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How Can We Inform Future Management for HWA Infested Hemlock Trees?

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BACKGROUND:

As Climate Change continues to increase global temperatures, invasive pests continue to arise and become more virulent. Hemlock Woolly Adelgid (HWA, *Adelges tsugae)* is an invasive pest that feeds on the sap of Hemlock trees at the base of their needles, causing them to fall off; posing a serious threat to Eastern Hemlocks (*Tsuga canadensis)*. First introduced from Japan in 1951 by imported, infected Hemlock trees, HWA has, and continues to kill masses of native trees in the Eastern U.S.. HWA is limited by cold temperatures, but warming winters in the Eastern US have allowed this pest to reach high densities. Our field research was conducted at Harvard Forest in Petersham, MA where the plots we worked in were infested between 2012-2015.

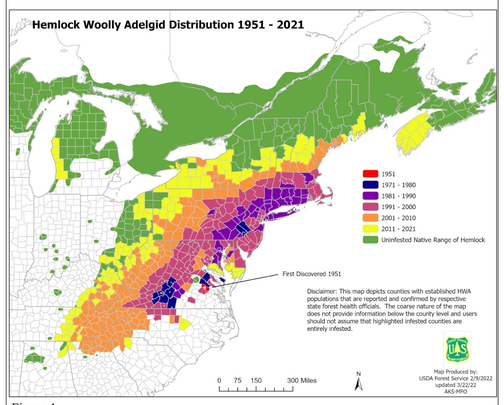


Figure 1

Photo taken by Amber Madeiras

The white on the base of the needles is HWA eggs laid in the winter. It is an indication of the presence of HWA.

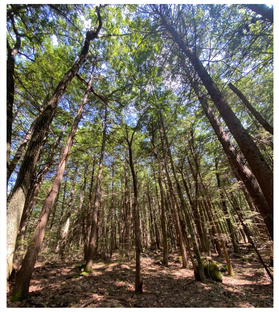
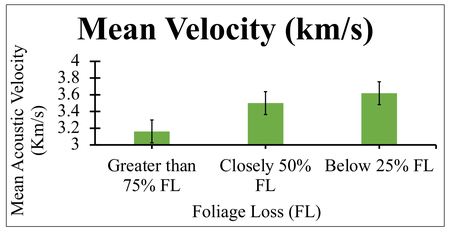
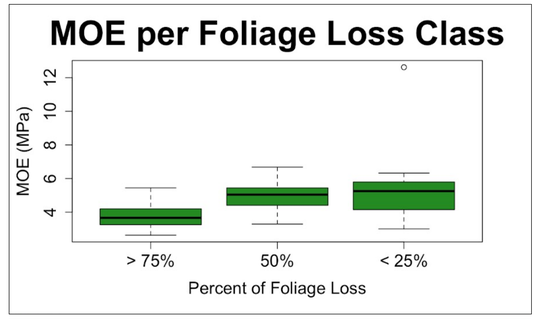


Photo taken by Amber Madeiras

Inside the Megaplot at Harvard Forest, Petersham, MA

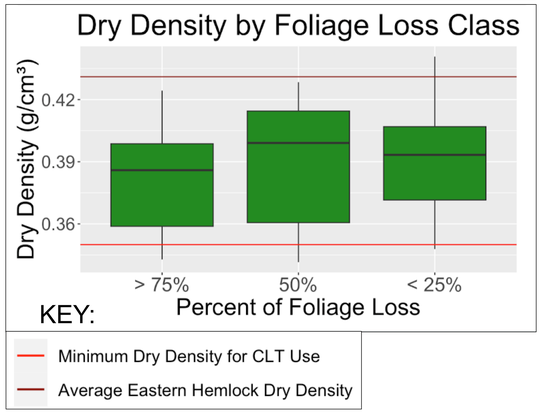
RESULTS:





Both Velocity Means, and MOE Means increase with Percent of Foliage.

