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

Shenandoah National Park,Virginia

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Penn State GEOG 596A

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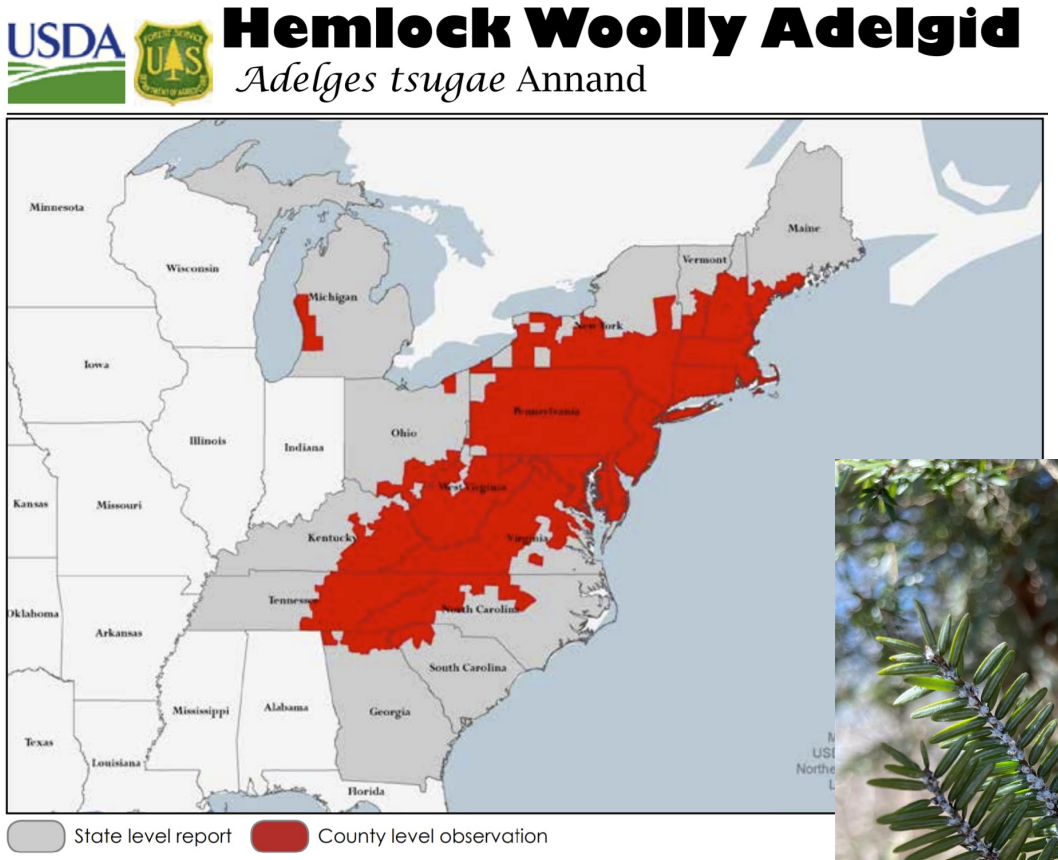
Overview

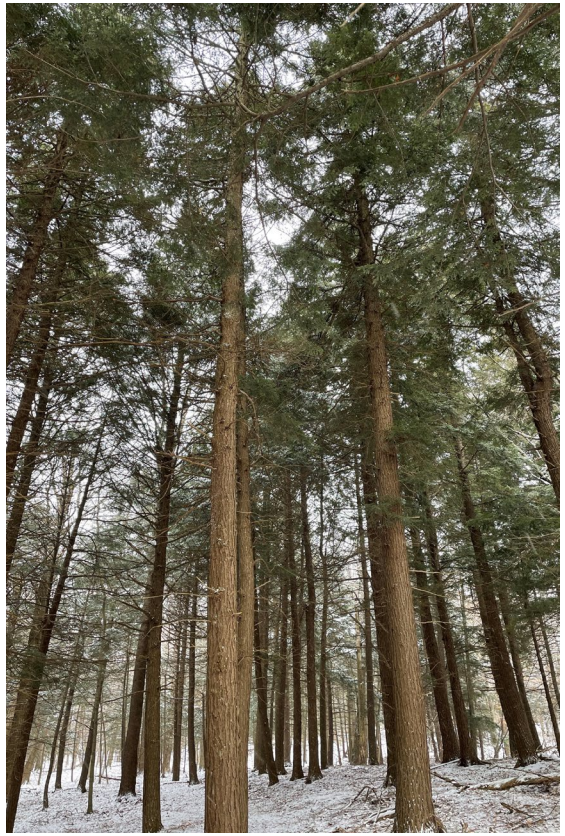
- Background
  - Hemlock Woolly Adelgid and Eastern Hemlock Trees
  - Shenandoah National Park
- Goals and Objectives
- Methodology
  - Necessary Data
  - General Workflow
  - Pilot Project Example
- Timeline
- Anticipated Results

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.

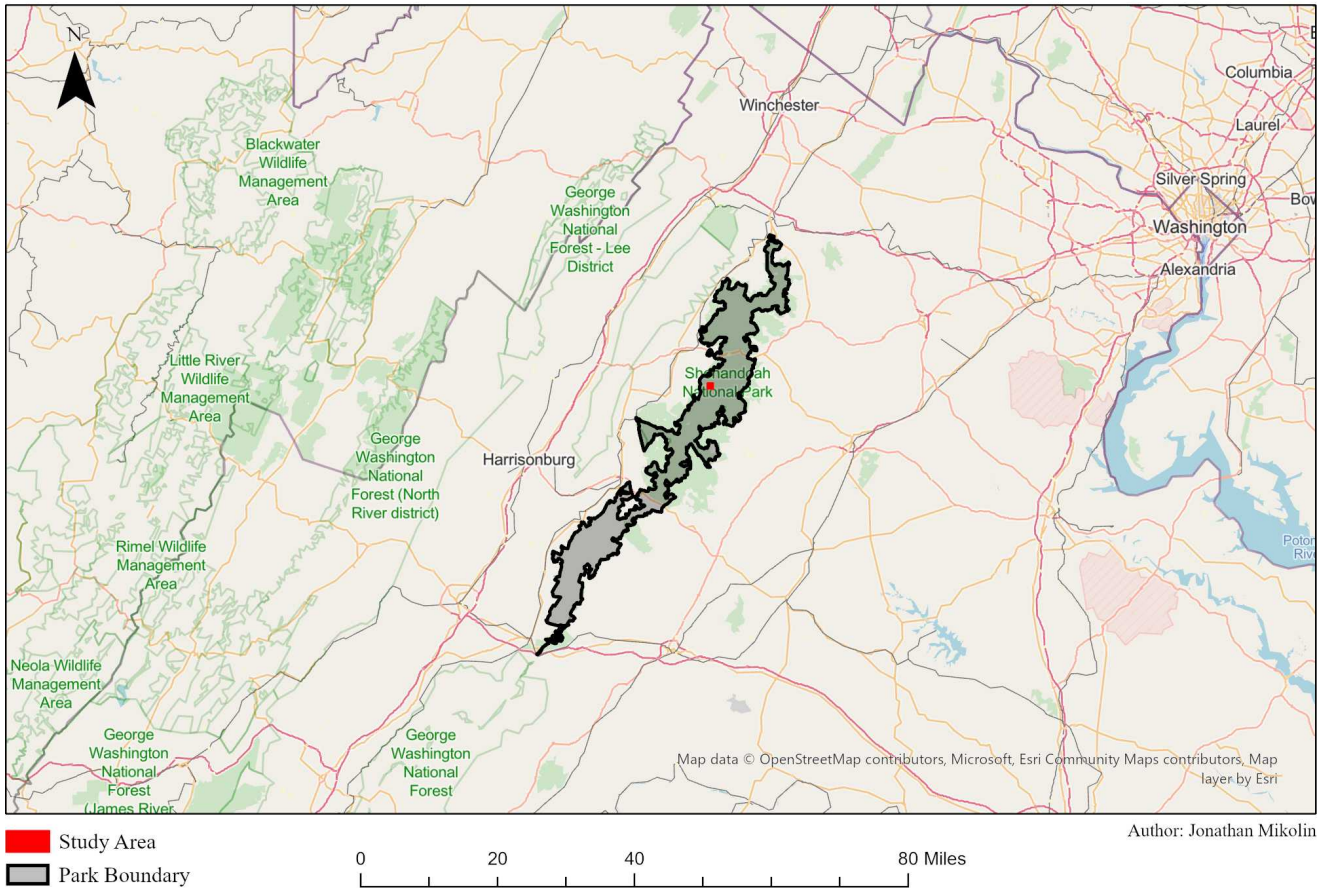
- Influences forest structure and the surrounding ecosystem

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

Region of Interest

Shenandoah National Park, Virginia



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.

