Capsis / AMAPstudio

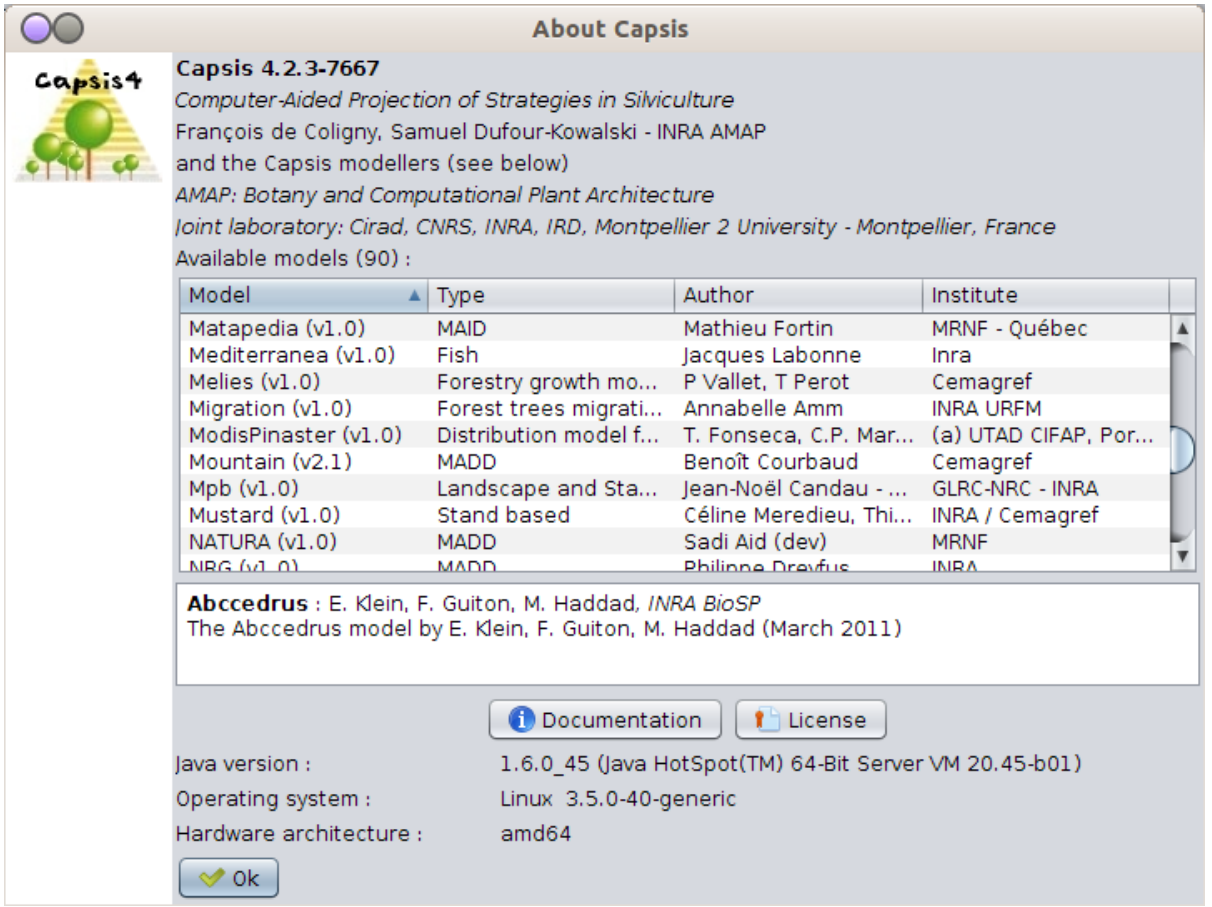
The benefit of integrative software platforms for models mutualisation and chaining

Francois de Coligny (INRA AMAP)
Sébastien Griffon (Cirad AMAP)

AMAP - Botany and Computational Plant Architecture
Montpellier, France

Capsis - Computer-Aided Projection of Strategies In Silviculture

Objectives: Build a **software platform** to integrate **forest growth & yield / dynamics models** for **modellers, managers and teaching**



