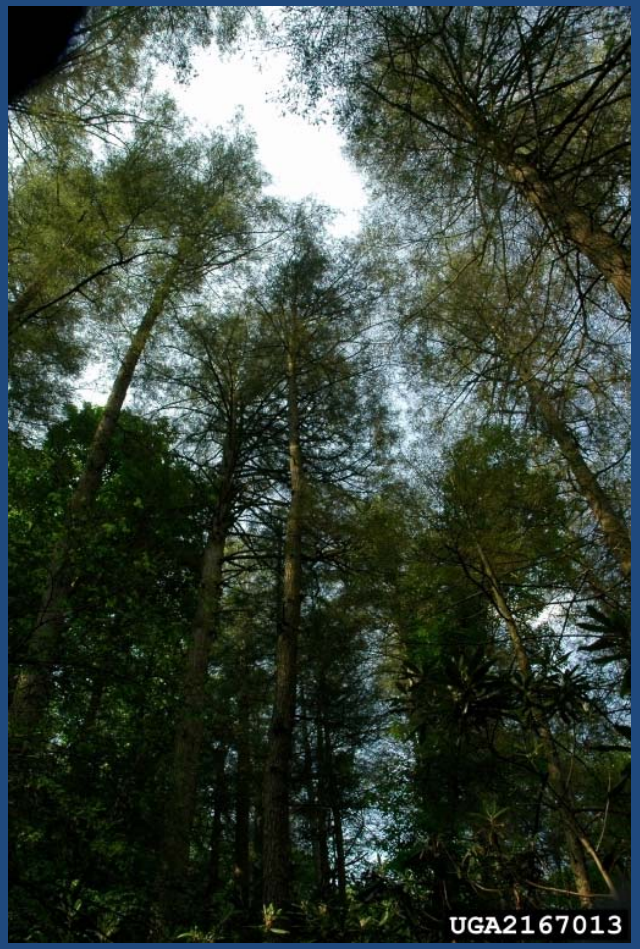
- Early detection is important
- Monitor annually
- Signs are easy to detect
  - White woolly masses (October to mid-July)
  - 10-25 trees and 2-4 branches per tree

Carol Cheah, Conn. Agricultural Experimental Station


USDA Forest Service

# Monitor and Survey

- Symptoms appear a few years after initial infection




William Ceisla, Forest Health Management International

- Good indication of tree/stand health
- Look at crown health
  (defoliation, crown transparency, lateral shoot growth)
- At 60% crown transparency, tree can't recover

# Reactive Measures

- Prioritize the stands receiving treatment
    - Treat sites not predisposed to drought
- Biological controls will likely be most effective
    - In developmental phase
    - Have been shown to reduce HWA populations
    - Most effective on trees infected within last 5 years
- Chemical treatments
    - Best when used in eradication efforts on the leading edge
    - Must be reapplied every two years

# Reactive Measures

- Minimally infested stands can be thinned
  - Remove the most infested trees
  - Increase vigor of remaining trees
- Prune
  - Remove infected branches
- Heavily infested stands can be salvaged

# Feasibility

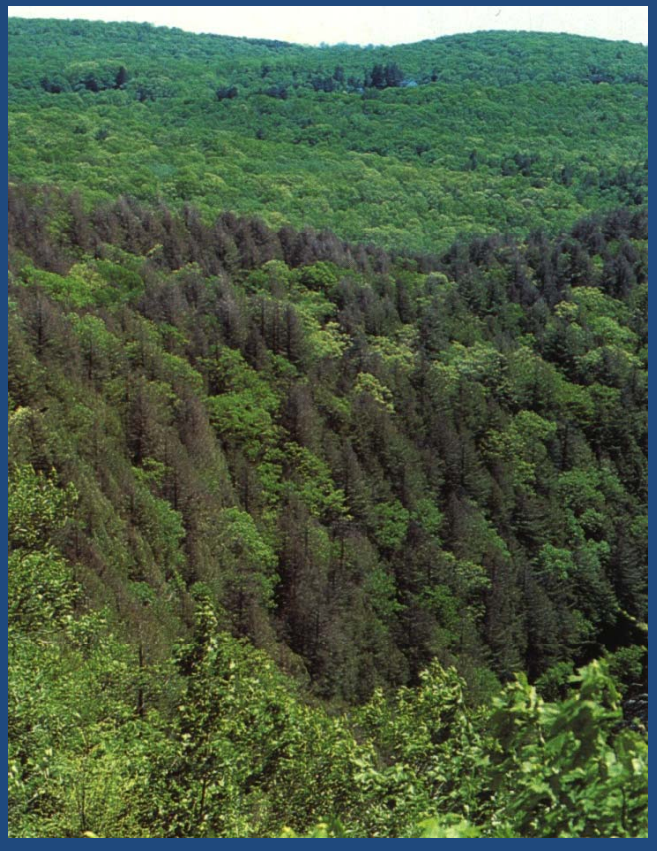
- Biological controls are the most promising
  - self perpetuating so little cost

- Silvicultural and chemical control options will depend on cost vs. benefit of the treatment

- Quarantines are important

# Conclusion

- Hemlock is an ecologically important species
- HWA is threatening survival of many stands in the eastern US
- Monitoring for signs and symptoms is crucial
- Biological controls are the best hope for the elimination of HWA infestations



# Questions?