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Using ALS LiDAR data to characterize different stages of secondary succession in the Amazon forest

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The large scale loss of primary forest in the Amazon region, primarily due deforestation followed by land abandonment, place in evidence the importance of secondary forests for carbon sequestration in the tropics. Secondary succession (SS) in the Amazon is one of the major sources of uncertainties in net biomass estimation, especially due to lack of information on the different stages of succession. Hence, to discriminate between stages of secondary succession is not a straightforward task. Here we tested different structural metrics of Airborne Laser Scanning (ALS LiDAR) to characterise stages of secondary succession (SS) in the Amazonian tropical forests at the Tapajos National Forest, Para state, Brazil. We used metrics of height, canopy cover and canopy density for three different stages of SS: SS1, SS2 and SS3, that represents young, intermediate and old stages of forest succession, respectively. The analysis of height showed an increase from SS1 to SS3, as expected. The mean height for SS1, SS2 and SS3, was 6m ($\pm$4m), 19m ($\pm$7m) and 21m ($\pm$6m). Besides the subtler difference between SS2 to SS3, we observed that the canopy density representing big trees was slightly higher for SS3 than for SS2. The SS1 presented a small variation in canopy cover, probably due to its low structural complexity and smallest trees. Meanwhile, a higher heterogeneity in terms of canopy structure was found for SS2, indicating a more complex strata composition and diversity associated with vertical structure. The canopy cover results have also shown homogeneous canopy with some emergent trees for SS3. LiDAR metrics have a strong potential to discriminate the characteristics between stages of SS, especially due to its ability to directly provide information of forest structure. We recommend the use of LiDAR combined with other remote sensing and inventory data to map large areas of SS across the Amazon region. In future investigations the GEDI (Global Ecosystem Dynamics Investigation) datasets can be explored as well. This data might be promising since will produce high resolution laser ranging observations of the 3D structure of the Earth.