Understanding patterns of vegetation structure and distribution across Great Smoky Mountains National Park using LiDAR and meteorology data

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Objectives

- The GSMNP is the most visited national park in the U.S. and hosts a rich and diverse ecosystem of plants and wildlife. GSMNP spans 816 sq. miles across Tennessee and North Carolina and ranges in elevation from 876 to 6,643 feet above mean sea level.
- Mapping and understanding the vegetation composition and structure is important for:
  - forest health management
  - maintaining and tracking changes in plant and wildlife habitats and biodiversity in the park
  - aid in the forest management planning and decisions
- Study objectives:
  1. Characterize three dimensional structure of the vegetation (whole vegetation canopy and understory) in GSMNP
  2. Analyze the vegetation distribution across the park across topographic and climate gradient
  3. Understand structural diversity within and across various forest types

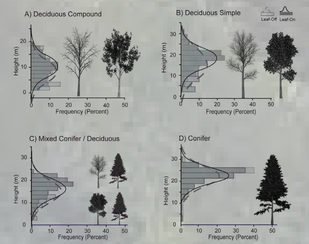


Figure 1: *Different forest type exhibit different vertical canopy structures*

Environmental gradients across GSMNP

Topographic complexity and environmental gradients across the GSMNP has significant influences on forest types and distributions.

Virtual Mountain: We represent the variability across the topography using a *Virtual Mountain* plot that captures the distribution of data across elevation and aspect gradient for the entire park. Radial direction represents elevation with highest elevation at the center to lower elvations in radially outward direction. Azimuth direction represent the topographic aspect on the landscape.

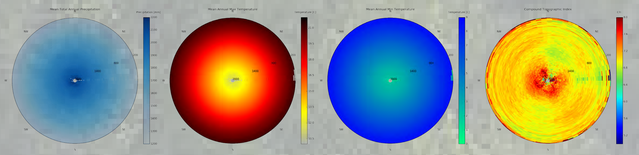


Figure 2: *Annual mean meteorological conditions (derived from DAYMET*

Elevation play key role in determining the climatic conditions (based on DAYMET datasets) across the park. Compound topographic index, which captures moisture availability, also variable patterns across the park, with higher moisture availability on south facing regions.

Airborne LiDAR for GSMNP

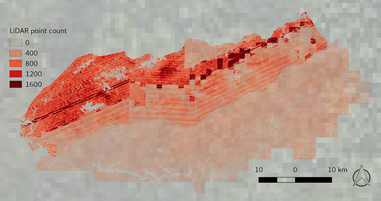


Figure 3: *Density of LiDAR point cloud vary across TN and NC*

Analysis/synthesis of data sets from different sources and quality requires care to avoid errors and bias.

Tennessee:

- LiDAR data for 540 sq. miles of the TN portion of the GSMNP were collected during February–April 2011 by the U. of Georgia and Photo Science, Inc.
- Overlapping data were split into 724 non-overlapping 1,500 ÃU 1,500 m tiles, which we obtained from the National Park Service.
- Projection: UTM Units: meters

North Carolina:

- LiDAR data for North Carolina was collected by NC Floodplain Mapping Program in 2005.
- Overlapping data were split into non-overlapping 10,000 ÃU 10,000 ft tiles, which we obtained from the NC Floodplain Mapping Program.
- Projection: NC State Plane Units: ft

Vegetation structure and distribution across GSMNP

We processes the LiDAR point cloud dataset to derive vertical profiles at 30 m horizontal and 1 m vertical resolution. The landscape was classified based on the verical canopy profiles to identify dominant vegetation structure classes and their spatial distribution within the GSMNP.

While range of canopy structures are found in the GSMNP, their spatial distributions are often highly correlated with topographic and environmental gradients.

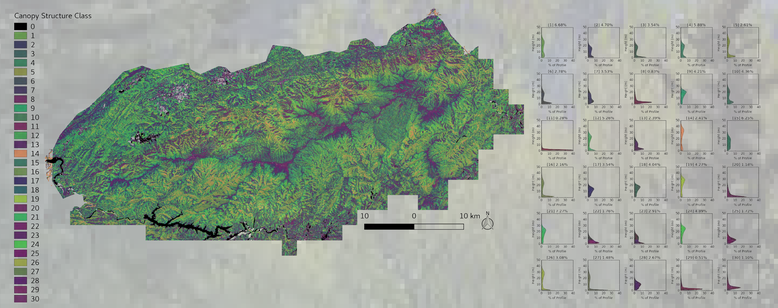


Figure 4: *Vegetation canopy structure and their distribution*

Understory vegetation is an important component of vegetation community in the ecosystem. To achive a better understanding of the understory vegetation within the park, we mapped and analyzed the understory separately by performing classification on subset of LiDAR point cloud representing understory vegetation (defined as vegetation below 8 m height).

