Mapping Vegetation Canopy Structure and Distribution for the Tennessee Side of Great Smoky Mountains National Park Using LiDAR

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Introduction

Objective: Utilize high resolution LiDAR to map vegetation canopy structure and distribution for Great Smoky Mountains National Park (GSMNP)

- Multiple-return LiDAR (Light Detection and Ranging) is a remote sensing tool that gathers high resolution 3D point cloud data.
- We processed and analyzed multiple-return LiDAR to investigate vertical canopy structures and their spatial distribution in the Tennessee side of GSMNP.
- We want to correlate vertical canopy structure with vegetation and validate with existing vegetation maps.
- *Big question*: Can LiDAR-based canopy structure improve vegetation mapping and monitoring efforts?

Data and Methods

Data

- High resolution LiDAR point cloud data sets were obtained from the National Park Service (NPS) and the Forest Service.
- The Tennessee side of GSMNP is composed of 724 tiles (LAS files) and each file contained about 2-6 million points.
- A Python workflow was developed to process the files in an embarrassingly parallel fashion on a multi-core machine.

Methods

- To match LANDSAT and NLCD resolution, we gridded the park at 30mx30m resolution and corrected for ground elevation changes within cells with a digital elevation map.
- From the LiDAR data, we created vertical canopy structures of vegetation and used a k-means cluster analysis algorithm to classify the landscape according to canopy structure.
- We prepared maps of spatial distribution of the canopy structure, and compared them to vegetation maps to determine the correspondence of canopy structures to vegetation types.

Vertical Canopy Structures from K-means Clustering

- Using the k-means cluster analysis we determined 30 canopy structures gave a good balance between discriminating unique canopy structures and minimizing outliers.
- Figure 1 shows 30 unique canopy structures from the cluster analysis, color coded to the spatial map in Figure 2.
- In Figure 1, note the two most frequent structures are 28 and 18 with over 7% of the total area each, while 3 and 11 are outliers covering less than 0.2% of the total area each.

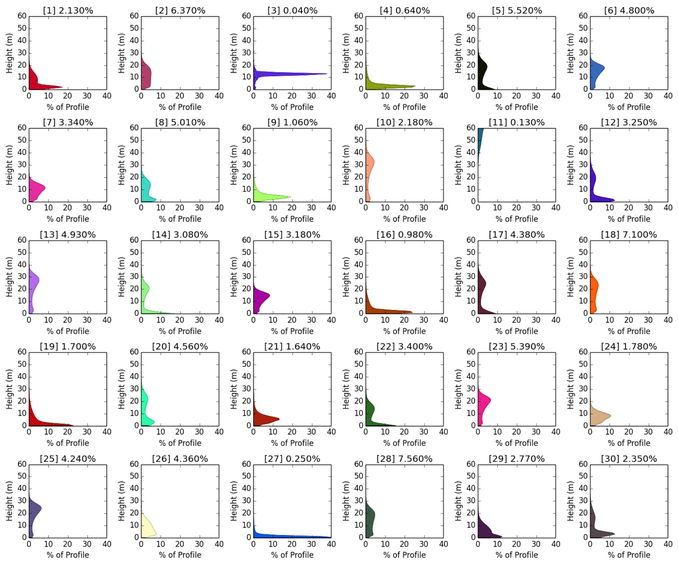

Figure 1: *30 canopy structures with percent map coverage*

Spatial Distribution of Vertical Canopy Structures

- Figure 2 shows the spatial distribution of the 30 canopy structures from Figure 1 across the Tennessee side of GSMNP.
- Preliminary analysis suggests that the map matches reality, e.g changes in canopy structure north-to-south (higher elevations).
- Low height vegetation regions, which often has high levels of noise, were filtered out in this analysis.
- Gridlines in Figure 2 and Figure 4 were part of the original data (most probably due to processing errors) and hence were unable to be removed.

Figure 2: *Spatial distribution of 30 canopy structures*

Validation at Great Smoky Mountains Institute at Tremont Phenology Plots

- To validate the canopy structures, we investigated phenology plots maintained by the Great Smoky Mountains Institute at Tremont (GSMIT) that are located in lower-lying coves.
- Figure 3 shows the GSMIT plots overlaid on a vegetation map provided by the NPS. The pink and green regions represent montane cove forests and we focus on the lower left two plots.
- Montane cove forests are known to have some of the tallest trees in GSMNP, and so we checked for tall canopy structures around these plots.