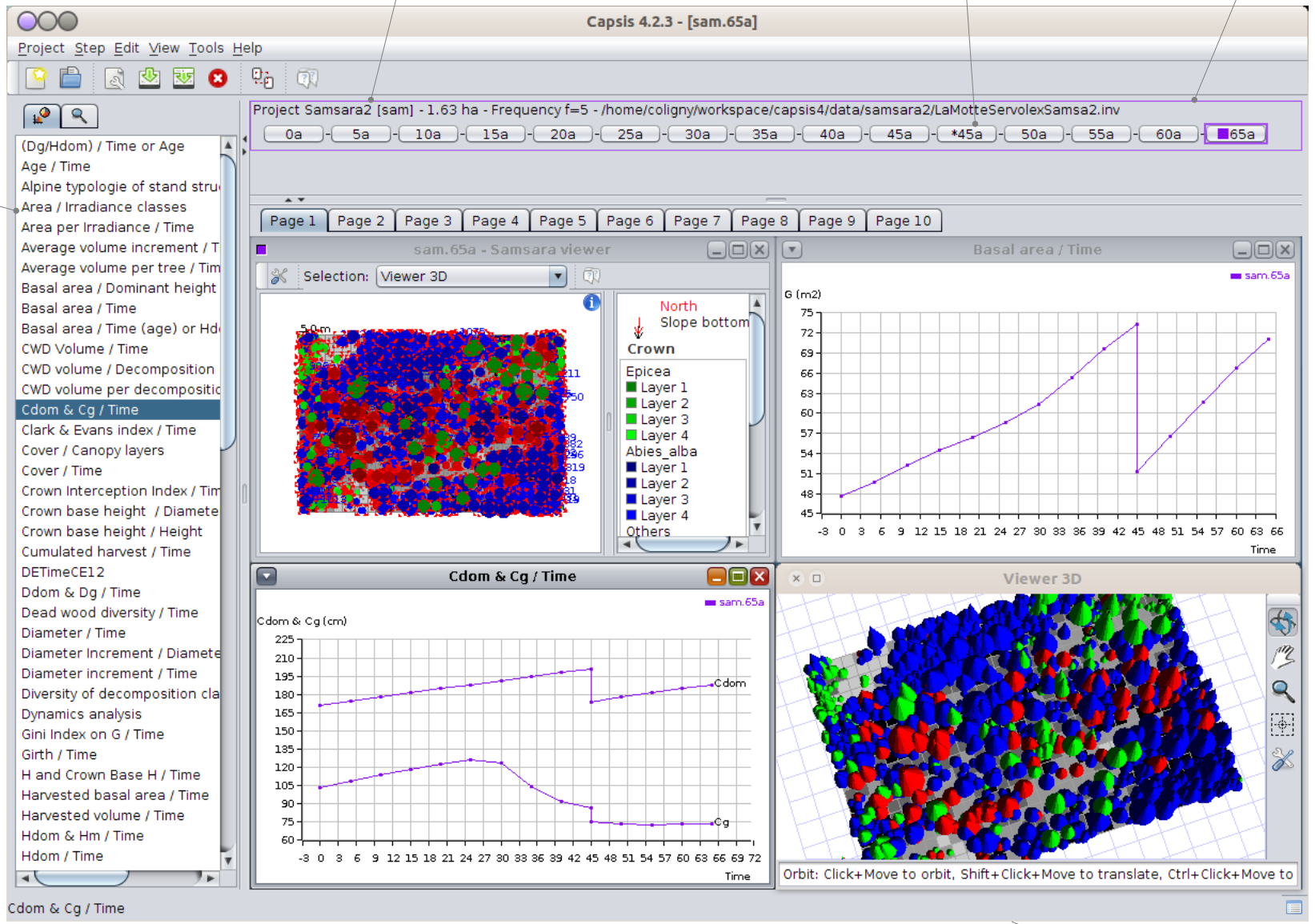
Capsis: how does it work ?

