Seeing through the point cloud: Mapping and monitoring local to landscape forest structure with LiDAR

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Outline

(1) Why do we care about forest structure?

(2) Estimating gridded forest structure from LiDAR

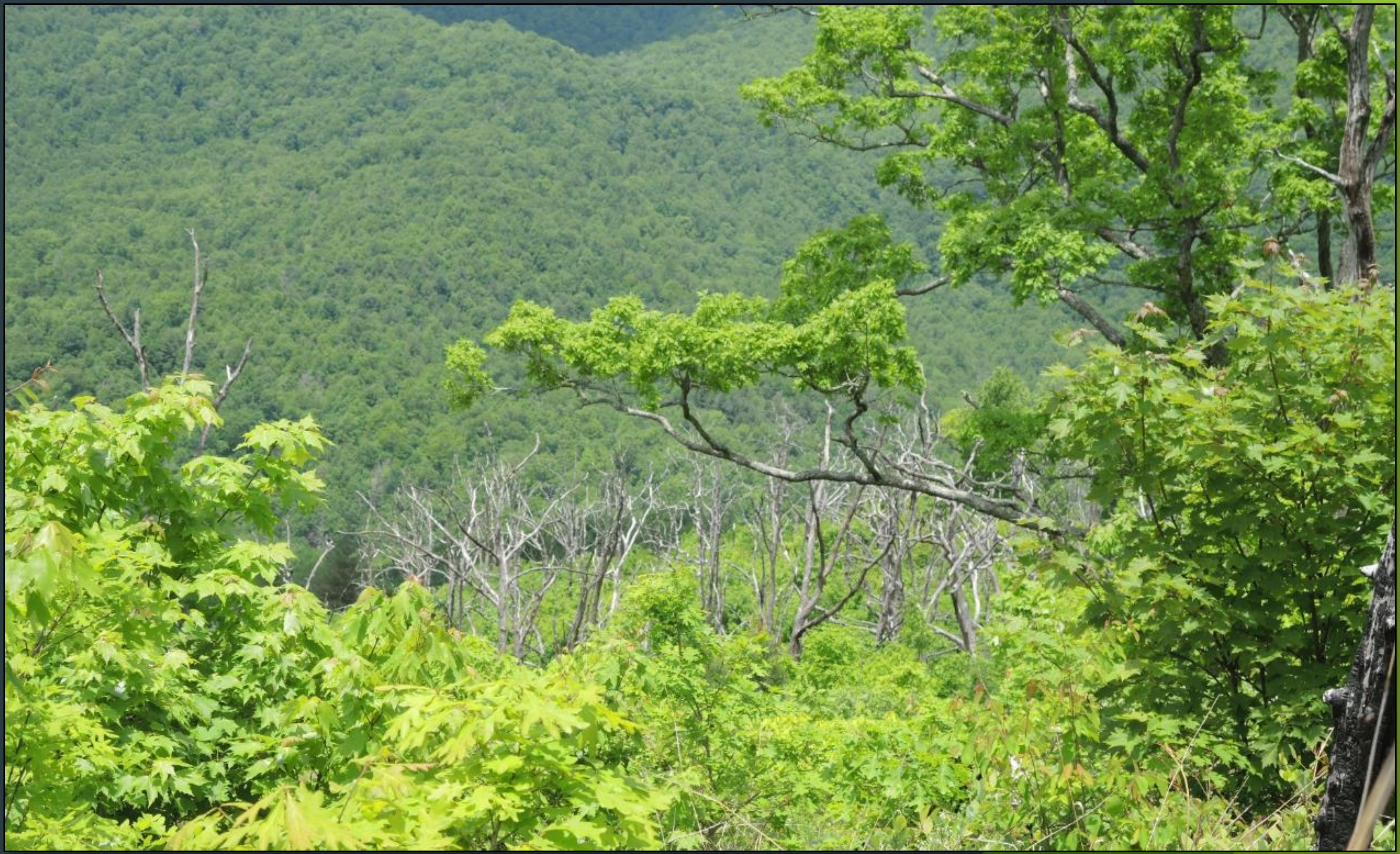
(3) Gridded data and products

Why do we care about forest structure?

1) It’s half the term “forest composition and structure”, but its usually only mapped by “stand age” and “site index”

Why do we care about forest structure?

2) Realized forest structure can change from management, disturbance and succession, even when composition doesn't



Why do we care about forest structure?

3) Measures of forest structure can characterize habitat, stand health and progress toward management objectives

Why do we care about forest structure?

Given these values and needs, what might an ideal 21st century forest structural dataset look like?

- Would the database be sample-based (plots), have a continuous mapped coverage, or both?
- Would we know the height and basal area of every stem known to species, or just the vertical distribution of biomass in a grid cell?
- Would it tell us all we need to know about competitive stress, or simply help prioritize where intervention may be most beneficial?
- Would data be updated in near-real time or just periodically?

How can we improve the current situation?

Outline

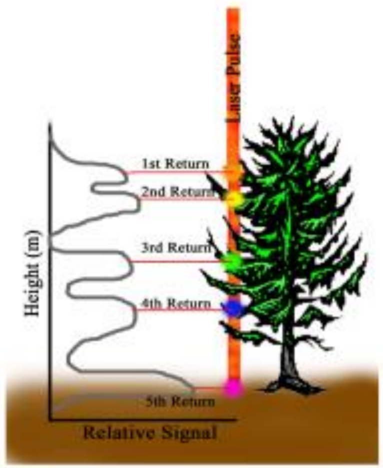
(1) Why do we care about forest structure?

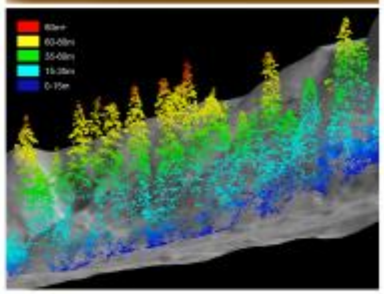
(2) Estimating gridded forest structure from LiDAR

(3) Gridded data and products

Estimating gridded forest structure from LiDAR

- Forests form a complex mosaic of diverse tree and coexisting plant and animal species.
- The structure of vegetation reveals information about stand age and height; forest composition, health, and disturbance; and suitability as habitat for birds and other animal species.
- Airborne Light Detection and Ranging (LiDAR) enables large scale remote sensing of topography, built infrastructure, and vegetation structure.
- Multiple laser "returns" produce "point clouds" used to map the ground surface, buildings, roads, and utility infrastructure, and to reconstruct the structure of vegetation canopies.
- Large data volumes pose significant computational challenges to employing LiDAR to monitor and manage forests and animal habitats.





Estimating gridded forest structure from LiDAR

From “Big Data” to “Humongous Data”

NC LiDAR 1.0 (2001-2005)
- Collected in 3 Phases
- 1-5m point spacing (3m average USGS Quality Level 4)
- 25.5 billion points statewide

NC LiDAR 2.0 (2014-2017)
- Collected in 5 phases (1-2 in 2014, 3 in 2015, 4-5 in 2016)
- 2 points/m for Phases 1-3 (USGS Quality Level 2), but
  8 points/m for Phases 4-5 are planned!
- Already have 240 billion points in just the first two phases
  in the 40 eastern NC counties (so ~1 trillion more!?)


"Let's shrink Big Data into Small Data ...
... and hope it magically becomes Great Data."

Outline

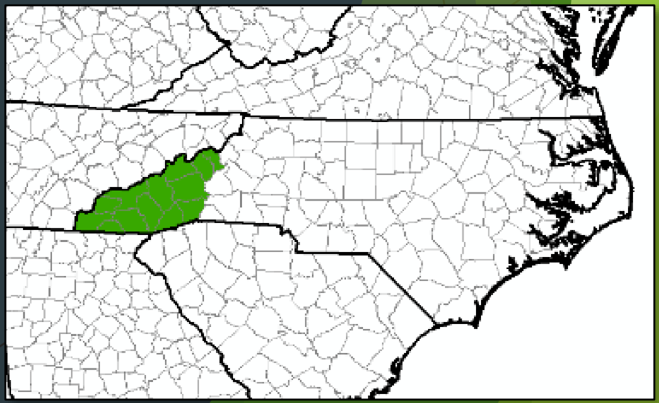
(1) Why do we care about forest structure?

(2) Estimating gridded forest structure from LiDAR

(3) Gridded data and products:

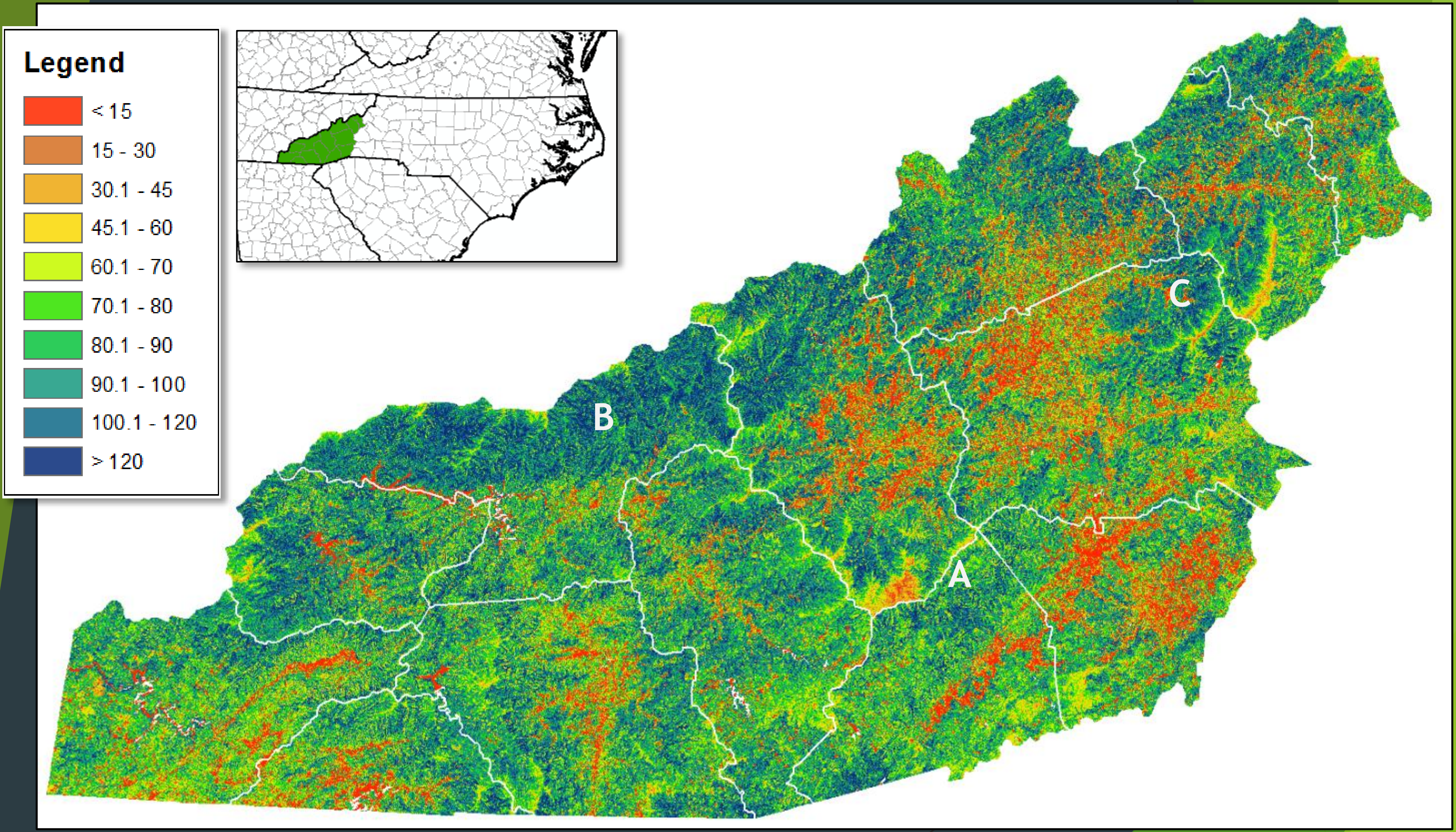
- Maximum vegetation height
- A classification of structural types

