

ALLOMETRIC EQUATIONS CREATION FOR SHADE TREES IN COFFEE AGROFORESTRY SYSTEMS AND REFINING THE ESTIMATION OF CARBON QUANTITY THROUGH REMOTE SENSING METHODS

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INTRODUCTION

Allometric equations are regression models linking biomass to certain independent variables, such as DBH (diameter at breast height), height, wood density or crown width. The lack of species-specific regression equations leads to the use of more generalized models, such as pantropical models, which is often a major cause of inaccurate biomass estimates (Brown et al., 1989; Chave et al., 2005; Henry et al., 2011; Goodman et al., 2014; Picard et al., 2015).

The most accurate method for estimating biomass is the destructive method (Brown et al., 1989, Chave et al., 2014). However, this method is time-consuming and financially demanding, and when creating allometric equations for entire ecosystems, it can lead to deforestation or degradation of the studied locations. Therefore, the destructive method for determining biomass is best used to develop mathematical models for predicting biomass for selected species (Chave et al., 2014).

The aim of the study was to create species-specific allometric equations for estimating the total amount of sequestered carbon in the species *Pinus tecunumanii* grown as a shade tree in coffee agroforestry plantations. To estimate biomass, two methods were used (1. The destructive method, from which allometric equations were created; 2. The 3D model method created using a) drone and b) LiDAR in mobile application) and compared. The adoption of new technologies such as drones or mobile applications with LiDAR could ensure rapid carbon assessment, even for the growers themselves, who could more easily enter the carbon market. Therefore, we aim to refine the method of carbon determination through remote sensing by precisely quantifying carbon using a destructive method.



Pinus tecunumanii, Finca San Alberto, Oxapampa

MATERIAL AND METHODS

The research was conducted in Finca San Alberto (at an altitude of 1850–2100 meters) in Oxapampa, which occurs in the central part of Peru, in the Pasco region. The coffee plantation in San Alberto was established in 2007 and was previously used for livestock grazing. Shade trees in coffee plantation are primarily *Pinus tecunumanii* and *Pinus oocarpa*. Finca San Alberto has Rainforest Alliance and organic certification.

For the destructive method, 22 shade trees with a diameter from 9.9 cm to 43.8 cm were cut down. Before felling the trees, DBH and heights of all selected trees were measured. Trees were cut down and divided into three parts: trunks; branches; and leaves, which were weighed individually. Belowground biomass was not included in the destructive biomass analysis. The predictor variables considered were diameter, tree height, and wood density. Additionally, a remote sensing method was used to estimate biomass. This alternative biomass estimation method (3D model) is especially suitable for larger areas (Kumar et al., 2015) or for difficult-to-access tropical regions, where estimating aboveground biomass can be particularly challenging. In our study, images were obtained through remote sensing using a drone and LiDAR.

The results obtained using the above-mentioned methods will be compared with each other, creating a calibration that can be used for further research to determine the biomass of trees using a drone and LiDAR.



Destructive method, *Pinus tecunumanii*

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