model : initialisation + time loop

intervention

project

integrated viewers and charts

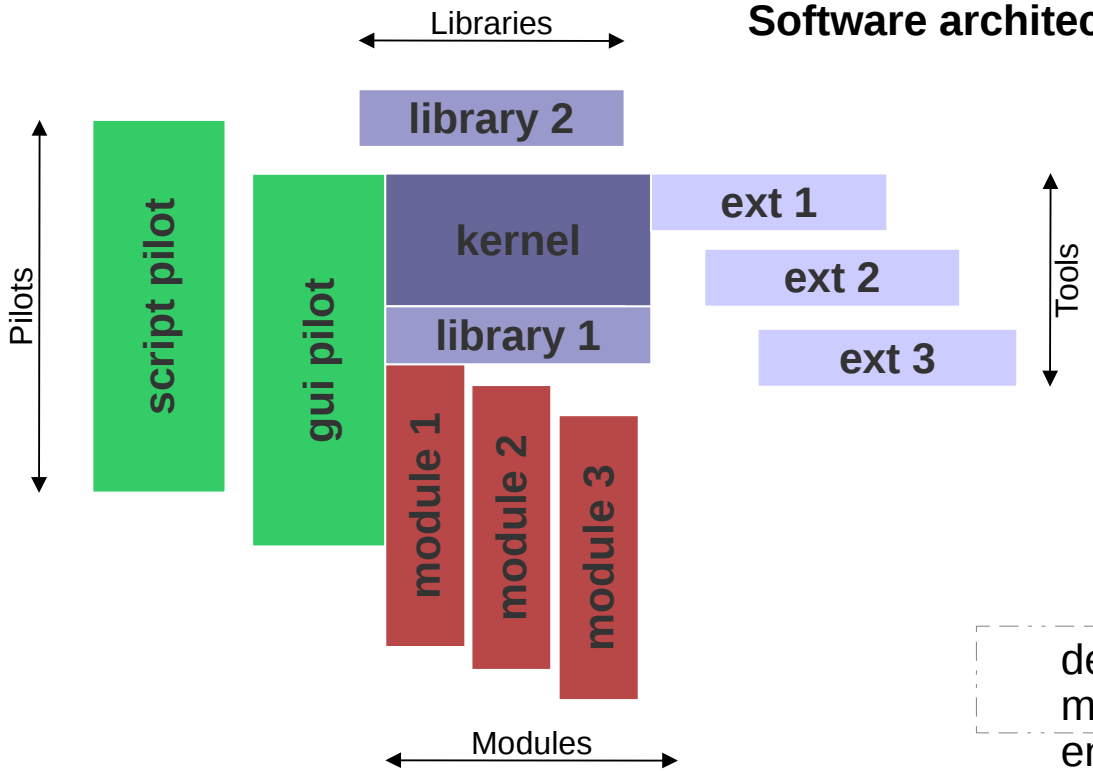


Capsis - Linux - Graphical user interface - English

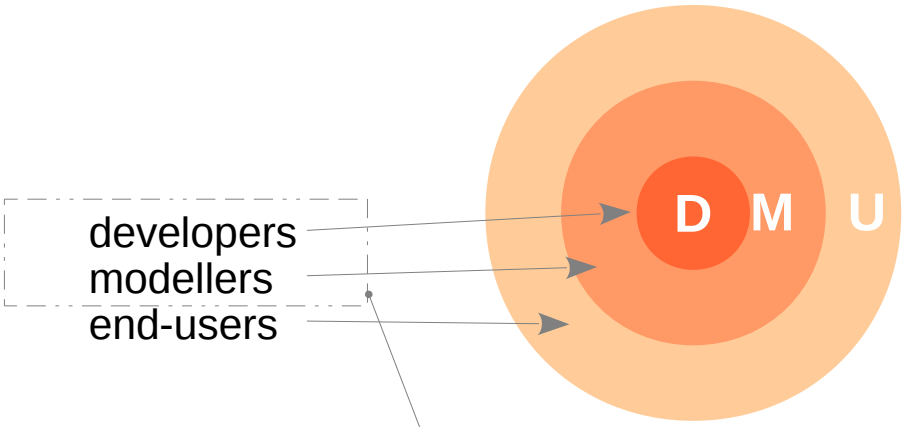
export

Capsis : main options

Software architecture



Actors and roles



The Capsis community:
developers + modellers
co-develop together

Clear participation rules

The common parts are free software (LGPL): everything except the **red parts** is reusable by anybody

The Capsis charter (extract):

- the modellers are in charge of the development of their models
- the growth models are not free: **red parts**
- all the source codes are freely accessible by all members in the Capsis community...

Methodology: help the modellers develop by themselves

- an accessible language

  Java is powerful and strict → accessible to scientists

- a short training course (1-2 days)

  scientists become beginer developers

- a customized starting session (2-3 days)

  start developping together
  work on the scientist's machine

- a permanent and effective support

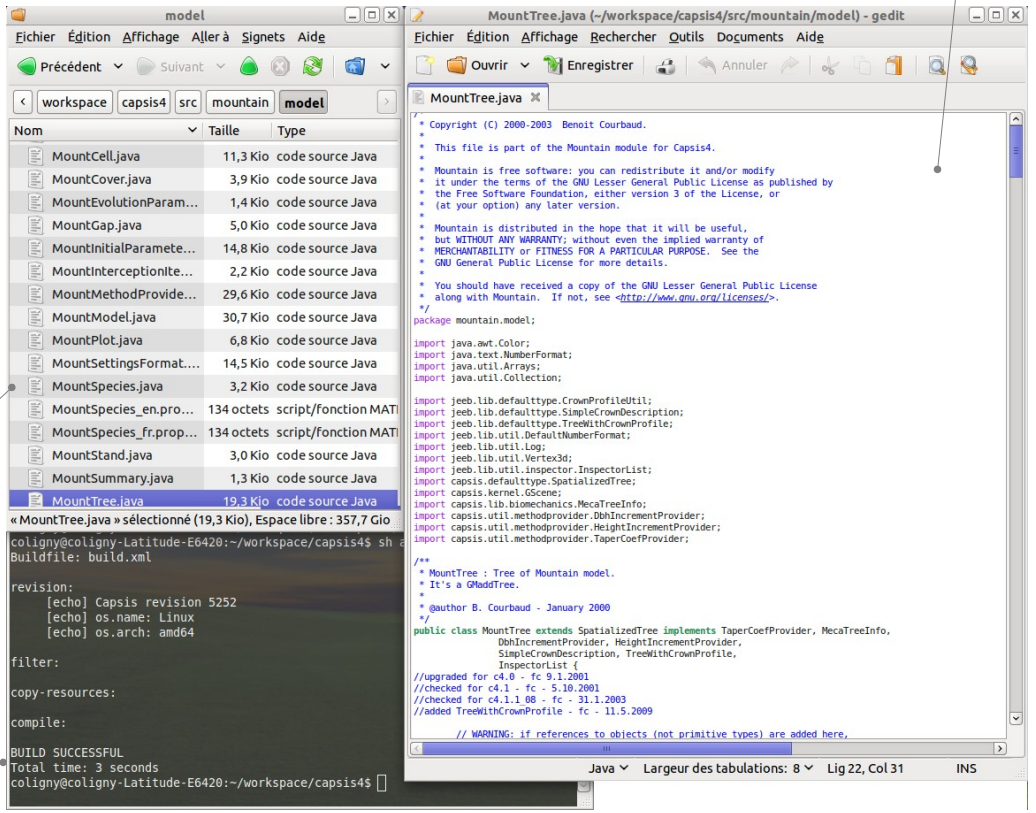
  reactivity, availability

Simple tools...