Project Area

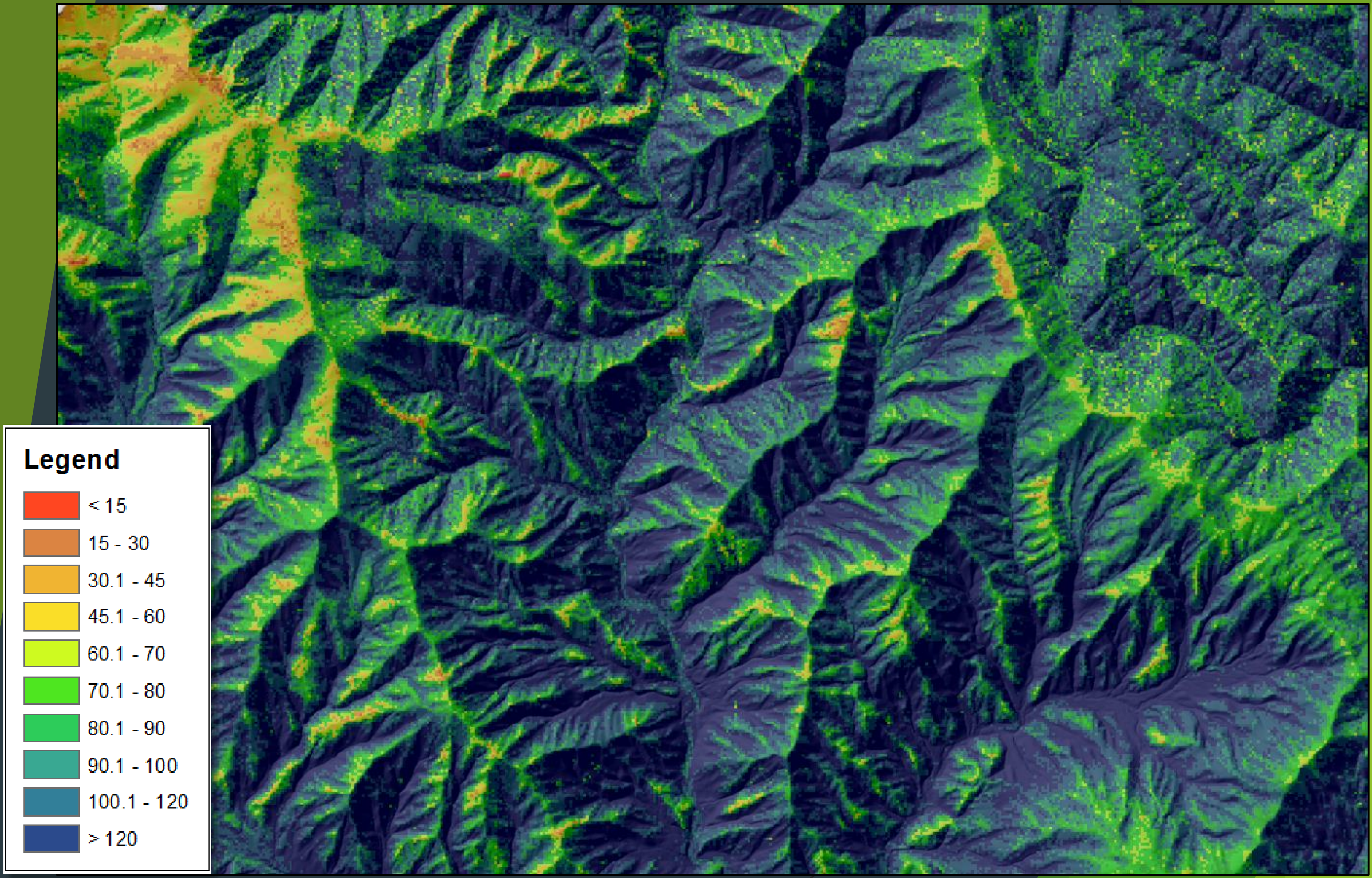


Products: Maximum vegetation height

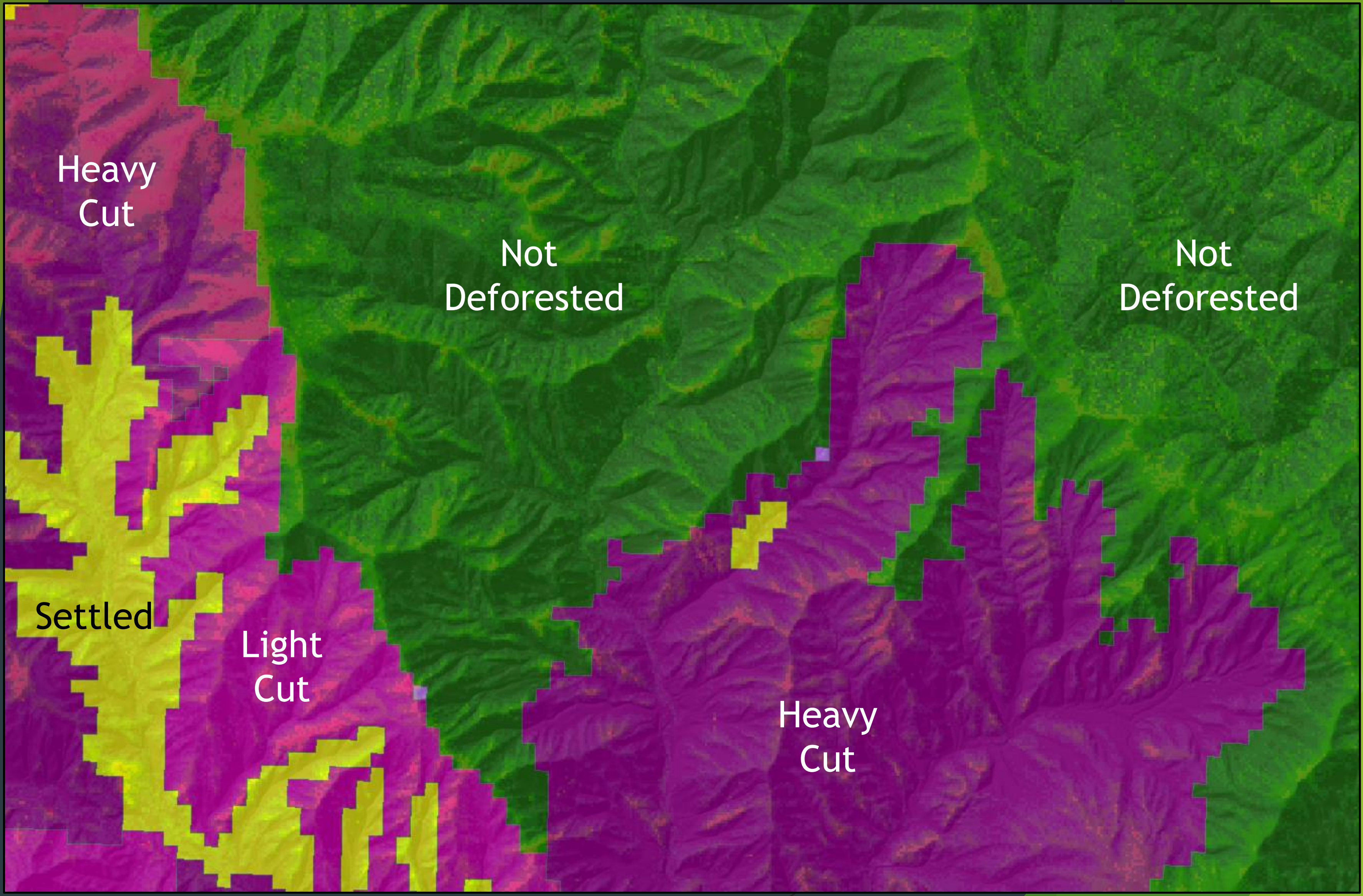
Focal area: 13-county area of western NC



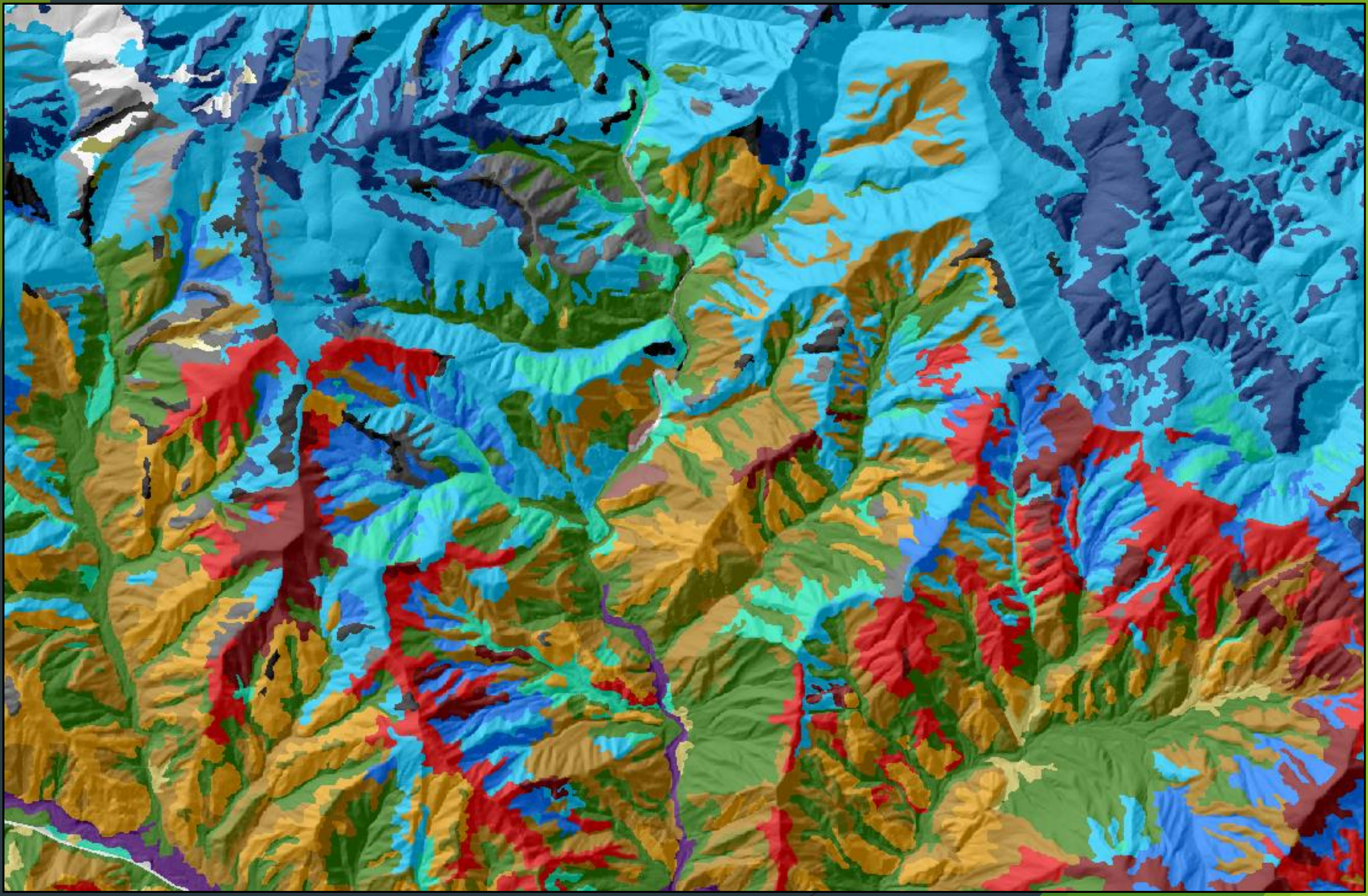
Products: Maximum vegetation height
Bradley Fork (upstream of Smokemont) GSMNP



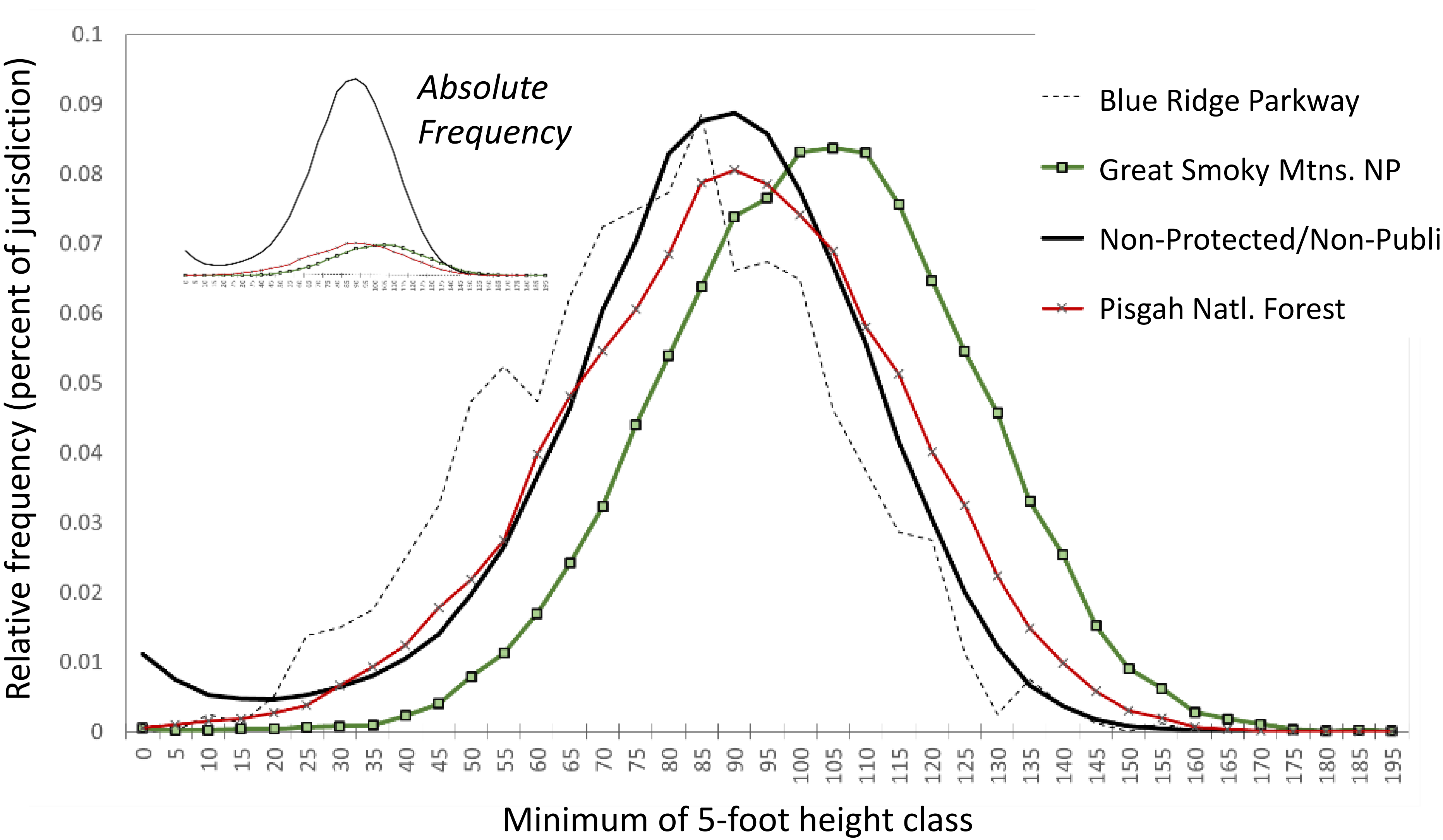
Landscape disturbance history
Bradley Fork (upstream of Smokemont) GSMNP



