Characterization and Comparison of Vegetation Structure in a Tropical Premontane Wet Forest

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Background

The ability of airborne light detection and ranging (LiDAR) remote sensing technology to measure various vegetation metrics, such as diameter at breast height (DBH) and above-ground biomass (AGB), has been tested extensively. However, sloping terrain degrades the quality of the data gathered. Contrarily, terrestrial LiDAR maintains relatively high accuracy when scanning steeply sloped plots. Measuring in the LiDAR scans allows for greater repeatability and precision, as one can isolate and deconstruct individual trees in the virtual scans, allowing for easy measurements. The suitability of LiDAR as a substitute for traditional vegetation measurement methods, such as diameter tape, wedge prisms, and clinometers, was tested.

Research Goals

Determine whether terrestrial LiDAR is a suitable substitute for airborne LiDAR and/or manual vegetation measurement methods by comparing LiDAR measurements against manual vegetation measurements of tree height, tree DBH, and basal area, and AGB in three tropical premontane wet forest plots with different land use histories.

Study Site

The Soltis Center for Research and Education is located near San Isidro, Costa Rica, on the Caribbean side of the Monteverde Reserve, and covers about 50,000 ha of land from 450 to 1800 m above sea level. It contains primary and secondary transitional pre-montane wet forest at different stages of succession.

Methods

- Three 30 m diameter plots with different land use classes were selected
- Thirty largest trees in each plot were sampled
- Tree DBH measured with DBH tape
- Tree height measured with a laser clinometer
- Stem basal area (BA) measured with a wedge prism
- Three poles were placed at different fixed positions in the plot visible from each of the LiDAR scan positions
- Plots were scanned from several angles using a Leica ScanStation 2 to generate a three-dimensional virtual point cloud at +/- 2 mm range accuracy
- Individual scan point clouds were compiled into a single scan world by overlaying them, using the three height poles as reference points

Results

Fig. 1 and 2 show linear regressions between the manual and LiDAR DBH and height measurements at the tree plantation, respectively. Both show a strong correlation, indicating the efficacy of measurements in LiDAR scans. The same can be seen in Fig. 5 and 6. Both metrics have a lower R² value at the primary forest site. This is due, in part, to the difficulty of manually measuring the DBH on trees with large buttresses (which were not present at the plantation) and manually calculating height on trees whose crowns were hidden in the dense canopy. Therefore, LiDAR metrics are likely to be more accurate in dense tropical environments.

Tables 1 and 2 display the averages plus-minus the standard deviations for various metrics calculated manually and in the LiDAR scans at both the tree plantation and primary forest plot. Measurements using both methods, at each site, are comparable. The manually gathered BA measurements for the plantation are double that calculated in the scanworld. The wedge prism BA measurement at the primary forest are half that of the LiDAR. This is likely due to the high level of subjectivity involved in the manual data collection process with the wedge prism and its low level of sophistication.

Fig. 3 and 7 are a visual representation of the plantation and primary forest plots, generated in Excel. The large numbers outside of the dot are the tree labels, while the smaller numbers inside are the respective diameters. Fig. 4 and 8 are the virtual point clouds of the carbon farm and primary forest site. The carbon farm image was filtered to make measuring DBH easier. The primary forest site is unfiltered. The different colors refer to different heights.

Conclusions

The mean DBH and height measurements obtained from the LiDAR scans at the plantation had 0.6 and 0.26 percent error. The LiDAR’s DBH and height measurements in primary forest had mean percent error of 5.18 and 20.19. In actuality, the baseline manual measurements at this site were biased because of buttresses increasing average DBH and difficulty seeing tree crowns decreasing average height. Therefore, terrestrial LiDAR is an accurate method of making dendrometric measurements in steeply sloped tropical environments.