A GEOGRAPHIC OBJECT-BASED IMAGE ANALYSIS APPROACH TO EASTERN HEMLOCK MANAGEMENT

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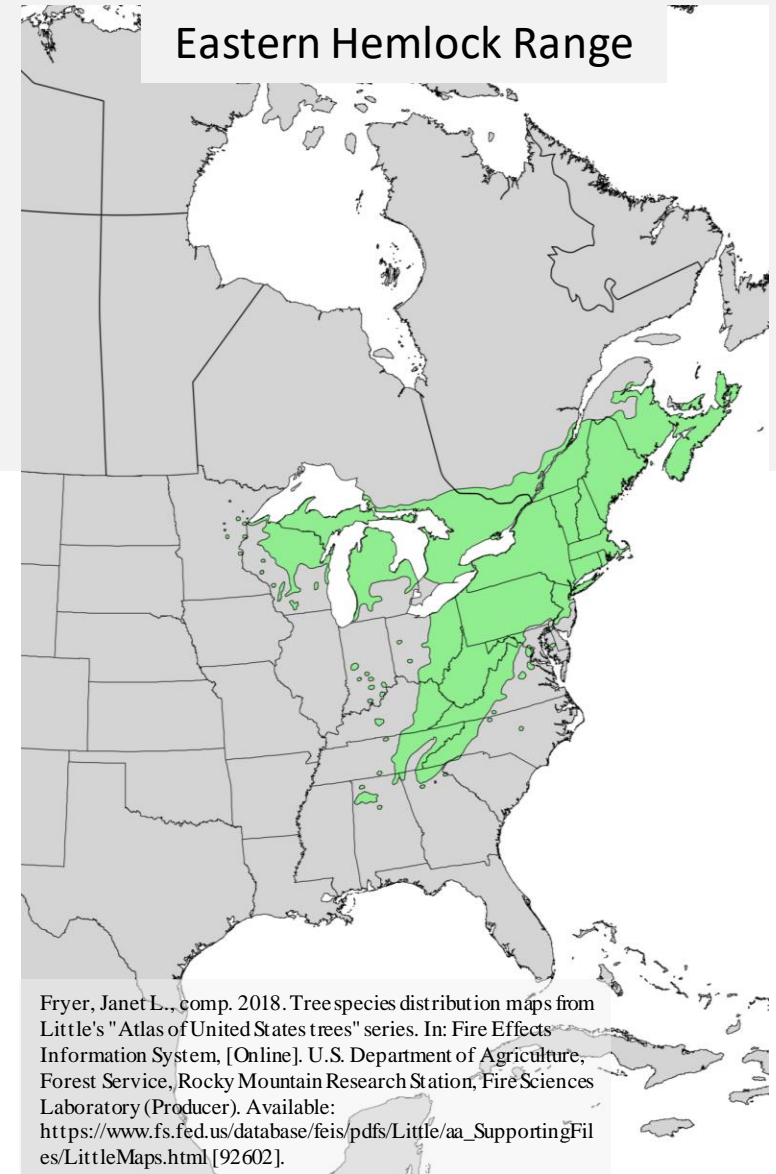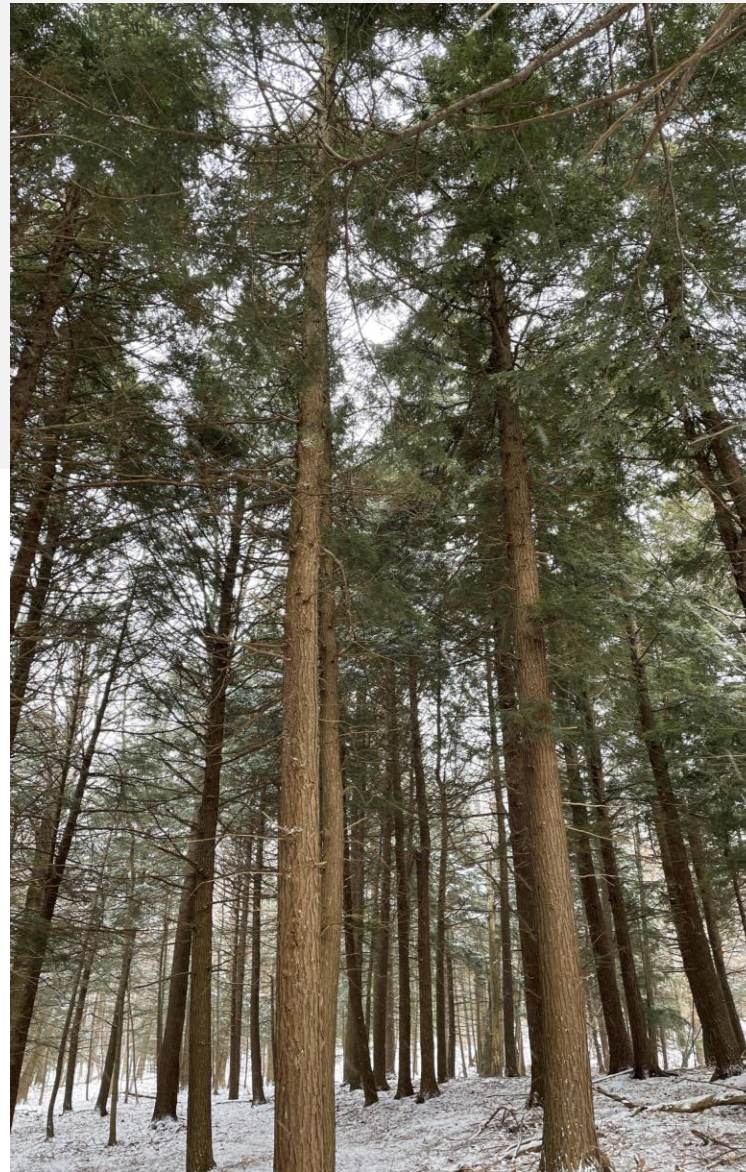
Overview