Landscape compositional types
Bradley Fork (upstream of Smokemont) GSMNP

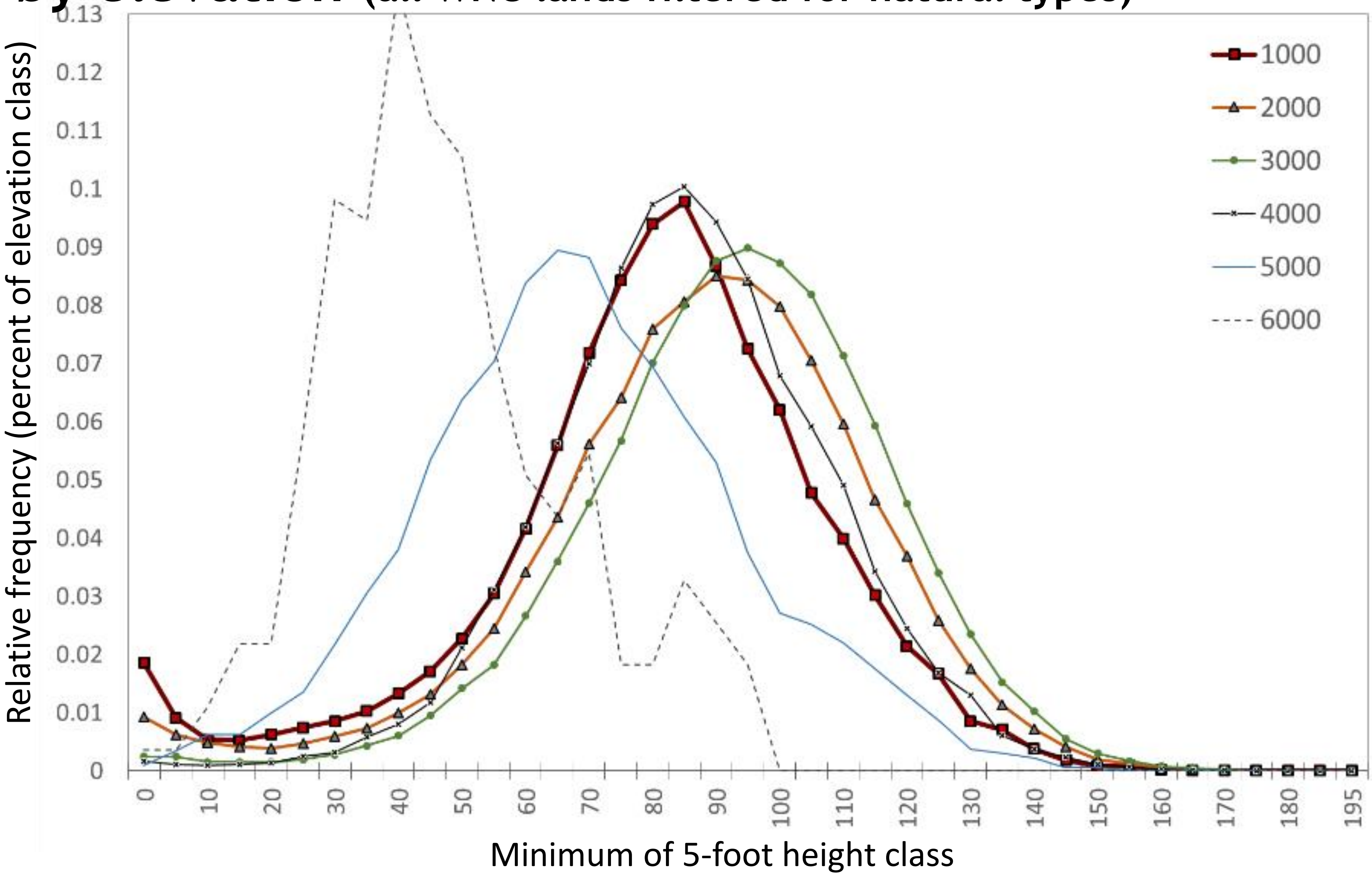


Landscape distributions of maximum tree height by jurisdiction (using a NLCD filter for all WNC natural types)



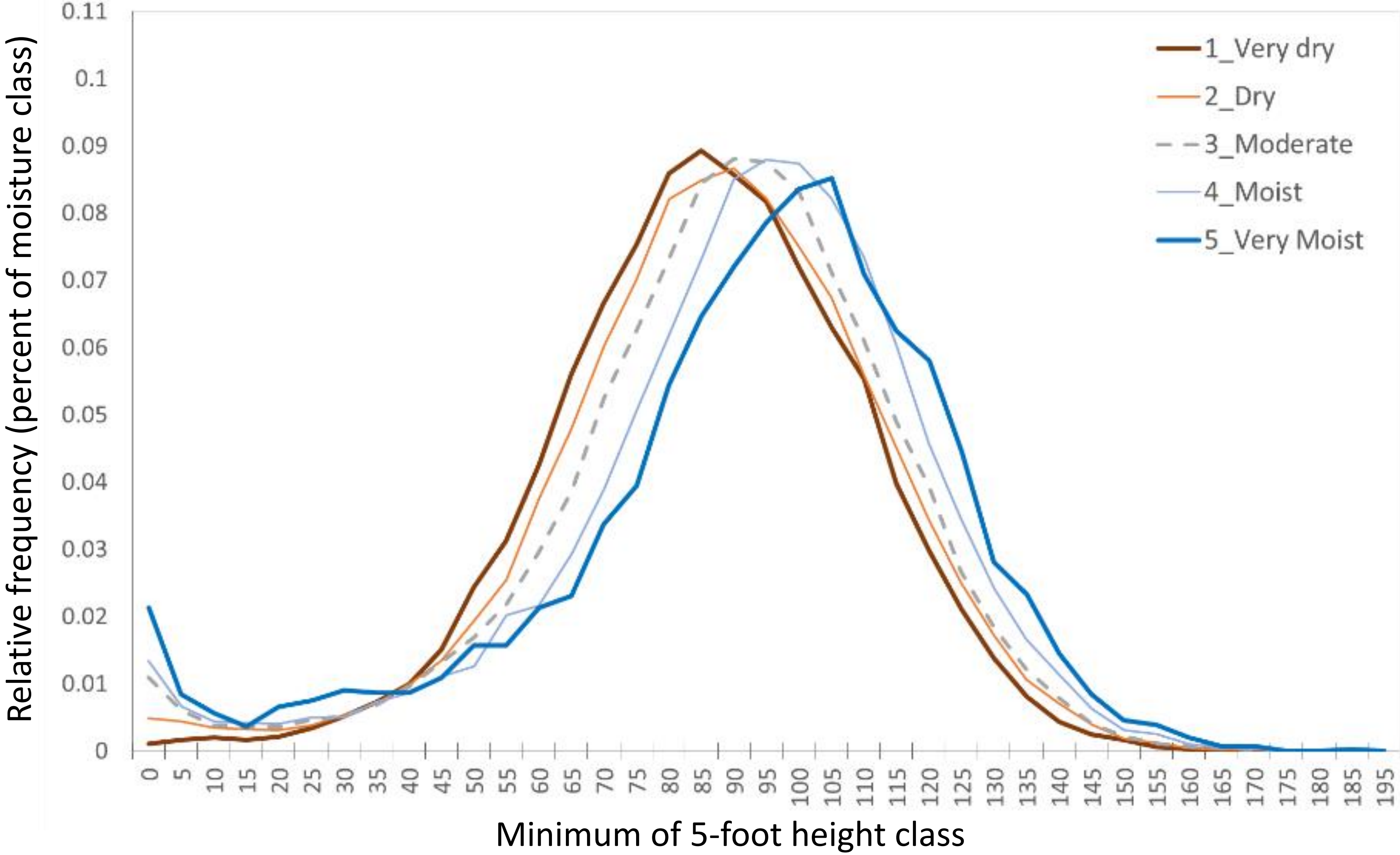
N= BRP: 802; GSMNP: 19,839; Non: 120,514; Pisgah NF: 21,991 (Sum: 163,146)

Landscape distributions of maximum tree height by elevation (all WNC lands filtered for natural types)



N=210,248 randomly sampled 20x20m LiDAR grid cells

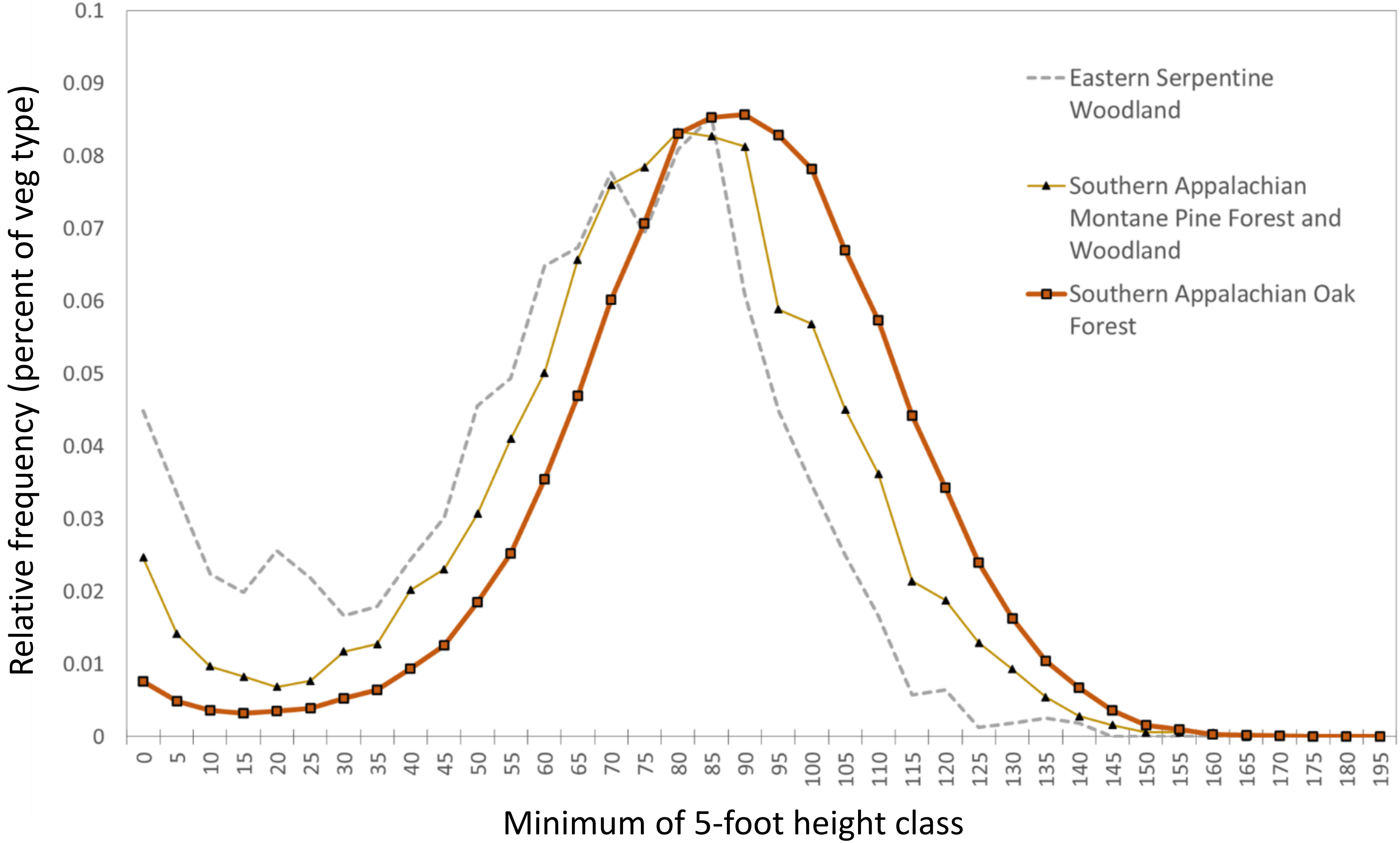
Landscape distributions of maximum tree height by moisture index (all WNC lands filtered for natural types)



N=210,248 randomly sampled 20x20m LiDAR grid cells

Landscape distributions of maximum tree height

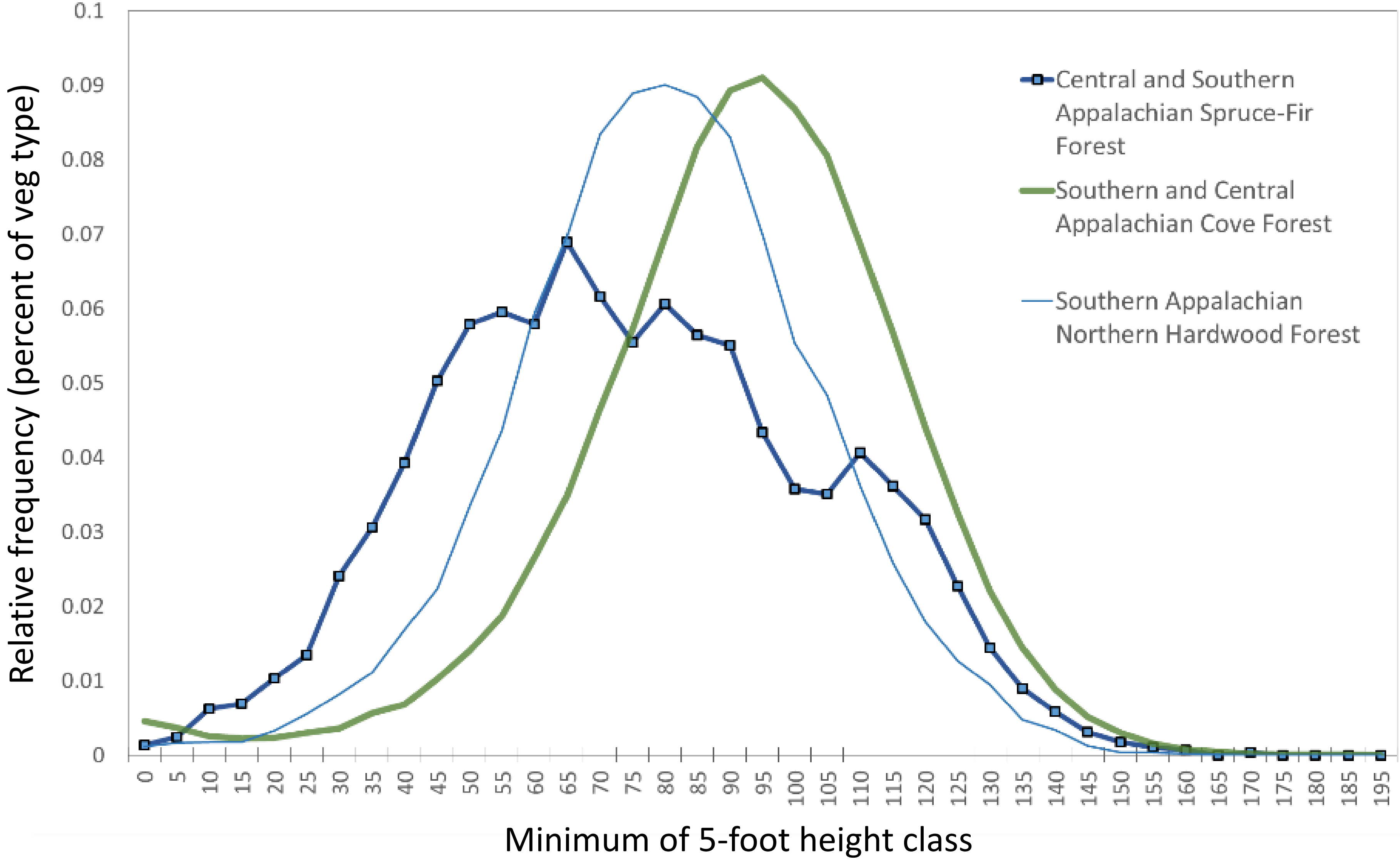
for selected xeric Landfire existing vegetation types



