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Project/Expedition Name: Estimating tropical forest carbon stocks using small-footprint lidar remote sensing data

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Abstract

Tropical forests play an extremely important role in the global carbon cycle and international policy, but forest carbon stock estimates and the techniques used to assess them still need to be developed to meet international standards and improve efficiency. The overarching goal of this study is to improve estimates of tropical forest carbon stocks, especially in the context of the United Nation's program for reducing the rates of deforestation and degradation (REDD/ REDD+), in an important area for conservation, Madre de Dios, Peru. In this fieldwork campaign, we conducted detailed inventories in nine 1-ha within the Tambopata National Reserve. We measured height and crown diameter on all trees and palms. This data will be used to apply new tree and palm equations (developed by R. Goodman) to estimate aboveground biomass stocks of (i) trees, using height and crown dimensions and (ii) palms (family Arecaceae) using palm-specific models. We will also explore the possibly of estimating the biomass of single, emergent trees directly from light detection and ranging (LiDAR) imagery. This work could be used to calibrate LiDAR metrics with plot biomass and forest structure. Ultimately, this work will be applicable to forest and carbon conservation, management, and international policy, such as REDD+ schemes.

Project description and key findings

We conducted detailed inventories in the Tambopata National Reserve. We worked on nine 1-ha permanent measurement plots, in which all trees and palms with diameter ≥ 10 cm have been measured (diameter) and species identified as part of the RAINFOR network (Malhi et al., 2002). Eight plots are on classified as mature, *terra firme* forest, and one plot lies within a swamp with a large palm (*Mauritia flexuosa*) component. In this field campaign, we measured total height, stem height, and crown width to use in new models developed by R. Goodman to estimate aboveground biomass of trees and palms. We will (i) determine the importance of including tree height and crown dimensions for biomass estimates, (ii) estimate palm biomass using the first palm-specific equations for species in this region, and (iii) explore the possibly of estimating individual tree biomass directly from lidar images. Due to changes in

circumstances, we may not be able calibrate lidar metrics to plot data during the current analysis. Nonetheless, the models and biomass estimates used here will enable others to do so if desired.

We have found that including tree crown dimensions in allometric equations has the potential to improve biomass estimates greatly, especially for large trees (Goodman et al., (in review)). We have not yet used these equations to estimate forest plot biomass, but we except that large trees will weigh more than previously estimated, which may have important implications for carbon stocks if the largest trees are removed during selective logging operations. Secondly, calculating palm biomass with appropriate equations (rather than those created for dicotyledonous trees) also has the potential to make substantial differences in total forest biomass estimates, especially in the western Amazon where palms are particularly abundant (Kahn et al., 1988). In Tambopata, we found that palm biomass is actually higher using species-specific palm models than would have been estimated by dicot equations (Goodman et al., (in preparation)). Finally, we explore the possibility of estimating individual, emergent tree biomass from crown area detected from lidar images. We will compare crown areas determined from the aerial images to the ground-based measurements as well as biomass estimates made from crown area and height alone compared to all the data obtained in the ground inventories. This work will add to research aiming to develop low-cost tropical forest carbon stock estimates and change detection.

The results of this research will be published in a peer-reviewed journal and appear as a chapter in R. Goodman's doctoral thesis.

Budget

Exchange rate (PEN/£)	4.51
Exchange rate (USD/£)	1.64

Expense	USD/day	PEN/day	No. days	Total (USD)	Total (PEN)	**Total (£)**
Assistant		50	20		1000	222
Accommodation: National	20		20	400		244
Accommodation: Foreigner	40		24	960		585
In-country travel				460		280
Supplies						60
Total						**1391**

References

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Kahn, F., Mejia, K., Decastro, A., 1988. Species richness and density of palms in terra firme forests of Amazonia. Biotropica 20, 266-269.

Malhi, Y., Phillips, O.L., Lloyd, J., Baker, T., Wright, J., Almeida, S., Arroyo, L., Frederiksen, T., Grace, J., Higuchi, N., Killeen, T., Laurance, W.F., Leano, C., Lewis, S., Meir, P., Monteagudo, A., Neill, D., Vargas, P.N., Panfil, S.N., Patino, S., Pitman, N., Quesada, C.A., Rudas-Ll, A., Salomao, R., Saleska, S., Silva, N., Silveira, M., Sombroek, W.G., Valencia, R., Martinez, R.V., Vieira, I.C.G., Vinceti, B., 2002. An international network to monitor the structure, composition and dynamics of Amazonian forests (RAINFOR). Journal of Vegetation Science 13, 439-450.