

Early Warning System for Hemlock Woolly Adelgid in the Southern Appalachians

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Introduction

The hemlock woolly adelgid (HWA; *Adelges tsugae*) has made significant inroads into the southern Appalachians in the last few years. It infests both of the region's native hemlock species, eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*T. caroliniana*). Unfortunately, neither species is resistant, and can be killed in as little as four years. We have been working on the development of an "early warning system" to help managers target their HWA control efforts in the region. The system has two components: (1) a protocol for mapping hemlock stands, and (2) models that predict areas at risk of early infestation by HWA.

Component One: Technique for Mapping Hemlocks

- Selected multispectral images from eastern and western areas of Great Smoky Mountains National Park (GRSM)

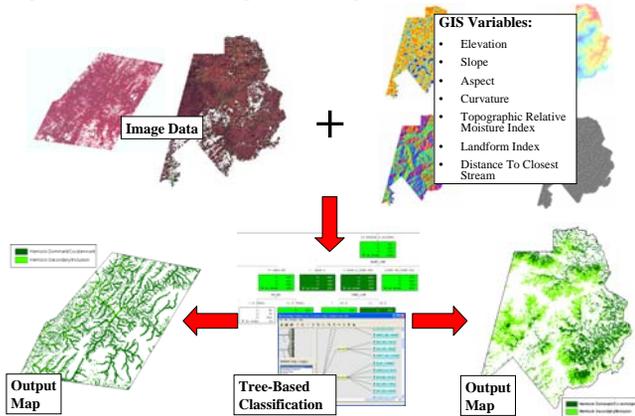
- East: winter 2001 Landsat 7 image (leaf-off), summer 2000 ASTER image (leaf-on)
- West: winter 2003 ASTER image (leaf-off), summer 2000 ASTER image (leaf-on)



- ASTER images already 15-meter resolution, Landsat multispectral fused with panchromatic to create 15-m image
- Images were geometrically corrected using polynomial equations (RMSE < 0.5 pixel) and topographically normalized via C-correction method
- Evergreen/non-evergreen maps created from winter images via several iterations of unsupervised classification ("cluster busting")
- Used these maps to mask out non-evergreen areas from the summer images



- Collected ~14,500 stratified random sample points from hemlock areas and non-hemlock areas of the masked summer images. Hemlock presence (in dominant/co-dominant and secondary component/inclusion classes) based on air-photo-derived vegetation map of GRSM
- Sample points used in training data set for tree-based classification. Each sample point included values from image data and environmental variables
- Performed tree-based classification using SAS Enterprise Miner. Results used to construct a decision-rules-based "expert" classifier
- Expert classifier used to create output hemlock maps for the western and eastern study areas

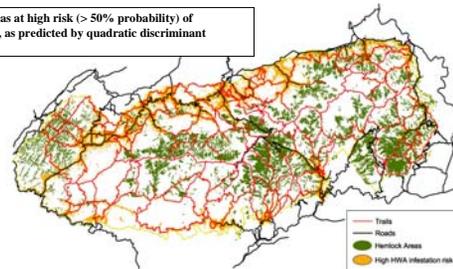


- Three-class output map (hemlock, non-hemlock evergreen, non-evergreen) for eastern study area assessed for accuracy based on 170 points from field survey or aerial photographs (where appropriate)
- Limited assessment for the western study area based on 32 hemlock survey points
- Overall accuracy of eastern study area map greater than 85%, with all producer's and user's accuracies greater than 74%
- Accurately captured 69% of hemlock survey points in western study area. Lower accuracy may be due to small sample size, limitations of the air-photo-based vegetation map used for input, or because elevation and other variables less distinguishing in gentler terrain of this area

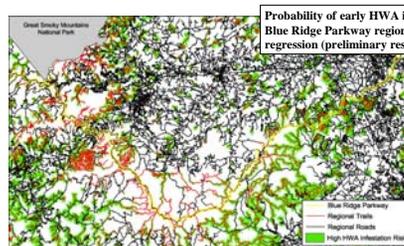
Component Two: Predicting Areas at Risk of Early HWA Infestation

- Started with first-year HWA infestation locations from GRSM (first detected 2002) and the Blue Ridge Parkway (first detected 2003)
- For 56 infested and 45 non-infested sites, calculated values for suite of variables in GIS:
 - Topographic: elevation, aspect, curvature, TRMI, landform index
 - Environmental: geology, vegetation type, disturbance history
 - Proximity: to roads, to trails, to streams
- Applied logistic regression to predict infestation/non-infestation based on input sample
- Employed other techniques for comparison:
 - Multivariate analysis of variance (MANOVA) – for variable selection
 - Non-parametric and quadratic discriminant analysis
 - Tree-based classification
- Used resulting equations to generate GIS maps of HWA infestation risk in GRSM; still working on maps for greater Blue Ridge Parkway region
- Logistic regression equation employed four variables—proximity to trails, elevation, slope, and aspect—to correctly classify 83% of the input sample, as well as 75% of infested sites set aside for testing
- Other procedures yielded similar results (70-87% correct for the initial sample, 79-89% for the test sample), and typically added proximity to roads as another significant variable
- Depending on method, derived infestation probability maps placed between 16% and 38% of GRSM hemlock areas at high risk (> 50% chance) of early HWA infestation
- All maps placed areas near roads and major trailheads at high risk

GRSM areas at high risk (> 50% probability) of infestation, as predicted by quadratic discriminant analysis



Probability of early HWA infestation for southern Blue Ridge Parkway region, as predicted by logistic regression (preliminary result)



- Results consistent with other research indicating that forest edge areas tend to be infested first by HWA
- Results also suggest that roads, major trails, and similar features provide connectivity enabling long-distance dispersal of HWA by humans, birds, and mammals

Discussion

- HWA has already spread significantly throughout GRSM, and now appears in numerous sites along the Blue Ridge Parkway
- However, tools described here—while initially developed in these areas—can be applied elsewhere throughout the southern Appalachian region:
 - Hemlocks in the region are currently not mapped with much spatial detail. Because it is based on readily available or calculable GIS layers and inexpensive satellite imagery, "expert classifier" represents a straightforward way to map hemlock distribution
 - With adequate GIS data, can use any of the developed prediction equations to develop early-infestation probability maps for areas apparently not yet infested by HWA
- Together, these two tools allow managers to identify and prioritize areas for HWA control measures
- Both components can be refined by further validation and accuracy assessment

Acknowledgements

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