N= Serpentine woodland: 1,558; Pine forest-woodland: 4,945; Oak forest: 81,786

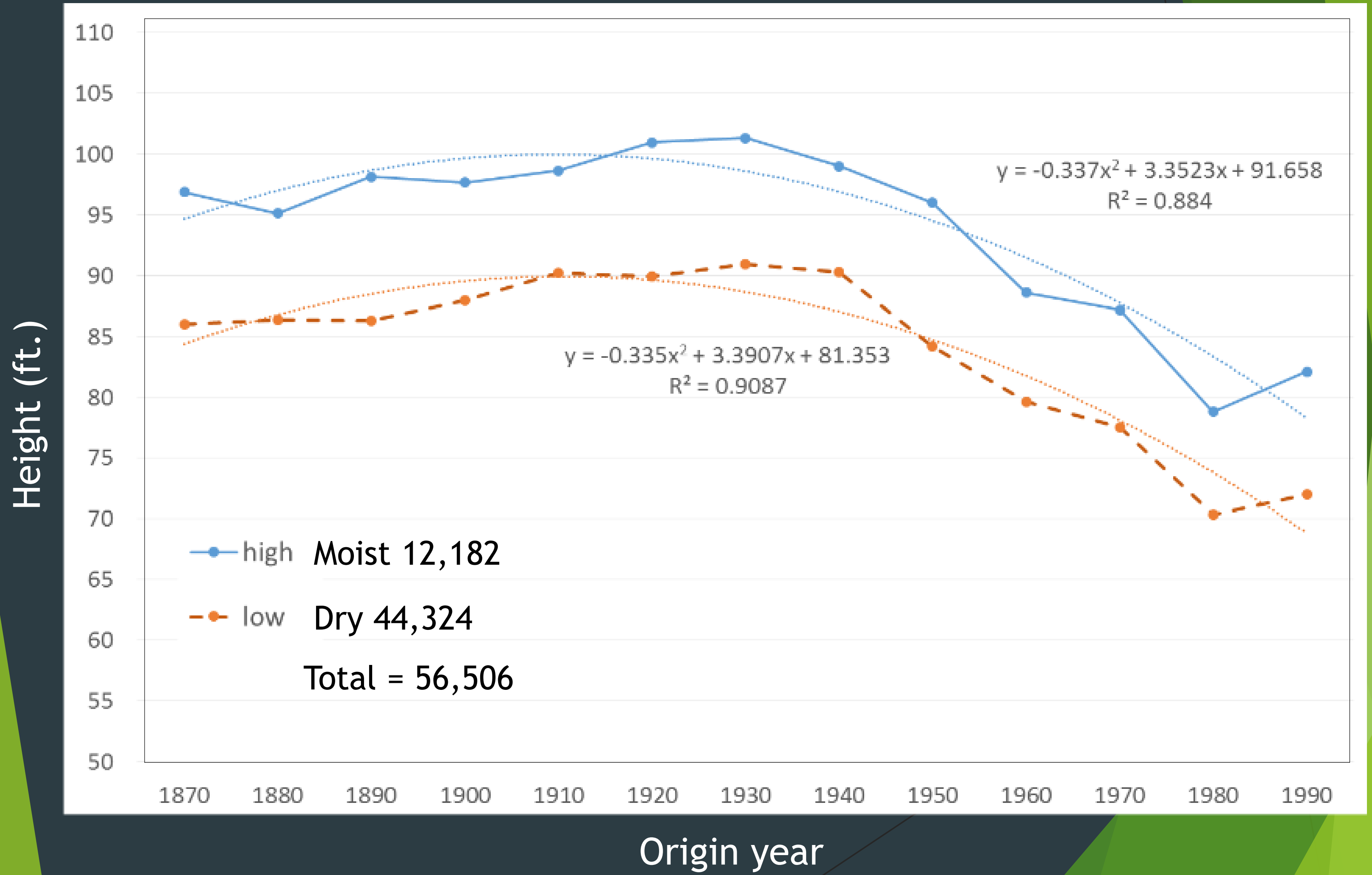
Landscape distributions of maximum tree height

for selected mesic Landfire existing vegetation types



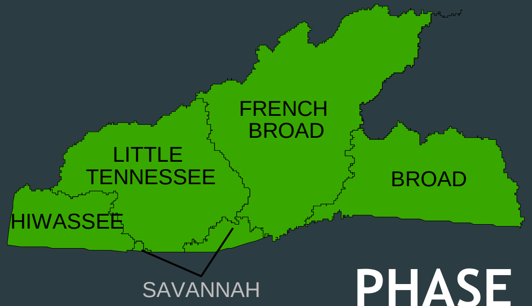
N= Spruce-fir forests: 2,904; Cove forests: 77,956; Northern Hardwood: 11,802

Mean height of stands of different origin years
Pisgah and Nantahala NFs, NC



A classification of structural types

(1) First, the above ground height for each point was calculated using a high resolution (LiDAR-based) digital elevation model.
(2) Points were then grouped into 5 ft height bands for each 60 ft grid cell.
(3) Relative density was calculated to overcome the problem of variable coverage intensity from overlap in flight lines. This gives the band’s percent of the total point cloud that constitutes the grid cell’s vegetation profile.
(4) These relative profile densities were then used as inputs into a non-hierarchical K-means clustering algorithm to reiteratively determine 10, 20, 40, 75 and 200 unique vegetation structural types.



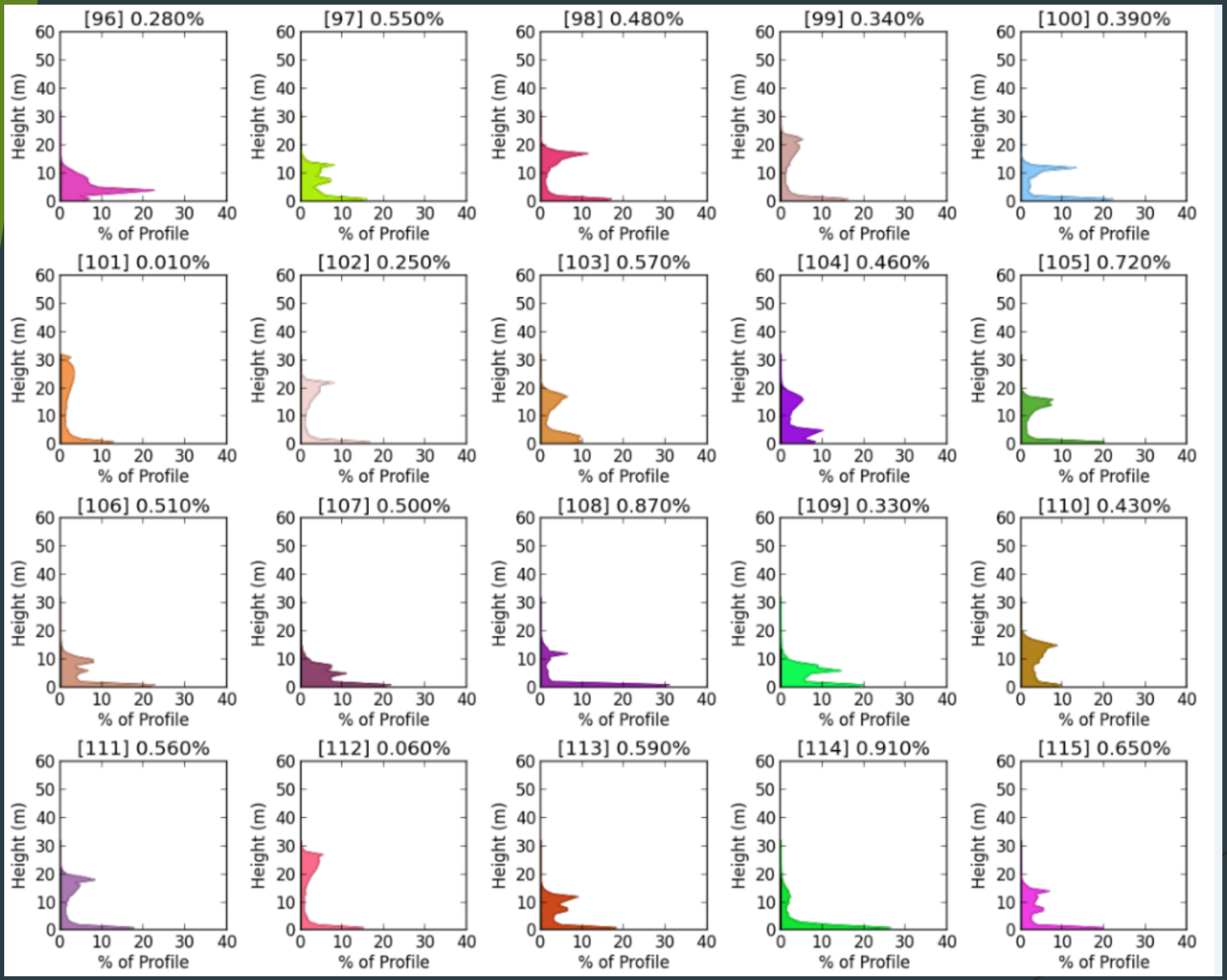
PHASE III

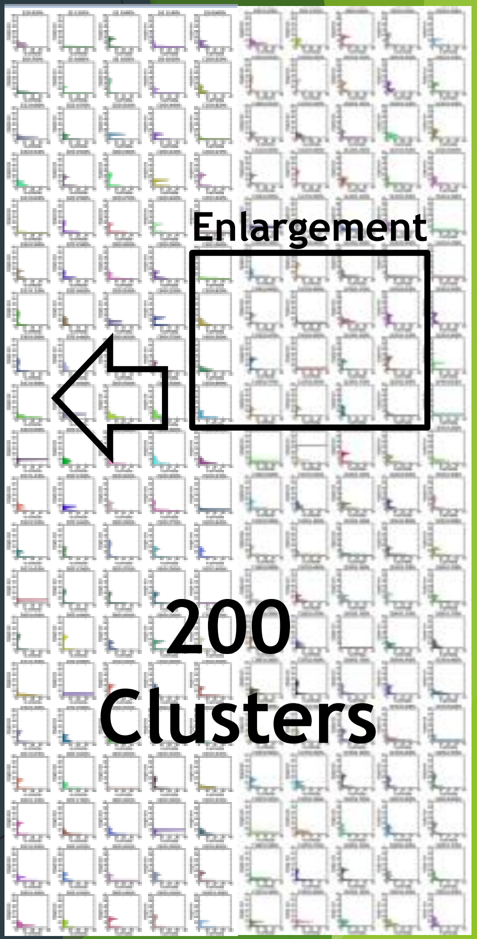
Processing was conducted using a supercomputer at Oak Ridge National Lab, TN.

