EVALUATING BIAS IN TREE-LEVEL MEASUREMENTS OBTAINED WITH A BACKPACK LIDAR UNIT

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EXTENDED ABSTRACT

The ability to rapidly acquire biometric data in forests allows for timely decisions to be made regarding harvest, fertilization, prescribed fire, or other silvicultural treatments. High resolution tree-level data can be used to assess tree conditions and in calculating tree- or stand-level volume estimates. Using mobile, terrestrial light detection and ranging (LiDAR) units, such data collection is possible and provides an archive of present stand conditions. This study seeks to apply a mobile backpack LiDAR unit to a 3-year-old planted stand in northern Louisiana. The objective of the present study is to compare LiDAR-derived measurements with *in situ* measurements for height and groundline diameter.

An outplanting of American sycamore (*Platanus occidentalis*) was planted in 2019 on Louisiana Tech University's campus using a 6-foot by 10-foot spacing (19 rows and 22 columns). Groundline diameters (GLD) were measured using calipers to the nearest 0.01 inch and a height pole used to measure heights to the nearest 0.1 foot. A terrestrial LiDAR unit was used to measure the trees. The LiDAR backpack consists of a Snoopy A-Series 60 unit incorporating a Velodyne Puck (VLP-16 LITE) generating approximately 600,000 points per second. For this trial, the backpack-housed sensor was walked between the rows of planted trees. Subsequent to the collection and validation of the base-station location via OPUS (Online Positioning User Service; https://geodesy.noaa.gov/OPUS/), the data was processed using Inertial Explorer. Once the LiDAR scenes were created, the LiDAR datasets were imported into ArcGIS Pro and surface and canopy layers were calculated. Subtracting the canopy and surface layers, heights were obtained. A polygon was created to represent crown diameter and a maximum value function was used on each tree with the result used as the height. These were then compared to each measured tree and bias was calculated to determine comparability of the height measurements.

Height measurements were underestimated using the LiDAR dataset. Comparing the two methods, there was average negative bias of 0.43 feet for the LiDAR data. There is a systematic bias with increasing underestimation of heights for taller trees; the bias is twice as great for trees >10 feet tall (fig. 1). This could be the result of some smoothing in

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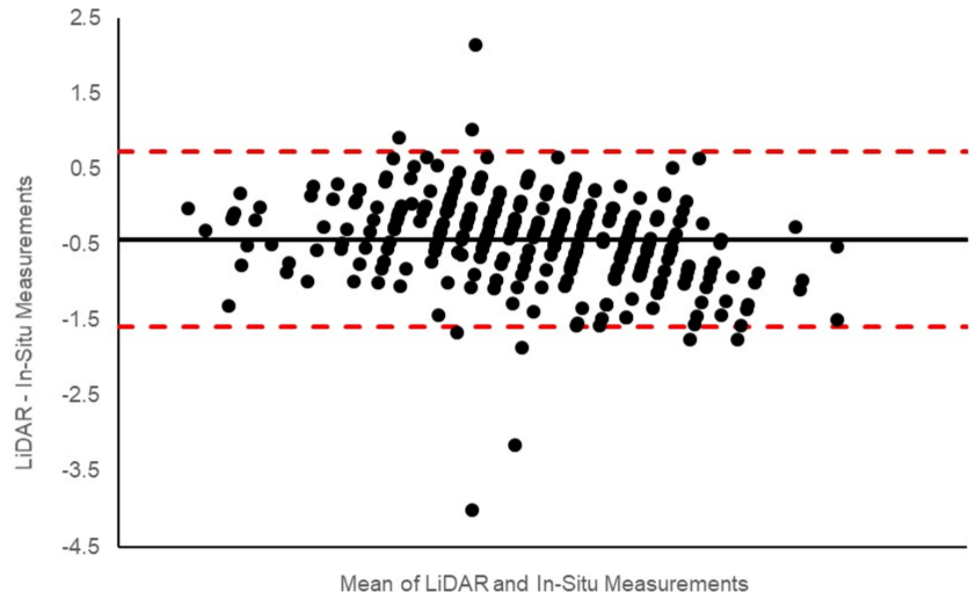

Figure 1—Bland-Altman plot comparing the two methods of measurement (LiDAR and *in situ*) for obtaining tree heights.

generating the raster grids for height estimation (resolution of the surfaces created for height estimation is 1 foot), or an indication sensor capability to detect tree heights in dense plantations. Given the spacing of the trees, small and narrow tops, and propagation of energy from the sensor, there may not be enough returns collected to accurately measure the top of the trees. Having two sensors scanning simultaneously may allow for more returns at height (Xie and others 2020, 2022) and allow for better height estimation.

For GLD measurements, there was a negative bias of 0.02 in for the LiDAR measurements. It is worth noting that given the density of understory vegetation and the presence of limbs at lower heights for some varieties, it was not possible to find enough points to measure an accurate diameter for all trees (hence 30 were selected). This could be an issue for GLD and diameter at breast height estimates if using LiDAR in a new planting because there may not be enough points penetrating foliage to accurately represent the bole of the tree. Leaf-off acquisition may help alleviate this issue. Measuring diameters one at a time is a cumbersome process that is likely most efficiently done in the field unless this can be automated. Artificial intelligence techniques will be explored in the future in an attempt to classify trees into diameter classes.

Previous work using terrestrial LiDAR has focused on mature forests. Incorporating such technology early provides an archive of stand conditions that can be used to monitor a variety of factors throughout the rotation. Future work will look to determine the potential of using a correction factor if bias is consistent and work to develop height-diameter relationships and test their validity in similar plantings as well as those of other species. It will also be important to consider collection and processing time to obtain measurements compared to *in situ* data collection in small plantings.

This study demonstrated the use of a terrestrial LiDAR unit for measuring tree heights and diameters. The results of this study provide a baseline for subsequent assessments using a terrestrial LiDAR unit. Data can be collected quickly and snapshots of trees documented for future comparison. In young stands, care should be taken if assessing total height.

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