➢ Background
- Eastern Hemlock Trees
- Hemlock Woolly Adelgid

➢ Research Objectives

➢ Methodology
- Study Area
- Data
- Software/Workflow
- Ruleset Demo

➢ Results/Reflection

➢ Q/A

Eastern Hemlock

➢ Coniferous tree species, holding needles year-round

➢ Range throughout the eastern United States

➢ Regarded as a foundational vegetation species.

- Influences forest structure and the surrounding ecosystem
- Cover & food for whitetail deer and various bird species
- Regulate stream temperatures through canopy shade
  - Vital for native trout species

Eastern Hemlock Range

Fryer, Janet L., comp. 2018. Tree species distribution maps from Little's "Atlas of United States trees" series. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us/database/feis/pdfs/Little/aa_SupportingFiles/LittleMaps.html [92602].
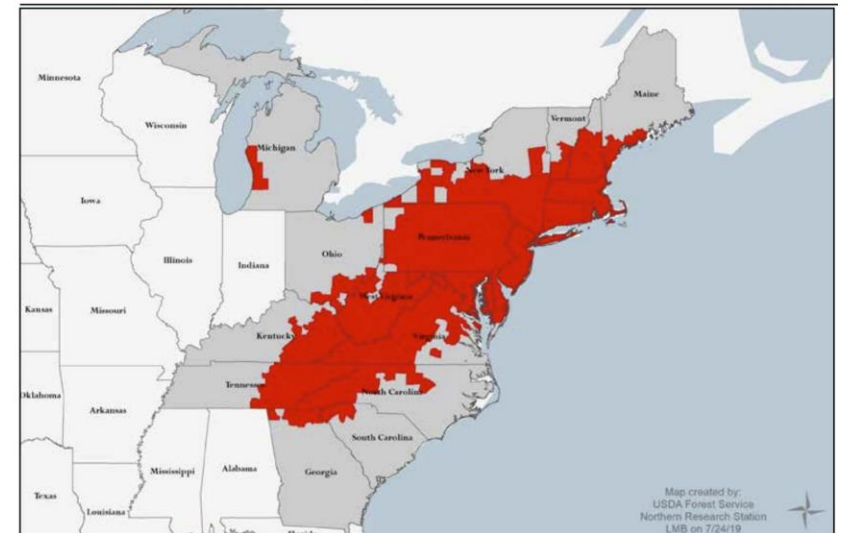
Hemlock Woolly Adelgid (HWA)

- Non-native invasive insect.
- Originated from Asia
  - Identified in 1950s within Eastern United States
- Feeds on eastern hemlock causing damage
  - Tree crown decline. Substantial needle loss.
  - Restricts water flow throughout plant system.
  - Mortality

Hemlock Woolly Adelgid
Adelges tsugae Annand

USDA Forest Service, Northern Research Station and Forest Health Protection. "Alien Forest Pest Explorer - species map." Database last updated 24 July 2019. https://www.nrs.fs.fed.us/tools/afpe/maps/ (11/29/2021).

Research Objectives

1. To determine the extent eastern hemlock trees could be identified through geographic object-based image analysis.

2. To assess hemlock health over time through vegetation indices.
   - NDVI and GNDVI

Study Area

➢ Shenandoah National Park

- • Northwestern Virginia
- • Approximately 200,000 acres
- • Home to eastern hemlock trees

➢ HWA discovered in 1988

- • Substantial decreases in hemlock stand health have been observed.

➢ Management techniques were initiated since the discovery of this pest, aiming to protect remaining individuals from HWA.

- • Monitoring efforts
- • Control techniques
  - • Chemically through soil injections.

➢ Firsthand experience indicates a need for a rapid assessment and identification tool.

- • Field work is resource intensive.
  - o Extensive time is needed to locate trees, assess their health, and treat them.