A classification of structural types

LiDAR relative density profiles for clusters

Height

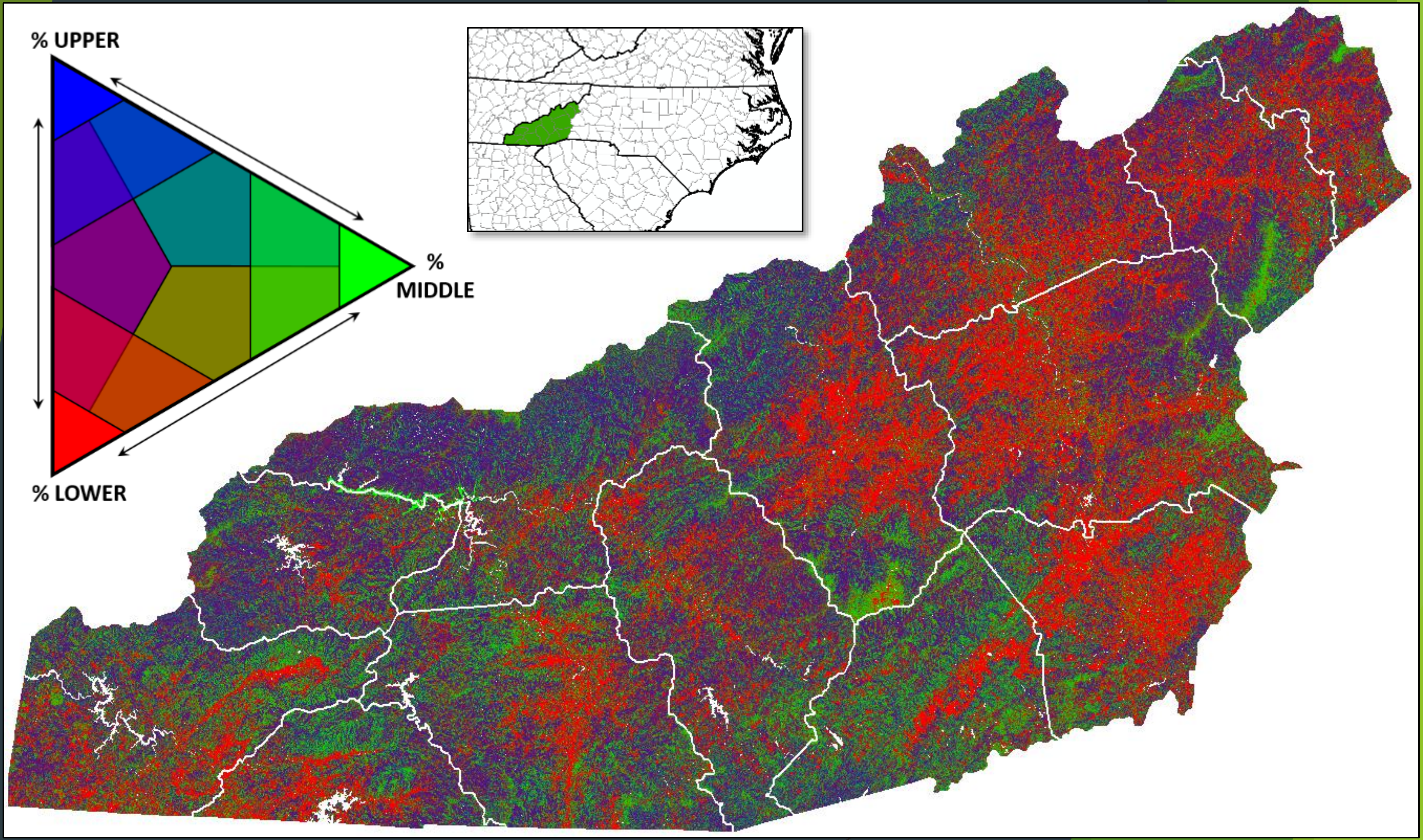




5-foot height band's percent of profile

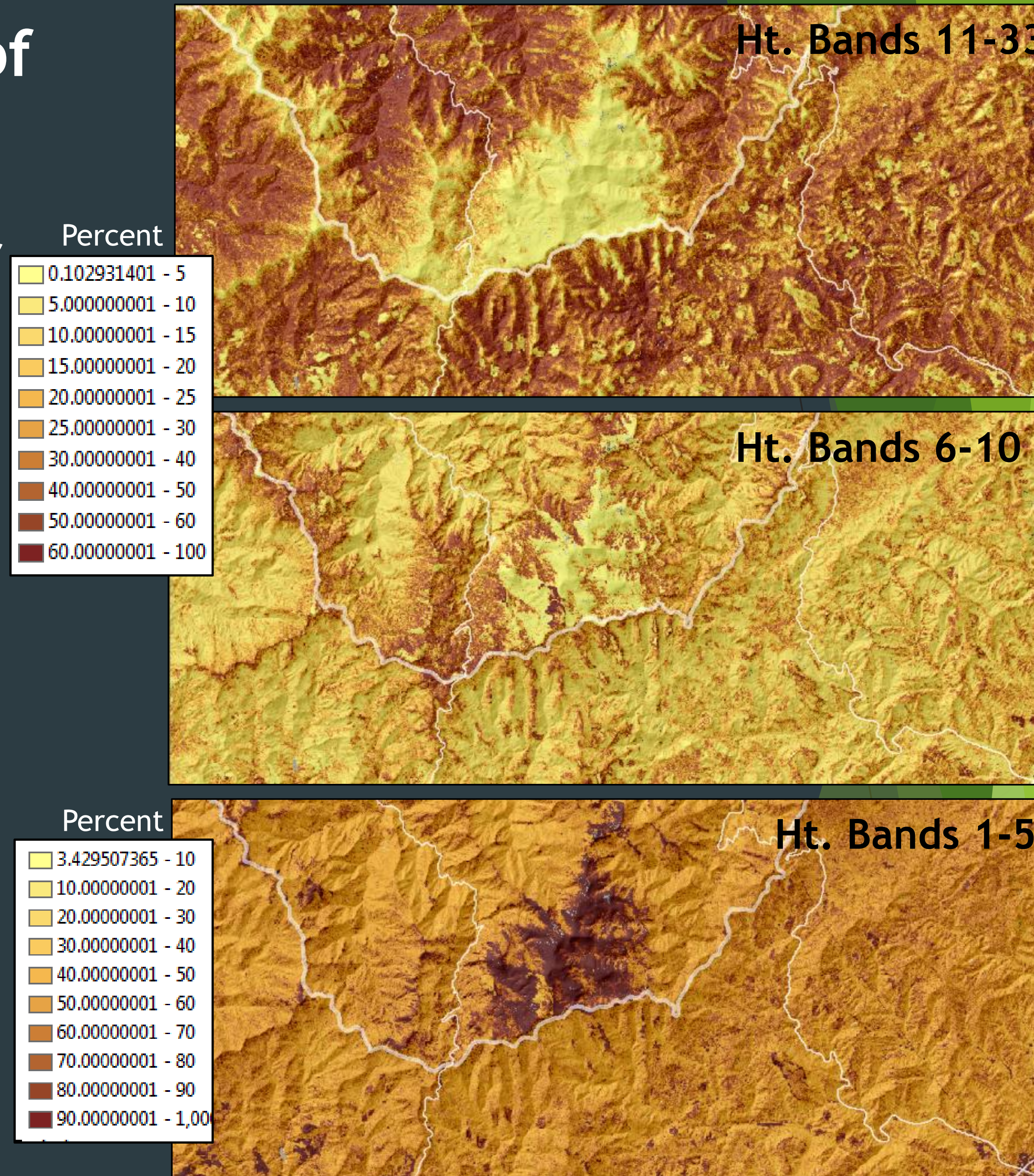
A classification of structural types

Tri-polar (R-G-B) colors on three height zones



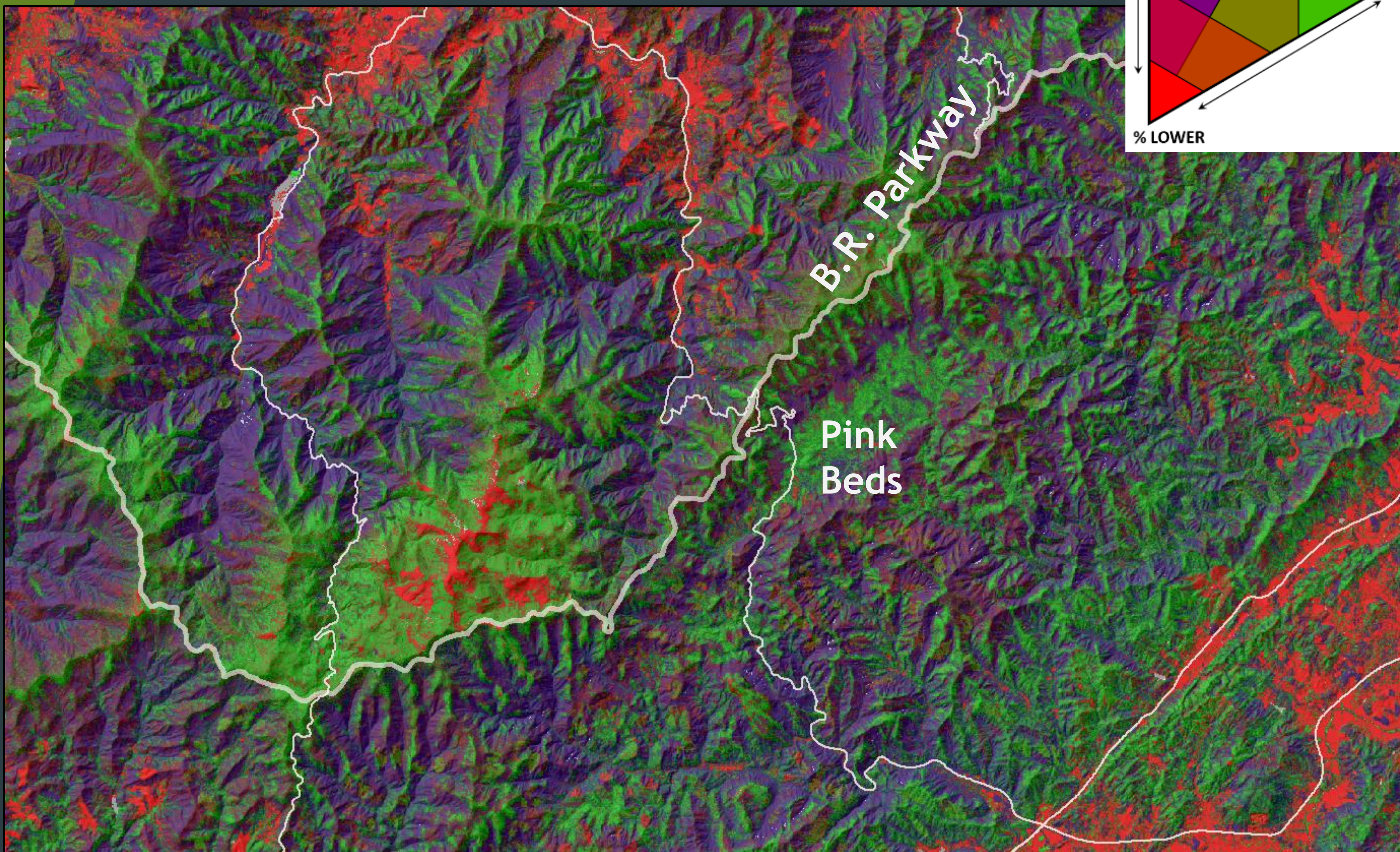
A classification of structural types

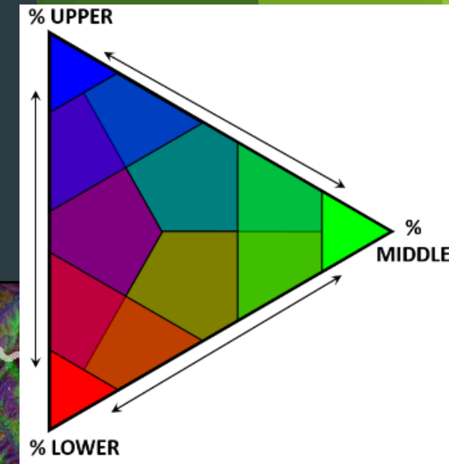
Relative proportion of LiDAR returns in Upper (bands 11-33), mid (6-10) and lower (1-5) fixed height bands for the Greater Shining Rock Wilderness Area, Pisgah NF and Blue Ridge Parkway



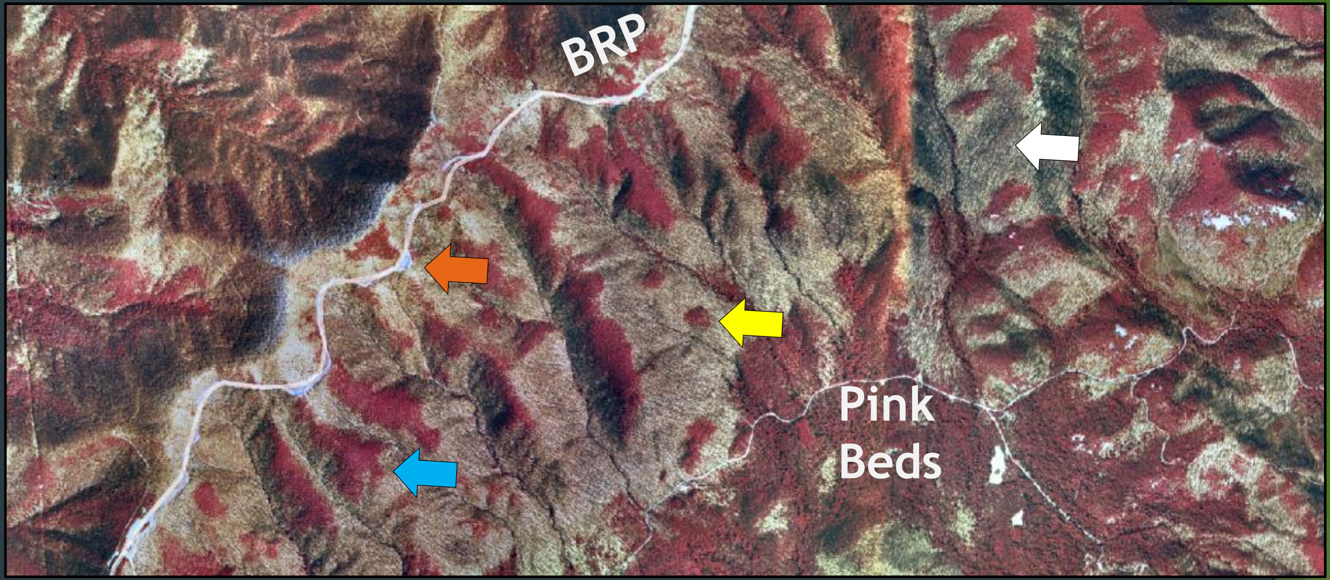
A classification of structural types

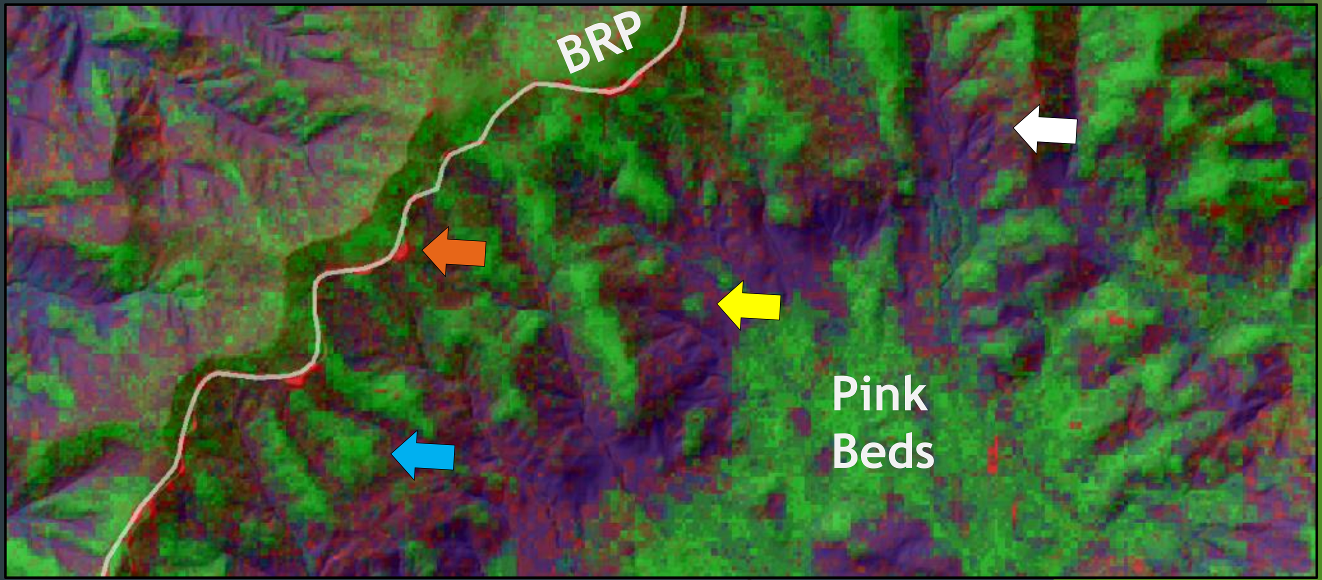
Pink Beds and Cold Mountain, Pisgah NF

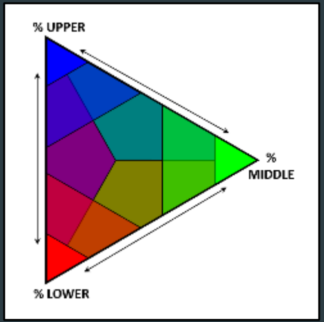




A classification of structural types
Detectability of key understory attributes Pink Beds, Pisgah NF

