A GEOBIA Approach to Locating and Assessing HWA Affected Eastern Hemlock Trees

Shenandoah National Park, Virginia

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Overview

- Background
  - Hemlock Woolly Adelgid and Eastern Hemlock Trees
  - Shenandoah National Park

- Goals and Objectives

- Methodology
  - Necessary Data
  - General Workflow
  - Pilot Project Example

- Timeline

- Anticipated Results
Background

Hemlock woolly adelgid (HWA), a non-native invasive insect.

- Originated from Asia
  - Identified in 1950s within Eastern United States

- Feeds on eastern hemlock and Carolina hemlock trees causing damage
  - Tree crown decline. Substantial needle loss.
  - Restricts water flow throughout plant system.
  - Mortality
Importance of hemlocks

Regarded as a foundational vegetation species.

- Influences forest structure and the surrounding ecosystem

Examples include

- Cover & food for whitetail deer and various bird species such as warblers
- Act as temperature regulators for streams
  - Vital for native trout species
Shenandoah National Park (SHEN) is approximately 200,000 acres in size.

HWA discovered in 1988
- Substantial decreases in hemlock stand health observed afterwards

Management techniques were initiated since the discovery of this pest.
1. Monitoring efforts
2. Control techniques
   - Chemically through soil injections.
   - Biologically through releases of natural predators of HWA.

Firsthand experience indicates a need for a rapid assessment and identification tool.
- Field work is resource intensive.
  - Extensive time is needed to locate trees, assess their health, and treat them.
Project Goals

To determine if a geographic object-based image analysis (GEOBIA) workflow can be utilized to identify and assess hemlock trees in a portion of SHEN from remotely sensed data.

Primary Objectives

1. Determine how accurately hemlocks trees can be located.

2. Create a health assessment of trees over time (2009 to 2018) through normalized difference vegetation index (NDVI) values.
Project Study Area

Size: 6 x 3km (6,300 Acres)

Selected due to large amount of ground truth information available and personal knowledge of area.
Study Area

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Hemlock Waypoints

- Act as ground truth information.
  - Vital for accuracy assessment
- Sourced from SHEN.
- Collected by Garmin GPS Units.
  - Average accuracy 4-meter
- Collection dates range from 2008 to 2021.
Digital Orthoimagery

- Primary imagery for analysis.
  - Sourced from the Virginia Geographic Information Network.
- Spatial resolution 0.3-meter in 8-bit format.
- Spectral resolution includes 4-image bands
  - Red/ Green/ Blue and Near Infrared

2009; Displayed in color infrared (412 band combination)
Lidar Point Cloud

- Key for deriving elevation products
  1. Digital elevation model
  2. Normalized digital surface model
  3. Normalized digital terrain model
- Sourced from the Virginia Geographic Information Network
  - Collected from 1/2014 to 5/2014
- Nominal point spacing of 0.6-meter
Digital Elevation Model

- Raster generated from all ground classified lidar points.
- Depicts bare earth surface.
- Useful for examining elevation of an area of interest, along with the structure of the earth’s surface.

Digital elevation model example. Units in meters.
Normalized Digital Surface Model

- Raster generated from first return lidar pulses, regardless of classification (noise filtered out).
- Depicts height of features above ground once normalized from DEM.
- Useful for examining forest structure and identifying features of interest.
Normalized Digital Surface Model

- Raster generated from first return lidar pulses, regardless of classification (noise filtered out).
- Depicts height of features above ground once normalized from DEM.
- Useful for examining forest structure and identifying features of interest.
Normalized Digital Terrain Model

- Generated from last return, regardless of classification (noise filtered out).
- Depicts lower portions of features with height.
  - Especially useful for hemlocks, captures lower section of tree canopy.
Methodology

Software

ArcGIS Pro
- Preprocessing
- Results

eCognition Developer
- GEOBIA
  - Segmentation
  - Classification
  - Export
Methodology

Summary of Workflow

**Preprocessing**
1. Coordinate system alignments
2. Mosaic imagery
   • Visual inspection
3. Generate elevation surfaces from lidar point clouds
   • Mainly a DEM, nDSM, and nDTM
4. Export rasters to an 8-bit TIF file clipped to AOI

**Analysis**
1. Segmentation to create representative objects for trees
2. Generate object information (find unique characteristics to identify hemlocks)
   • Spectral, spatial, textural, geometric measures
3. Schema (Classes)
4. Create Identification Keys
5. Classification
6. Export results

**Results**
1. Create map products
2. Produce statistical measures
   • Error Matrix
   • Image Scatterplot
   • Health Assessment (compare NDVI values and calculate change from 2009 to 2018)
Pilot Project