Project Study Areas

Secondary Study Area

Primary Study Area

Park Boundary   Study Area

Author: Jonathan Mikolin
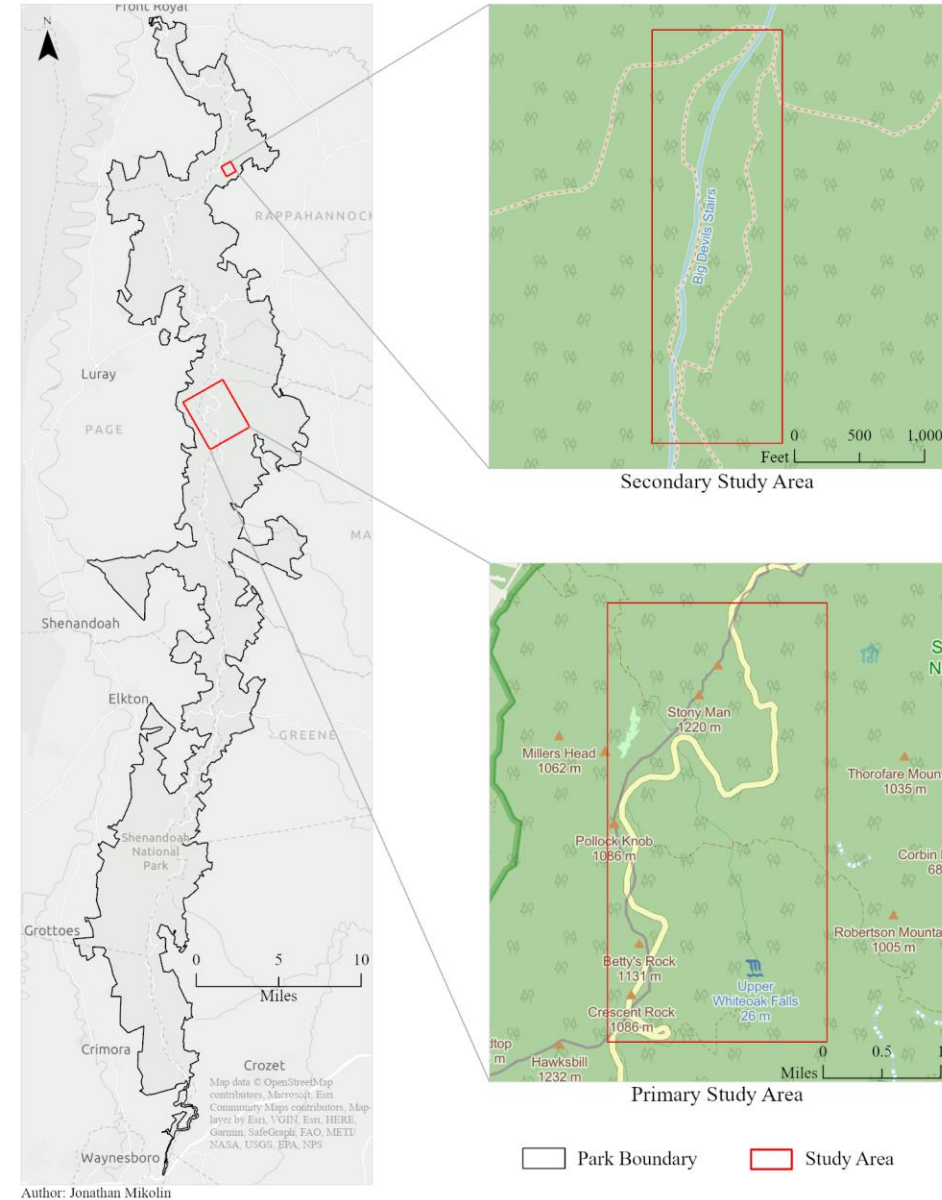
Data

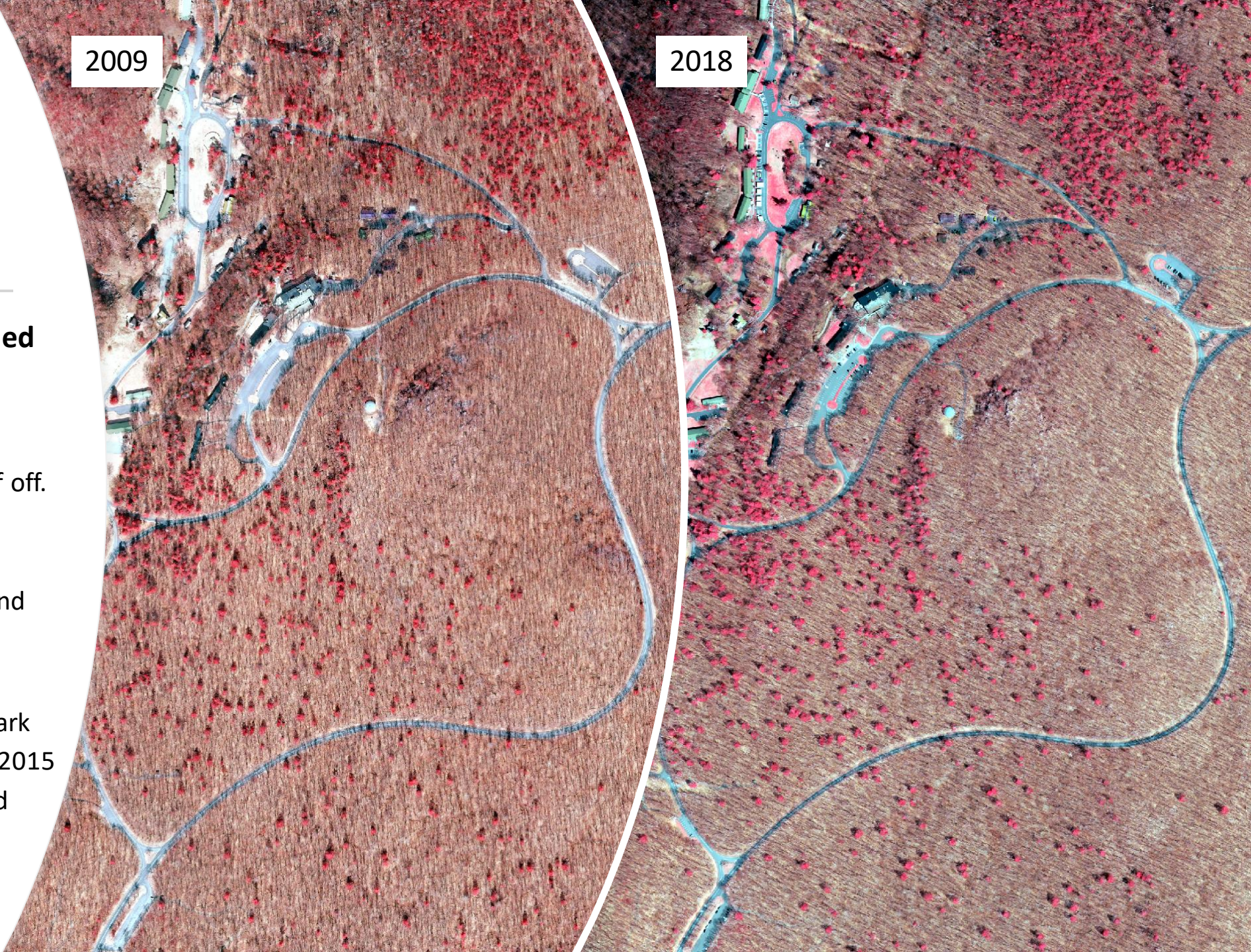**High Resolution Orthorectified Imagery**

