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Allometric Equations for Timber Stock and Stem Biomass Estimation of Phanerophytes in Dry Forests on the Mahafaly Plateau, Madagascar

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Abstract

In the southwestern region of Madagascar, the dry spiny forests represent a unique and highly diverse ecosystem with an exceptionally high number of endemic species. However, deforestation rates increased drastically during the last 20 years and is mainly caused by slash-and-burn agriculture, logging, and the production of fuelwood and charcoal for cooking. To establish sustainable forest management strategies, the accurate and rapid assessment of timber stock is crucial, notably on the Mahafaly Plateau where local people are entirely dependent on natural resources to survive. The present study therefore aims at elaborating reliable allometric equations for phanerophytes on the Mahafaly Plateau, which permit to estimate wood volume and stem biomass from measurable dimensions such as diameter and height.

We inventoried diameter (diameter at breast height or diameter at 0.1 m), height, volume or biomass for the main tree and shrub species (22 species) used for charcoal production with a diameter ranging from 5 to 67.8 cm (Total $n = 196$). For 74 tree individuals, we applied a section-wise volume measurement for the stem and branch ≥ 2.5 cm diameter of already logged individuals (diameter and length of the section) using Smalian's formula and collected samples for wood density determination. For 122 individuals of phanerophytes, stem biomass was estimated by direct measurement of the weight of the stem from the soil level to the branches ≥ 2.5 cm diameter. Wood samples were collected and dried until a constant weight was obtained.

Five different equation models were developed and compared: a power function model with multiplicative error, a polynomial model, a combined variable model, a square-root transformed model and a power function model with additive error. Results indicate that the power function with multiplicative error and the combined variable models show a high coefficient of determination ($R^2 > 0.90$) and best describe the relationship of stem biomass and measured parameters. These equations will be used to extrapolate and map the results of ongoing forest inventory and satellite image analysis.

Keywords: Allometric equation, biomass, diameter, height, Mahafaly Plateau, wood volume