A standard protocol for woody plant inventories and soil characterization using temporary 0.1-ha plots in tropical forests

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Why a protocol based on temporary plots?

The use of both uniform woody plant inventories and laboratory soil analyses facilitate data sharing and improve the understanding of large-scale biological patterns in tropical forests. Gathering data with particular purposes is often fully compatible with its use for more general purposes. Standardized methods are never perfect but, overall, an existing standardized method that fulfils specific objectives is preferable to a new or very specific method. Temporary 0.1-ha plots are fast and cheap to install and are being increasingly employed in the tropics. The following recommendations summarize and unify current methods employed. They represent reasonable trade-offs between investment and data quality, and all are oriented to obtain low-cost standardized baseline data that could be very useful in a broad range of studies. Temporary samples do not require permanent plot delimitation, or individual tagging or mapping, and each individual is measured only once. They are unsuitable for the study of forest dynamics or local biomass estimation. However, it is possible to establish 0.1-ha plots as permanent plots and repeat censuses at different times [1]. In this case please follow the recommendations of large permanent plot standards regarding individual tagging and measurement [2].

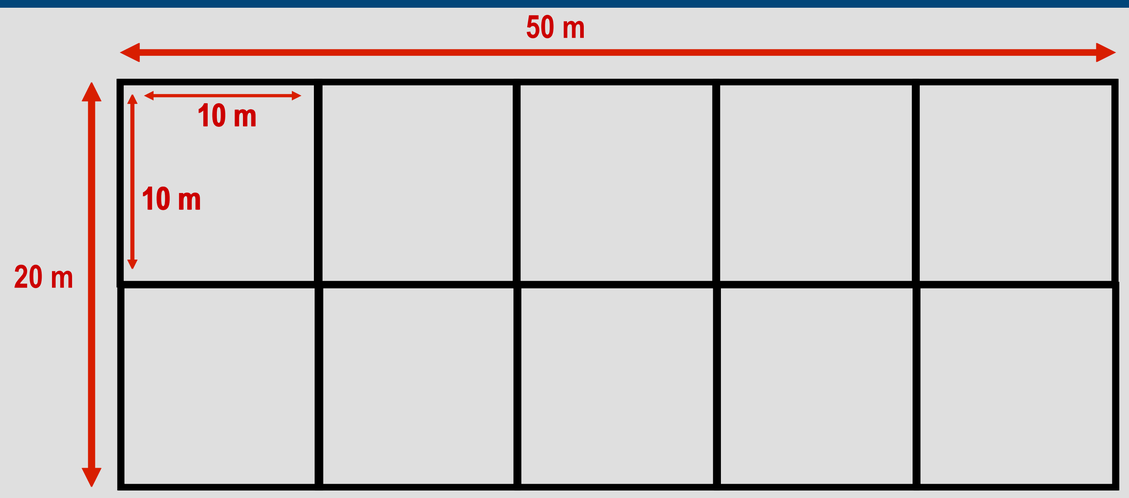
First, define a target site and decide where to place your plots

A site covers the variability present

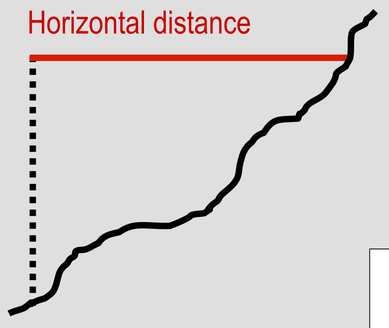
Plots must be internally homogeneous

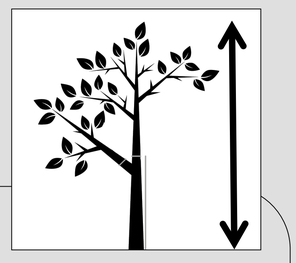
Use several plots to record species turnover. Define the size of your site as a function of available resources and ecological variability in the area. If the objective is to inventory a given locality of small size (e.g. < 25 km^2), a group of ten 0.1-ha plots (>2000 individuals) covering the whole environmental heterogeneity of the locality should be enough to reach approximate saturation on a species accumulation curve (SAC) and to record all common species. If the objective is to inventory only specific conditions or habitats (e.g. swamps), plots can be placed very differently but similar considerations regarding the SAC saturation and recording of common species apply. When there exist elevational changes within the targeted locality, sample plots within a 300 m elevational range. The inter-plot distances should depend on the species turnover of the targeted forest. Thumb rules: use 500 m in tropical lowland forests like the Amazon, and 250-300 m in the more heterogeneous montane forests like the Andes.