- Virginia Geographic Information Network
- Taken in late winter, leaf off.
- 4-bands: R/G/B/NIR
- 1-foot spatial resolution
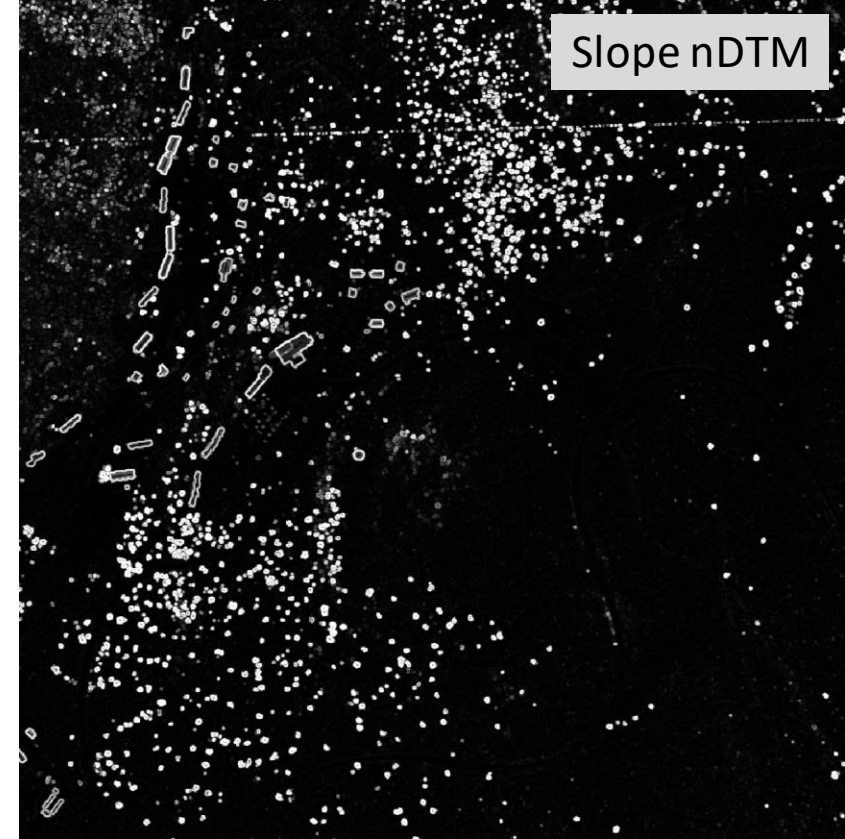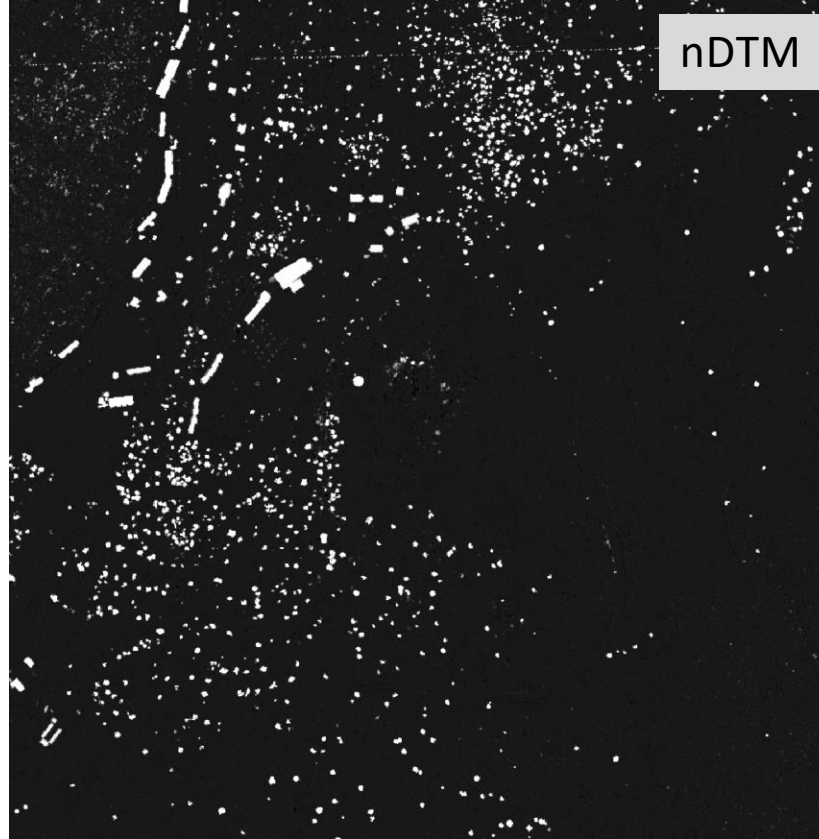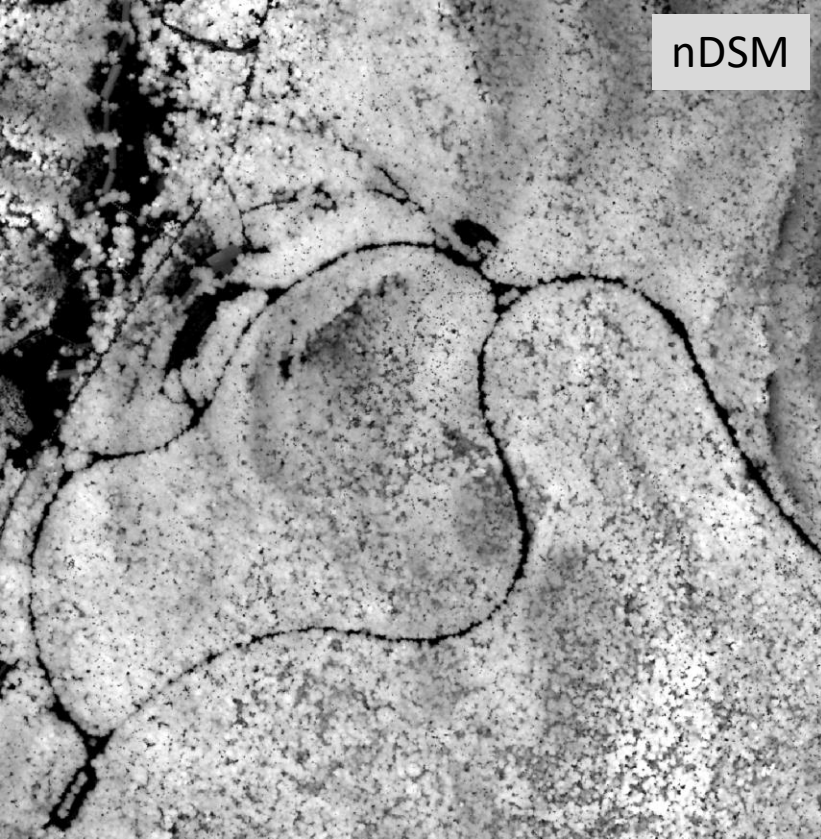- Basis for classification and health assessment

