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A non-destructive approach to estimate buttress volume using 3D point cloud data

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Buttressed trees have one of the largest sources of variation in volume or biomass estimates in tropical forests. Buttresses provide mechanical support for trees and offer other essential ecological functions such as nutrient acquisition. Here, we use an Alpha Shape Algorithm (ASA) based on a 3D point cloud to estimate the volume of 30 buttressed trees collected using Terrestrial Photogrammetry (TP). We also calculated the buttresses volume using allometric models developed using the Diameter Above the Buttress (DAB) and the Diameter computed from non-convex ($D_{area130}$) and convex area ($D_{convex130}$) at breast height (1.3 m). To demonstrate the broader generalization of our allometric models, we validated the developed models using independent data obtained by Terrestrial Laser Scanning (TLS) and destructive measurement. Volume estimated by the ASA showed a high agreement with the reference volume acquired by the Smalian formula (RRMSE of 0.08 and $R^2 = 0.99$ regardless of species effect). Our results suggest that the DAB seems to be the most advanced predictor for volume, with the lowest Akaike information criterion (AIC) of -62.4 than the $D_{area130}$ (49.2)and the $D_{convex130}$ (30.3). At the same time, the DAB (RRMSE of 0.2) and $D_{area130}$ (RRMSE of 0.2) show similar performance when validated with independent data sets. Our results indicate that the ASA is more reliable and efficient than allometric models for buttress modelling. Our results also provide a solid foundation for buttress modelling, as we use more buttressed trees (45) for allometric model development than previous studies. Furthermore, the proposed non-destructive method can help to correct the bias in present and past estimates of volume and biomass of large trees, which are keystone components to understanding biomass allocation and dynamics in tropical forests.