Goals and Objectives

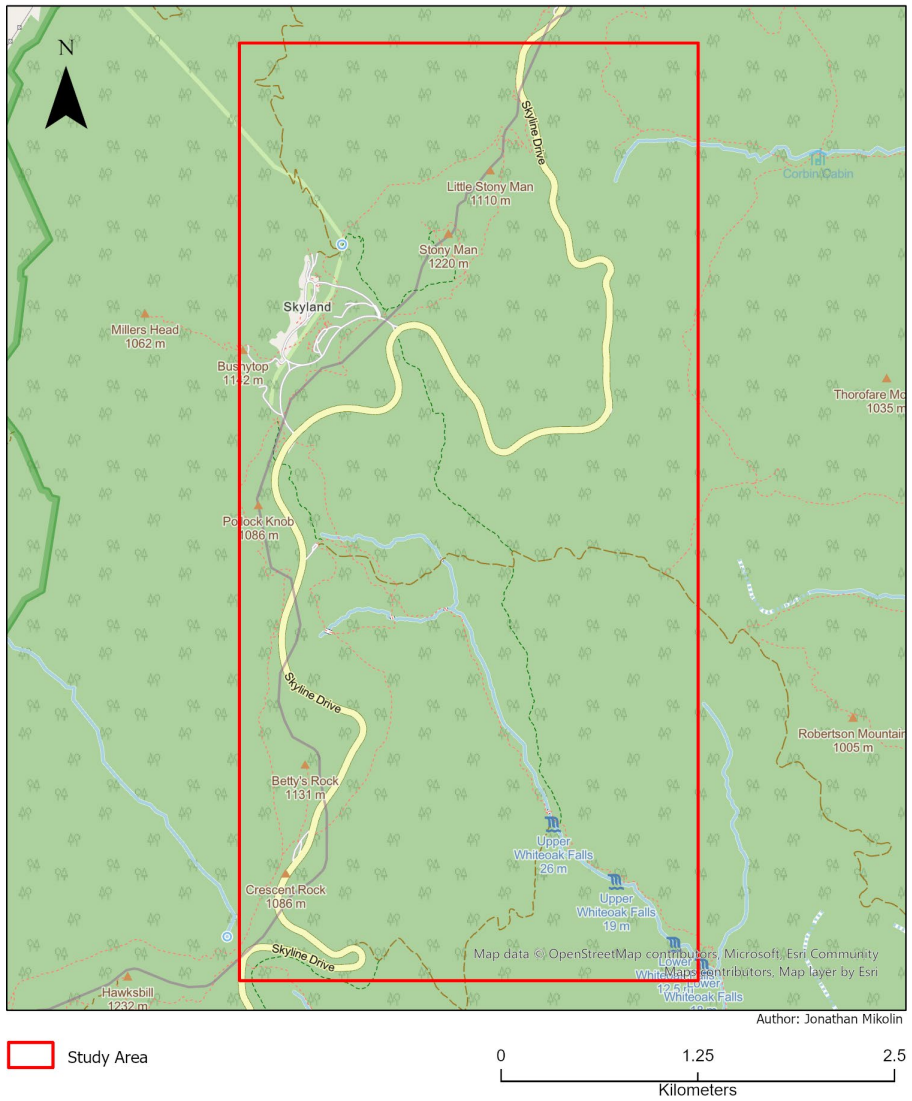
Project Goals

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

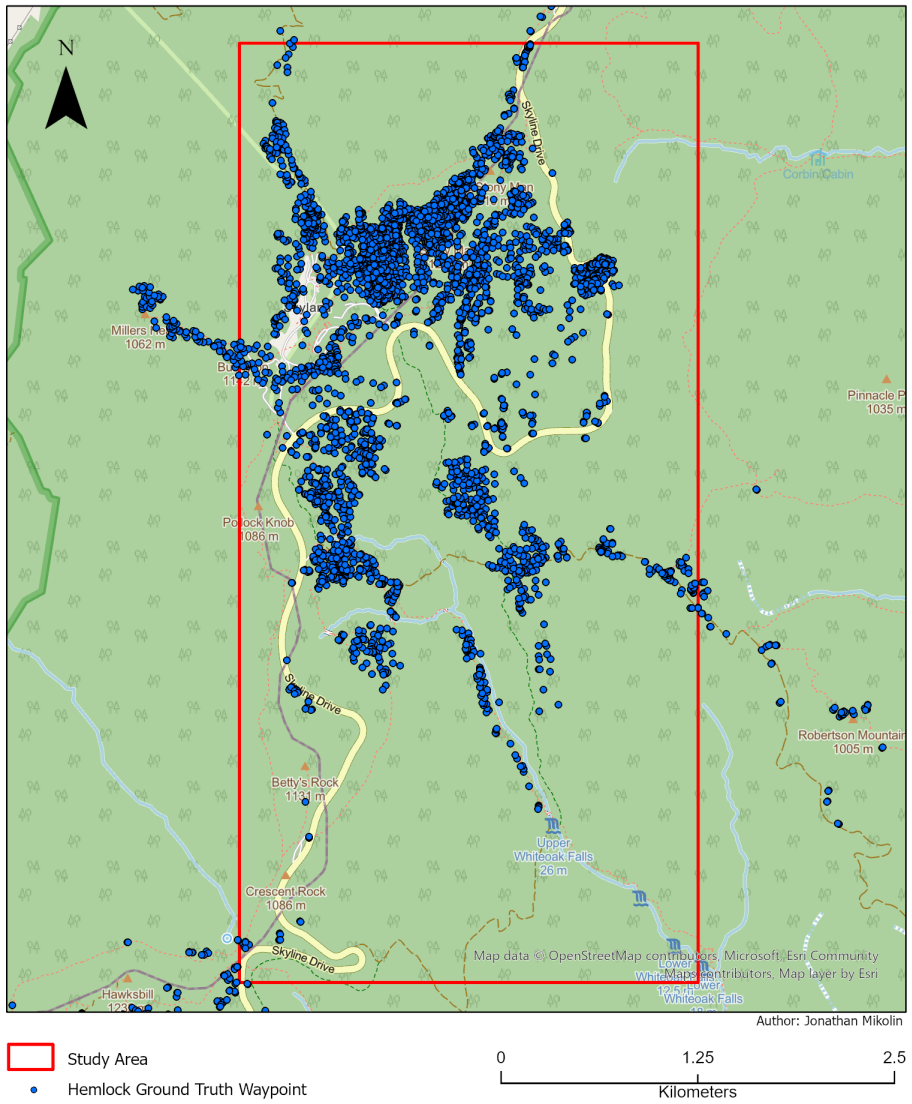


Study Area

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

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

Project Study Area



Study Area

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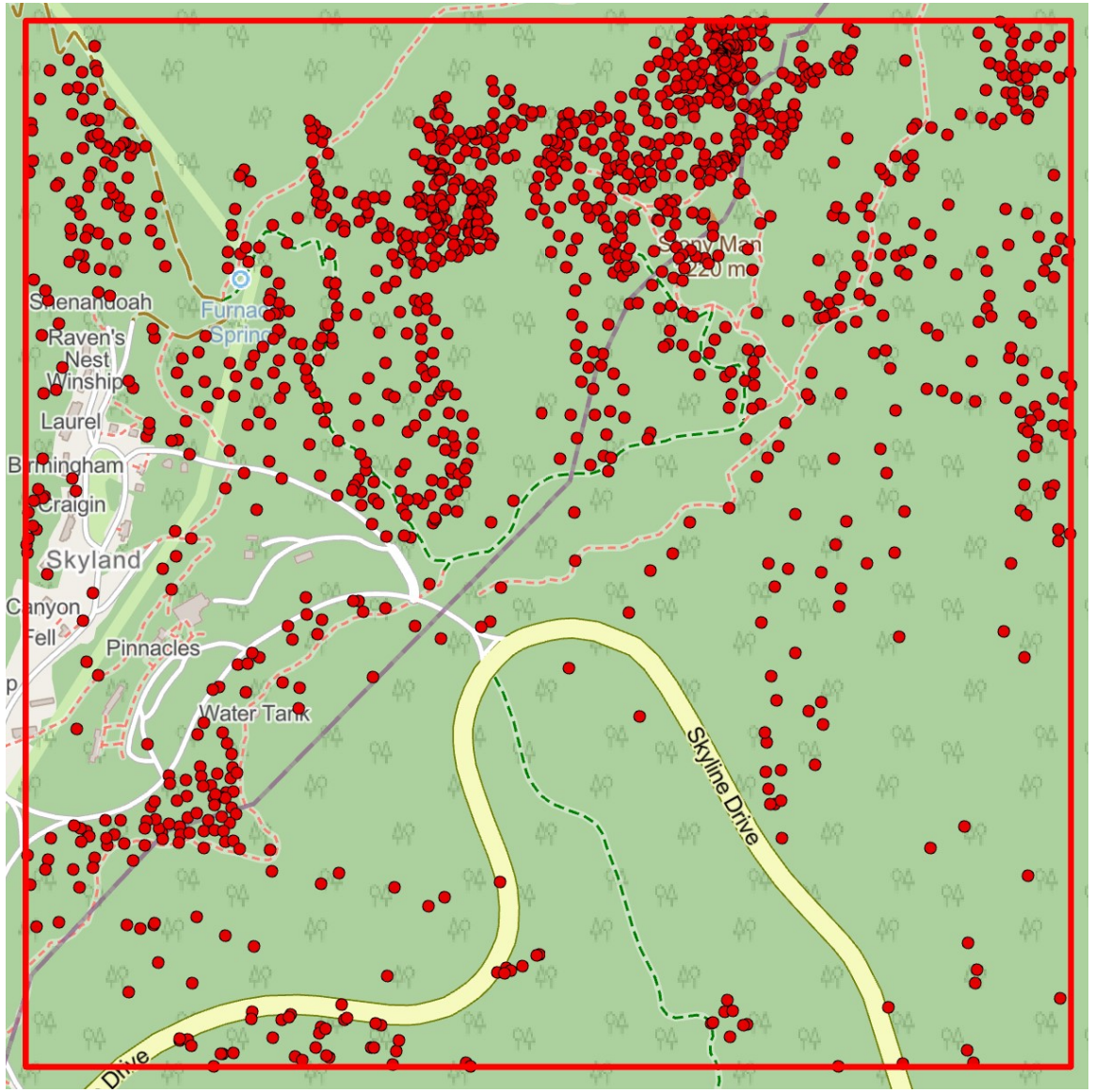
Selected due to large amount of ground truth information available and personal knowledge of area.

Necessary Data

Hemlock Waypoints

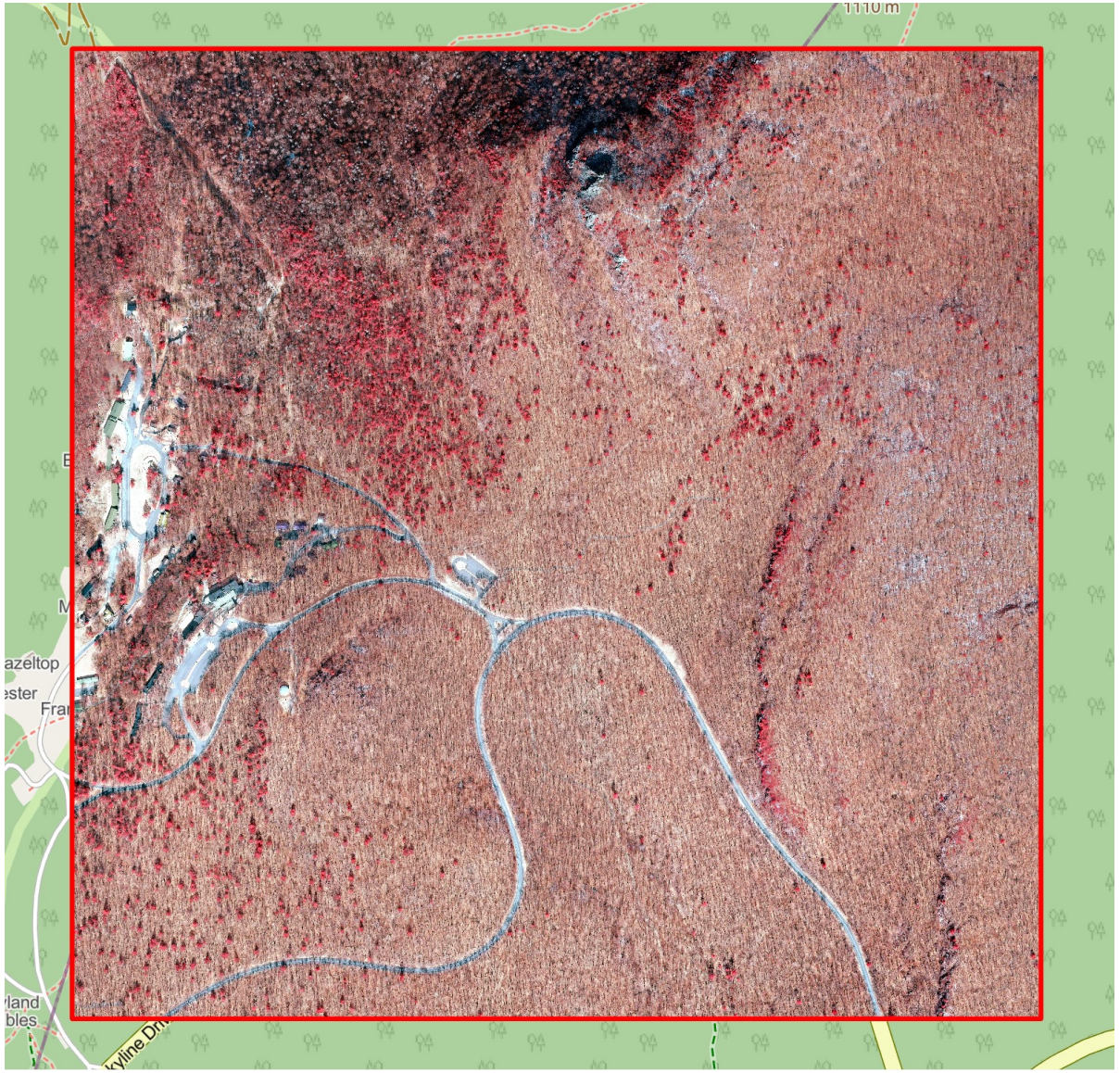
- Act as ground truth information.
  - Vital for accuracy assessment
- Sourced from SHEN.
- Collected by Garmin GPS Units.
  - Average accuracy 4-meter
- Collection dates range from 2008 to 2021.