a simple editor

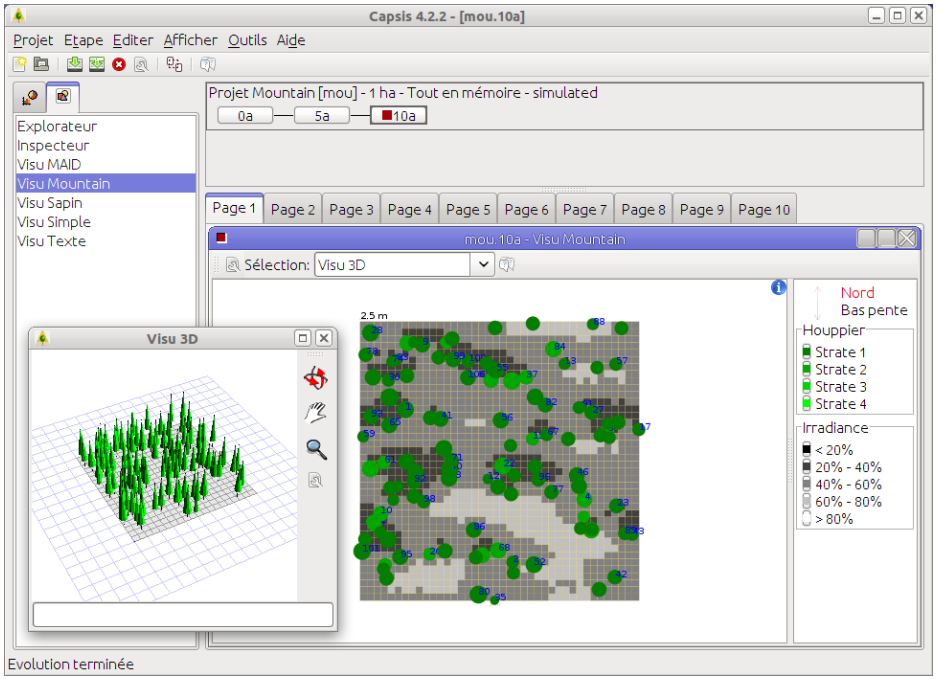
a file manager

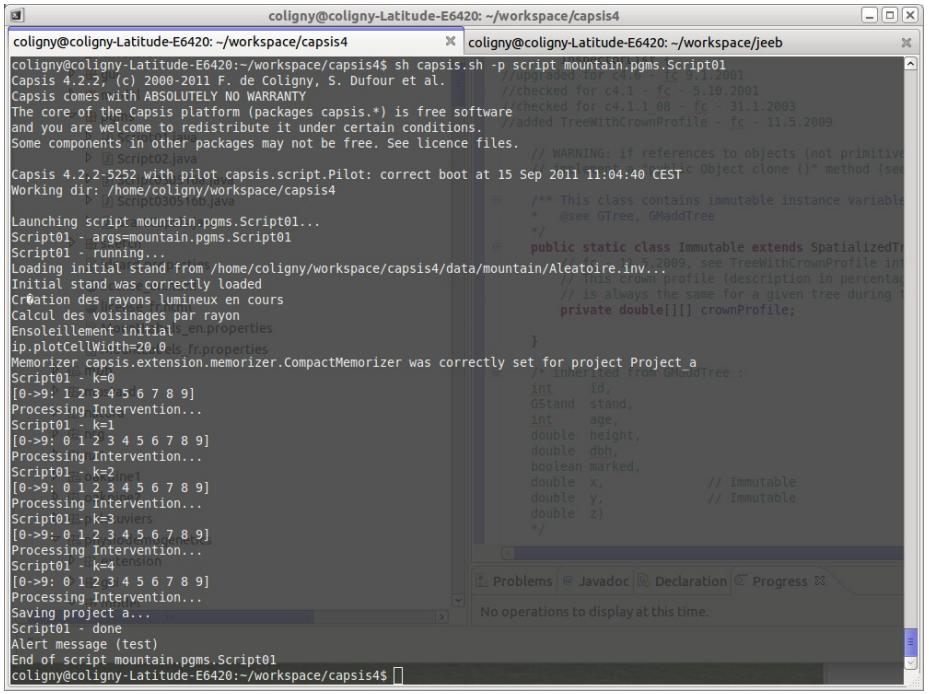
a terminal



Capsis: several ways of use

Interactive (french / english)

