We provide a tool 3DVBranch for visualizing an FBA tree. Figure 1A-D shows an example of aboveground tree shapes produced by different values of p. Trees with low p value are endowed with more branches and leaves; those with high p have less branches and leaves, due to more significant branch tapering.

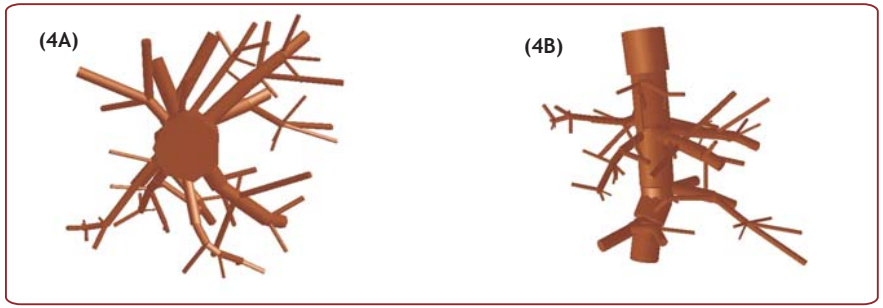

Figure 4. An example of tree root architecture produced by the FBA model seen from the top (A) and from the side (B).

How to get the model?

The FBA model is made available through the website (http://www.worldagroforestry.org/sea/Products/AFModels/WaNulCAS/downloadc.htm) that allows users to derive results for new parameter combinations and/or seek new applications. The allometric scaling relations as derived with the FBA module can be directly used in the WaNuLCAS model of tree-soil-crop interactions.

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Tree architecture and scaling rules: Functional Branch Analysis (FBA), above and belowground

A supporting tool for analysis of multifunctional landscapes

Trees in Multi-Use Landscape in Southeast Asia (TUL-SEA)
A negotiation support toolbox for Integrated Natural Resource Management

Trees of many kinds

Trees come in various shapes, grow at different rates and interact with their neighbours during development. Yet, many of the properties of an individual tree can be predicted if we know the diameter of its stem. The relationship between this diameter and properties such as tree height, tree biomass, leaf area and harvestable timber are called 'scaling rules' or *allometrics*. Empirical allometric scaling equations (the most generic form is $Y = a D^b$) for tree biomass Y on the basis of stem diameter D are often used in forest inventories and assessment of carbon and nutrient stocks in vegetation. They are based on cutting selected trees and obtaining destructive measurements to relate to the stem diameter. When shifting from plantation forestry to mixed forestry or multi-species agroforestry systems, however, short-cuts to the empirical approach are desirable. Certain regularities in the development of tree form are captured in 'fractal branching' models; such models can provide a transparent scheme for deriving tree-specific scaling rules on the basis of easily observable, non-destructive methods. Apart from total tree biomass, the models can provide rules for total leaf area, relative allocation of current growth to leaves, branches, stem or litter, or the ratio of green to brown projection area that modulates tree-crop interactions in savanna.

