Lidar Can Improve Ecosystem Modeling by Incorporating Canopy Structure

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Background: Forest canopies are an important component of forest ecosystems and forest canopy structure influences a wide range of critical forest functions, including productivity, nutrient cycling, and habitat provisioning. The complexity of forest canopy structure is also crucial, especially regarding forest resilience and resistance to exotic invasion. However, accurately measuring canopy structural complexity can be a challenge, and is thus oftentimes drastically simplified for ecological models or left out altogether.

Introduction: Lidar (light detection and ranging) is a remote sensing technology that has exhibited the capacity to measure and characterize forest canopy structure and its complexity. Utilizing lidar data is a promising way forward to accurately incorporate canopy structure in ecological modeling to improve models, forest management, and conservation strategies. Terrestrial lidar has been shown to measure structure with important links to ecosystem function but is limited to local spatial extents. Aerial lidar has the capacity to measure structure across large spatial extents but lacks the detail of terrestrial lidar. Our objective was to establish the compatibility of aerial and terrestrial lidar to upscale detailed measures of canopy structure to large spatial extents.

Methodology: We looked at aerial and terrestrial lidar compatibility in two separate studies— a study using seven National Ecological Observatory Network (NEON) sites and a study at Martell Forest in Indiana. Data from four different lidar systems was used— PCL (Figure 1) and stationary terrestrial systems, and plane- and UAV-flown aerial systems. Aerial and terrestrial structural metrics were generated and used to establish the compatibility of the lidar systems.

Results: There were several key outcomes from the two studies:

- Lidar systems showed agreement between measures of vertical and horizontal canopy structure, canopy complexity, and canopy leaf area.

- In both studies there was agreement between the systems in the classification of study sites and plots.

- Lidar can be used to define canopy structural types, which can be linked to ecosystem functioning.

Figure 1. Portable Canopy Lidar (PCL) system being used to measure 2-D forest canopy structure. The PCL system is mobile and efficient for measuring canopy structure.
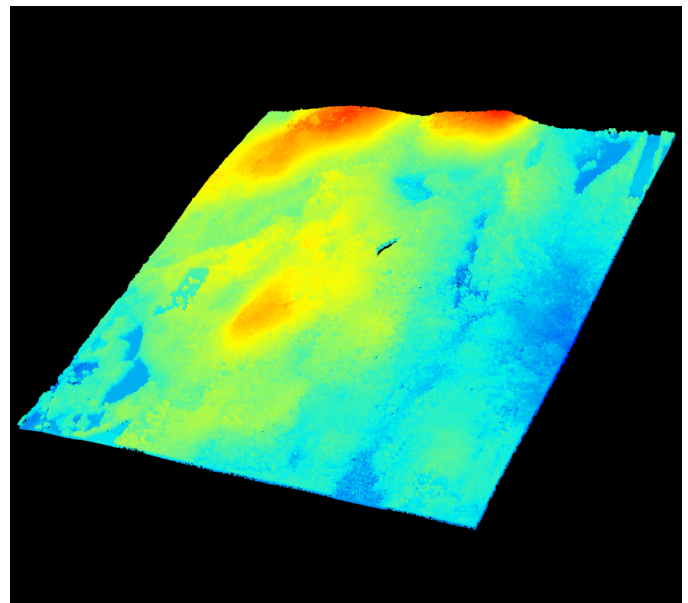

Figure 2. Aerial lidar systems can be used to measure canopy structure across large spatial extents. Pictured here is a lidar point cloud collected at Harvard Forest in Massachusetts.