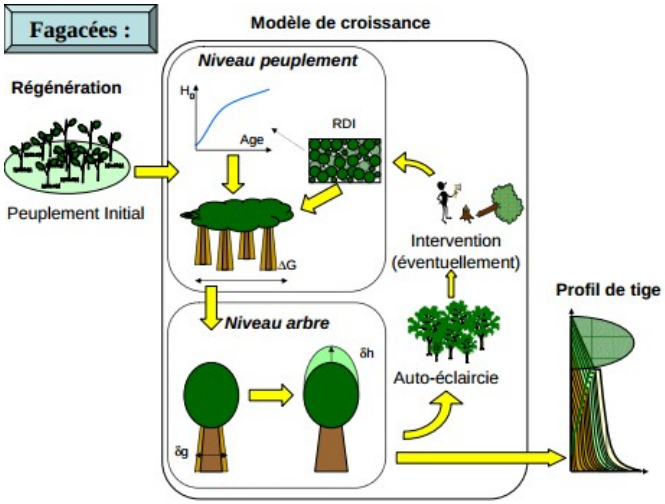




Not interactive: with scripts
- long simulations
- run on clusters
- sensitivity analyses...

Jean-Francois Dhôte (ONF), Patrick Vallet (Irstea), Mathieu Fortin (AgroParisTech Lerfob), Gilles Le Moguedec (INRA AMAP)

Fagacées: an invidual-based model for oak and beech



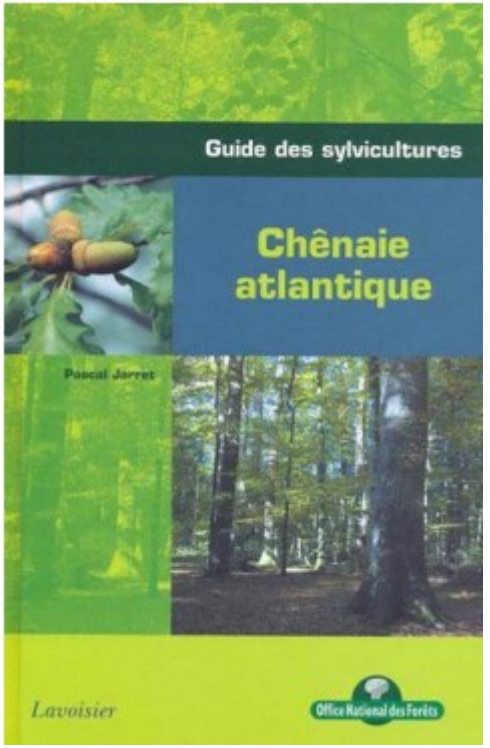
Fagacées relies on 5 fundamental relations at 2 levels

1. stand level
   - a growth model for dominant height (H0)
   - a self thinning model giving the relative density index (RDI)
   - a basal area (G) productivity model (Eichhorn)

2. tree level
   - a model for distributing the increases at the tree scale
   - a height / diameter model

Work under progress on the model to help revise the ONF *Chênaie Atlantique* silvicultural guide (Pascal Jarret, 2004)

Changing context, climatic change, productivity change...



Le Moguédec G., Dhôte J.-F., 2012. Fagacées: a tree-centered growth and yield model for sessile oak (Quercus petraea L.) and common beech (Fagus sylvatica L.). Annals of Forest Science (2012) 69:257–269.

Marie-Ange Ngo Bieng (Cirad System, Montpellier), Thomas Perot (Irstea Ecosystèmes Forestiers, Nogent sur Vernisson)

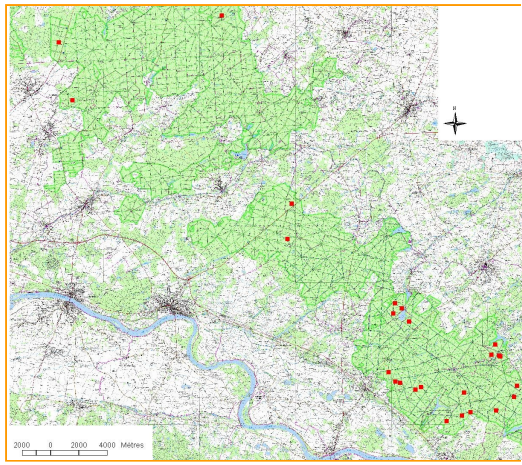
Oakpine: oak and pine growing at the same time

Quantify the impact of the spatial structure type on the productivity of oak-pine forests
Method:

- simulate several types of realistic spatial structure (same list of trees)
- simulate growth for each structure type
- compare the obtained productivities