Necessary Data

Digital Orthoimagery

- Primary imagery for analysis.
  - Sourced from the Virginia Geographic Information Network.
  - Collected in 2009 and 2018.
- Spatial resolution 0.3-meter in 8-bit format.
- Spectral resolution includes 4-image bands
  - Red/ Green/ Blue and Near Infrared

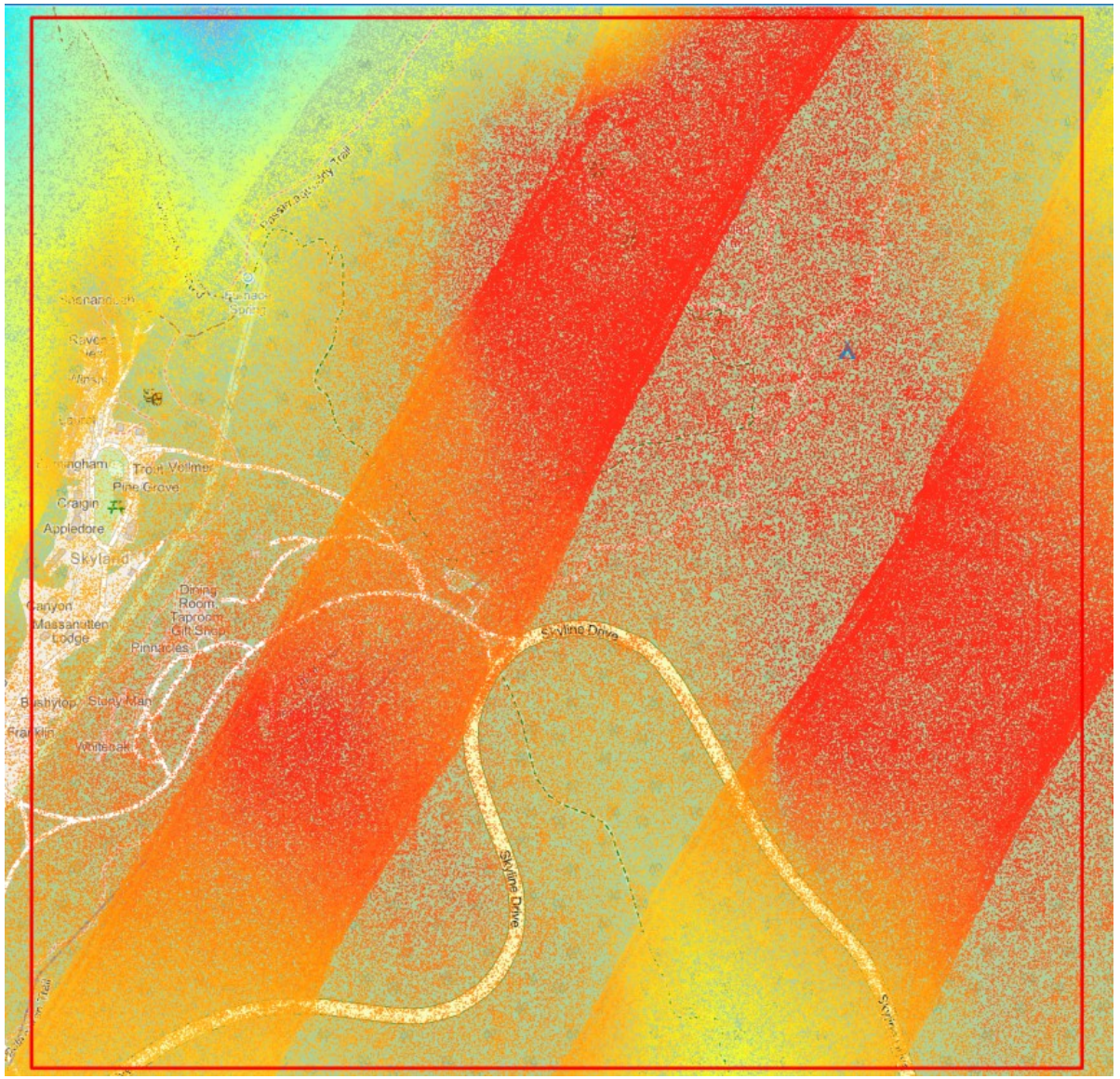


2009; Displayed in color infrared (412 band combination)

Necessary Data

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

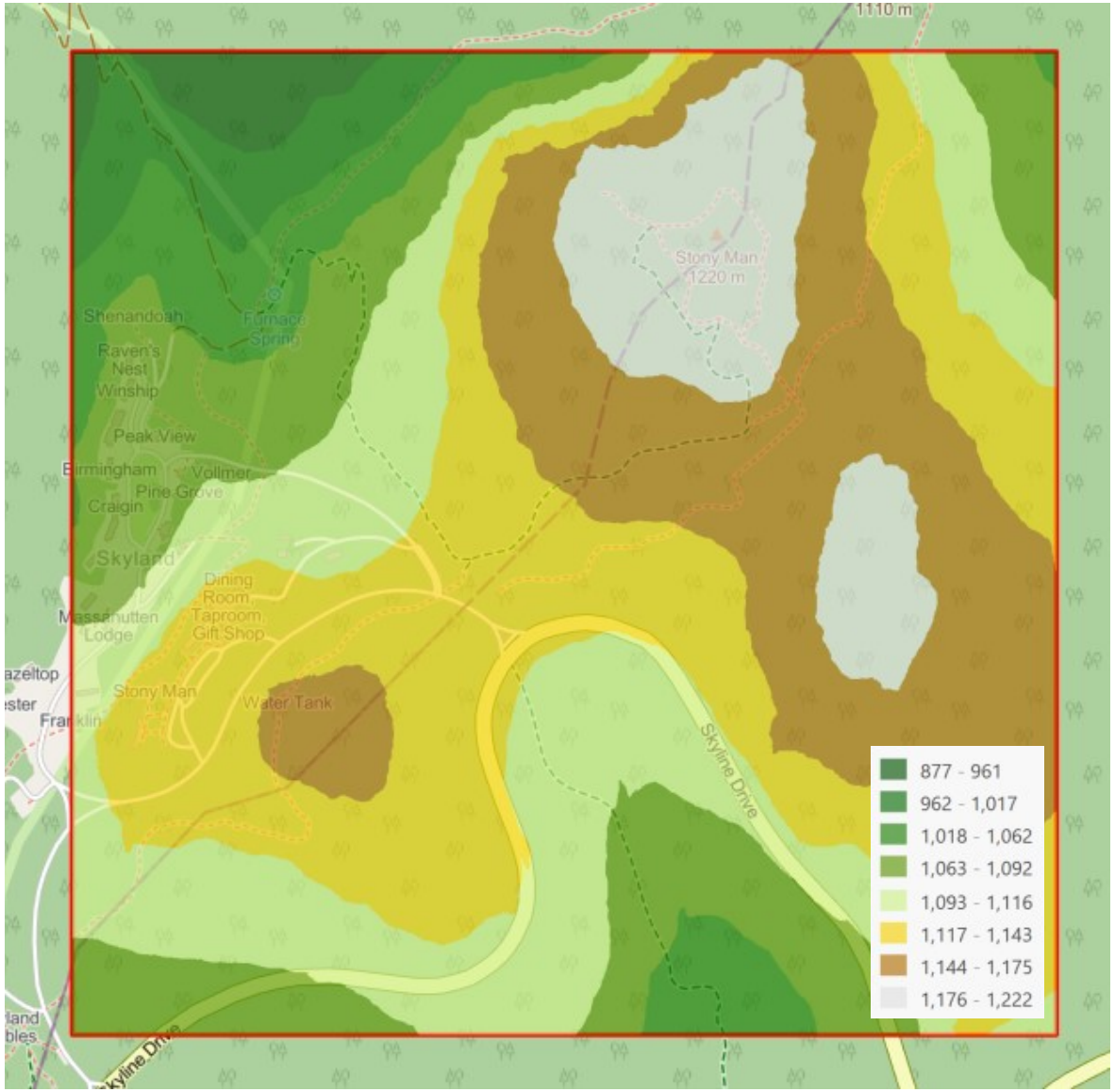


2014; Lidar point cloud example

Necessary Data

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.