Ground Truth Waypoints

- Shenandoah National Park
- Collected from 2008 to 2015
- Represent live, managed hemlocks

nDSM

nDTM

Slope nDTM

Data

LiDAR Point Cloud, 2014

Key layers produced:
- nDSM -- first return, height of features above ground
- nDTM -- last return, height of lower sections of features
- Slope of nDTM -- defines edges
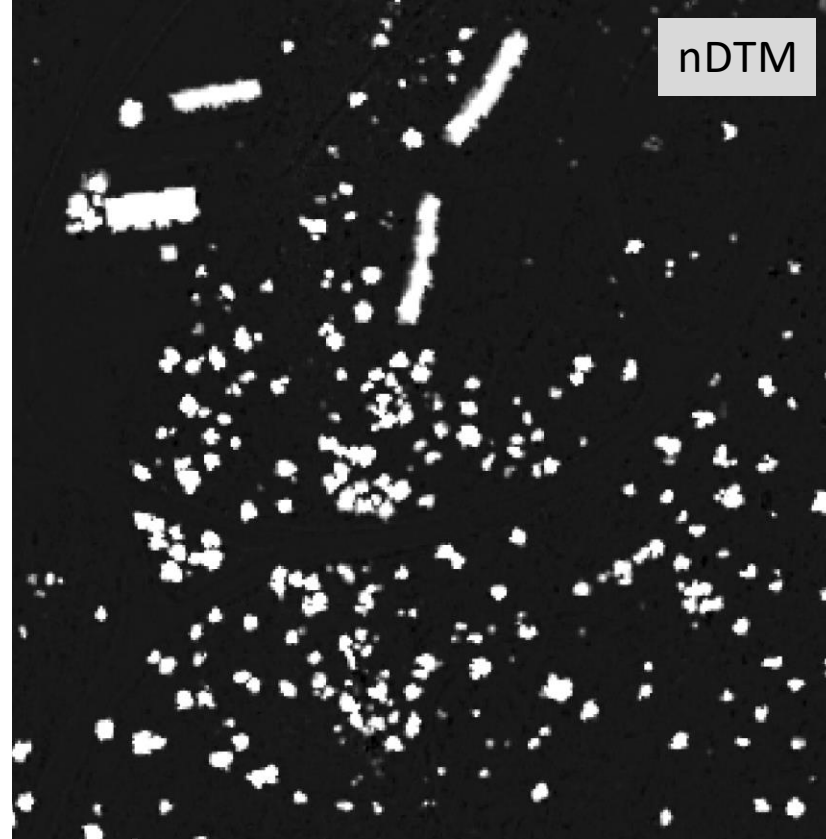 - Useful for discerning between vegetation types
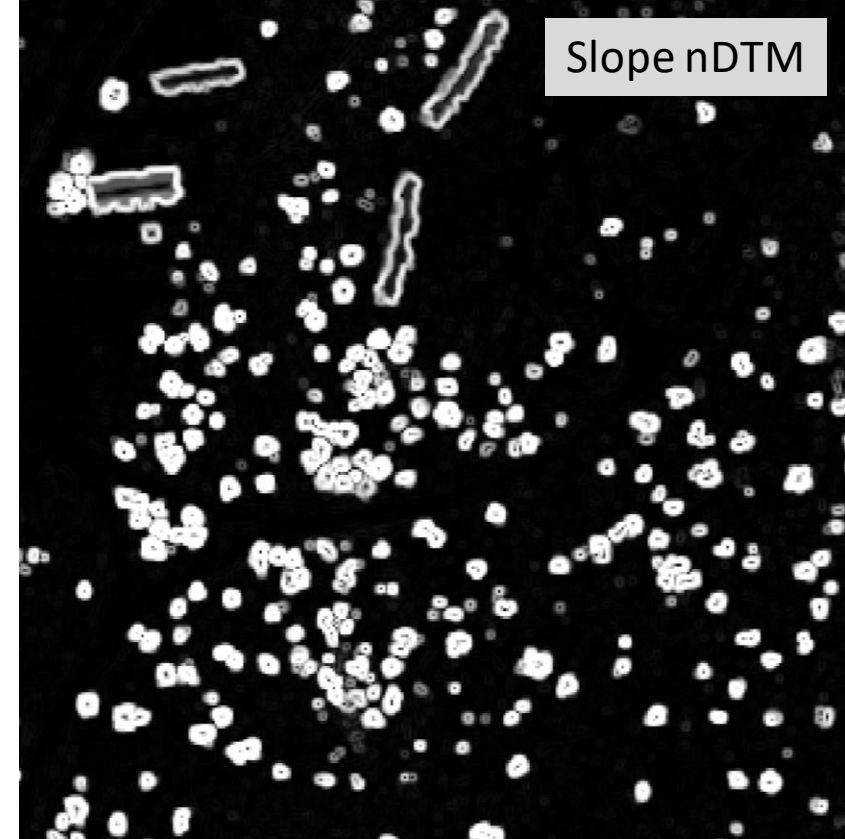
nDTM