Spatial structure analysis on 34 plots:

typology: 4 types for the canopy / 3 types for the understorey

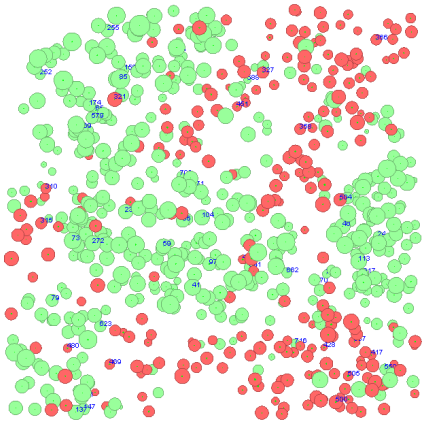


Spatial structures simulation: a combination of point processes

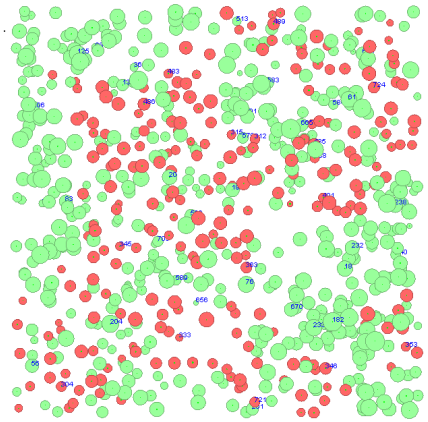
- specific structure: aggregation, random, regularity
- intertype structure: attraction, independence, repulsion

Simulation examples:

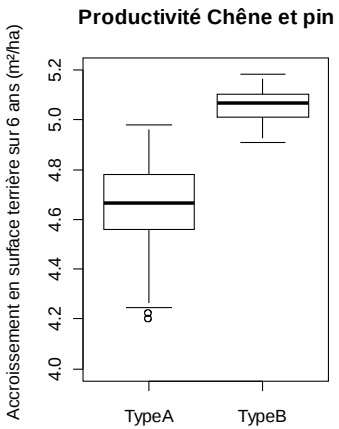
Canopée Type 1, modèle C7
Ss étage Type 2, modèle SE6

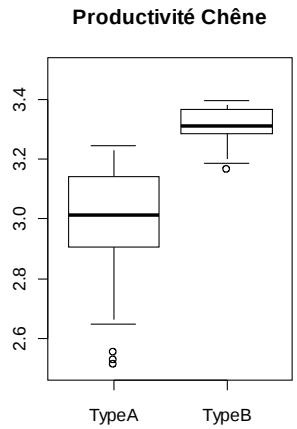


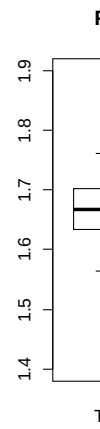
Canopée Type 3, modèle C4
Ss étage Type 2, modèle SE6



Script mode, repetitions, example of results:







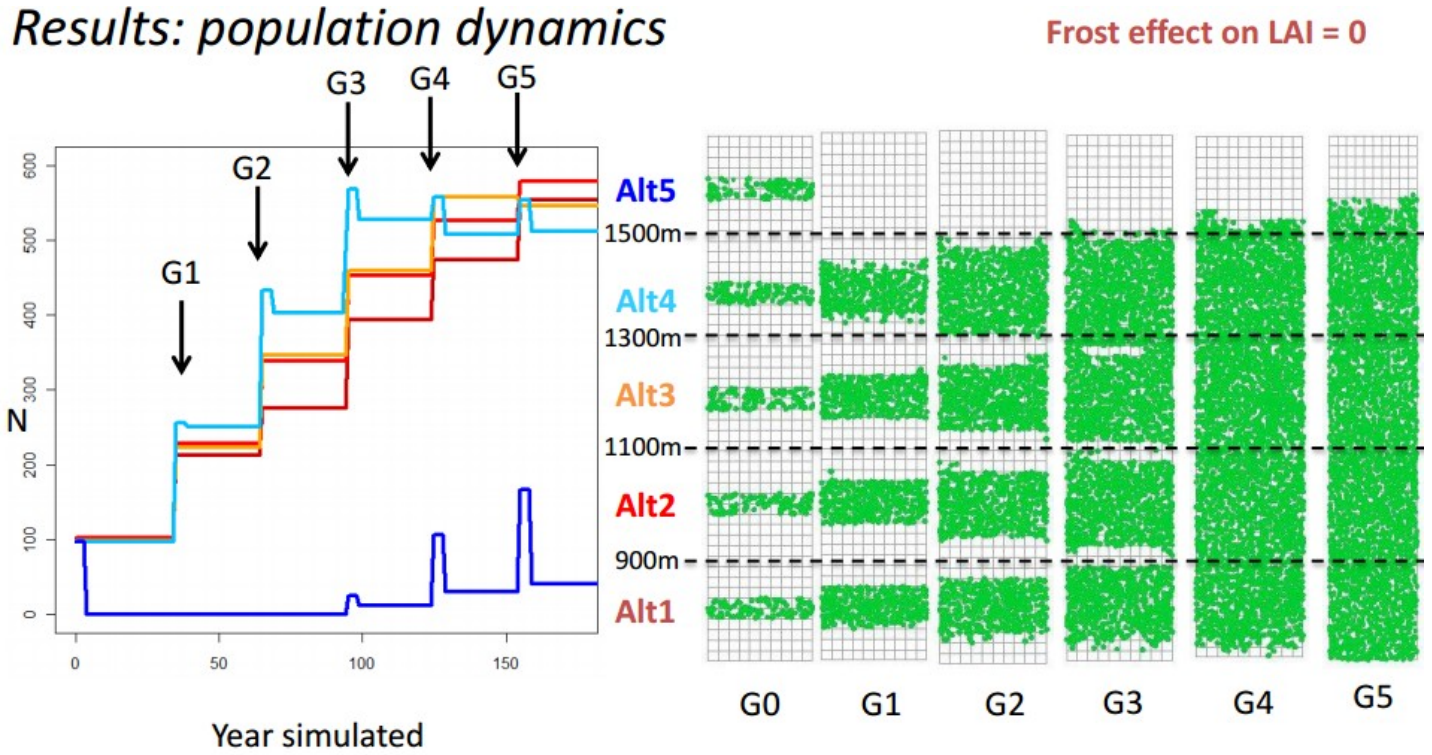
Ngo Bieng M.-A., Perot T., de Coligny F., Goreaud F., 2013. Spatial pattern of trees influences species productivity in a mature oak–pine mixed forest. Eur J Forest Res, in press, DOI: 10.1007/s10342-013-0716-z

