What LIDAR can tell us about Forest Metrics in an Unmanaged Temperate Forest

Physical & Environmental Sciences
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Background

Remote sensing is the science of obtaining information about objects or areas from a distance using satellites, aircrafts, or more recently through LIDAR. Light Detection and Ranging (**LIDAR**) is a growing remote sensing method that works by transmitting pulses onto a surface and measuring the time needed for a reflected laser emission, also known as a **return**. These returns are combined with a position orientation system to register the data to a geographic reference frame. Returns from many pulses are known as a **point cloud** and is our starting data source in this exploration study.

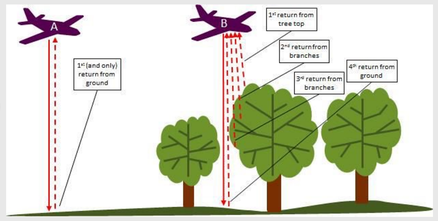


Fig. 1- The order of returns tells us about the underlying surface

There are five main platforms for LIDAR deployment: **Airborne Laser Scanning (ALS)** from a manned aircraft, Unmanned Aerial Vehicle (UAV), Terrestrial Laser Scanning (TLS) from a static ground platform, Mobile Laser Scanning (MLS) from a moving ground platform, and Spaceflight Lidar (SDS). These systems provide a different level of spatial resolution (level of canopy structural detail), occlusion (the blocking of laser pulses by leaves and branches), and coverage (the survey area based on a coverage-cost analysis) and can be used interchangeably to obtain the best data fit/ point cloud density. We used the ALS platform in our study.

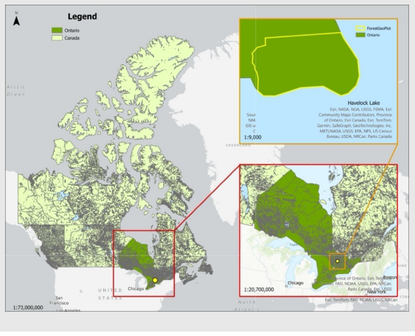
Study Location

ForestGEO (Global Earth Observatory) is a global network of scientists working in 71 long-term protected forest plots, called forest dynamics plots (FDPs), aiming to improve our understanding of forest science and any changes across large spatial and temporal scales.

Fig. 2- Current FDPs that are a part of the ForestGEO network

Fig. 3- Below map shows the location of the HFDP compared to a national and provincial scale.

Our study area is the **Haliburton Forest Dynamics Plot (HFDP)**, currently the only FDP in Canada, and intensive field-based measurements for individual trees on the site was completed by 10 researchers over 2 field seasons from 2020-2023. Our LIDAR scan was done during the most recent field season in July 2023.



Objective

Utilizing ALS-Lidar data collected from the HFDP, this exploratory project aims to increase our understanding of the applications and analysis of LIDAR data for Forest Carbon Dynamics and Forest Metrics.

Methods and Results

1. Strip Alignment of Point Clouds

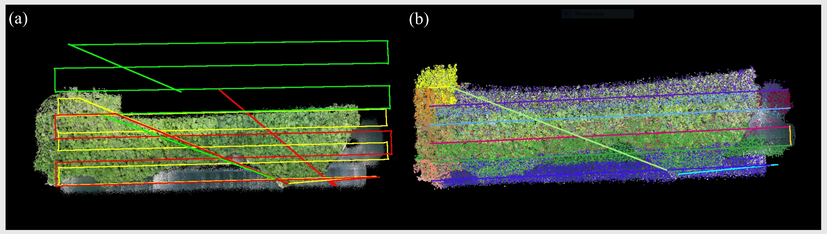


Fig. 4- a) Trajectories are matched with their corresponding point cloud and split, outliers and duplicates are removed, and point clouds are cut by trajectory. Result is b) a smooth point cloud with reduced error.

2. Lidar 360 ALS Forest Workflow

Fig. 5- Ground points are classified, point clouds normalized by ground points, and forest metrics calculated by grid. Results include a) number of returns and b) intensity maps.

