

# Functional –structural modelling using the generic tool PIAF-1 : a simulation example on young walnut

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## Introduction

The generic functional-structural tree modelling tool PIAF-1 was introduced in the previous FSPM workshop (Donès and Lacoïnte, 2004). Its modular structure allowed to choose (1) which process modules should be included within a simulation, and (2) the specific way to represent each process. Another feature of PIAF-1 was its ability to use time and space scales relevant to each process or tree element, making it possible, for example, to describe one branch at a very detailed temporal or spatial level while the rest of the tree, including other branches, was described at a courser scale. Such extended flexibility of the data structure is a major characteristic of PIAF-1 among other modelling tools of similar scope, e.g. LIGNUM (Perttunen et al., 2001) or GreenLab (Yan et al., 2004). However, that preliminary version was just a modelling tool, i.e. a data structure with a generic module pattern including data access procedures and a module chaining engine: no biological model was implemented yet; this has been done since. This presentation is aimed at showing the current development status of the project, with a simulation example on young walnut.

## Data structure

In the original version, the description of tree structure was based solely on topology: an ordered, dual sequence of nodes and segments. The current version has been extended with more biological concepts like root types or stem growth units, considering them as extended, optional attributes of segments to keep the scaling flexibility (Fig. 1).

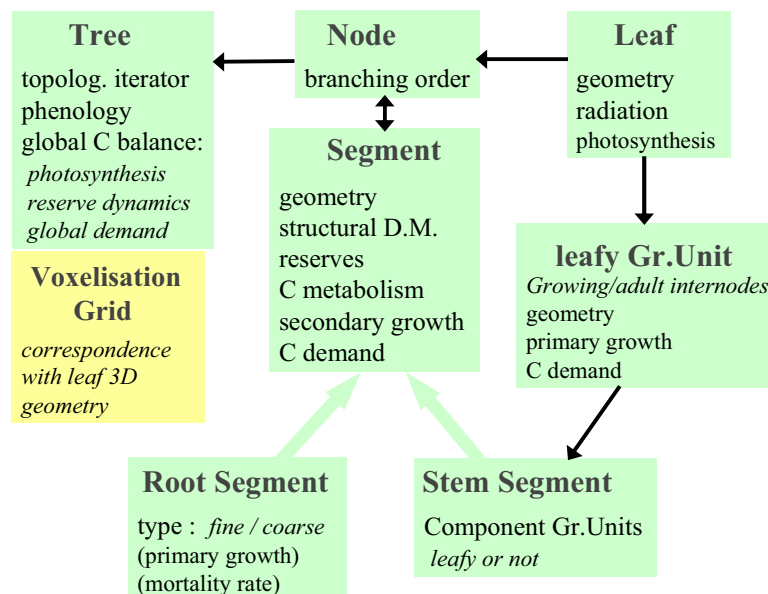


Fig. 1. Data structure of PIAF-1 (simplified) showing the major biological attributes attached to each class.

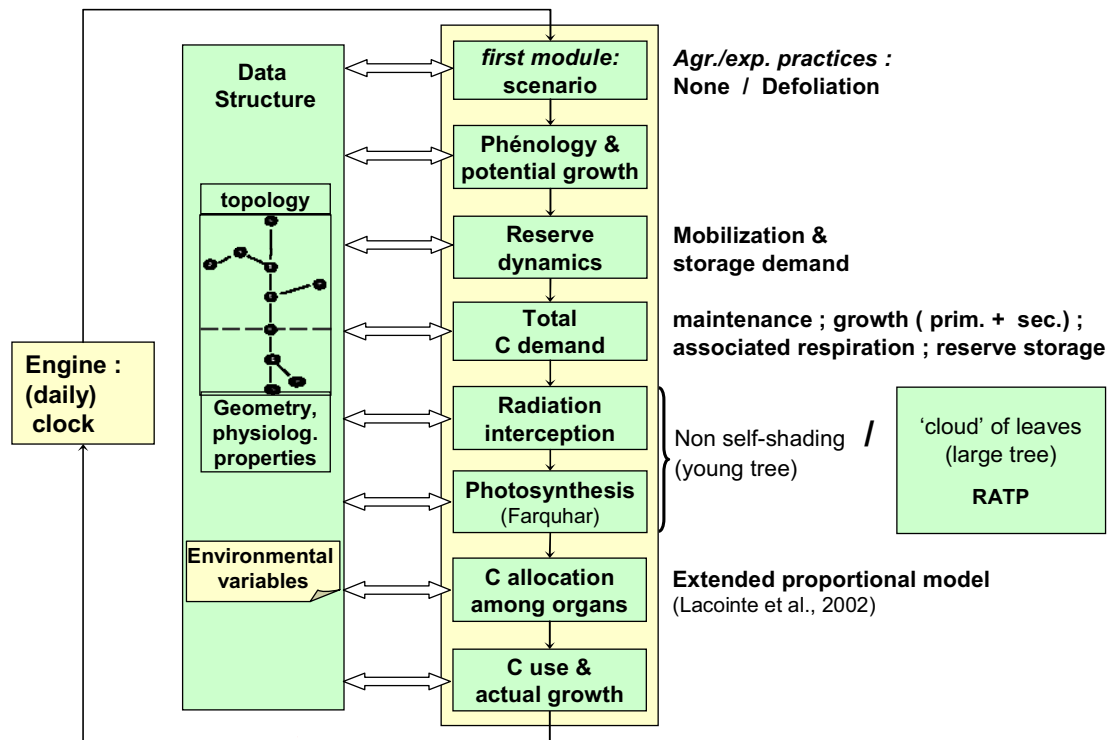


Fig. 2. Chaining of process modules currently implemented in PIAF-1.