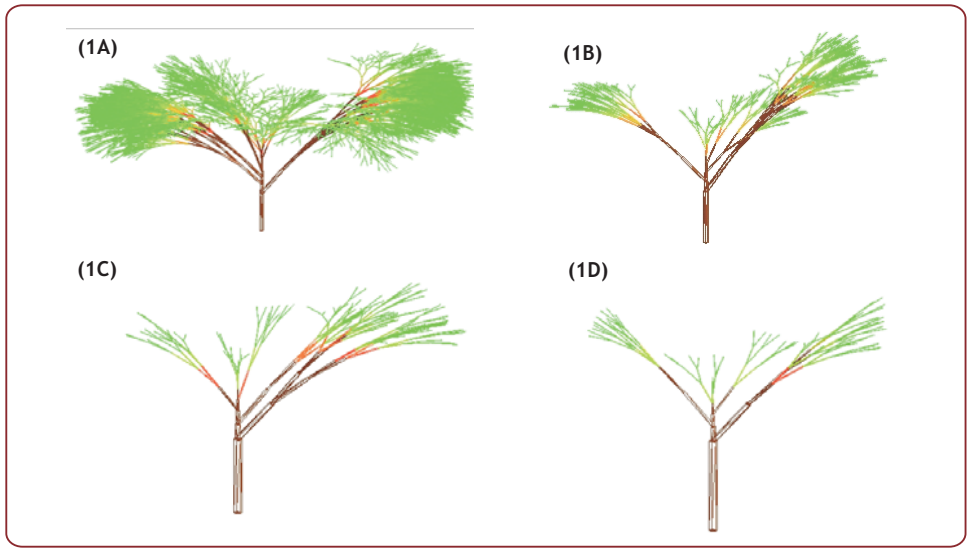

Figure 1. An example of tree shapes obtained by varying just 1 parameter in the fractal branching routine: the proportionality factor p for change of stem diameter at a branching point has the values 0.8, 1.0, 1.2, and 1.4 respectively in figures A-D.

Belowground, similar descriptions hold for individual root axes, where the proximal root diameter at the stem base can be used for predicting total length or biomass of all its branches. The basic assumptions underlying fractal branching have been tested and found to be applicable as acceptable approximation for a wide range of tropical trees, aboveground as well as for their root systems.

Objective of FBA protocol and program

The functional branch analysis protocol and program are designed to efficiently describe the architecture and key properties of a tree, and to use the derived parameters to reconstruct trees with simple, repetitive ('fractal') rules and derive scaling rules that relate stem and/or proximal root diameter to total biomass and other properties.

How does it work?

Fractal branching models repeatedly apply the same equations to derive subsequent orders of the branching process ('self-repetition rule'). For practical applications, a rule is added for stopping when a certain minimum size is reached. The rules can refer to the diameter, length and/or orientation of the next order of branches. Figure 2 describes the elements of a 'functional branching analysis' (FBA) scheme, which can be applied for above as well as belowground parts of trees. The combinations of the various parameters can be used to predict total size (weight, surface area, length, height, lateral extent) and the allometric scaling equations between these.