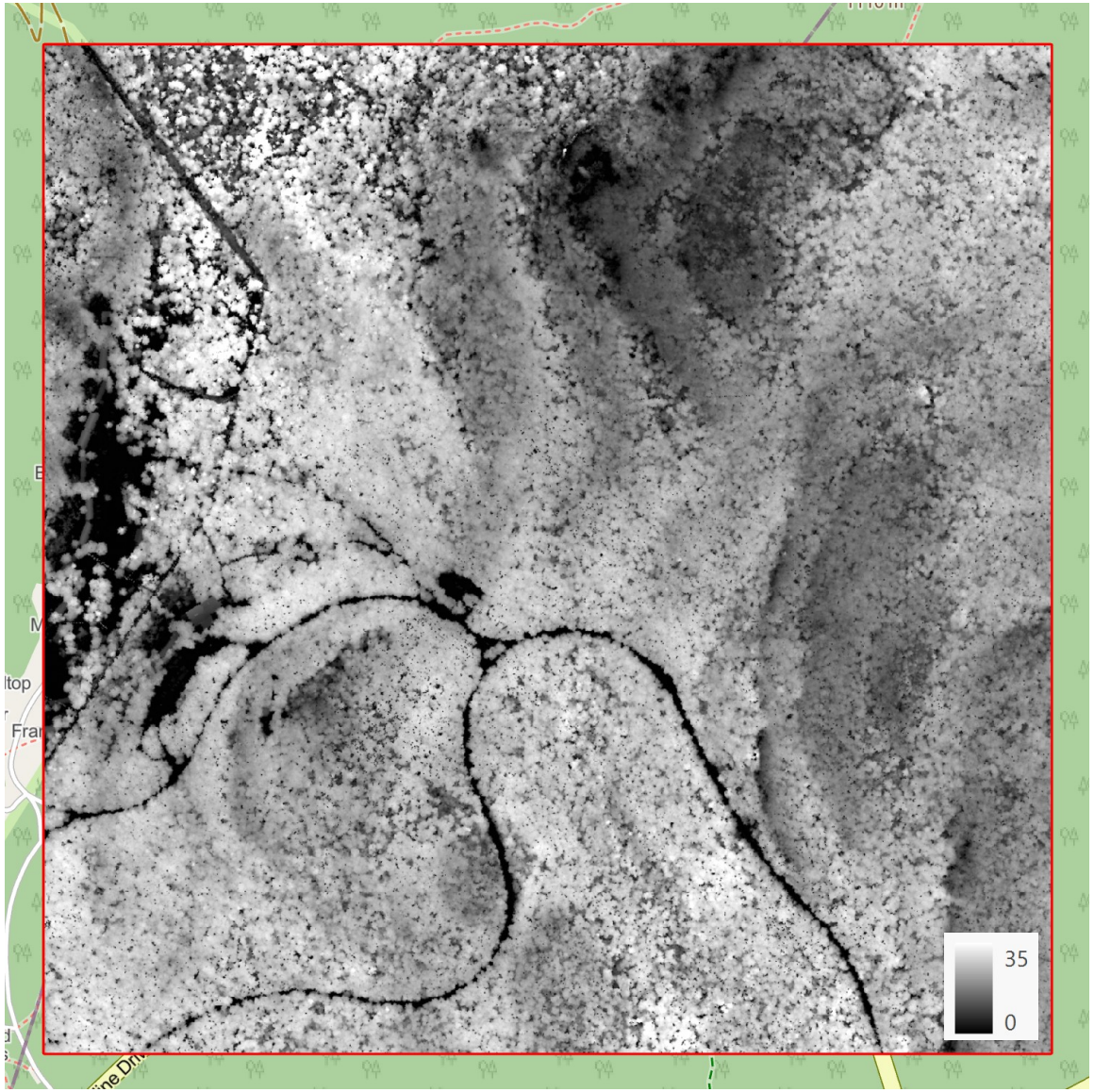


Digital elevation model example. Units in meters.

Necessary Data

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 example. Units in meters.

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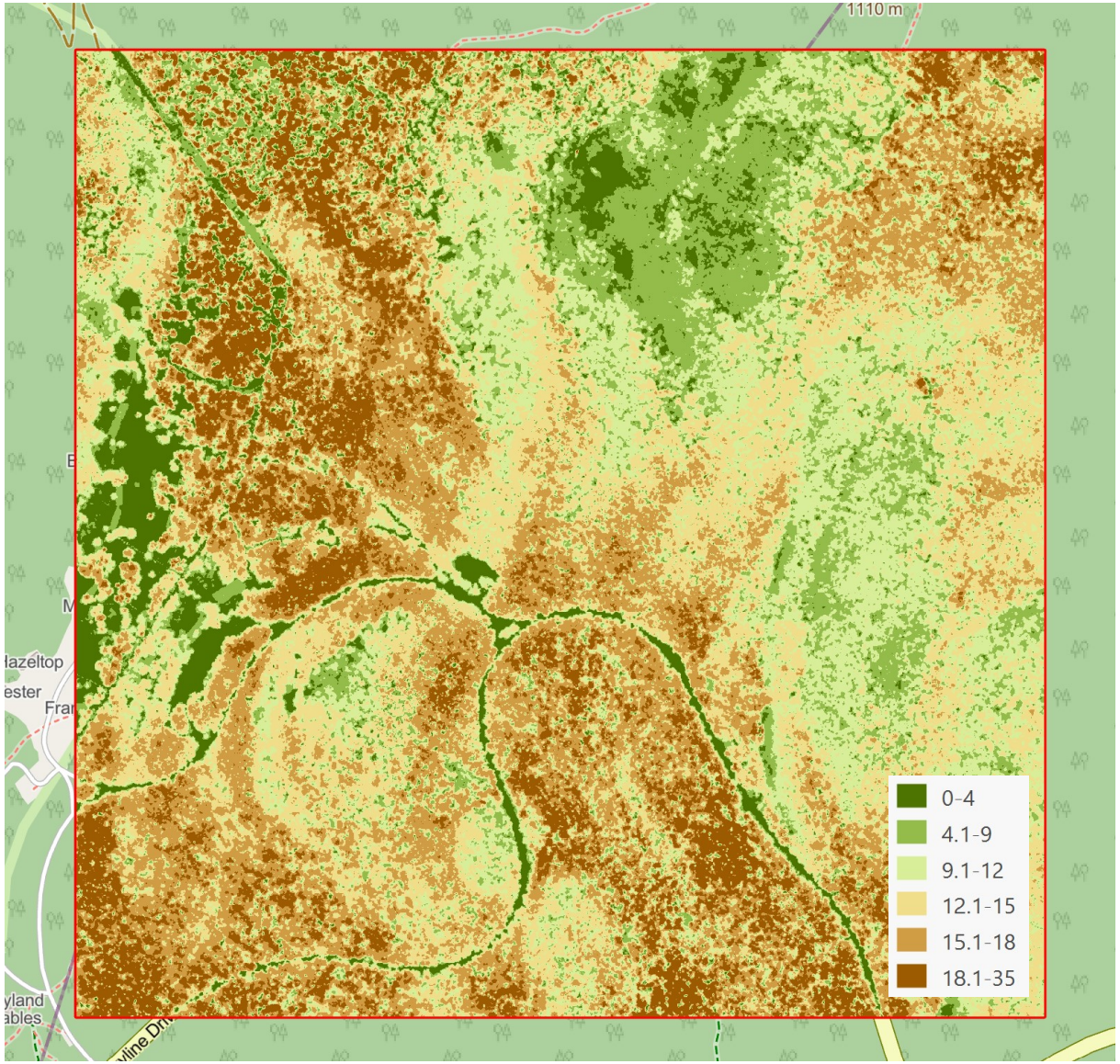
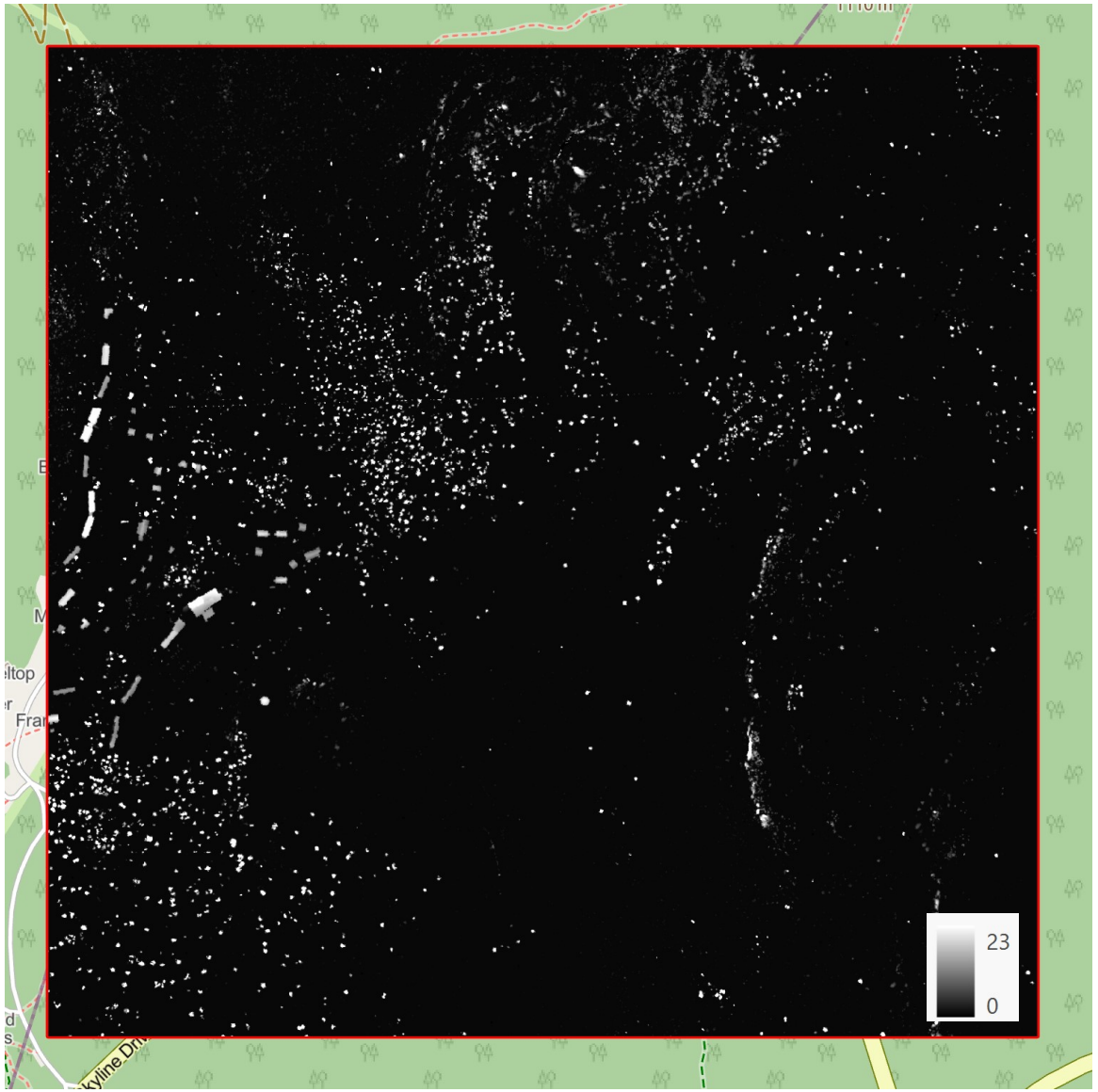


Normalized digital surface model example. Units in meters.

Necessary Data

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.



Normalized digital terrain model example. Units in meters.