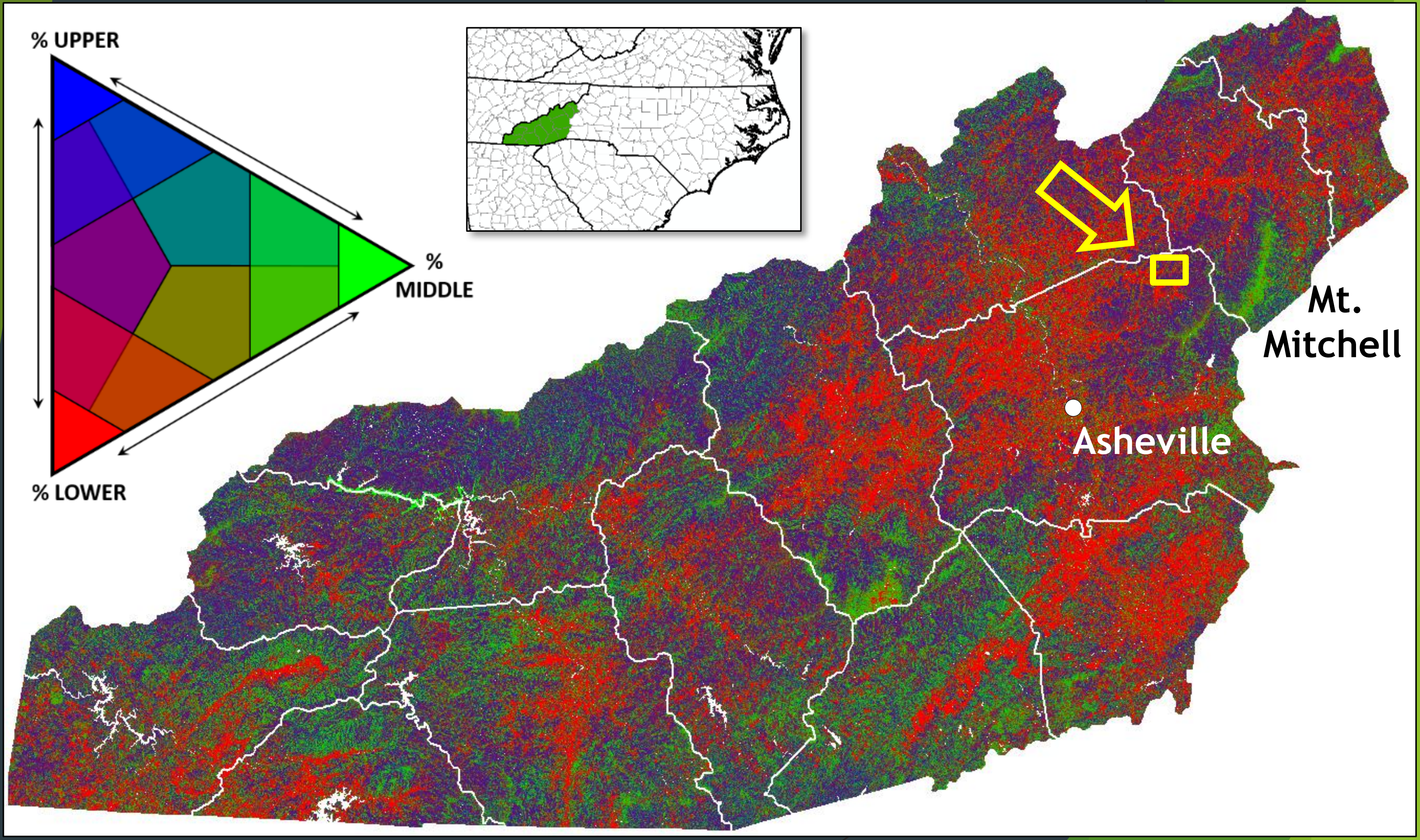




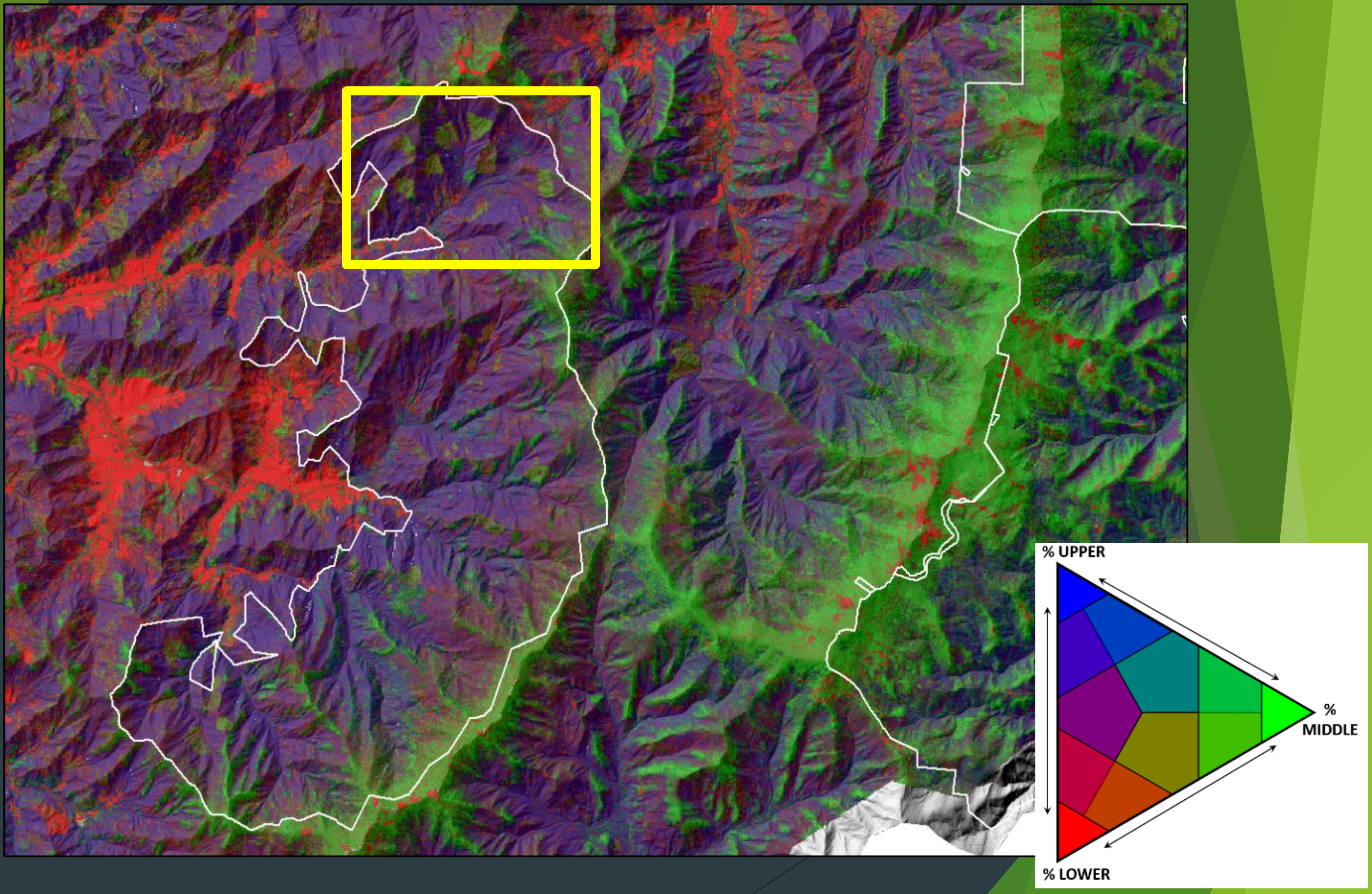


Focal area

NE Buncombe County, Pisgah National Forest

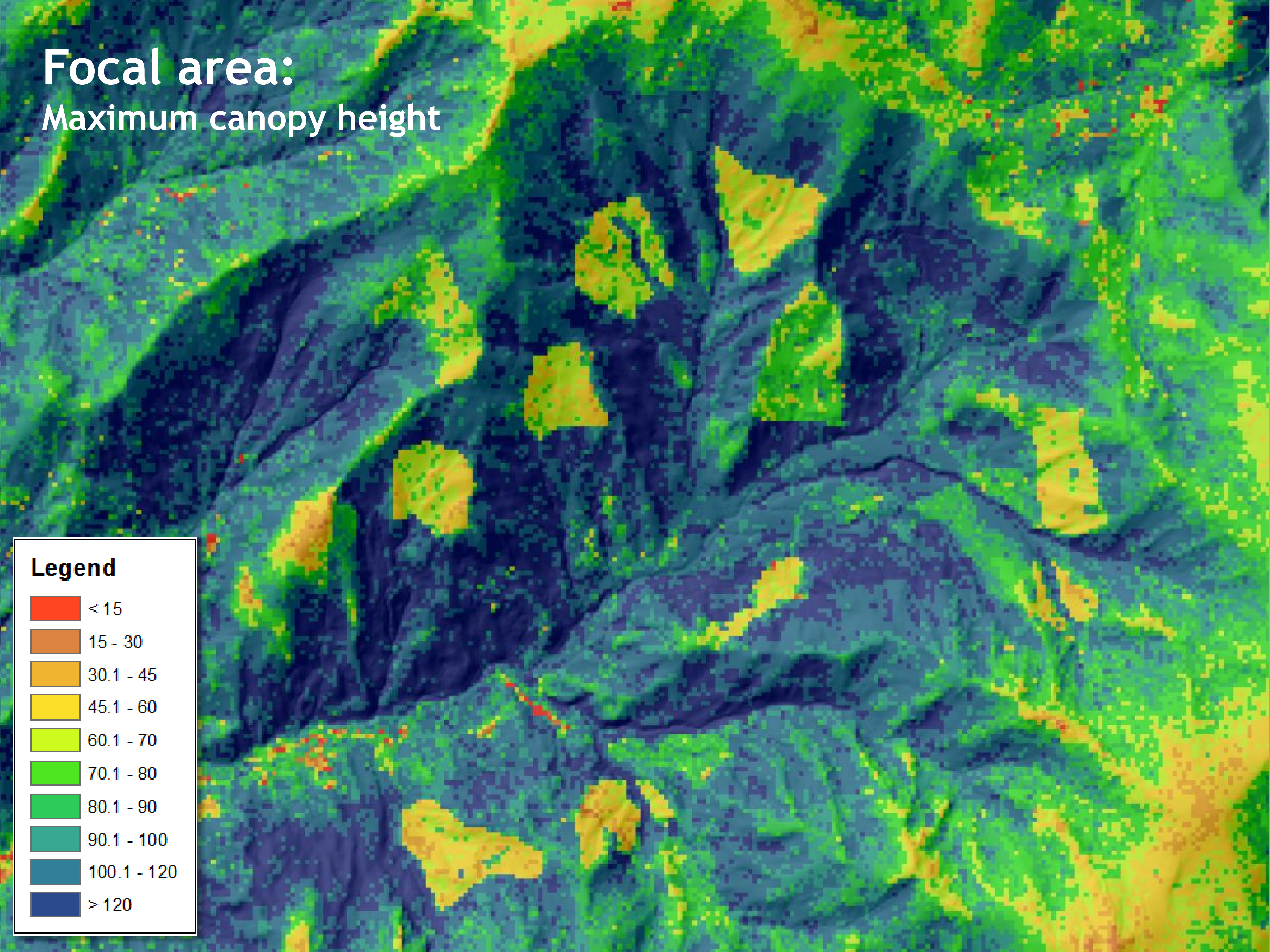


Focal area:
Classification of structural types

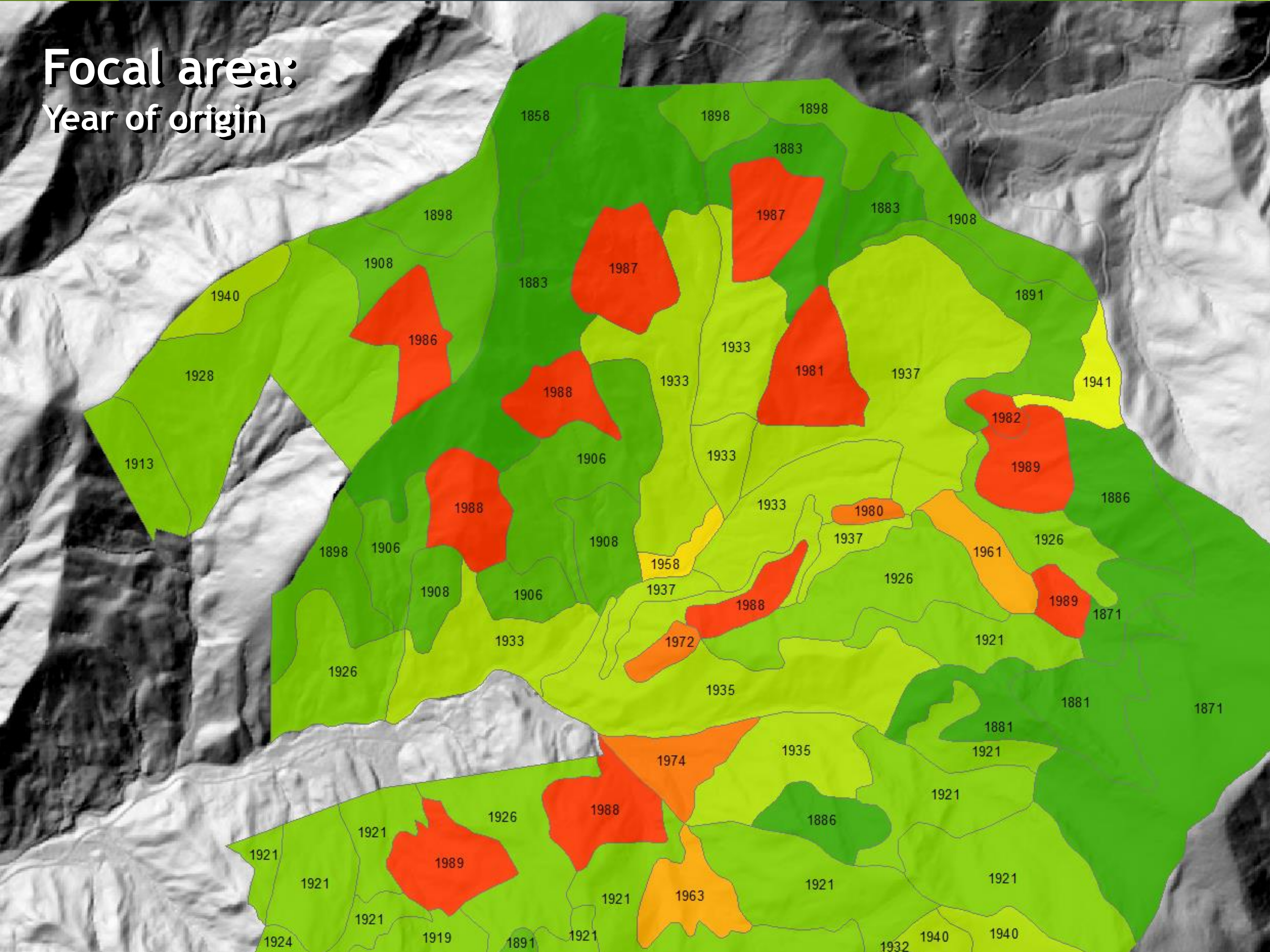


