NSF Research Experience for Undergraduates: 3-D Characterization and Comparison of Vegetation Structure in a Tropical Premontane Wet Forest

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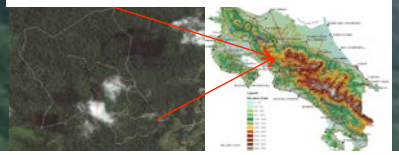
Introduction

This National Science Foundation (NSF) Research Experience for Undergraduates (REU) site hosted by Texas A&M University to allow selected undergraduate students to conduct original research on various aspects of the ecohydrology of understudied tropical pre-montane forest at the Texas A&M Soltis Center for Research and Education in Central Costa Rica. This particular study was conducted by 3 students under the guidance of 5 mentors who assisted in experimental design, equipment use, maintenance, and training, plant species identification and other logistical requirements. The goal of this study was to determine the change in 3-D structure of tropical premontane wet forest under 3 different land uses: a carbon tree farm, secondary logged forest, and primary unlogged forest. Traditional forest mensuration techniques including glass prisms (stand basal area), laser clinometers (height), vertical and horizontal PAR, spherical densiometers, and hemispherical photography (GAP fraction and LAI) and diameter-at-breast height (DBH) tapes were used to acquire metrics in one 30-m diameter plot per land use and compared to similar metrics collected by a terrestrial scanning laser (TSL) and ground penetrating radar (GPR) at 400 MHz and 1.5 GHz. The 3 land uses were situated. Besides discovery, another goal of this study was to see if the TSL and GPR can help meet the monitoring and verification goals of the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD) for estimating above- and below-ground biomass using remote sensing. This is of particular importance because the GPR may be able to capture below-ground biomass in a more efficient manner than traditional coring and the TSL and GPR can capture data on highly sloped terrain where both airborne and satellite RADAR and LIDAR are limited.

Methods

Study Area

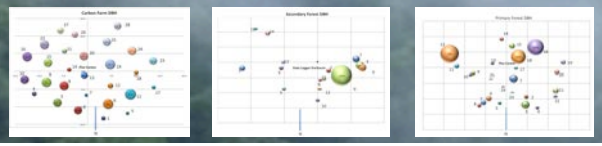


The Texas A&M University Soltis Center for Research and Education in Central Costa Rica is a 100 ha site established in 2009. Its vegetation is classified as Windward Primary & Secondary Growth Cloud Forest with elevations from 400-m to 800-m, Mean Annual Precipitation of 4000-mm/yr and Mean Annual Temperature of 28°C. The soils are primarily Andosols and the geomorphology is primarily footslopes.

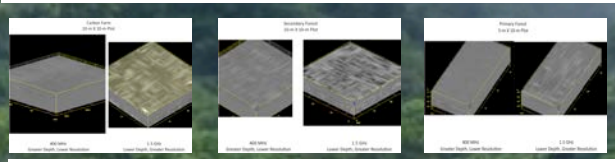
Terrestrial scanning laser (TSL) at 4-cm spacing, Stand Basal Area (Prism), DBH (tape), and tree height (laser hypsometer) data were acquired in a 30-m diameter stand plot on a 61 degree slope.

GPR data was collected in a 10-m X 10-m plot divided into 1-m X 1-m grids within the 30-m diamter stand plot. This data was collected at 400 MHz and 1.5 GHz.

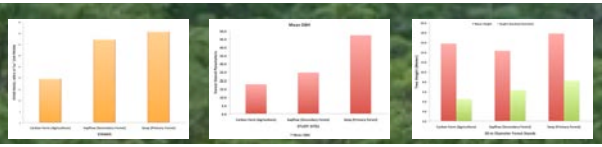
Results & Discussion



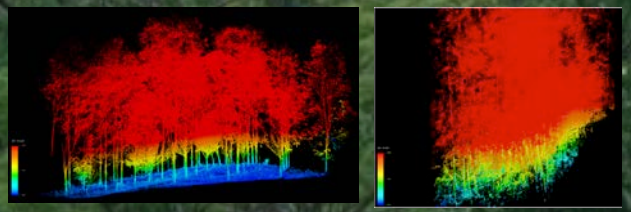
30-m diameter stand plots were selected in each land use along an elevation gradient from ~380-masl to 525-masl. Between 25 to 30 trees were measured for species, height, DBH, LAI, PAR, and stand basal area.



Ground Penetrating radar data in each land use. With the exception of the carbon farm where roots appear to be detected, the other two sites appear to detect primarily different strata of soil moisture.

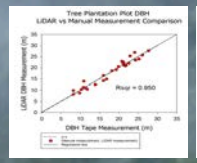


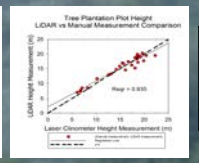
Comparison of field measures between sites indicates for the carbon farm to the secondary forest to the primary forest increasing SBA and DBH. Both the managed carbon farm and the primary forest had comparable heights.



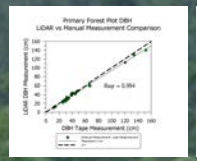
Five scans were taken per stand starting at the center and cardinal compass directions. The scans were geometrically registered within ±6-mm. The 3-D virtual point clouds were > 100-million points and were completed for the carbon farm and primary forest plots. Manual measures of height, DBH, and SBA were made in the virtual environment.

Results & Discussion





	Manual	LiDAR
DBH	17.94±5.89 cm	18.05±6.04 cm
Height	15.39±4.73 m	15.43±4.22 m
SBA	20 m²/ha	11 m²/ha



	Manual	LiDAR
DBH	47.37±36.08 cm	44.92±33.81 cm
Height	17.8±8.01 m	21.39±8.17 m
SBA	41 m²/ha	86 m²/ha

Very good relationships within the REDD Tier requirements (Gibbs et al. 2007) were found between the field measures and the manual measures within the 3-D virtual environment of the Carbon Farm and the Primary Forest.

Conclusions

GPR measures for below-ground biomass estimates are harder to obtain in cloud forest ecosystems because of the high soil moisture.

DBH error measures ranged from ± 0.6 to 5.18 % and height was 0.26 to 20.19 % for carbon farm to primary forest. The height comparison indicated that the field measures overestimated height in the primary forest and underestimated tree height in the carbon farm compared to the TSL. 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.

Terrestrial LiDAR is an accurate method of making vegetation measurements in steep tropical environments.

Literature Cited

Gibbs, H.K. et al. 2007. Monitoring and estimating tropical forest carbon stocks: Making REDD a reality. Environmental Research Letters 2 doi:10.1088/1748-9326/2/4/045023