Software

ArcGIS Pro

- Preprocessing
- Results

eCognition Developer

- GEOBIA
  - Segmentation
  - Classification
  - Export

Methodology

Summary of Workflow

ArcGIS Pro

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

eCognition

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

ArcGIS Pro

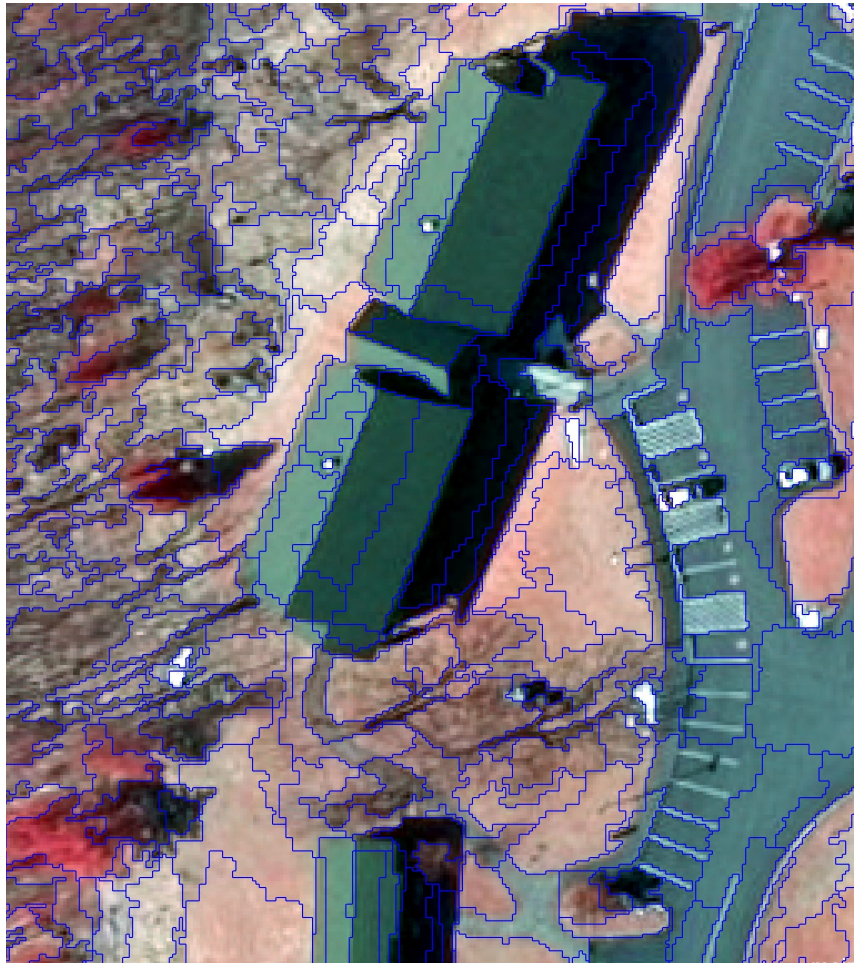
Results
1. Create map products
2. Produce statistical measures
   - Error Matrix
   - Image Scatterplot
   - Health Assessment (compare NDVI values and calculate change from 2009 to 2018)

2013 Ruleset

Process Tree

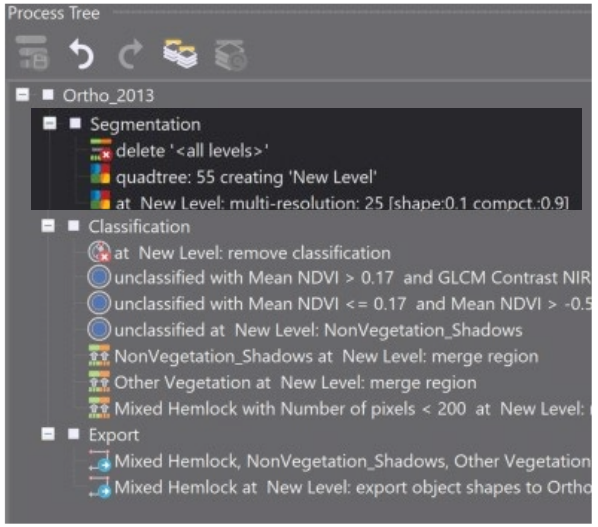
- Ortho_2013
  - Segmentation
    - delete '<all levels>'
    - quadtree: 55 creating 'New Level'
    - at New Level: multi-resolution: 25 [shape:0.1 compct.:0.9]
  - Classification
    - at New Level: remove classification
    - unclassified with Mean NDVI > 0.17 and GLCM Contrast NIR (all dir.) < 2000 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

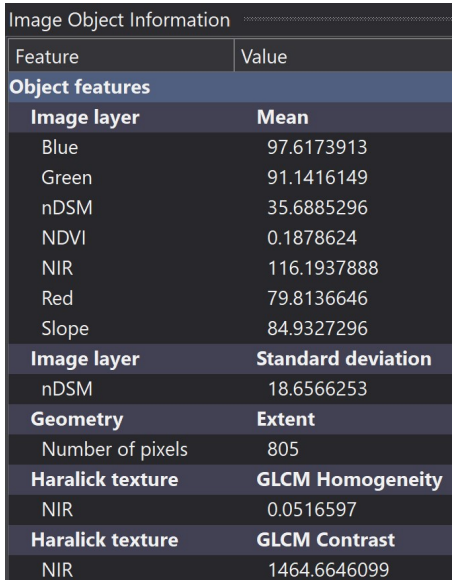
2013 Ruleset



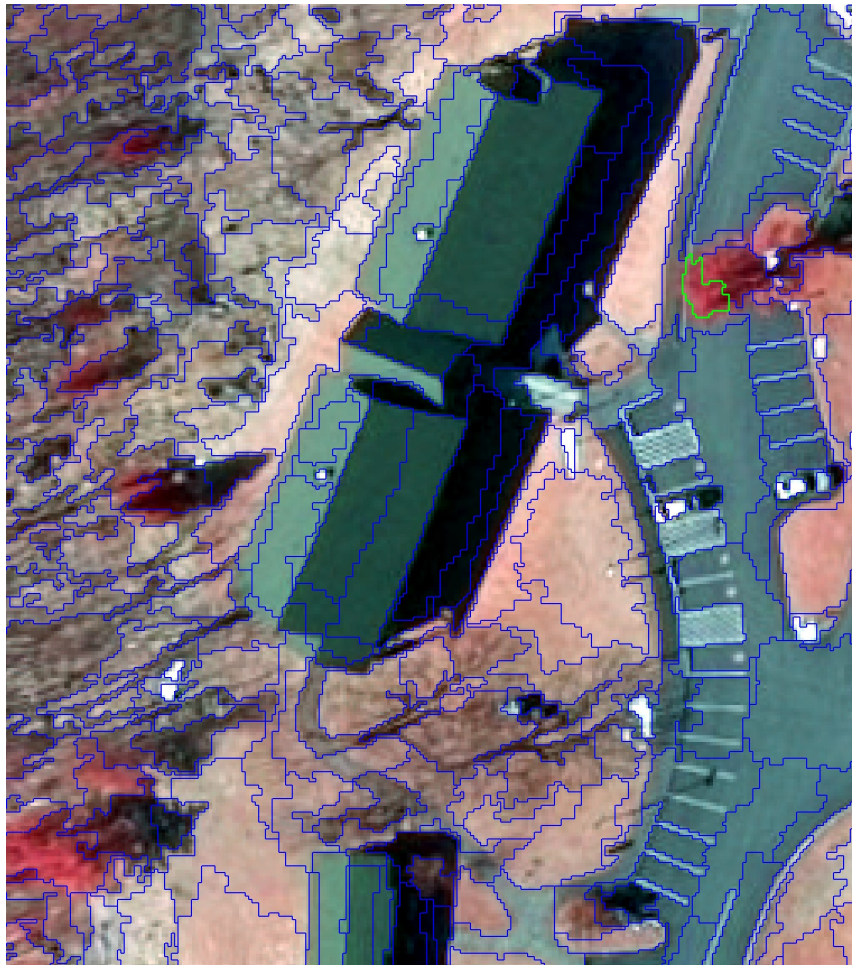
Pilot Project

2013 Ruleset





Object	Blue	Green	Red	NIR	NDVI	nDSM	Z-Dev	GLCM Homog	GLCM Contrast
1	105	105	92	138	.20	45	14	.04	1178
2	114	117	102	169	.25	24	18	.03	1151
3	105	108	97	152	.22	31	7.6	.03	914
4	126	133	124	182	.19	27	17	.03	1437
5	119	125	116	162	.17	33	16	.04	1359



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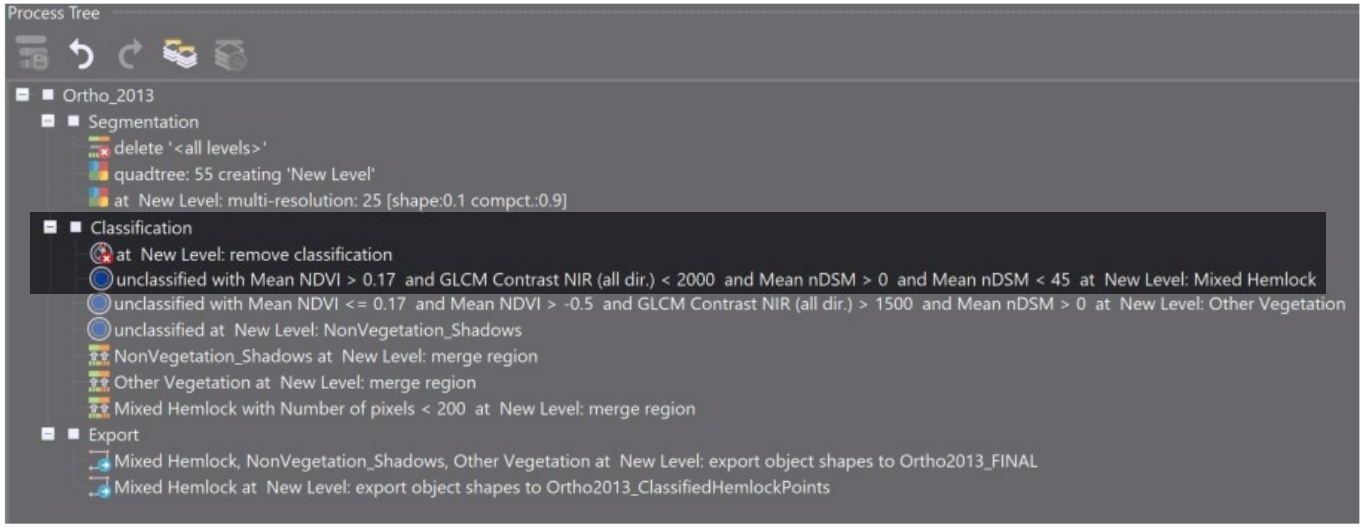