Sylvie Oddou-Muratorio, Hendrik Davi (INRA URFM, Avignon)

PhysioDemoGenetics

PhysioDemoGenetics aims at studying the genetic adaptation through natural selection driven by climatic variables in a continuous tree population
-> accounts for complex interactions among genes, functional traits and climate when environment or demography are unstable.

It relies on (1) explicit modelling of the genetic determinism of ecophysiology-related traits and (2) the coupling of ecophysiological processes at tree level (Castanea library in Capsis) with dynamical processes (dispersal, growth, mortality) and genetic processes (Genetics library in Capsis)



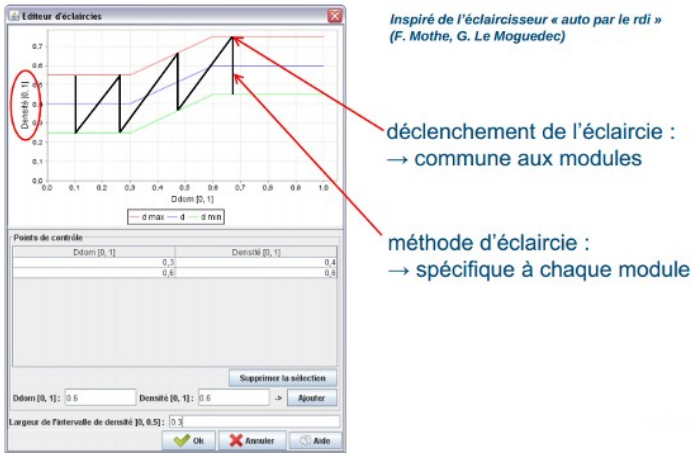
- Extinction of Alt5 at G0 and recolonisation at G3
- Treeline at 1620 m (versus observed =1700 m)

Patrick Vallet, Véronique Cucchi (Irstea, Nogent sur Vernisson)

Simmem: modelling several forests

Simmem is a model simulating the management of several forests at the same time
Each forest grows with a specific Capsis model according to its species and forest structure
Connections to Fasy, Fagacées, FTChene, Gymnos, Lemoine, Melies, Laricio and Sylvestris

The management rules are configured for the whole site



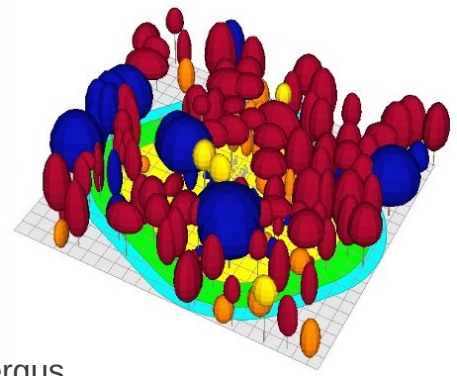
It is developed in the frame of the ANR Forgeco project by three teams:

- Irstea, Nogent sur Vernisson (P. Vallet, T. Cordonnier)
  - -> Foret d'Orleans
  - -> Massif du Vercors
- ULG, Gembloux, Belgium (P. Lejeune, G. Ligot)
  - -> Ardennes belges
- EFI Atlantic, Bordeaux (C. Orazio)
  - -> Aquitaine

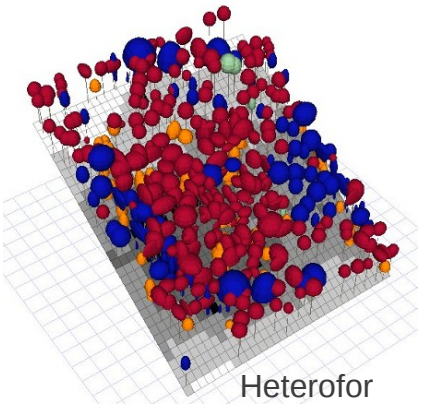
SamsaraLight: a reusable library for radiative balance

A library implementing the radiative balance of the Samsara model, to make it possible to reuse it in other models (Quergus, Heterofor, RReShar, Samsara and Samsara2, Mountain).