When available, different versions for one process are indicated by the character ‘ / ’

### Process modules

Beside common processes that are usually included in FS plant models, like photosynthesis, carbon allocation or actual growth, some more specific processes have been implemented that are not so common in simulation models in spite of their increasingly acknowledged significance (Le Roux et al. 2001), *e.g.* reserve dynamics. Some of them, like radiation and photosynthesis, have been implemented in two versions, one of them more appropriate to small- and the other to large-sized trees. Specific agricultural practices or experimental protocols, *e.g.* harvesting, pruning or defoliation, can be easily included or discarded through a special ‘scenario’ module (fig 2).

### User interface

The software provides a user-friendly graphic interface (Fig. 3) to specify the sequence of modules to include in the next simulation run; module-specific dialog boxes will be available for parameter editing, but these have not been designed yet. At runtime, real-time 3D visualization is available to follow the structural changes together with a log window for model output. Also available is automatic capture of the 3D image at every simulation time step to make video sequences.

### A simulation example

This presentation will include a short demonstration of the software, simulating the carbon economy and growth of young walnut trees over one year. Two conditions are compared: control *vs.* periodic defoliation, as experimentally investigated in the PIAF laboratory, Clermont-Ferrand. Walnut-specific parameters were derived from the earlier model SimWal (Balandier et al., 2000) or

from more recent experiments (e.g. Lacoïnte et al., 2004). Beside a significant effect on growth, the impact on the reserve status is emphasized (Fig. 4), which is also found in current experiments. However, an extended parameterization/validation work still has to be done, including of course longer-term simulations.

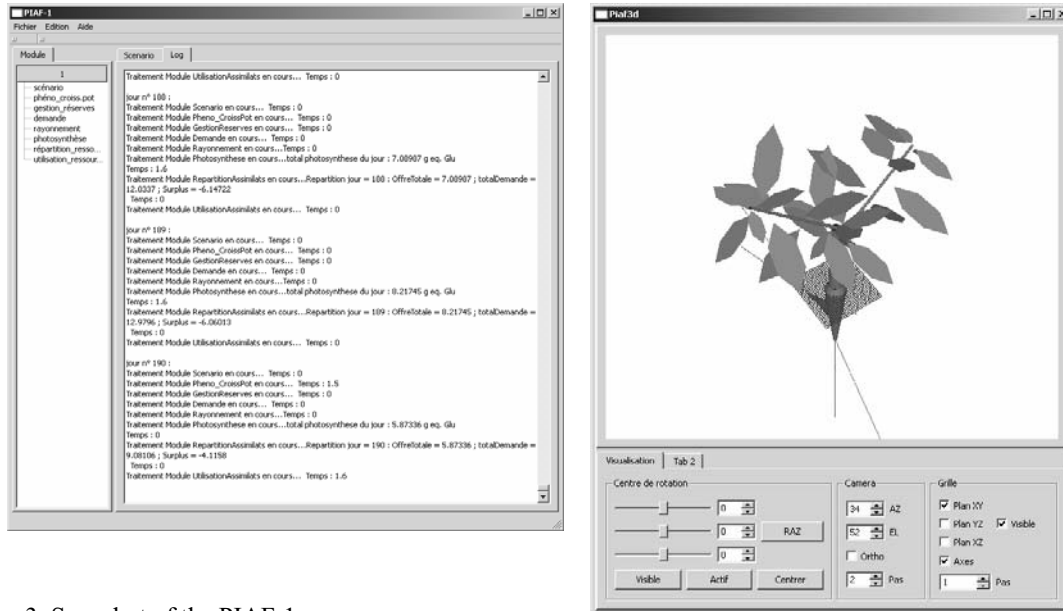


Fig. 3. Snapshot of the PIAF-1 screen. The log window to the left displays output and error messages. The window to the right provides real-time 3D visualization, allowing to change the visualization angle.

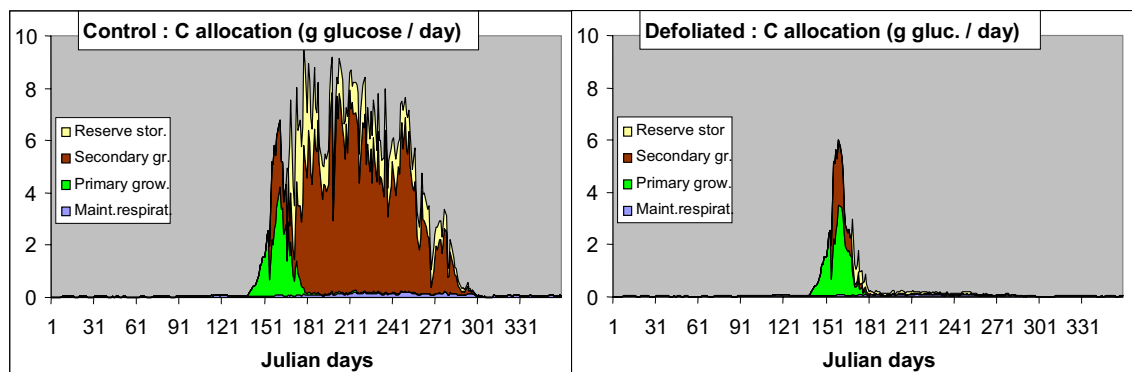


Fig. 4. An example of simulation results on young walnut: whole-tree level daily C allocation in two situations : control vs. defoliated.

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