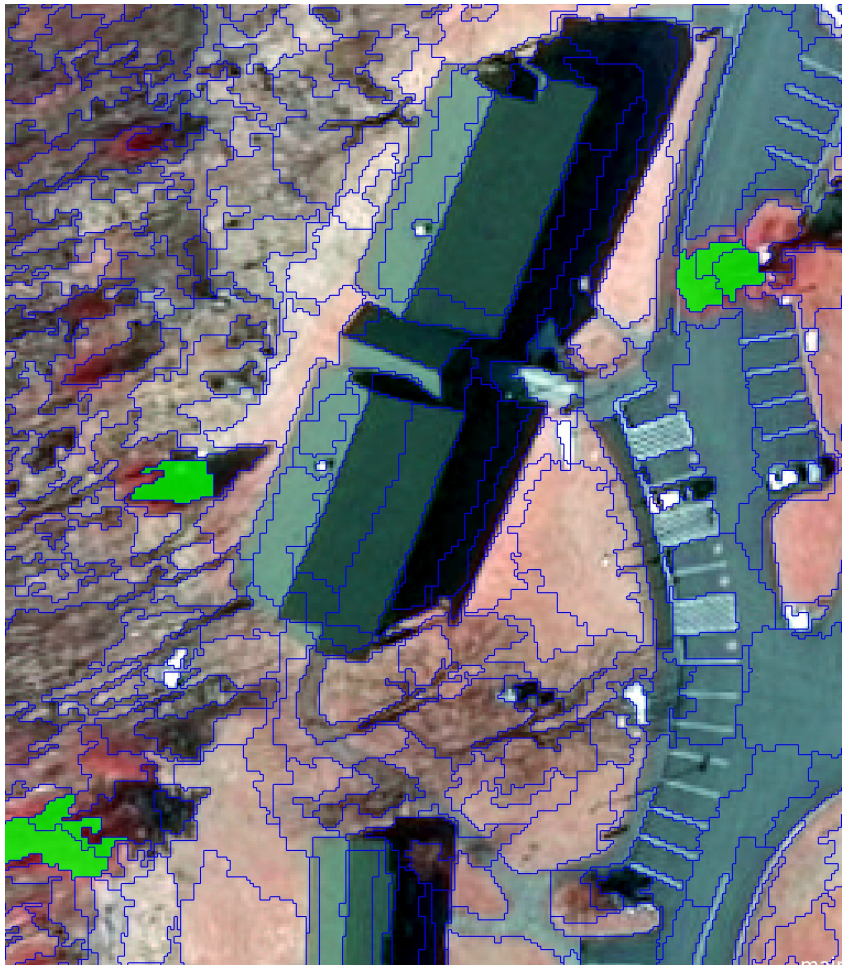

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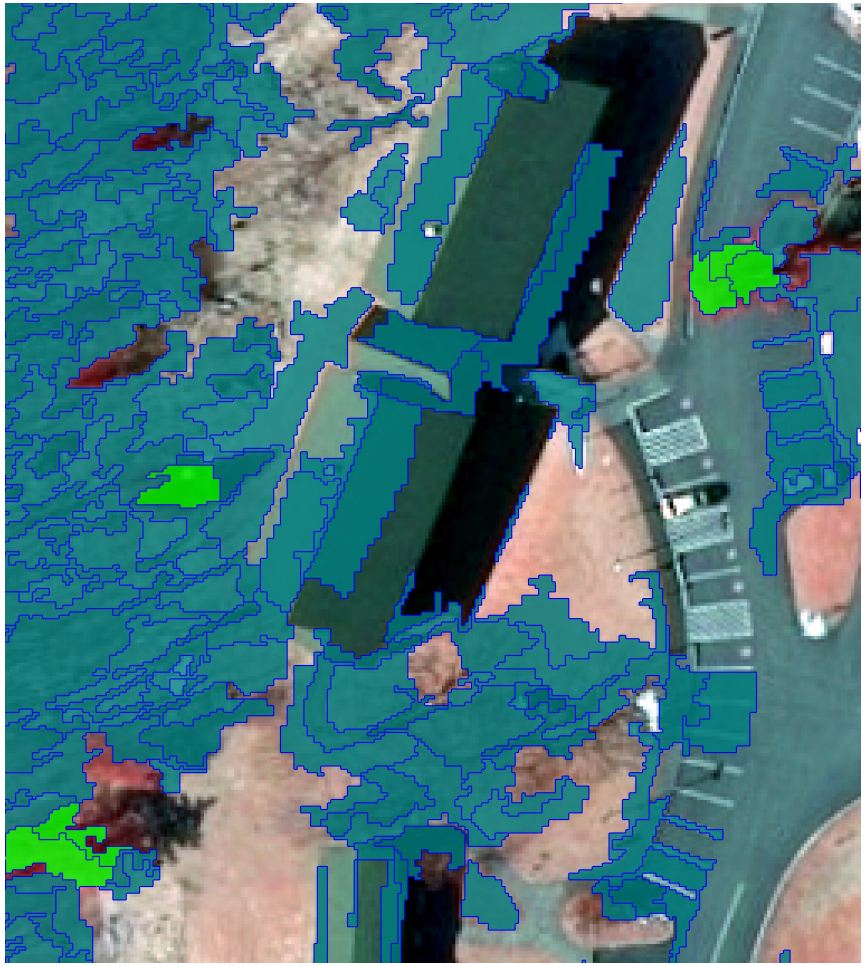

Pilot Project

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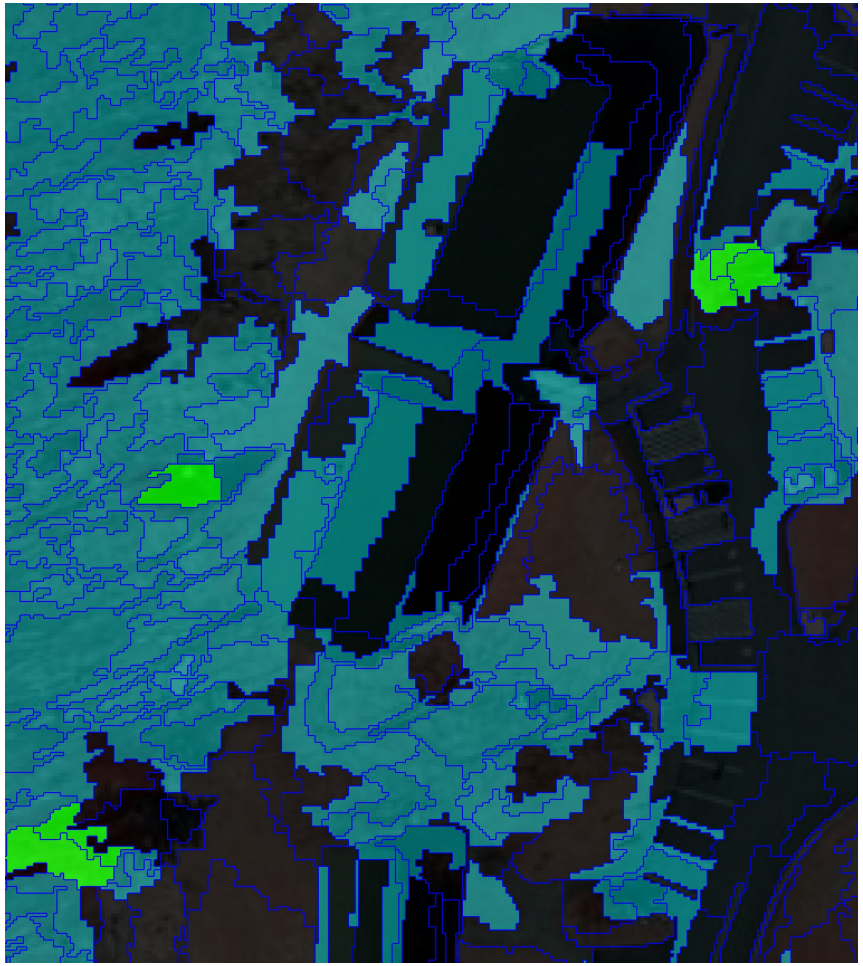

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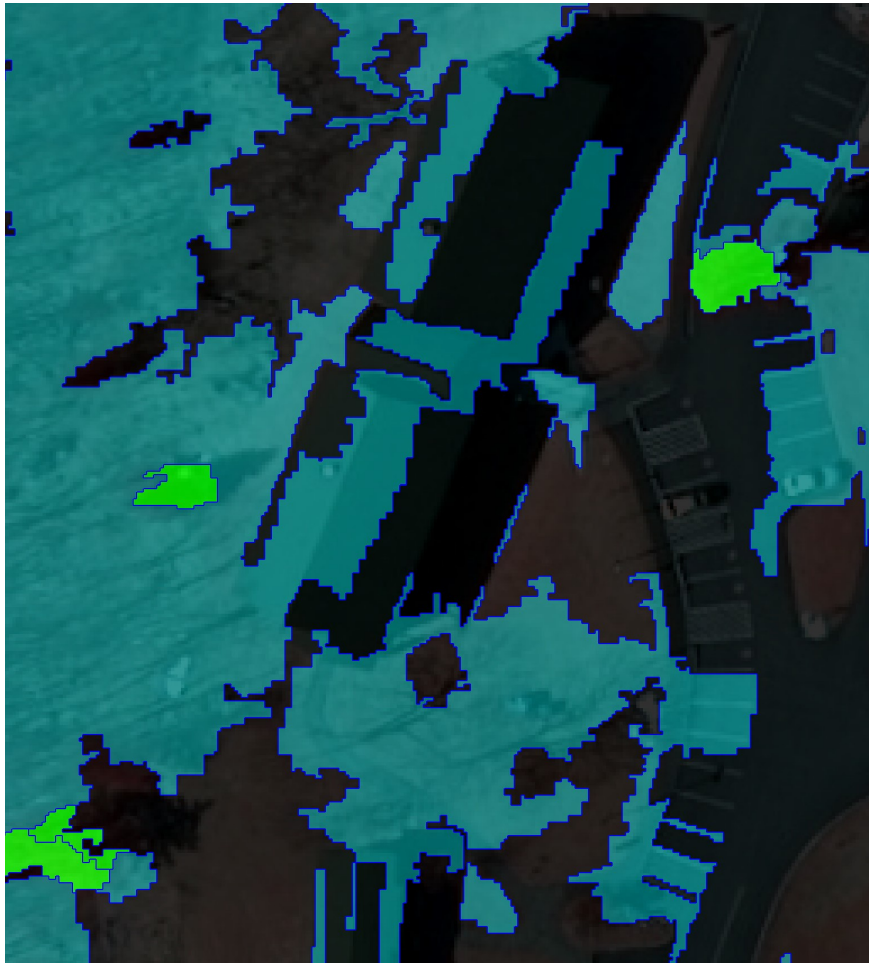
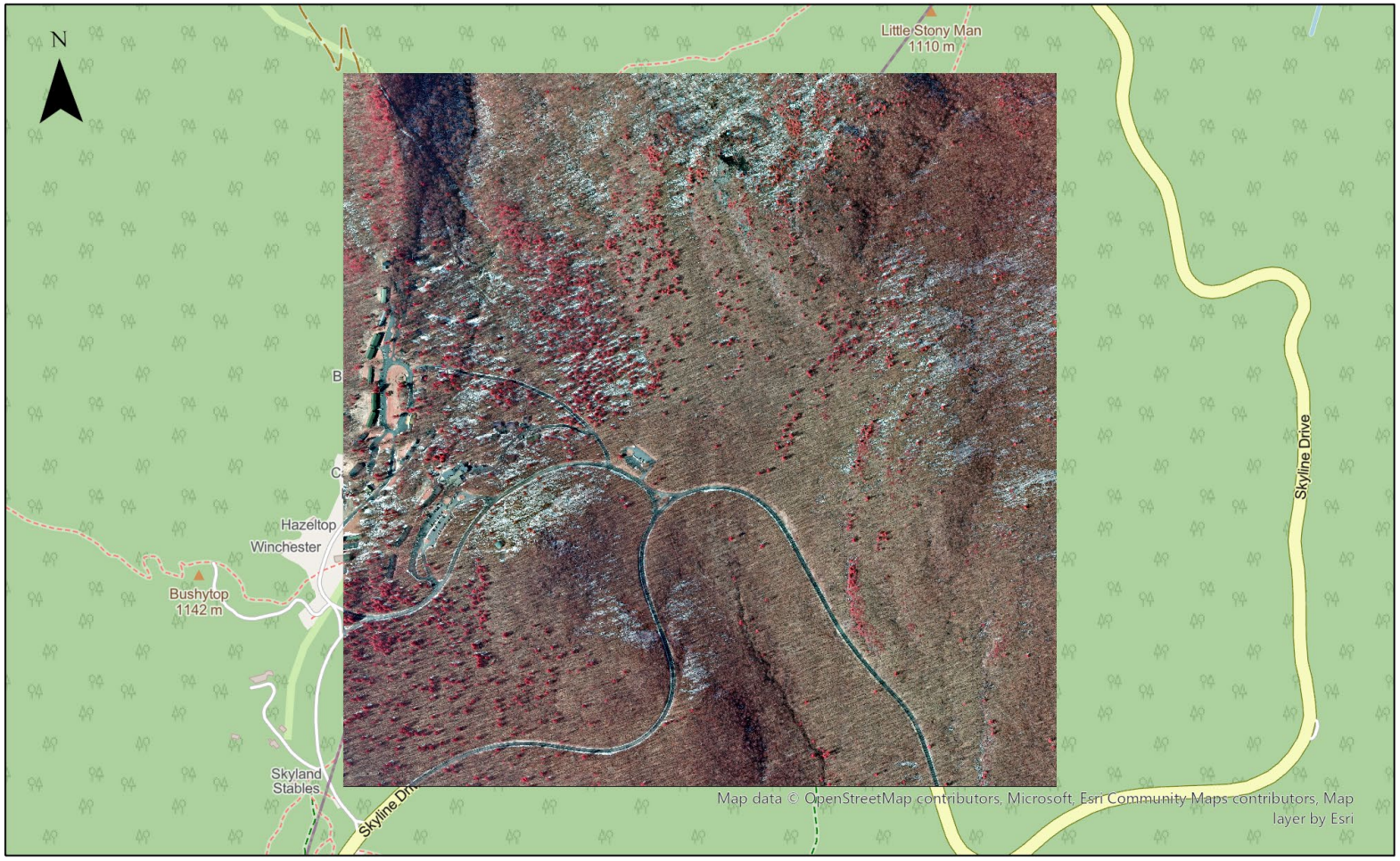