Slope nDTM

Data

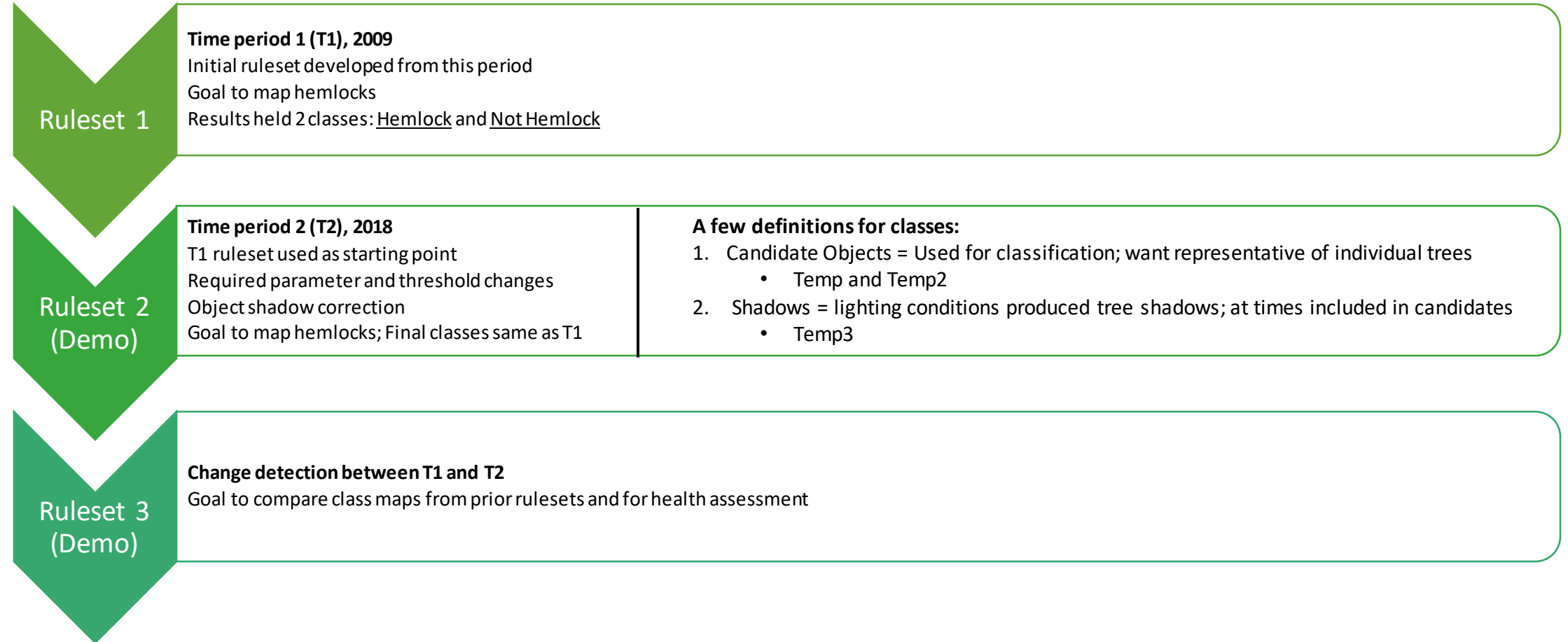## LiDAR Point Cloud, 2014

Key layers produced:
- nDSM -- first return, height of features above ground
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  - Useful for discerning between vegetation types

eCognition Workflow

Primary Study Area

Ruleset 1

Time period 1 (T1), 2009
Initial ruleset developed from this period
Goal to map hemlocks
Results held 2 classes: <u>Hemlock</u> and <u>Not Hemlock</u>

Ruleset 2 (Demo)

Time period 2 (T2), 2018
T1 ruleset used as starting point
Required parameter and threshold changes
Object shadow correction
Goal to map hemlocks; Final classes same as T1

A few definitions for classes:
1. Candidate Objects = Used for classification; want representative of individual trees
   - Temp and Temp2
2. Shadows = lighting conditions produced tree shadows; at times included in candidates
   - Temp3

Ruleset 3 (Demo)

Change detection between T1 and T2
Goal to compare class maps from prior rulesets and for health assessment

Demo

Results, 2009

Class	Hemlock	Not Hemlock	Total	User's Accuracy	Kappa
Hemlock	68	182	250	27.20%	0
Not Hemlock	4	246	250	98.40%	0
Total	72	428	500	0	0
Producer's Accuracy	94.44%	57.48%	0	62.80%	0
Kappa	0	0	0	0	0.256

➢ Overall accuracy: 62.8%
➢ High producer's accuracy for hemlock, but low user's accuracy.
➢ Captured a large amount of the hemlock trees but included other tree species too.