How to establish a plot? The key points

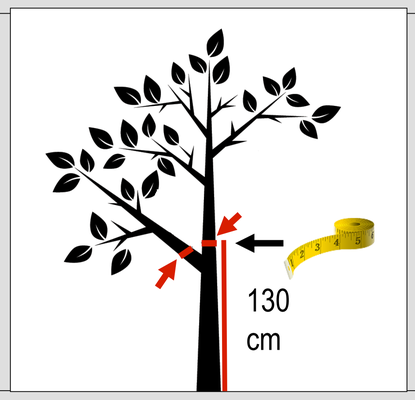


1. SIZE and DISTANCES: 50 x 20 m, often divided into ten 10 x 10 m subplots. Distances must be measured horizontally. Place the long side of the plot horizontally if significant slope exists.





2. DBH: Measure all woody stems with diameter at 130 cm from the rooting point ≥ 2.5 cm. Follow [2] for trees and [3, 4] for lianas. Use an alternative cut-off of 1 cm for lianas (if particularly interested in lianas) or if studying a young secondary forest with many small stems.



Multiple stems: Measure all stems with DBH ≥ 2.5 cm. Stems must be recorded individually. The diameters of the different stems can be combined later in a single estimate for the individual:

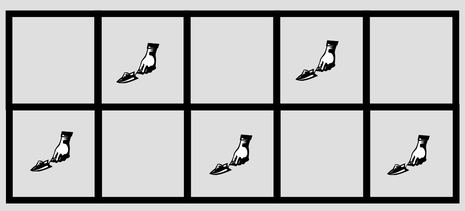
$$DBH = \sqrt{\sum\left(dbh_i^2\right)}$$

3. HEIGHT: For fast temporary plots, a height estimate is enough. For lianas, consider how far the top of its crown is from the ground as its "height". For a more precise estimation, follow the protocols of permanent plots [5, 6, 7]

4. PLOT DATA and METADATA: Keep record of all the relevant information: geographical coordinates, compass directions, elevation, exposure, slope, topographic position (e.g., ridge, valley, slope, soil structure and drainage, forest type, and habitat particularities. Record frequency and types of common disturbances. Estimate time since the major disturbance (using aerial/satellite images or interviews with neighbors). Estimate the successional forest phase.

The long-term value of any ecological data to be used in large-scale analysis depend on the availability of suitable and adequate metadata, i.e., a technical description the data content, context, quality, structure and accessibility [8]. Use standardized databases minimizing data redundancy [9].

5. SOIL: Gather a superficial sample (0-15 cm, below the litter layer) composed by five subsamples disposed in zig-zag (from the centers of 5 subplots). Air-dry the samples and pass through a 2-mm sieve. Calculate the bulk density of the sample.



Soil analyses to do, in order of preference: (1) available base content (Ca, Mg, K, Na); (2) texture; (3) pH; (4) total C and N; (5) available P; (6) available Al; and (7) available micronutrients (Fe, Cu, Zn, Mn, etc).

Methods to employ: universal extractor Mehlich-3 followed by measurement with ICP to measure Ca, Mg, Na, K, Al, P, and micronutrients. Alternatives to ICP: molybdenum-blue method (P) and atomic absorption spectrophotometry (metallic elements). Auto-analyzer to determine simultaneously total C and N by total combustion. Texture with the hydrometer method. pH in a 1:2.5 soil:water suspension.

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