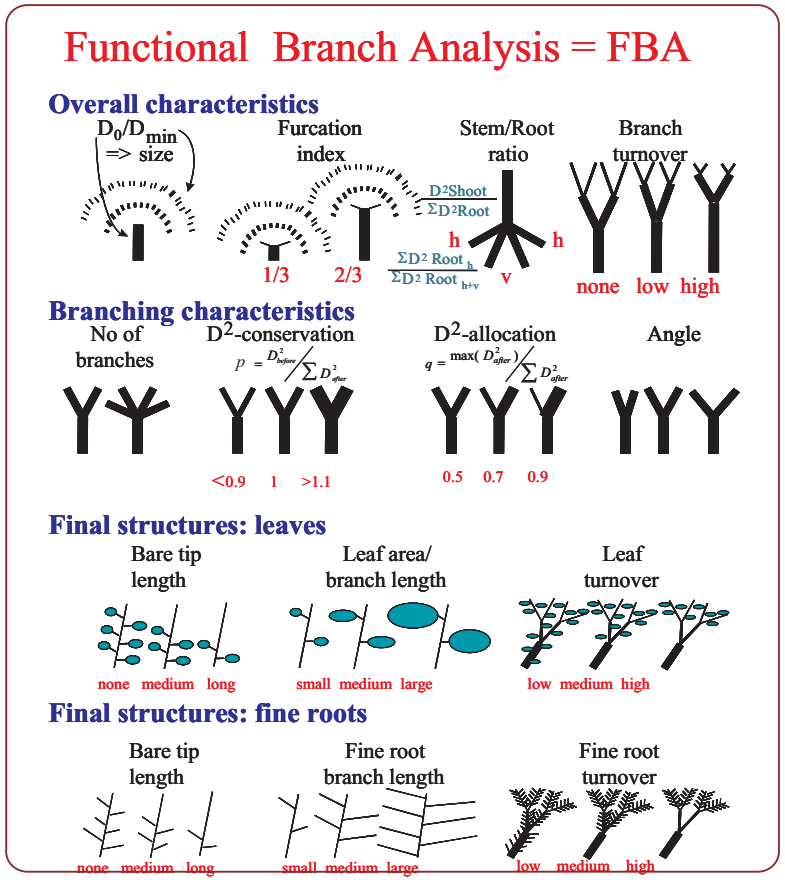

Figure 2. Elements of the Functional Branch Analysis (FBA) model to derive allometric scaling equations between above or belowground tree parts.

Estimation of the model's elements is based on a visual assessment or field observation. The model needs information of link (i.e. shoot or root segment) diameter and length, and final structure (leaves or fine roots). Not all, but at least 50 and preferably 100 successive links are to be measured to get a precise estimate of branch parameters. The model's elements governing branching pattern can be calculated with FBA Help-File, and the independency of p (proportionality factor) and q (equity factor) to link diameter should be checked since it (i.e. the independency) is an underlying requisite to apply the self-repetition rule.

How good is it?

One comparison between model estimation and real observation on tree aboveground biomass and its part was done related to four tropical trees grow in the Philippines and shown in Figure 3. Total aboveground tree biomass as calculated with the allometric equations from FBA model, fits well with the biomass measurements obtained from destructive methods (Figure 3A). Slight differences were found for tree components: wood (Figure 3B) and leave biomass (Figure 3C) for all four tree spices. Statistical test analysis also confirm the viability of the FBA model for all tree species. Indeed, all test performed on FBA results indicated that the model is applicable and provides an acceptable approximation for total aboveground biomass estimation as well as for the tree components (wood and leaf).

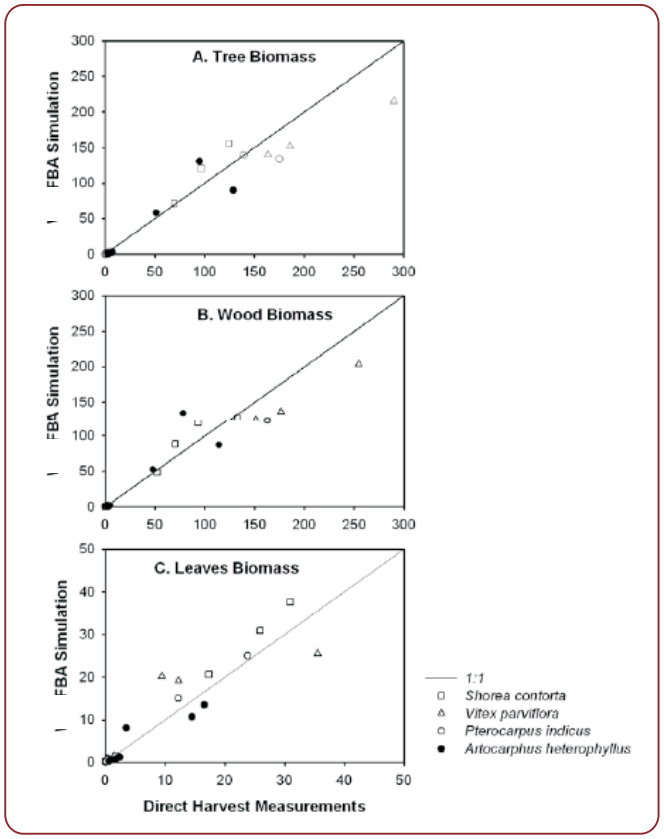

Figure 3. Comparison between FBA estimation and direct harvest biomass values for four tropical tree species in the Philippines (Martin, 2008): A. tree aboveground biomass (kg), B. wood biomass (kg) and C. Leaf biomass (kg).

TUL-SEA: A negotiation support toolbox for Integrated Natural Resource Management