Pilot Project

Shenandoah National Park, 2013

CIR 4-1-2 Band Combination Orthophoto



0 0.25 0.5 0.75 1 Miles

Author: Jonathan Mikolin

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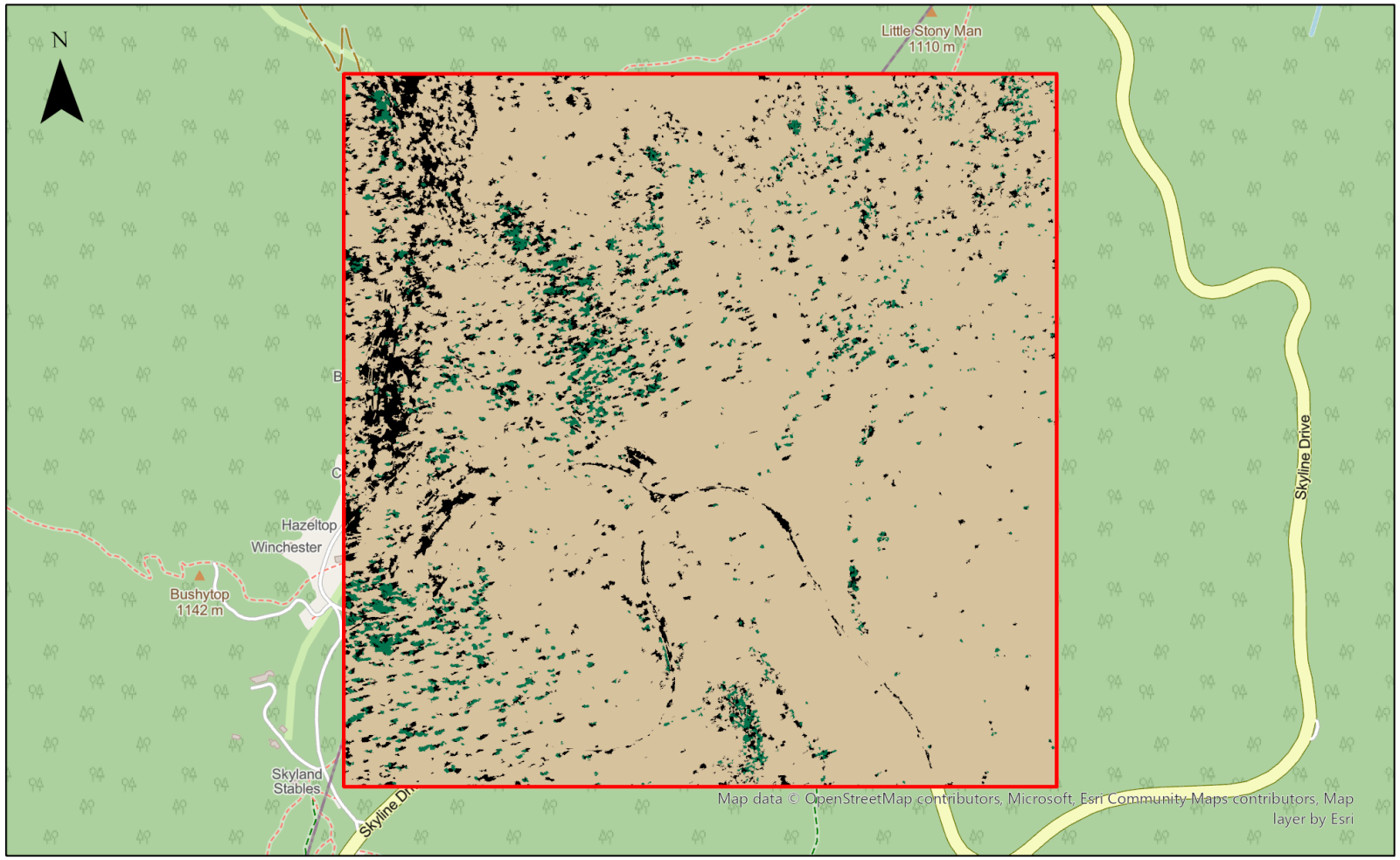
Classification Results

Shenandoah National Park, 2013



Study Area | Mixed Hemlock | Non-Vegetation/Shadows | Other Vegetation

0 0.25 0.5 0.75 1 Miles

Author: Jonathan Mikolin

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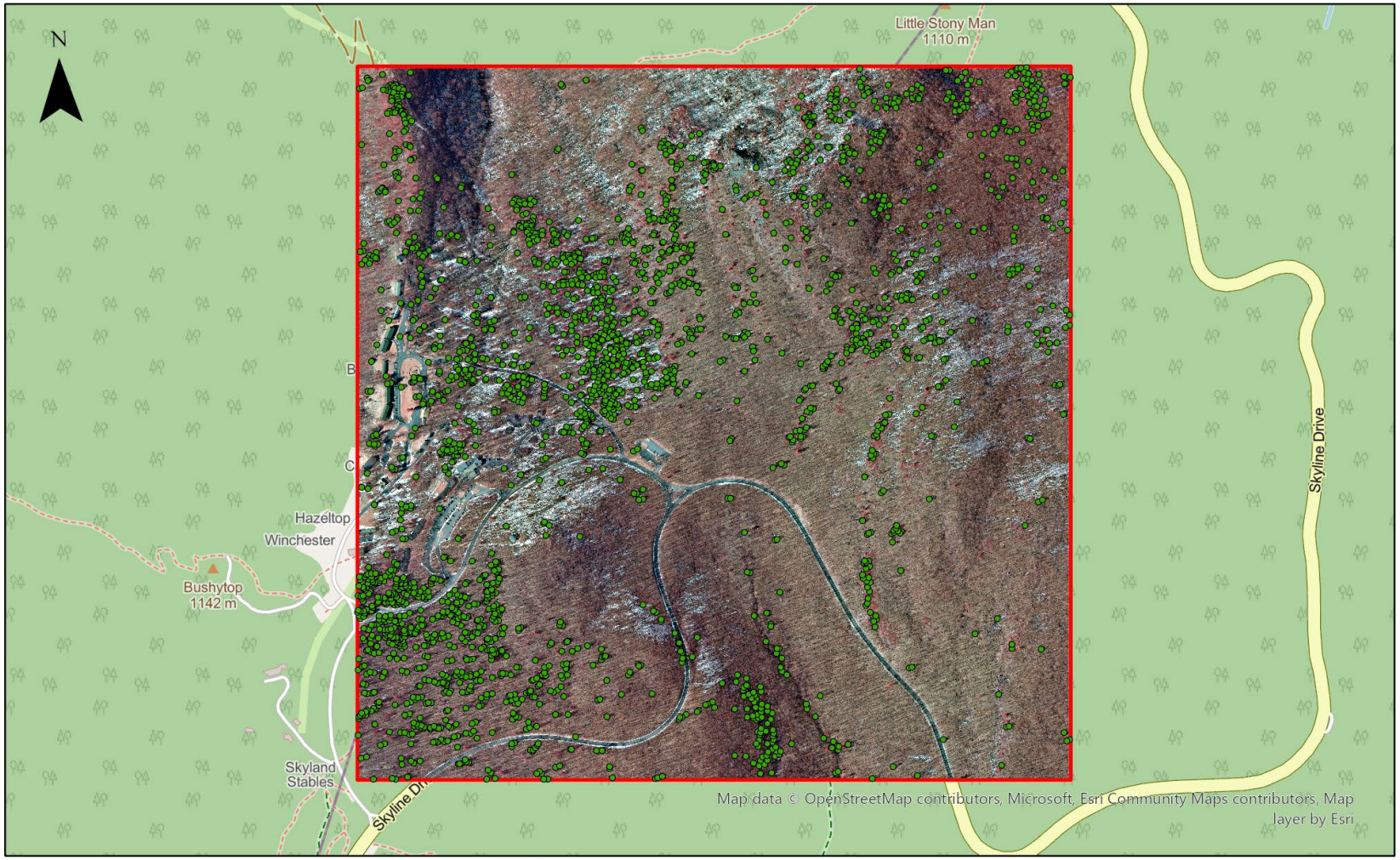
Classification Results Waypoint Format

