What is 3-PG?

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3-PG is a simple process-based, stand-level model of forest growth developed by Landsberg and Waring (1997). It requires only readily available site and climatic data as inputs, and predicts the time-course of stand development in a form familiar to the forest manager, as well as biomass pools, stand water use, and available soil water.

3PGPJS is a user-friendly interface to 3-PG. The interface is a Microsoft Excel workbook which supplies all input data required by 3-PG and to which results are written, and an Excel add-in containing the code for 3PGPJS the 3-PG model. The input spreadsheets facilitate easy modification of site and climatic data, default parameter values and run-time options. The use of normal spreadsheet operations and graphing with 3PGPJS gives added flexibility.

Overview of 3-PG

3-PG is a deliberate attempt to bridge the gap between conventional empirical, mensuration-based growth and yield models, and process-based, carbon-balance models. It can be applied to plantations, or to even-aged, relatively homogeneous forests. It is a generic stand model, in the sense that its structure is not site or species-specific. However, it must be parameterised for individual species.

3-PG consists of five simple submodels: the assimilation of carbohydrates, the distribution of biomass between foliage, roots and stems, the determination of stem number, soil water balance, and conversion of biomass into variables of interest to forest managers. **Fig. 1** illustrates the structure of 3-PG and its major inputs and outputs. The state of the stand is updated each month. For a more detailed description see Landsberg and Waring (1997) and Sands and Landsberg (2002).

The model has found numerous applications for various species (Coops and Waring, 2000; Landsberg et al. 2000; Law et al. 2000; Sands and Landsberg 2002; Waring, 2000). A modified version, 3-PG Spatial (Coops et al. 1998a), has been applied to study forest productivity across landscape areas (Coops et al. 1998a, 1998b; Coops and Waring, 2000).

Data inputs

3-PG requires as climatic inputs monthly average values of solar radiation, mean daily air temperature, atmospheric vapour pressure deficit, rainfall, and frost days. If mean maximum and minimum air temperatures mean daily temperature and VPD can be estimated from these. 3-PG can be run for any number of years, using either actual monthly weather data or long-term monthly averages. Using averages is the normal procedure unless there is particular interest in specific events, such as droughts.

Other inputs are factors describing the physical properties of the site: latitude, a site fertility rating, maximum available soil water, and a general descriptor of soil texture.

3-PG outputs

The primary output variables from 3-PG include stem, root and foliage biomass, available soil water and stand transpiration, and net primary production. It also provides stand-level outputs familiar to the forest manager, and often used as inputs into management programs. These include canopy leaf area index (LAI), main-stem volume, average stem diameter at breast height, mean annual stem-volume increment (MAI), and stem number.

Outputs from 3-PG can be either monthly or annual values.

Gross and net primary production

The photosynthetically active radiation (APAR) absorbed by the canopy by the canopy is determined from total solar radiation and canopy LAI through Beer's law. Gross primary production (GPP) is proportional to APAR. The proportionality factor is called the canopy quantum efficiency (α_C) and takes into account environmental modifiers f_x ($0 \le f_x \le 1$) based on atmospheric vapour pressure deficit, available soil water, mean air temperature, frost days per month, site nutrition, and stand age. Only the most limiting of the VPD and soil water factors is used, but the other factors are applied multiplicatively.

Net primary production (NPP) is a constant fraction (47%) of GPP.

Biomass allocation

Allocation of NPP to roots is determined by growing conditions as expressed by available soil water, vapour pressure deficit and site nutrition. The proportion of NPP allocated to roots increases when nutritional status and/or available soil water are low. Biomass allocation to foliage and to stems also varies with growing conditions, but also depends on average tree size in such a manner that allocation to foliage declines and that to stems increases as stands age. Average tree size is measured by mean stem diameter at breast height, determined from the stand-level stem biomass and the current stem number.

Stem mortality

Changes in stem populations are calculated using the $-^3/_2$ self-thinning law to estimate an upper limit to the mean, single-tree stem mass for the current stem population. If the current mean single-tree stem mass is greater than this upper limit, the stem population is reduced to a level consistent with this limit. When stems are removed it is assumed that each stem removed has a fraction of the biomass of the average stem, and that little foliage biomass is lost. This simulates the fact that those trees that die are often the smaller trees with low stem biomass and little or no foliage.

Soil water balance

3-PG includes a simple, single-layer soil-water-balance model working on a monthly time step. Monthly rainfall (plus irrigation) is balanced against monthly evapotranspiration computed using the Penman-Monteith equation. Canopy interception is a fraction of rainfall and depends on the canopy LAI. Soil water in excess of the intrinsic soil-water holding capacity for the site is assumed to be lost as runoff (or deep drainage).