Fig. 6- True colour point cloud is shown in 3D using DJI Terra

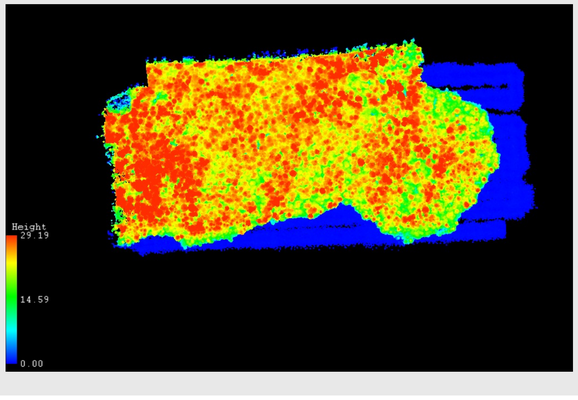


Fig. 7- Map of normalized heights was produced after strip alignment and the ALS forest workflow. This gives us an estimate of tree heights up to 30m in our study area and their appx locations.

Discussion

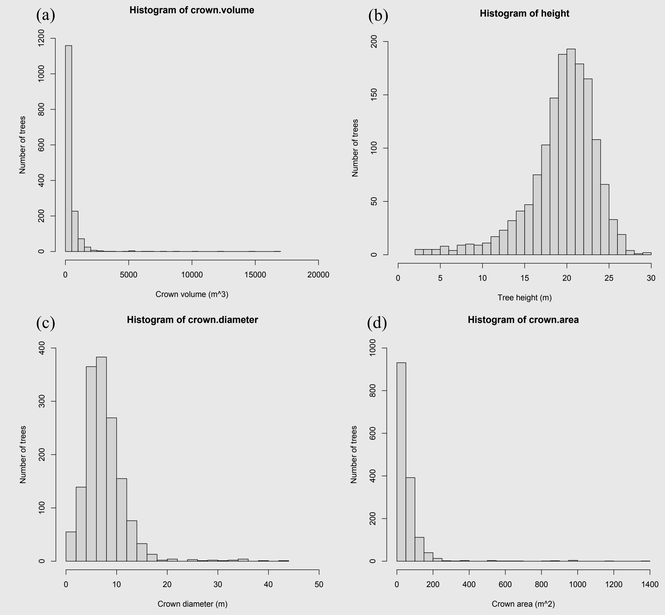


Fig. 8- Histograms show the spread of a) crown volume, b) tree height, c) crown diameter, and d) crown area in our study area. Overall, crown volume <500m^3, crown diameter < 20m, crown area <200m^2, and most trees are between 15-25m tall.

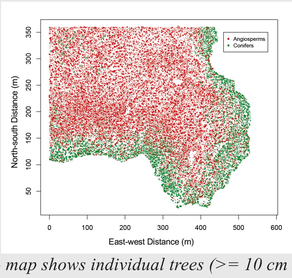


Fig. 9- map shows individual trees (>= 10 cm in diameter) in the HFDP. Points are colored according to tree taxonomic division. Comparing with Fig 7 shows us that most conifers are shorter than angiosperms.

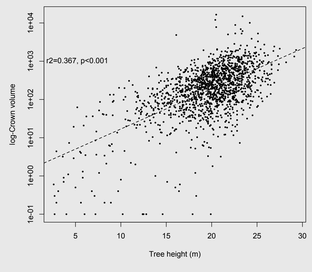


Fig. 10- Scatter plot shows tree height is positively correlated to crown volume.

Further Research

- With July 2023 being the first LIDAR scan of the HFDP, continued scanning will allow us to compare and visualize changes in the forest over a temporal scale
- LIDAR data can be compared to ground measurements of individual trees to calculate carbon biomass and validate field findings
- Changes in forest metrics can be utilized to forecast impacts of diseases like Beech Bark Disease, a prevalent tree species in the HFDP

References

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