Hemlock Woolly Adelgid and its Impacts on Forest Ecosystems

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Imported forest pests are the most pressing & under-appreciated forest health issue in US today. The only threat that can decimate species in just decades. Cost billions annually

Winter Moth, Martha’s Vineyard, MA

Hemlock woolly adelgid-southern CT
Invasive pests and pathogens

Pre-1850: a dozen or so insects damaging trees

Post 1850: > 400 – virtually all insect orders

Important component of global change - > $ 4 Billion annually

2.5/yr

Damaging one every 2-3 years
Pests and pathogens arrive in a variety of ways:

1) nursery related materials (plants, seeds)

2) pallets, crates, packing material

3) Lumber

Trade volume leads to new introductions
Pathways

90% of recent wood-boring insects arrived in the US via solid wood packaging
- (also spools, dunnage)
  - *ALB, EAB*

70% of all damaging forest pests arrived in the US via imported plants
- Now > 3 billion/yr
  - *Chestnut blight, BBD, HWA*
All states have many imported forest pests

Why do some states have such high numbers?
Overview of HWA
Impacts on Stand structure
Landscape patterns HWA + EHS
Management options
Hemlock is important for:

Old-growth forests

CWD to upland and streams

Moderation of stream temps

important for trout
Hemlock provides valuable habitat for a variety of wildlife species.

Ward et al. 2004

Hemlock regeneration is limited by deer browsing.
Hemlock woolly adelgid (*Adelges tsugae*)

- 2 generations /year
- Parthenogenetic
- Rapid dispersal
- Feed and kill all sizes and ages
- Hemlock resistance?
- No effective native predators
HWA life cycle in E. North America (USDA)
Recent work shows egg laying as early as Dec/Jan!!

Still seeing adults 2019

HWA life cycle in E. North America (USDA)
Adelges tsugae documented on all 9 hemlocks worldwide
Recent genetics: from So. and low elevations in Japan
Serious pest only in Eastern U.S.
Harvard Forest HWA studies include:

1) Stand and community analyses

2) Landscape investigations of hemlock structure and HWA infestation patterns

3) Ecosystem analyses of HWA infestations including n cycling, decomp, throughfall chemistry

4) Comparisons of HWA vs. Hemlock Logging

5) Wildlife studies

6) Hydrological Investigations

7) HWA dispersal

Figure 1. HWA space-for-time study area, representing 7500 km². Hemlock represents >86,000 ha or 21% of the mapped area in MA (up to 36% in northern MA), and 16,500 ha or ~5% of the mapped area of CT.
Overstory mortality trends, high in many, but not all stands
Crowns continue to deteriorate, with no sign of recovery
Continuous feeding leads to progressive needle loss, interior branches
However, at some sites, decline is slower (cold temps.?)
Variability in winter temps important (esp. cold following warm)
Rapid birch establishment
Occurs with canopy thinning
Invasives and ferns can also increase tremendously
White pine establishing
In dry site in CT
Trees remain standing for 5-8 years; branches, then tops fall off; then boles.
Birch forms the new forest
What will replace hemlock in Massachusetts?

Secondary Species # of Occurrences in 123 Hemlock Stands

<table>
<thead>
<tr>
<th>Species</th>
<th>Trees</th>
<th>Saplings</th>
<th>Seedlings</th>
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<tbody>
<tr>
<td>White Pine</td>
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<td>Black Birch</td>
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<td>Red Maple</td>
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<td>Red Oak</td>
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LANDSCAPE PATTERNS

CT: 114 stands
MA: 123 stands

HWA found within a few km of Vermont (2004)!
[now 1/3 way up VT & NH]

Latitudinal pattern present
But damage not as rapid

Only 2 stands > 50%
Overstory mortality in MA
HWA change in abundance over time

S. Gómez et al. 2015
Northern Massachusetts Sites with major infestation- 2013

Along Swift River, Petersham MA

Bernardston, MA
Harvard Forest 2016
Overstory and understory thinning

7 years after initial infestation
Distribution of 116,226 stems (live and dead > 1cm dbh)
Eastern hemlock (green) and all other species

Resampling this plot has begun this summer
In this region ~ 20% Hemlocks now dead

Orwig et al. 2018

Figures courtesy of Peter Boucher
2018-2019: widespread decline in HWA populations: still investigating
So, what can be done?

Imidacloprid (Merit) pesticide of choice:

Tree I.V.
Kioritz soil injection
Soil drench
Stem injection—important near streams
CoreTect time-release tablet
often provides 2 to 4+ years protection
Soil application widely used

There is also a time-release tablet

*Safari* (Dinotefuran) Fast-acting systemic, spring applications
Effective, not persistent, often used first, then Merit

*There will be other casualties!*
Biological Controls

From Japan, over 1.5 million have been released in over 100 sites in 15 Eastern sites including MA

Native to British Columbia, over 7000 adults have been released at 19 sites in 8 eastern states-recovery 2 years later

Others being evaluated:
- Scymnus sinuanodulus
- Tetraphleps galchanoides
- Pathogenic fungi
- Uncertain success, impact
So, how can we incorporate the study of invasive species into a school curriculum?

what can students do to add to this body of work?
Student research can provide:

year by year assessments of HWA densities

year to year branch growth, related to HWA

important data at the northern extent of HWA range

new discoveries of HWA at their homes, schools, towns
Katherine Bennett’s 5th Grade class

Measuring snow depth
A co-occurring pest on the rise! Students can also contribute here

Elongate Hemlock Scale (EHS; *Fiorinia externa*)

Also from Japan, introduced in NYC in 1908

Now located in 14 eastern states, range overlaps with HWA

Often co-occur with HWA on same tree: uncertain consequences
Woolly Bully Protocol revolves around 2 measurements:

1) Measurement of new branch growth in early Autumn
Core measurements:

Spring counts of HWA egg sacs along outer 10 cm

HF provides data sheets, protocols