CIR 4-1-2 Band Combination Orthophoto

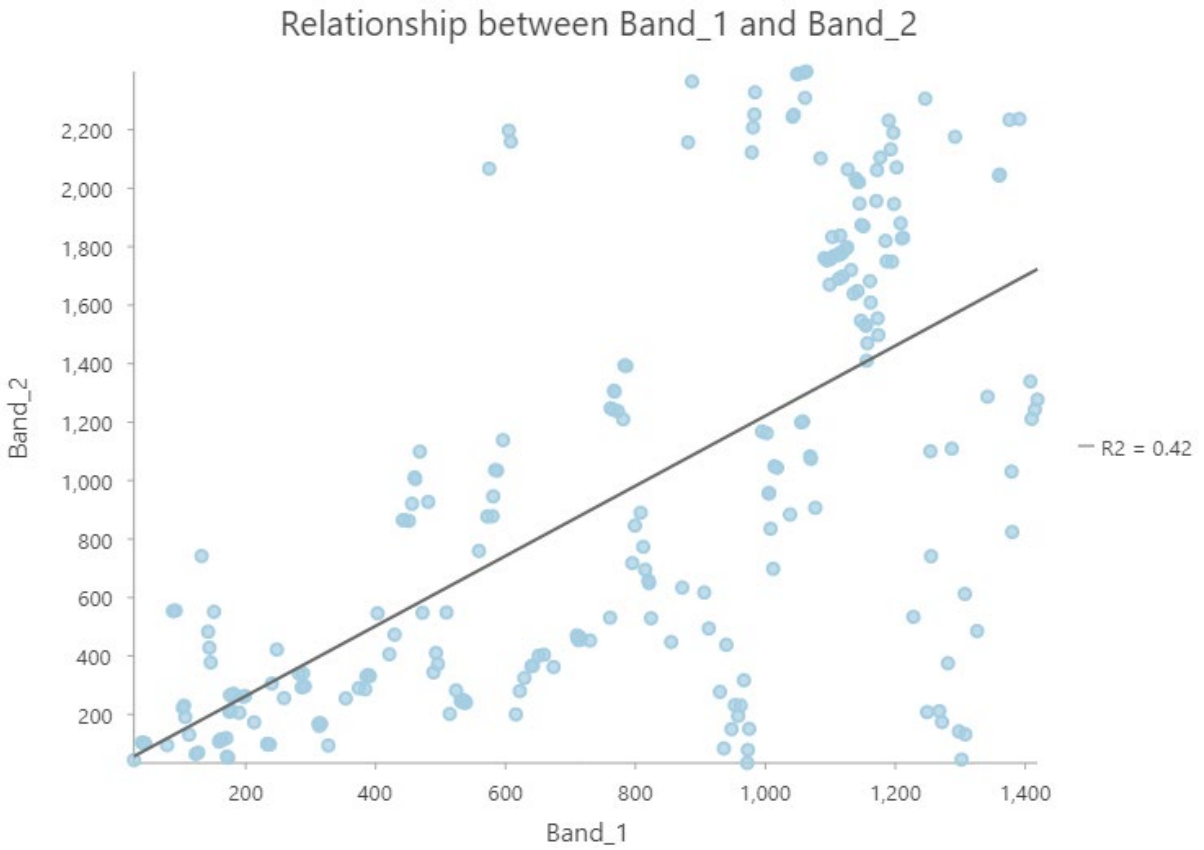
Shenandoah National Park, 2013



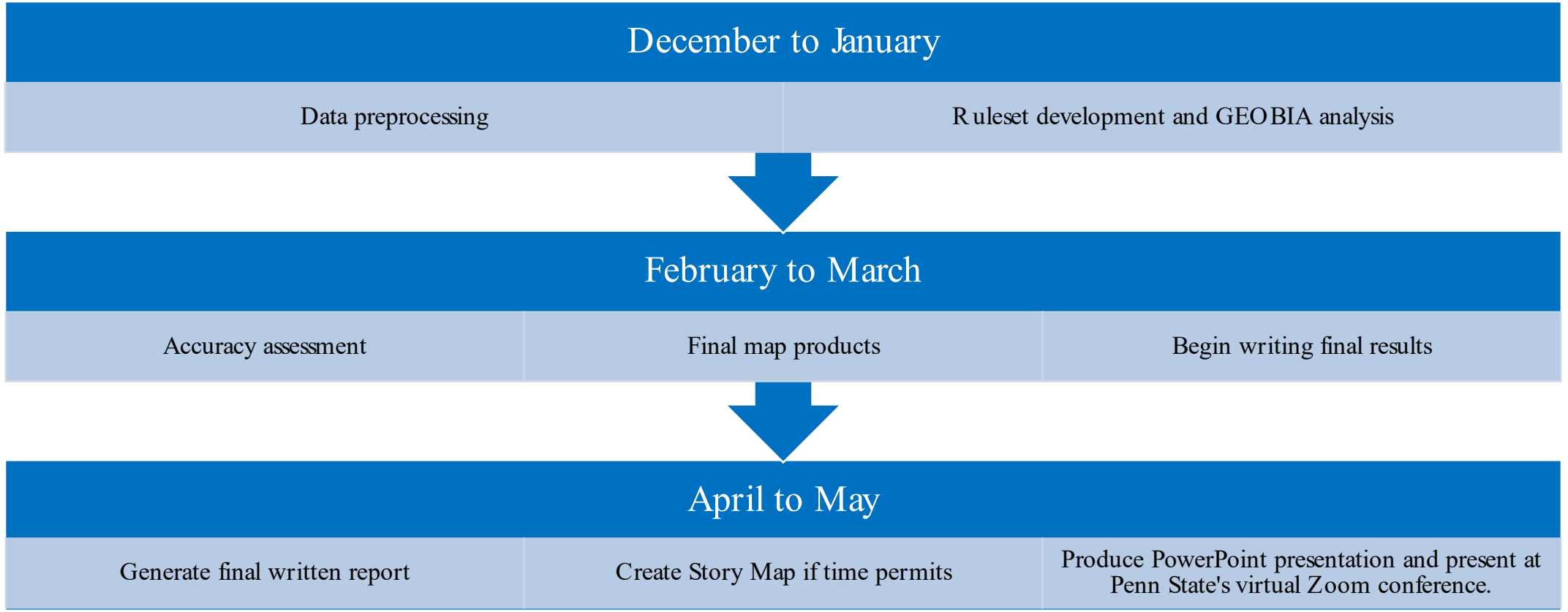
Author: Jonathan Mikolin

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.



Timeline

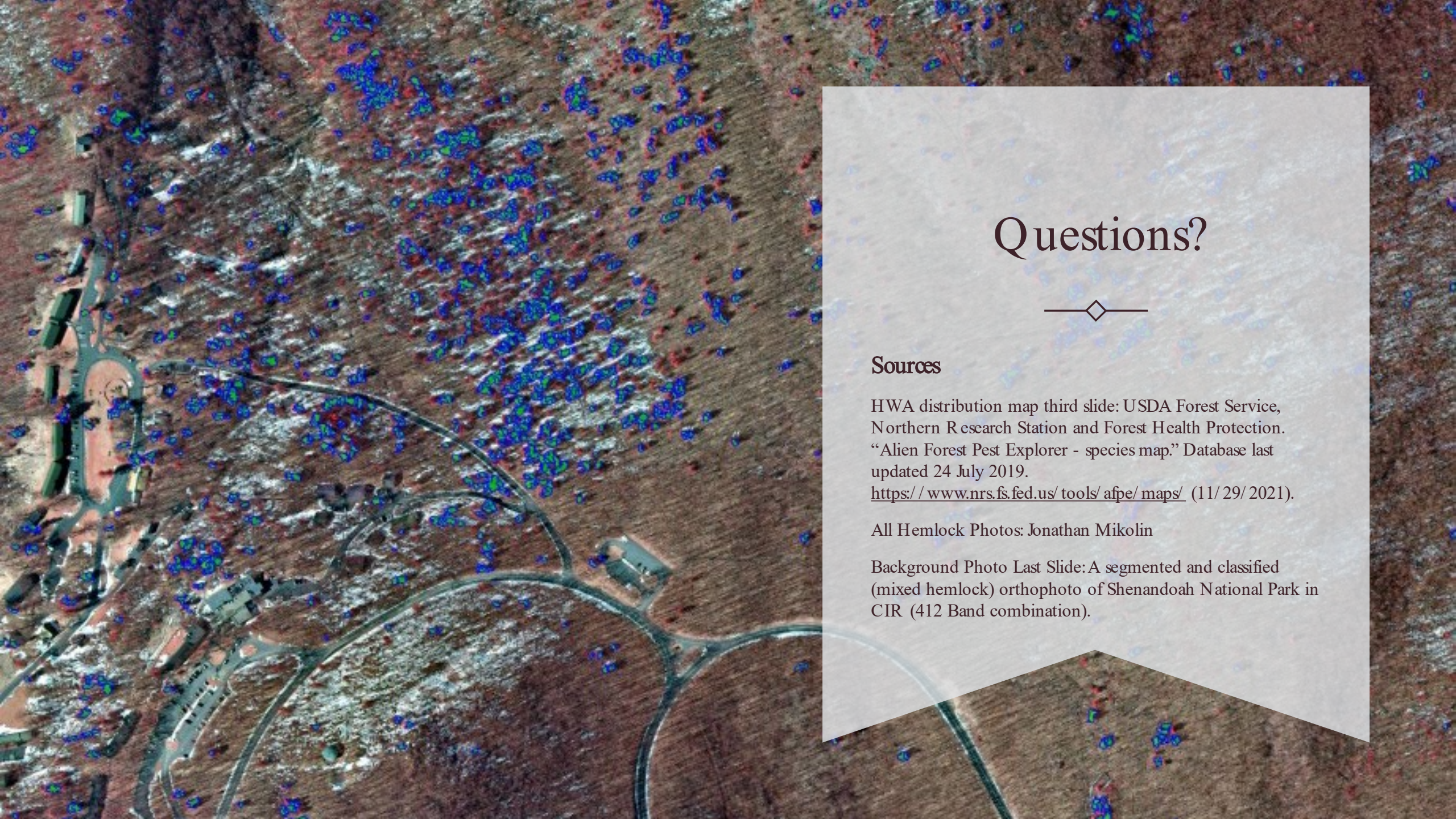

December to January
Data preprocessing
Ruleset development and GEOBIA analysis
February to March
Accuracy assessment
Final map products
Begin writing final results
April to May
Generate final written report
Create Story Map if time permits
Produce PowerPoint presentation and present at Penn State's virtual Zoom conference.

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

HWA distribution map third slide: 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).

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).