Focal area:

Maximum canopy height

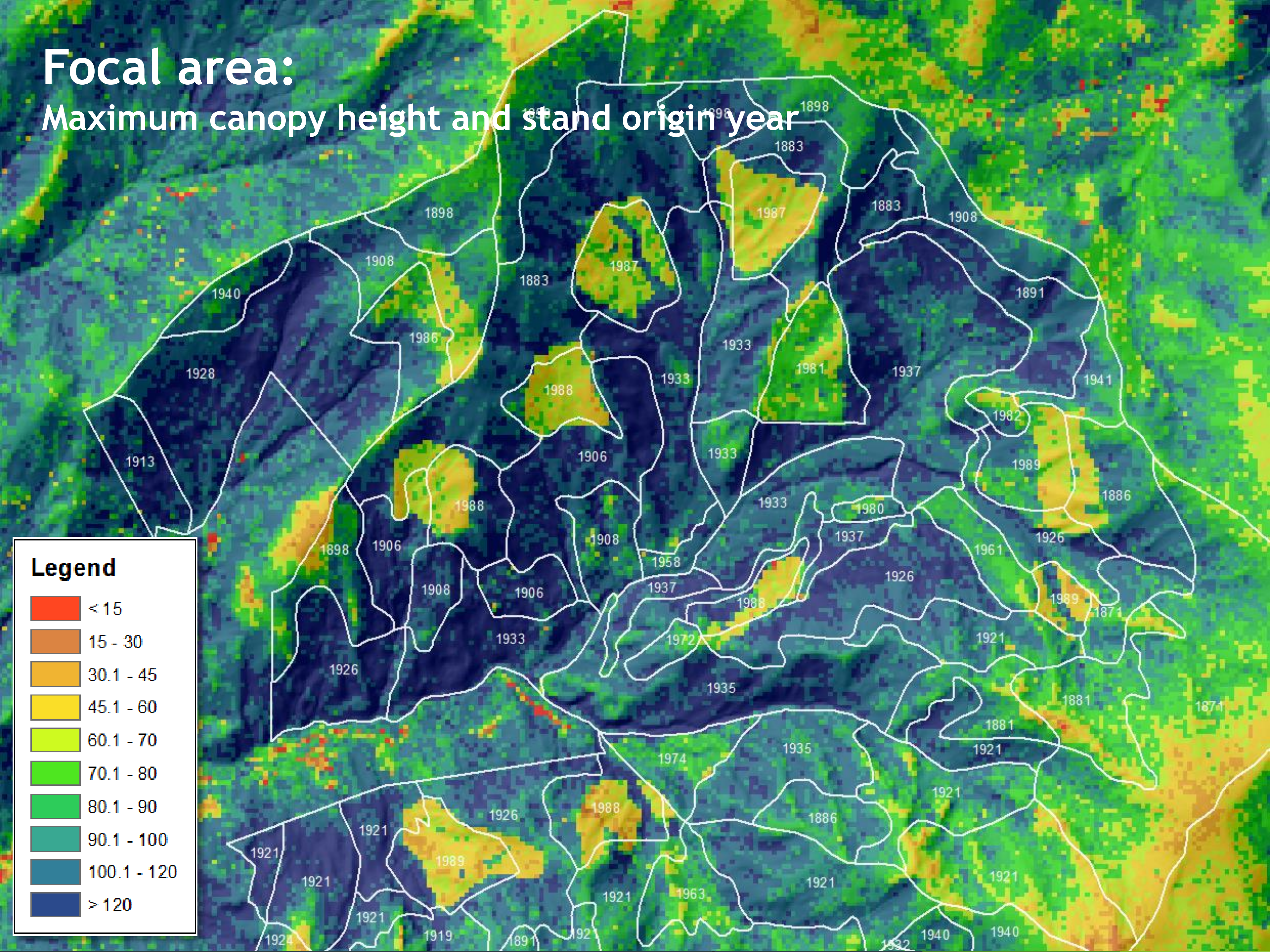


Focal area:
Year of origin



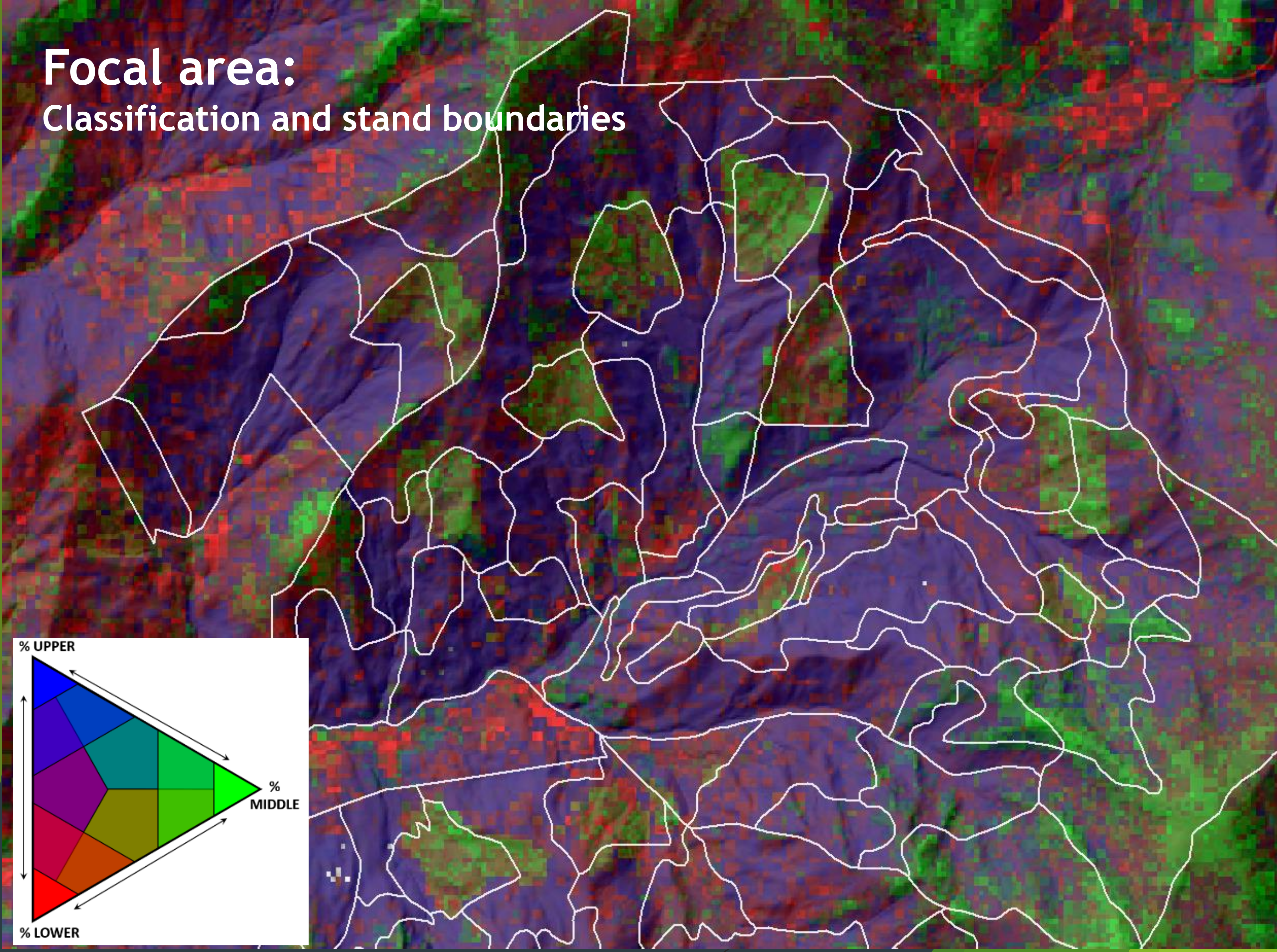
Focal area:

Maximum canopy height and stand origin year

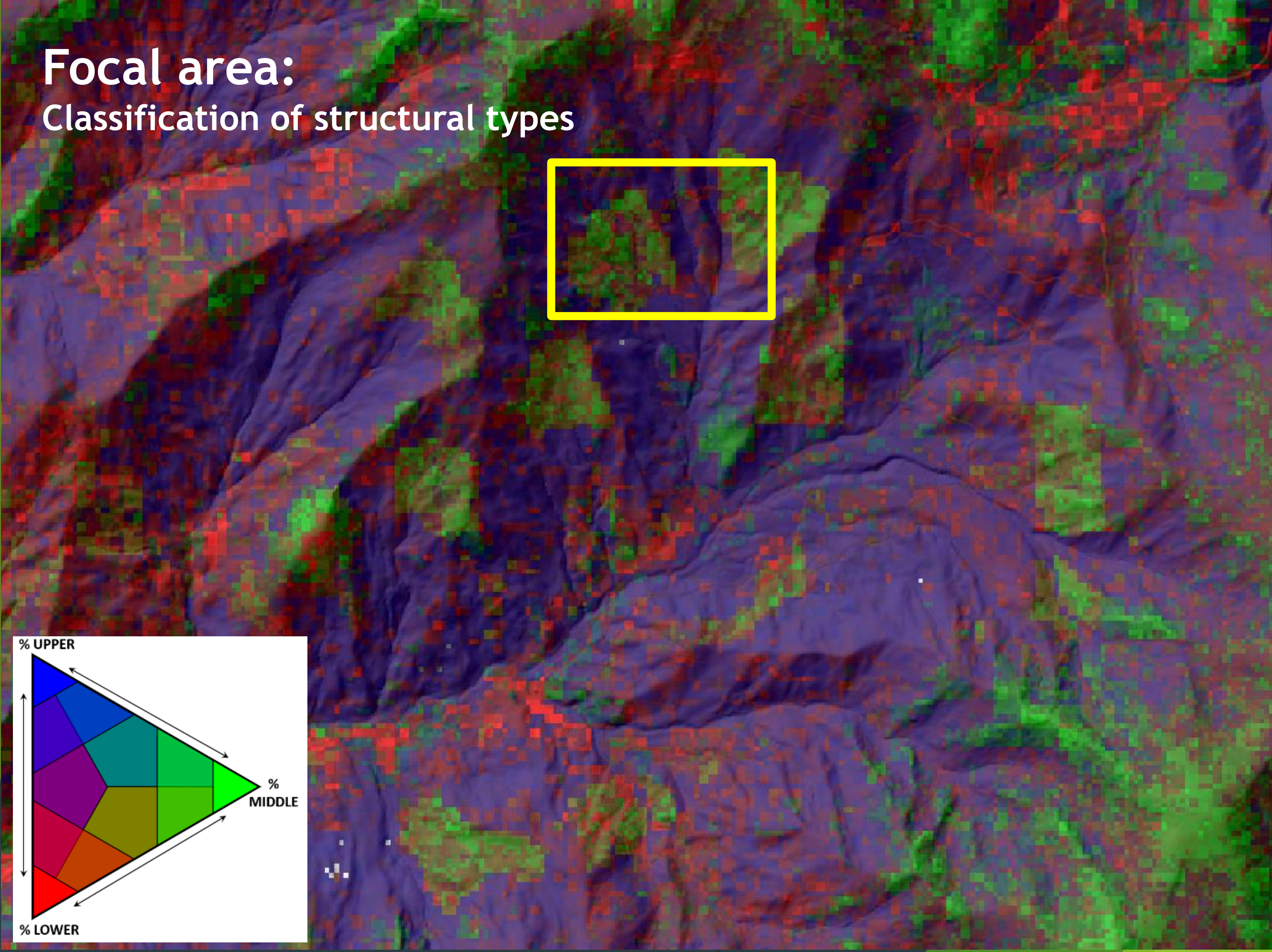


Focal area:

