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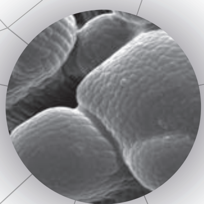
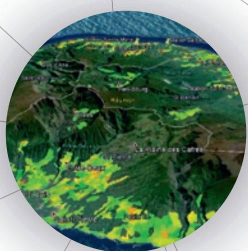
COMPLEX SYSTEMS
From biology to landscapes





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Plant growth modelling and simulation – a complex dynamic system

The structure of a plant results from a genetically determined deployment scheme whose expression is influenced by environmental conditions. It involves a dual mechanism linking development—or organogenesis, i.e. the development of new organs via terminal meristems, and growth, involving the expansion of the organs until they reach maturity. The so-called 'structural' development models provide realistic representations of plants, but do not quantify biomass, while crop models link photosynthesis produced via the leaf surface to resources (water, light), where biomass is distributed in the plant compartments in proportion to their requirements. These models generate good predictions for crops under stable environmental conditions. Structure-function models couple development and growth in a dynamic system via more or less complicated simulators.

By the GreenLab approach, organogenesis is considered as stochastic, defined by laws of probabilistic functioning of meristems (growth, branching and mortality) as inferred from field observations. New sets of organs are generated with each growth cycle. The growth model is then applied—it is calculated for each set of organs according to the plant's demand and available resources. The supply/demand ratio is seen as a pressure exerted on meristems and organs by the available biomass supply, while directly affecting their functioning. By impacting the laws of probability, this ratio allows for feedback on meristem functioning and hence on the plant's architectural development. This choice, derived from the model equations, is in keeping with many plant observations: on trees, the architectures show great plasticity depending on environmental conditions; simulations illustrate known emergent properties of complex systems, such as the occurrence of pseudo-rhythmic phenomena during fruiting in some agronomic plants or the development of main branches on mature trees.

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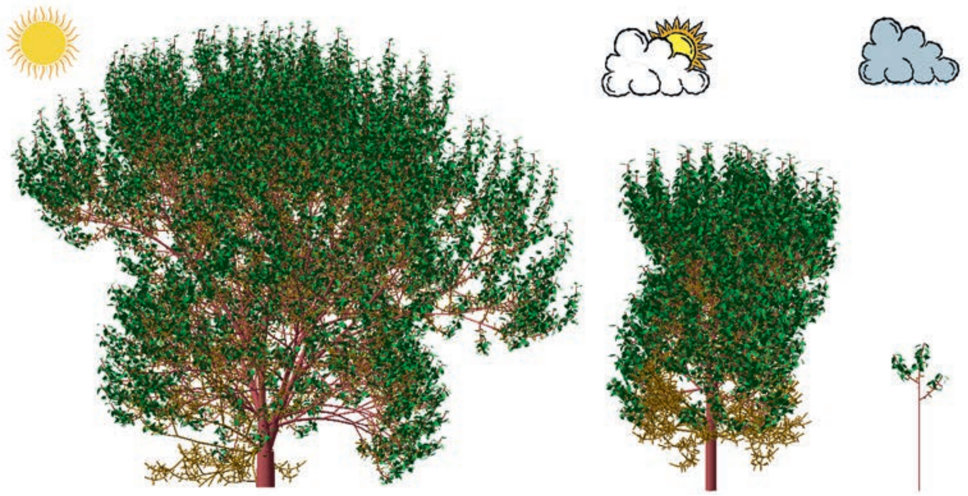
For further information: http://greenlab.cirad.fr/GLUVED
www.quae.com/fr/r5053-architecture-et-croissance-des-plantes.html
https://interstices.info/jcms/c_38032/une-histoire-de-la-modelisation-des-plantes



◀ *A GreenLab model simulation of the effect of light on growth-development feedback, illustrating architectural plasticity in the same 15 year-old tree. The synthesized biomass is proportional to the radiation. Its increase boosts the supply/demand ratio value, which in turn directly affects the development intensity.* From Mathieu et al., 2009. Annals of Botany. 103(8): 1173-1186.

▲ *A GreenLab model simulation of the effect of the density on the development and architecture by growth-development feedback, illustrating the architectural plasticity. The available production area (Sd) declines as the density increases. This surface limits the production per tree and therefore the supply/demand ratio, which by feedback reduces the branching intensity and shortens the life span of the branches.* From Hua et al., 2011. CASE. IEEE. 4: 185-188.