3.5. WANULCAS

By:
Meine van Noordwijk and Betha Lusiana

3.5.1. AGROFORESTRY SYSTEMS

WaNuLCAS (Water, Nutrient, and Light Capture in Agroforestry System) is a model of tree-crop interaction in agroforestry system. The model is formulated in the STELLA Research modelling environment. Emphasis was given to below-ground interactions, where competition for water and nutrients (nitrogen) depends on the effective root length densities of both plant components and current demands by tree and crop. An up-to-date version can be obtained from *http://www.cgiar.org/icraf/sea/wanulcas/* (operational per June 1999).

The key feature of the model is the description of uptake of water and nutrients (at the recent stage only N) on the basis of root length densities of both the tree and the crop, plant demand factors and the effective supply by diffusion at a given soil water content.

The model represents a four-layer soil profile (vertical), with four spatial zones (horizontal), a water and nitrogen balance and uptake by a crop and a tree (Figure 3.10).

The user can define the width and depth of each zone and adjust it to the type of system simulated. The model can be used both for simultaneous and sequential agroforestry systems and may help to understand the continuum of options ranging from improved fallow via relay planting of tree fallow to rotational and simultaneous forms of hedgerow intercropping. The model explicitly incorporates management options such as tree spacing, pruning regime and choice of species or provenance. The model includes various tree characteristics, such as (dynamic) root distribution (over 16 cells, 4 layers x 4 zones), canopy shape (above 4 spatial zones), litter quality, maximum growth rate and speed of recovery after pruning.

If applied to hedgerow intercropping, the model allows for the evaluation of crop growth at different distance from the hedgerow for different pruning regimes and hedgerow tree spacing or fertiliser application rates. When applied to rotational fallow systems, the edge effects between currently cropped parts of a field and the areas where a tree fallow is growing can be simulated, by letting the first zone represent a fallow plot and zone 2, 3 and 4 represent three zones in a neighbouring cropped field. For isolated trees in parkland systems, equidistant zones around individual trees can be pooled (Table 3.1).