Classification and stand boundaries

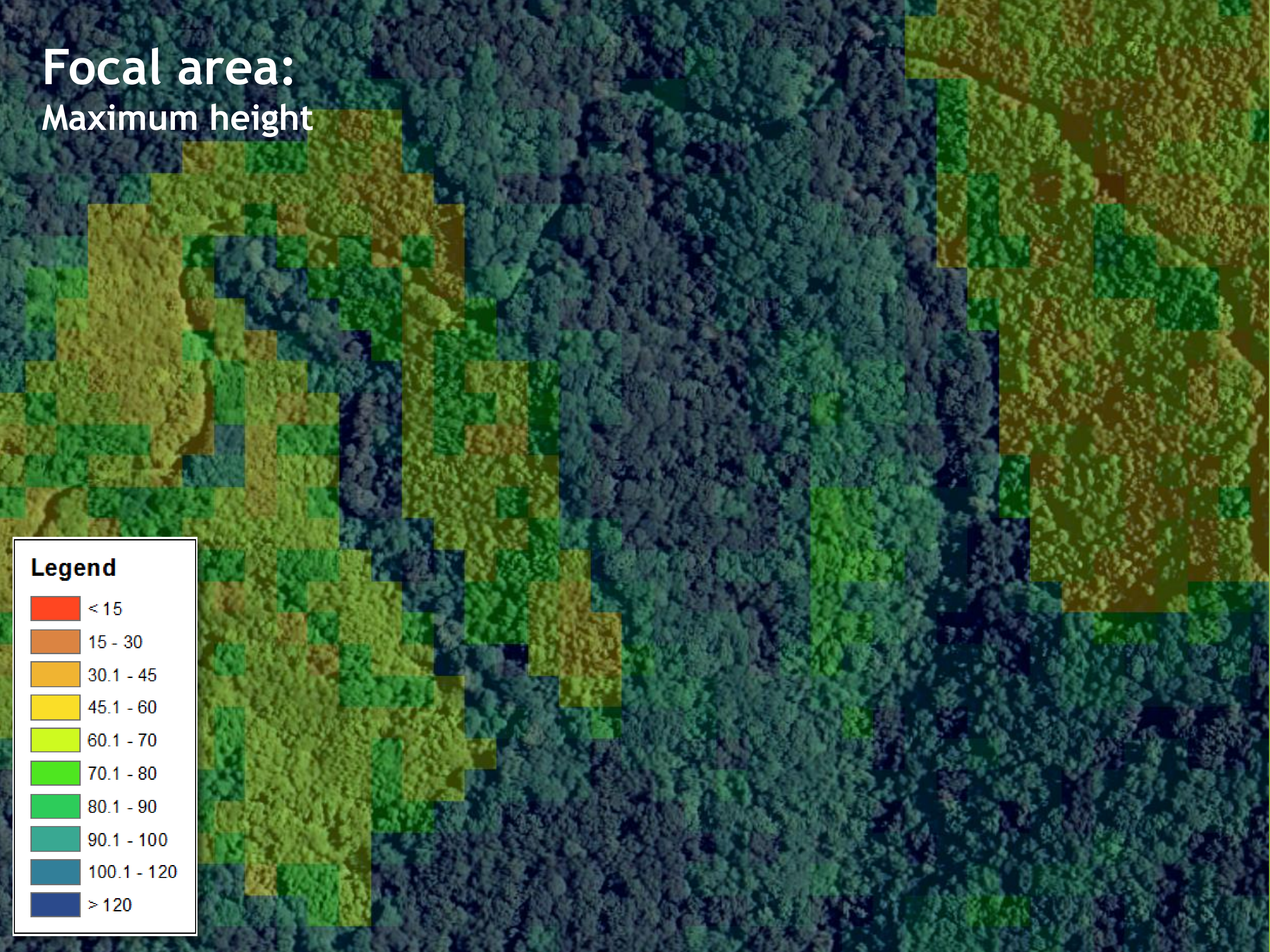


Focal area:
Classification of structural types

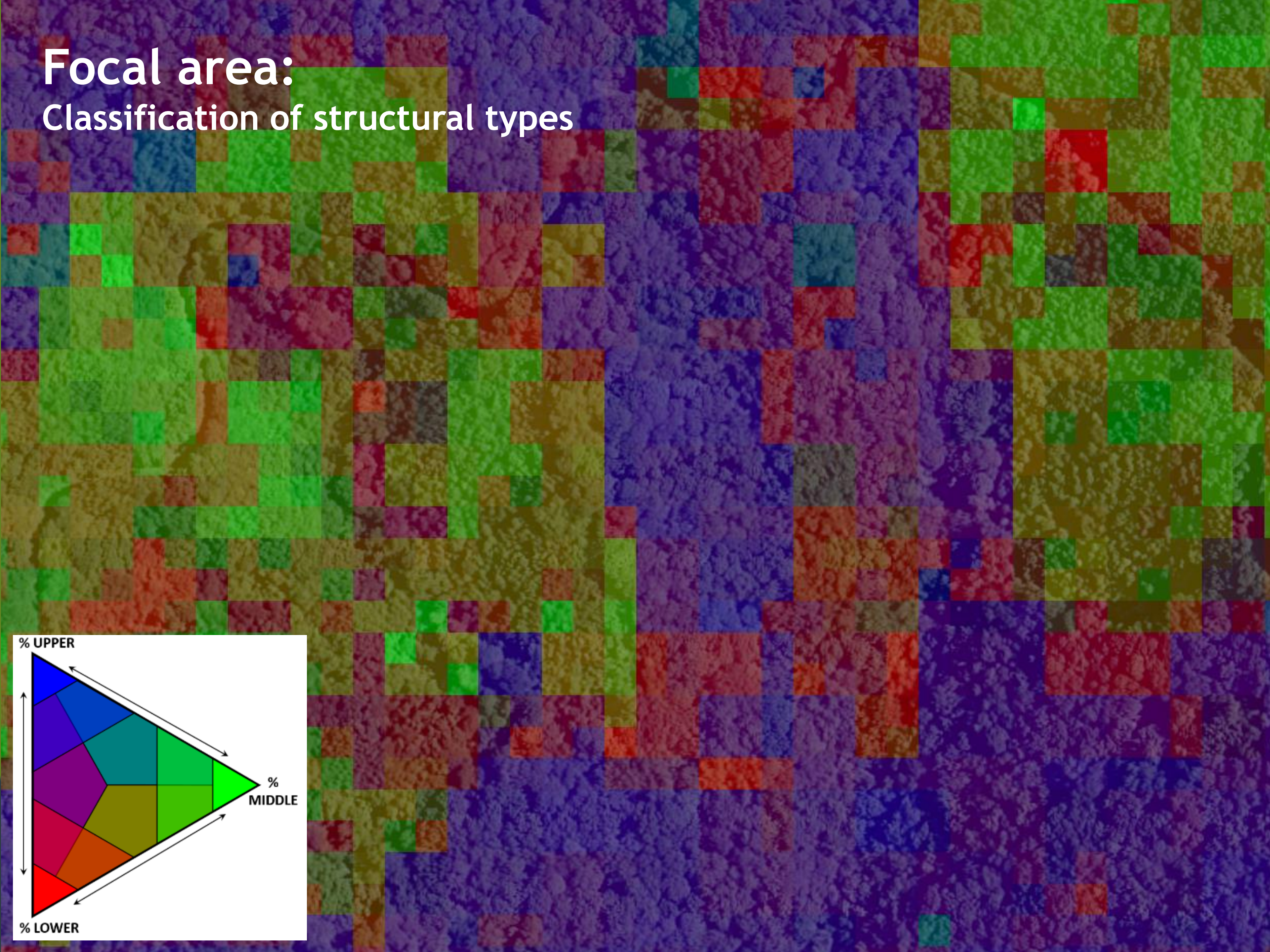



Focal area:
Aerial photo

Focal area:
Maximum height

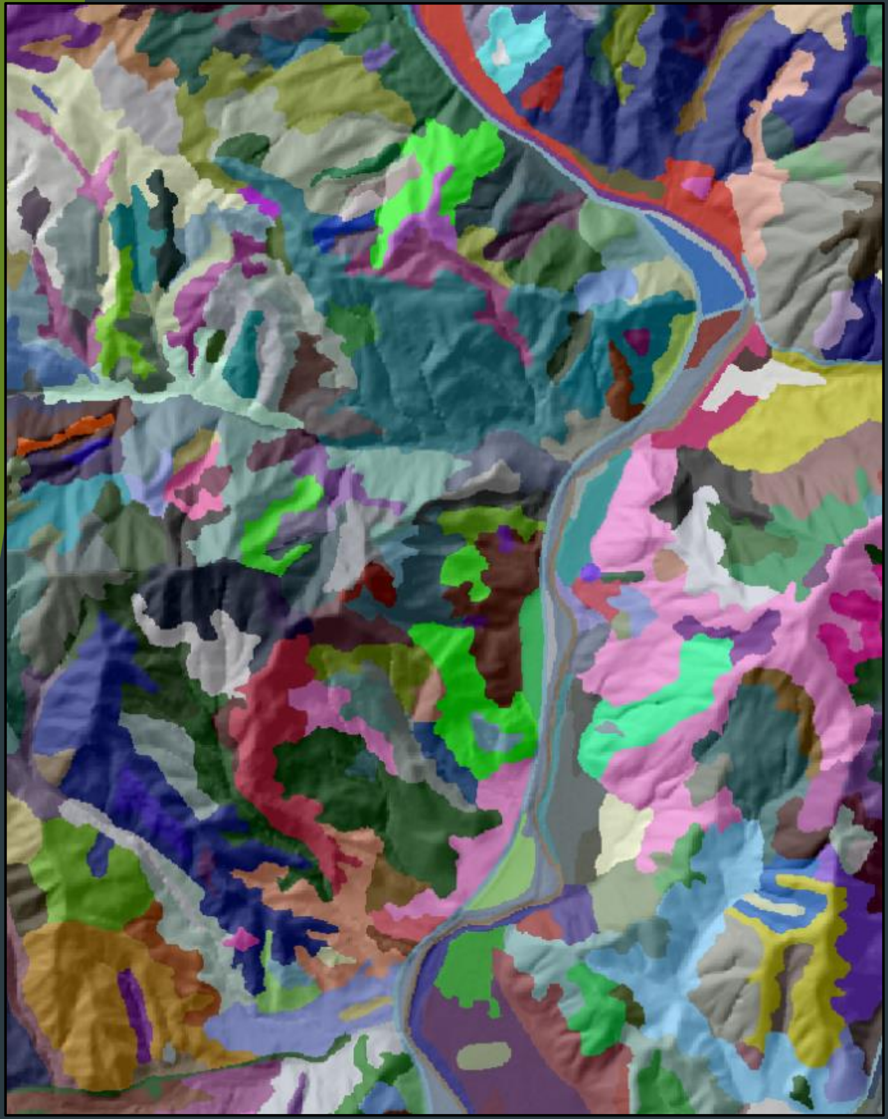


Focal area:
Classification of structural types

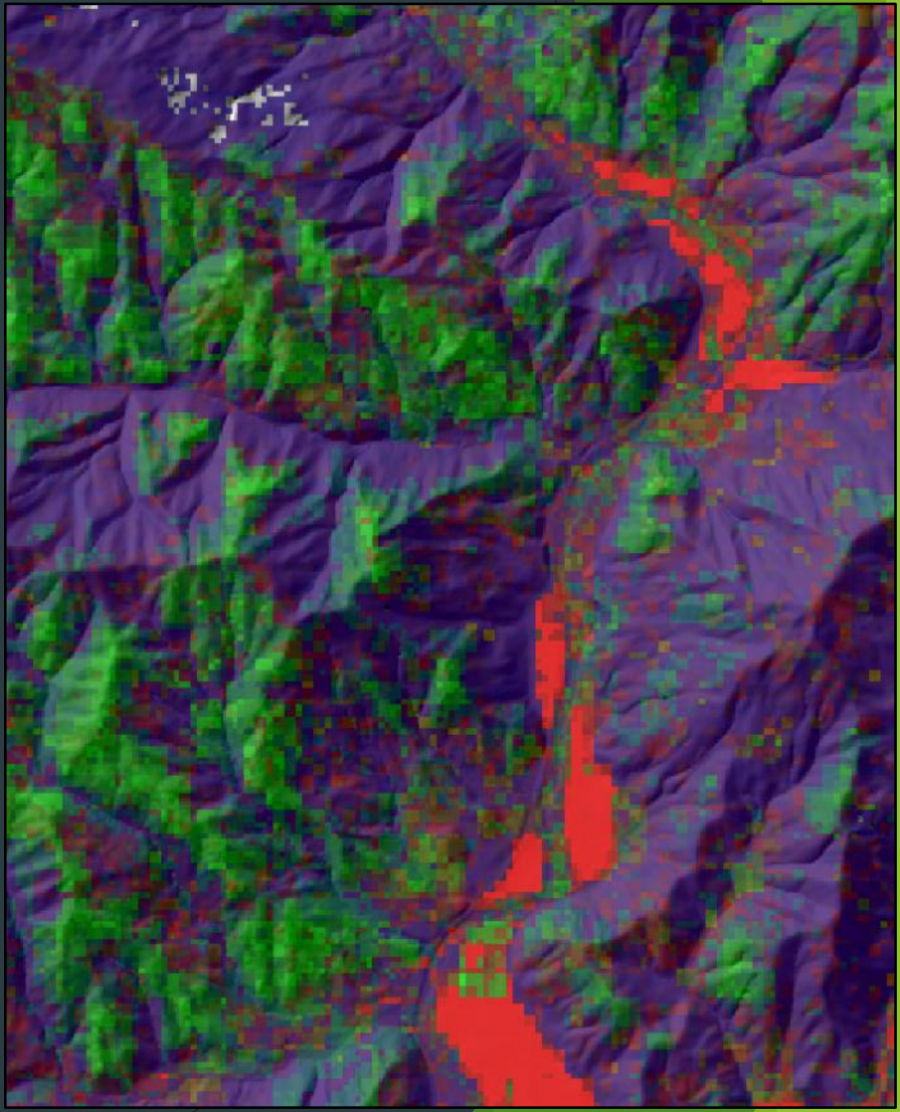


LiDAR products nuance our map units

Compositional Classification



Structural Classification



Conclusions

(1) LiDAR based maps of gridded forest structure capture continuous variability in forest structure along environmental gradients and within units having similar “cut dates” and disturbance histories.

(2) Therefore, LiDAR products can provide powerful additional information to complement existing vegetation type and stand management maps.

(3) Existing and upcoming LiDAR-based products overcome substantial data processing hurdles. By leveraging institutional capabilities, technology is made accessible for both local and landscape applications.

(4) Many potential applications await your imagination.

Contact

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