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A stochastic algorithm for reconstructing tree height growth with stem analysis data

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Keywords: height growth models, mixed-effects models, growth rates, site productivity.

Tree growth is very important for understanding forest dynamics and forest management planning. Among the alternatives for measuring tree growth, stem analysis, a destructive technique that involves cutting trees, yields detailed information on each tree through time, such as diameter, taper, and total height. Several algorithms have been proposed to adjust the section-height-age information from stem analysis to obtain the real time series data of tree height. Here, we present a stochastic algorithm for reconstructing height-age data pairs from stem analysis data. We use stem analysis data from two deciduous broadleaves tree species (*Nothofagus alpina* and *N. obliqua*), an evergreen tree species (*N. dombeyi*) growing in the southern hemisphere, and a conifer (Douglas-fir) growing in the northern hemisphere for our analysis. We reconstruct pairs of height-age data for each species by the widely used Carmean algorithm and the one proposed here. For each species, we fit the Bertalanffy growth model using both data. A mixed-effects model strategy was used for fitting this non-linear model. Comparisons between the models generated from the two types of data consider confidence intervals of the estimated parameters, as well as a regression-based equivalence test within a non-parametric bootstrapping framework. Results showed that fitted height growth models obtained from these two algorithms are equivalent from a statistical point of view. However, the proposed algorithm is simpler than the Carmean one and most likely more accurate as well, and therefore we propose its use.

Simultaneous fit of biomass-component equations: statistical analysis and practical implications

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Keywords: biomass modelling, regression techniques, statistical inference.

Accurate quantification of tree biomass is key for estimating and understanding fiber production and carbon sequestration by trees, however, tree biomass is also influenced by several factors affecting tree growth. Given the highly intensive set of measurements needed for measuring tree biomass (w), we are forced to build statistical relationships between w and predictor variables that are easily recorded, e.g., tree diameter (d). Modelling of tree biomass components (i.e., stem, branches, and

foliage) has traditionally been carried out by fitting a set of independent equations for each component (and even for total biomass). However, this does not take into account that independent predictions for those components will not produce a total biomass prediction that is consistent with predictions given by a model for total biomass. This problem is known as the property of additivity. Here, we present a statistical analysis for ensuring the property of additivity among the components of tree biomass and total tree biomass for a dataset of *Nothofagus* species in southern Chile. Using a set of base-models for each biomass-component, we compare the statistical inference and the model performance of the following statistical strategies: seemingly unrelated regression (SUR), two-stage least squares (2SLS), weighted two-stage least squares (W2SLS), and three-stage least squares (3SLS). Comparisons among the strategies focused on the estimated covariance matrix of the residuals, and its implications for statistical inference. We also explore the difference in predictions at the stand level for all the modeling strategies.

Positioning of the role of remote sensing – radar for estimating forest biomass in the tropical environmental

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Keywords: biomass modeling, forest inventory, radar data, tropical forest, Eucalyptus stand.

Remote sensing - radar has been used for analysis of forest mapping and biomass estimates in the Brazilian territory. Two examples of SAR attributes for modeling of aboveground biomass of forest stands are presented: (1) the use of full-polarimetric attributes of PALSAR/ALOS for modeling in Amazonian tropical forest, considering the influence of the geomorphometric aspects on this radar response, (2) the use of polarimetric and interferometric airborne data (X_{HH} and full-polarimetric of P-band) for modeling in *Eucalyptus* sp. stands. In both cases, we first realized an analysis of forest structure variability through polarimetric signatures. Multivariate regression was used to integrate variables from polarimetric and/or interferometric radar attributes and field inventory. Considering the terrain aspects where the tropical forest is located, the most significant variables for biomass modeling were the Volumetric Scattering of Freeman-Durden target decomposition, Anisotropy, Relief Elevation, Slope, first and third Helicity components of the Touzi model. For the *Eucalyptus* biomass model, the Interferometry Height and Canopy Scattering Index variables were significant. A set of independent data from field inventory were generated for validation of each model, which indicated an error of ~12% to estimate the biomass, showing the importance of SAR attributes, focusing on models of natural and planted forest stock density.