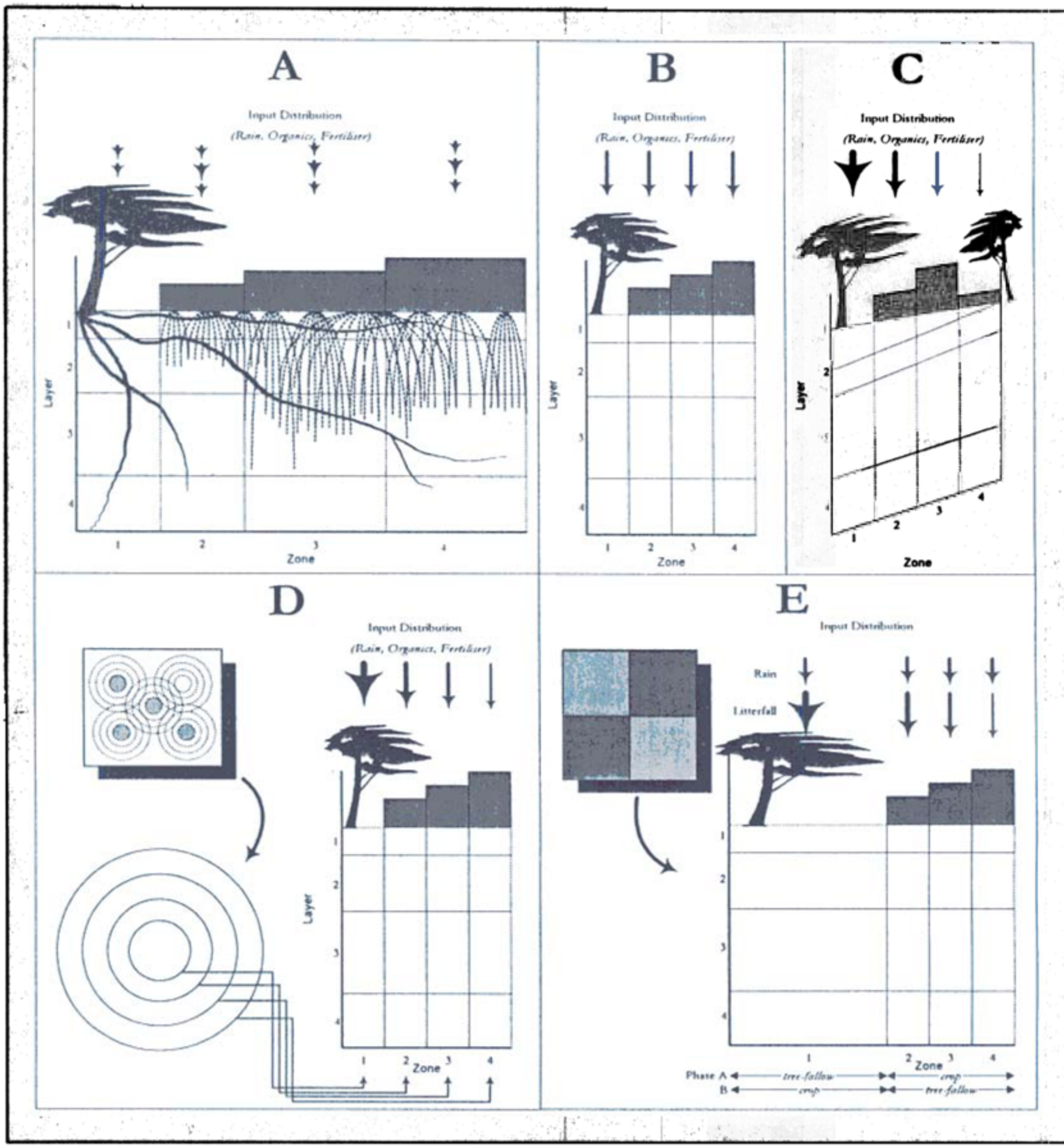

Figure 3.10. General lay out of zones and layers in the WaNuLCAS model (A) and applications to four types of agroforestry system: (B) Alley cropping, (C) Contour hedgerows on slopes, with variable topsoil depth, (D) Parkland systems, with a circular geometry around individual trees, (E) Fallow-crop mosaics with border effects

Table 3.1. Characteristic settings for four types of agroforestry system.

Type of Agroforestry System	Geometry	Tree canopy	Topsoil Depth	Water Infiltration	Time Sequence
Alley cropping on flat land	Linear	Zone 1-4	Homogeneous	Homogeneous	Continuous
Alley cropping on slopes	Linear	Zone 1-4 + symmetrical canopy 4-1	Gradient	Heterogeneous (runoff + runon)	Continuous (soil redistribution can be simulated)
Parkland trees	Circle	Zone 1-4	Homogeneous	Heterogeneous	Continuous
Tree fallow/ mosaic	Linear	Zone 1 (fallow plot size)	Homogeneous	Homogeneous	Switching between fallow and crop stage

A number of inputs to the soil surface can be distributed proportional to the relative surface areas or heterogeneously. This way, it for example account for surface runoff of rainfall in one zone and its infiltration in another. Separately, patch-level net run-on or run-off can be implemented. Similar weighting factors are used for allocating litterfall, tree pruning, fertilisers and crop residues to the various zones, while conserving their overall mass balance.

The model assumes the same crop to be grown in all three zones, simultaneously. Sequencing of crops is possible by specifying the crop type, planting year and day of year for each subsequent crop. The vegetative and generative duration of that crop (at standard temperature) is used as input, and modification of phenological development by actual temperature can be accommodated. Each crop should be specified on the basis of its maximum dry matter production rate per day, expressed in kg m^{-2} day^{-1}, and a graphic or tabulated input of its relative light use efficiency (dry matter production per unit light intercepted) and its leaf weight ratio as a function of crop stage. These parameters may be derived for a given location from more specific models, such as the DSSAT family of crop growth models.

Trees can be pruned in the model to a specified degree, on the basis of two criteria: concurrence with a crop on the field and tree biomass above a prune limit. Alternatively, calendar dates for pruning events can be given as input. Prunings can be returned to the soil as organic input (in the standard case with regular distribution over the zones).