Vapour pressure deficit, available soil water and stand age are all assumed to affect stomatal conductance. Canopy conductance is determined from a nominal stomatal conductance scaled by the age, VPD and soil-water related modifiers referred to above, and increases with increasing canopy LAI up to a maximum canopy conductance.

Stand characteristics

Stand level characteristics such as stem volume, mean stem diameter, basal area, and mean annual increment are computed from the biomass pools and stem numbers. These inputs are of more intrinsic interest to forest managers than are the biomass pools and flows.

References

The following are basic references to the development of 3-PG and vario0us applications:

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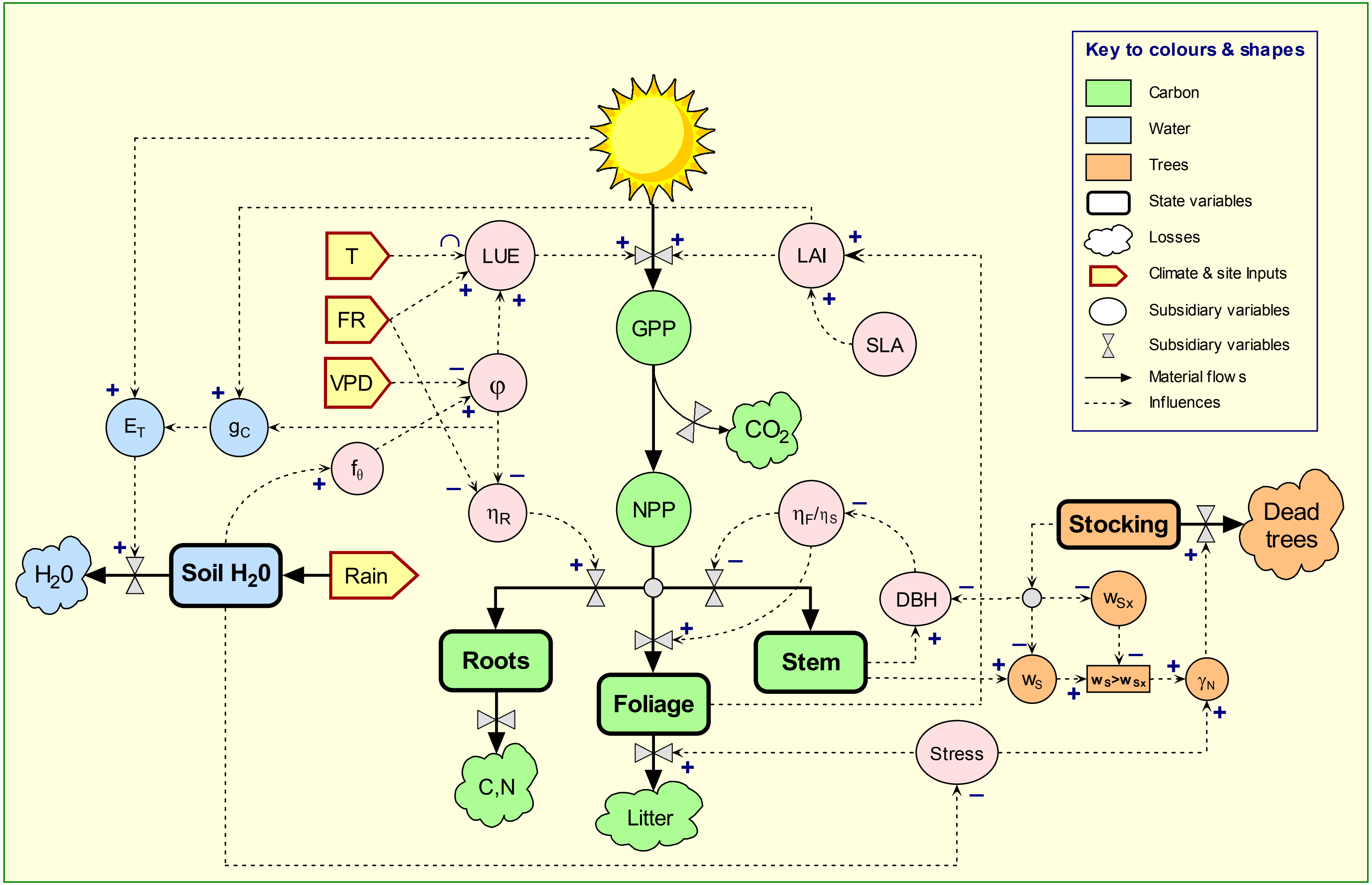

Fig. 1. Structure of 3-PG, and its input and output data.