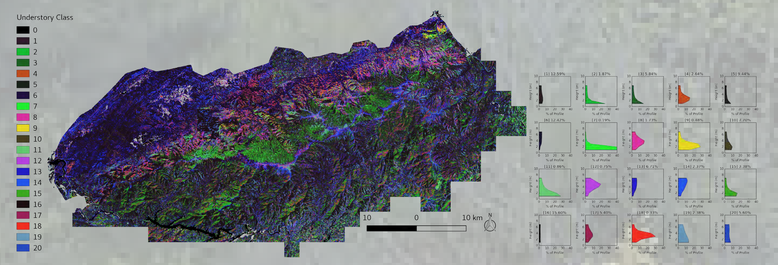
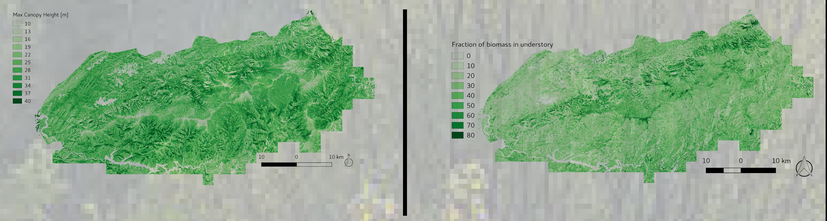


Figure 5: *Structure and distribution of understory vegetation (0-8m)*

Forest at lower/mid elevation have taller canopies and lower understory vegetation, while the higher elevations exhibit shorter canopies with denser understory vegetation.



High spatial variability in the forest type is also found across the topographic gradient. Lower to mid elevation areas also support higher forest type diversity, while high elevation areas of the park show lower divrsity.

Patterns of vegetation across the park

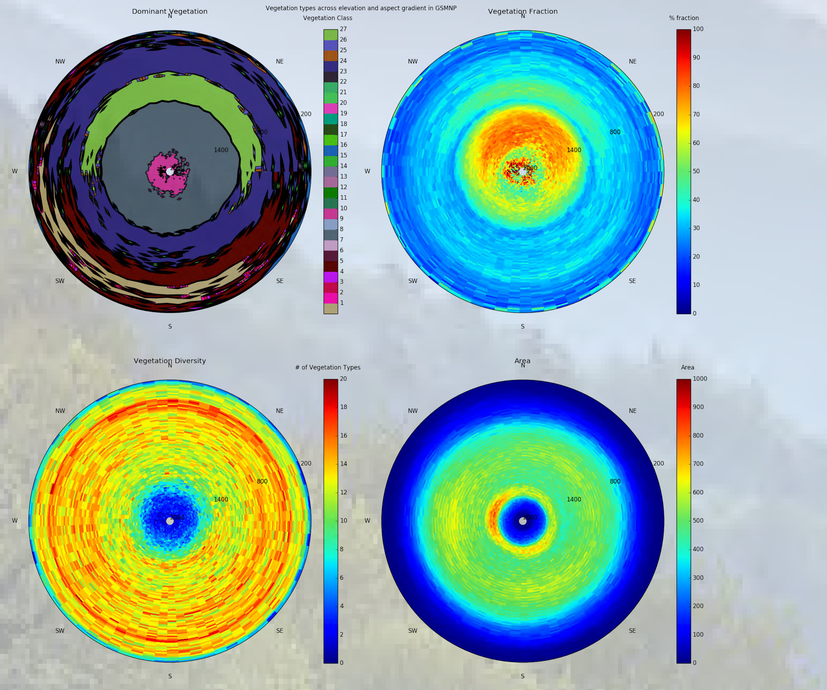


Figure 8: *Distribution of vegetation/forest types. Higher vegetation diversity at low to mid elevations, while lower diversity at high elevations*

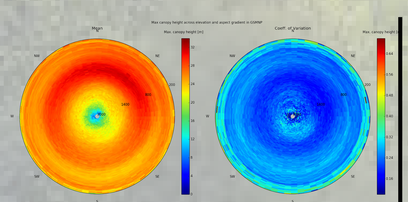


Figure 9: *Forest canopies are taller at low to mid elevations, and shorter vegetation at higher elevations*

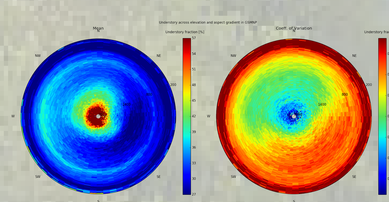


Figure 10: *Dense understory and low height vegetations are dominant at higher elevations in the park*

Summary

- Using rich LiDAR datasets we have characterized and mapped the structure and distribution of vegetation in GSMNP
- We have also mapped the understory vegetation and analyzed the variability in full canopy vs understory vegetation
- We summarize the distribution of vegetation along the elevation and aspect gradients in the park for a landscape scale understanding
- We have summarized every location within GSMNP onto the sides of this **Virtual Mountain**, in an exhaustive use of ALL of the GSMNP LiDAR data. Our **Virtual Mountain** is then viewed from above, so that LiDAR characteristics can be seen across all aspects and elevations.

Acknowledgments

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