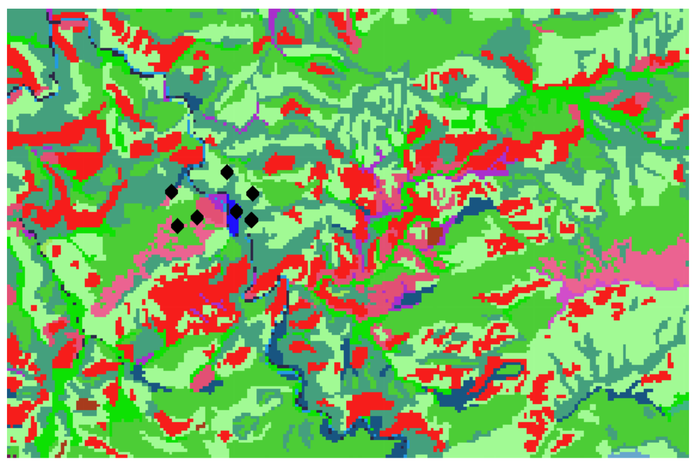

Figure 3: *Vegetation map in the area around the GSMIT (with phenology plots indicated by black markers)*

Source: Overstory Vegetation at Great Smoky Mountains National Park, Tennessee and North Carolina, provided by NPS, Author: Dr. Marguerite Madden

- In Figure 4, the lower left two plots are in canopy structures 10 (peach) and 13 (light purple) as seen in Figure 5.
- Canopy structures 10 and 13 are the two tallest canopies and their immediate extent in Figure 4 matches closely the extent of the pink and green regions in Figure 3. We can then say with some certainty that they match the montane cove forest vegetation type.

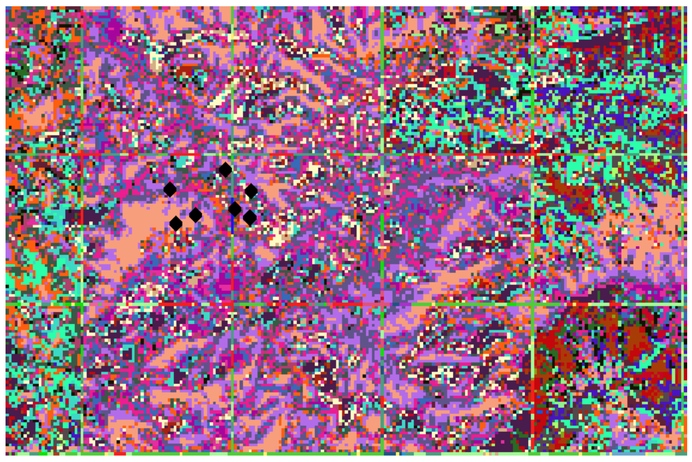

Figure 4: *Spatial distribution of canopy structures in the area around the GSMIT (with phenology plots indicated by black markers)*

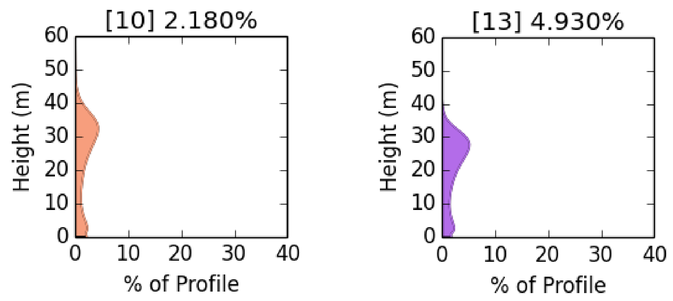

Figure 5: *Canopy structure types 10 and 13*

Summary

- Using a Python workflow, we processed and analyzed a large volume of LiDAR data for GSMNP.
- We generated vertical canopy structures at a 30m resolution to match LANDSAT and NLCD resolutions.
- Initial results show good correlation between canopy structure and vegetation, but further tests are needed to establish confidence.
- The next step is to expand to the North Carolina side of GSMNP to be able to properly characterize and classify the entire park.
- This method offers the ability to discern remote vegetation using LiDAR and could guide future high resolution vegetation mapping efforts by the NPS.

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