MOE = Modulus of Elasticity
- Measure of wood stiffness.
MOE= Dry Density x Velocity²



Statistical Analysis – Tukey Test Results:

	Velocity:		Dry Density:		MOE:	
Foliage Loss	diff	p-value	diff	p-value	diff	p-value
> 75%-< 25%	28.031	**1.01E-05**	1.13E-02	0.725	1.463	**4.70E-06**
50%-< 25%	5.657	0.641	2.63E-03	0.983	0.281	0.653
50%-> 75%	-22.374	**9.20E-04**	8.69E-03	0.783	1.182	**5.70E-04**

METHODS:

We sampled 90 Eastern Hemlock trees categorized by 3 different Foliage Loss (FL) classes: <25%, ~50%, and >75% by visually assessing each crown. We used 3 different Non-destructive technologies to collect our data, and also measured DBH.

Photo taken by Taylor Lucey

Amber using FAKOPP Acoutsitc Tehcnology, longitudinal method.

Photo taken by Amber Madeiras

Taylor Lucey using Resistograph.

- Moisture content (MC%) were estimated using incremental cores from the equation $MC = \frac{Green\ weight - Oven\_dry\ weight}{Oven\_dry\ weight}\ x\ 100\ \%$
- The density (ρ) of trees were estimated from the cores samples where the mass was taken at wet weight (w) and height (h). Treating the core as a cylinder. The volume (v) estimated as $v = \pi\left(\frac{d}{2}\right)^2 h$ where d is the diameter of the core. Density = $\frac{mass}{volume} = \frac{w}{\pi\left(\frac{d}{2}\right)^2 h}$
- The acoustic tool Fakopp 1D Microsecond Timer (Fakopp Enterprise, Agfalva, Hungary) was used to measure stress wave velocity based on the time of flight (TOF) technique where a vertically spaced 1.4 meter apart probe, inserted into the sapwood of each study tree at a 45-degree angle pointed towards each other in transverse.
- MOE was estimated from the acoustic velocity results though the following equations $V = \sqrt{\frac{MOE}{\rho}}$ where $MOE = E_L = V^2 \times \rho$
- A Resistograph technology were used by drilling a small needle through the stem of 10 trees per FL.
- The outputs of the resistograph were useful for a comparative qualitative analysis for determining the levels of internal decay.

OBJECTIVES/ HYPOTHESIS:

- Assess the effects of HWA on internal wood quality.
- Determine if low-grade HWA-infested trees could be used for engineered products such as Cross-Laminated Timber (CLT).
- Provide the application and use of Non-destructive tools in evaluating timber quality.
- Is there a significant difference between wood quality and foliage loss?
- Can Hemlocks with a high amount of foliage loss still be used for CLT?
- Would it be useful to harvest infested/ decaying Hemlock wood for product use?

CONCLUSIONS:

When running statistical analysis tests on each data set, we found that there was no significant difference between the < 25% and 50% FL classes for Velocity, Dry Density, and MOE, but we did find significant differences between the > 75% class and the other two FL classes for Velocity and MOE. This result indicates that at high levels of foliage loss, an indicator of the level of infestation, the wood quality begins to deteriorate but not below currently published estimates of densities acceptable for CLT. Of our sampling techniques, we found that the Fakopp Acoustic Tool was most reliable and had the least amount of variability, whereas the data produced from the core samples was more variable by FL class. The Resistograph outputs did not produce reliable results and could not be used quantitatively.

LIMITATIONS:

Since foliage loss was visually assessed based on the canopy during July of this year, the classes may vary by both user and year and my not precisely capture the long-term impacts of the HWA infestation. In addition, there were minimal healthy Hemlock trees at Harvard Forest that had less than 25% foliage loss, and therefore our groups were uneven- 37 in >75%, 2 in ~50%, and 29 in <25%. Hemlock wood is also highly susceptible to ring shake, knots, and other defects in their wood which has a variable impact on density. While we plan to investigate these relationships in the future, here we have not included age of trees, moisture, microenvironments, etc. as additional factors impacting MOE and wood density.

Implications for the Future:

- Harvesting HWA infested Eastern Hemlocks (even with 8+ years of infestations) for CLT products.
- Foliage Loss as an indicator for internal wood quality.
- Acoustic Technology is a viable non-destructive sampling option for assessing internal decay of HWA infested trees.
- Using Dry Density data for finding carbon sequestration, and decay rates for HWA infested trees to better understand the effects of invasive pests on wood.

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