2013 Ruleset

Process Tree

- Ortho 2013
  - Segmentation
    - delete <all levels>
    - adaftree: 55 growing 'New Level'
    - at New Level: multi-resolution: 25 [shape=0.1 compact=0.9]
  - Classification
    - at New Level: remove classification
    - unclassified with Mean NDVI > 0.17 and GLCM Contrast NIR (all dir) < 2000 and Mean nDSM < 0 and Mean nDSM < 45 at New Level: Mixed Hemlock
    - unclassified with Mean NDVI <= 0.17 and Mean NDVI > 0.5 and GLCM Contrast NIR (all dir) > 1500 and Mean nDSM > 0 at New Level: Other Vegetation
    - unclassified at New Level: NonVegetation Shadows
    - NonVegetation_Shadows at New Level: merge region
    - Other Vegetation at New Level: merge region
    - Mixed Hemlock with Number of pixels < 200 at New Level: merge region
  - Export
    - Mixed Hemlock, NonVegetation_Shadows, Other Vegetation at New Level: export object shapes to Ortho2013_FINAL
    - Mixed Hemlock at New Level: export object shapes to Ortho2013_ClassifiedHemlockPoints
Pilot Project

2013 Ruleset

- Process Tree
  - Ortho 2013
    - Segmentation
      - delete "all levels"
      - quadtree 55 creating "New Level"
    - postprocessing: non-recursive 25 (shape 0.1 compact 0.15)
  - Classification
    - at New Level: remove classification
    - Unclassified with Mean NDVI > 0.17 and GLCM Contrast NBR (all clumps) < 2000 and Mean rDSM > 0 and Mean rDSM < 285 at New Level: Mixed Hemlock
    - Unclassified with Mean NDVI < 0.17 and Mean NDVI > 0.5 and GLCM Contrast NBR (all clumps) >= 1500 and Mean rDSM > 0 at New Level: Other Vegetation
    - Unclassified at New Level: NonVegetation/SHadows
    - NonVegetation/SHadows at New Level: merge region
    - Other Vegetation at New Level: merge region
    - Mixed Hemlock with number of pixels < 200 at New Level: merge region
  - Export
    - Mixed Hemlock, NonVegetation/SHadows, Other Vegetation at New Level: export object shapes to Ortho2013_FINAL
    - Mixed Hemlock at New Level: export object shapes to Ortho2013_ClassifiedHemlockPoints
2013 Ruleset

Pilot Project
2013 Ruleset
Pilot Project

2013 Ruleset

Process Tree

- Ortho 2013
  - Segmentation
    - delete <all levels>
    - Scalefre: 55 creating 'New Level'
    - at New Level: multi-resolution: 25 (shape 0.1 compact 0.9)
  - Classification
    - at New Level: remove classification
    - Unclassified with Mean NDVI > 0.17 and GLCM Contrast NIR all dir < 1000 and Mean nDSM > 0 and Mean nDSM < 45 at New Level: Mixed Hemlock
    - Unclassified with Mean NDVI < 0.17 and Mean NDVI > 0.5 and GLCM Contrast NIR all dir > 1500 and Mean nDSM > 0 at New Level: Other Vegetation
    - Unclassified at New Level: NonVegetation_Shadows
    - NonVegetation_Shadows at New Level: merge region
    - Other Vegetation at New Level: merge region
    - Mixed Hemlock with number of pixels < 200 at New Level: merge region
  - Export
    - Mixed Hemlock, NonVegetation_Shadows, Other Vegetation at New Level: export object shapes to Ortho2013_FINAL
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Pilot Project

2013 Ruleset
Pilot Project

2013 Ruleset
Pilot Project

Shenandoah National Park, 2013

CIR 4-1-2 Band Combination Orthophoto
Pilot Project

**Image Scatter Plot**

- Provides a general overview of how well the classified objects compare to the ground truth waypoints.
- Approximately 42% match.
- Class confusion and object bleed likely contributing factors for errors.
  - Plan to spend more time creating identification keys and testing variations of rulesets to mitigate these errors.
<table>
<thead>
<tr>
<th>Month Range</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>December to January</td>
<td>Data preprocessing</td>
</tr>
<tr>
<td>February to March</td>
<td>Accuracy assessment</td>
</tr>
<tr>
<td>April to May</td>
<td>Generate final written report</td>
</tr>
</tbody>
</table>
Anticipated Results

1. GEOBIA workflow can adequately identify hemlock trees within the study area.

2. Overall health of the classified hemlocks expected to stay constant or increase slightly due to management efforts for HWA in this area.

Produce maps of final classified areas
  - Waypoints (Attributes to include latitude and longitude coordinates)
  - Polygons (Attributes to include tree width as a measure of canopy cover)
Questions?

Sources


All Hemlock Photos: Jonathan Mikolin

Background Photo Last Slide: A segmented and classified (mixed hemlock) orthophoto of Shenandoah National Park in CIR (412 Band combination).