Classified Hemlock, 2009

Hemlock Object Density Increases

■ Hemlock ⌐ ⌐ PSA Boundary

Author: Jonathan Mikolm
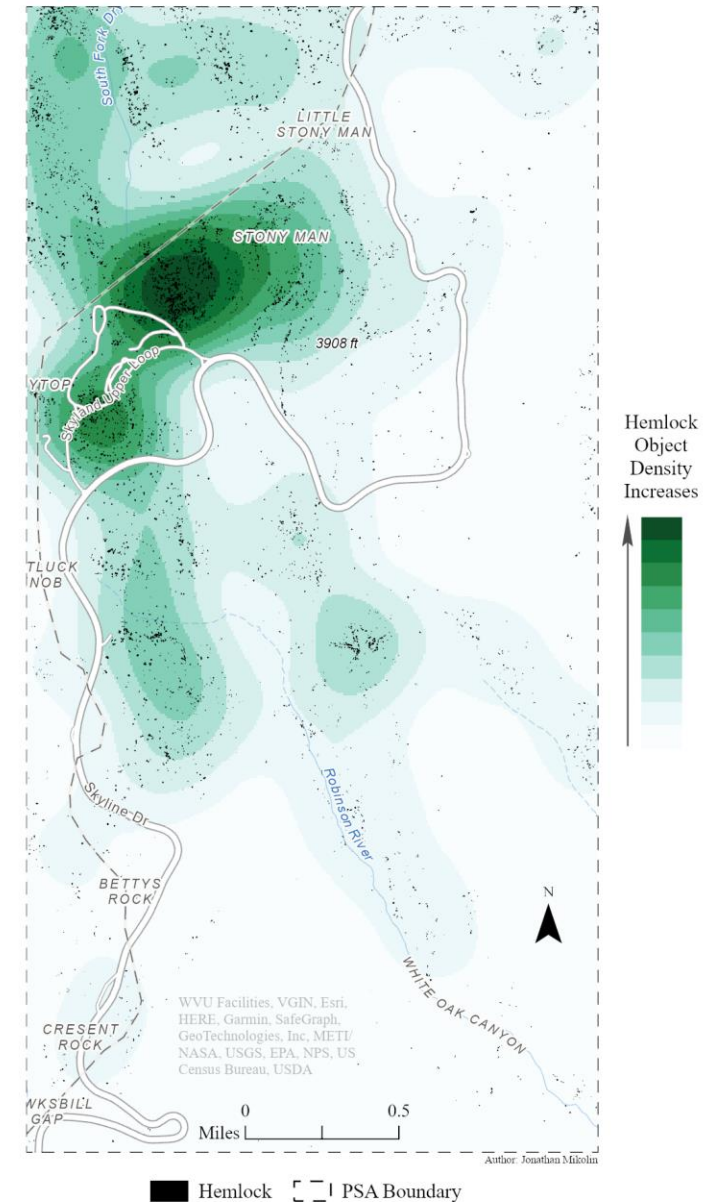
Results, 2018

Class	Hemlock	Not Hemlock	Total	User's Accuracy	Kappa
Hemlock	**55**	195	250	**22.00%**	0
Not Hemlock	11	**239**	250	**95.60%**	0
Total	66	434	**500**	0	0
Producer's Accuracy	**83.33%**	**55.07%**	**0**	**58.80%**	0
Kappa	0	0	0	0	**0.176**

➢ Overall accuracy: 58.8%
➢ Like 2009, classified a large amount of hemlock trees but also captured other non-target trees.

Classified Hemlock, 2018
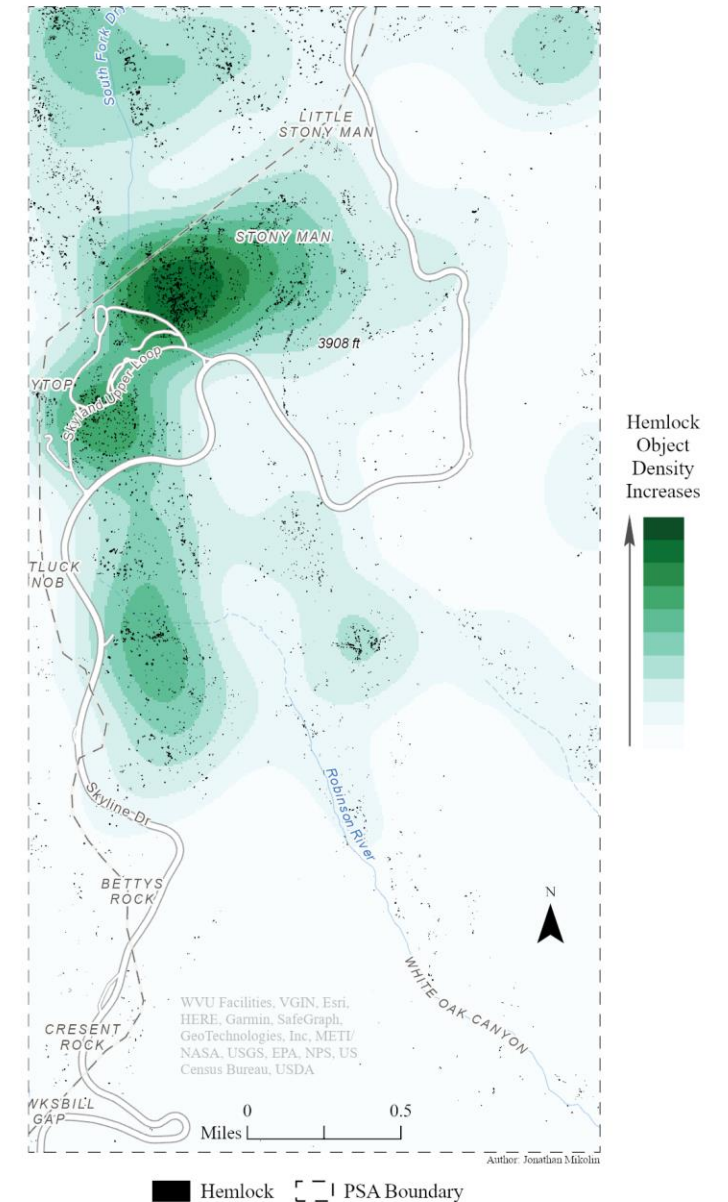
Results, Health Assessment

➢ Vegetation indices increased, suggesting hemlock health is increasing.
- NDVI increased 41%; from 0.35 to 0.49
- GNDVI increased by 39%; from 0.29 to 0.40

➢ Based on a subset of change detection results
- Reviewed objects matching ground truth data to ensure only hemlock trees were looked at. Took average indices values across all true hemlock objects.

Reflection

➢ Produced a robust mapping tool for individual coniferous trees.

➢ Health assessment worked well.

➢ T2 ruleset exhibited good ruleset transferability; overall accuracy increased to 73% in secondary study area, likely due a smaller region mapped and being dominated by hemlock trees.

➢ Future work
- Incorporate additional sensors: satellite and UAVs to improve classification accuracy
- Machine learning classifiers
- Scale up with eCognition server

Thank you!

Contact

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Sources

Slide 3

Fryer, J. (2018). *Tree species distribution range maps from Little's "Atlas of United States trees" series*. Fire Effects Information System U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. https://www.fs.fed.us/database/feis/pdfs/Little/aa_SupportingFiles/LittleMaps.html

Slide 4

USDA Forest Service. (2019, July 24). *Alien Forest Pest Explorer - species map*. Northern Research Station and Forest Health Protection. https://www.fs.fed.us/nrs/tools/afpe/maps/pdf/HWA.pdf

All hemlock photos and project screenshots: Jonathan Mikolin