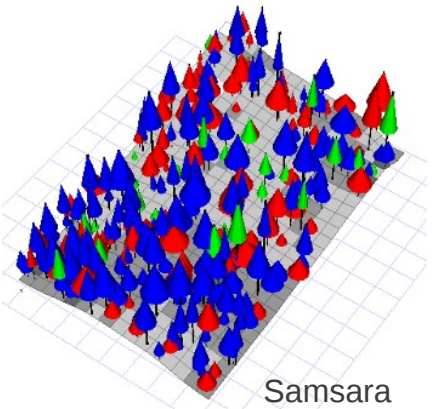
- adaptable to spatialized individual based models
- the crown is a kind of ellipsoid or a cone
- two modes: turbid medium volume or porous envelop
- irradiance (MJ) for each tree and each cell on the ground
- the irradiance can be considered for tree growth



Quergus
(G. Ligot, ULG, Belgium)



Heterofor
(M. Jonard, UCL, Belgium)

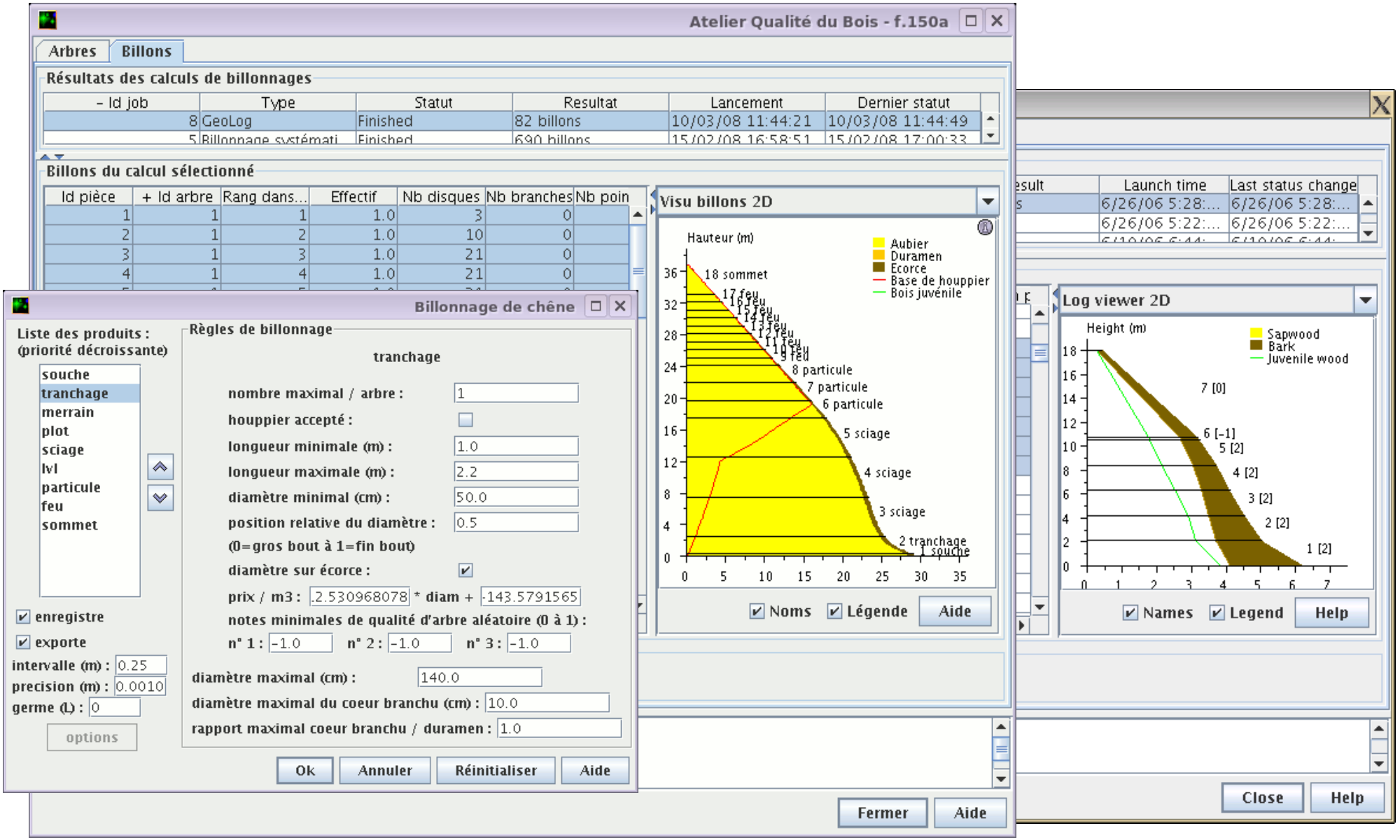


Samsara
(B. Courbaud, IRSTEA)

Dave Pont (Scion, New Zeland), Frédéric Mothe, Patrick Vallet (INRA Lerfob, Nancy), Céline Meredieu, Thierry Labbé (INRA Biogeco, Bordeaux)

Wood Quality Workshop

Coupled to a growth model (Radiata pine, Maritime pine, Oak), logging algorithms, sawing is possible



Capsis-ONF-2012 - 21 dec 2012

- a Capsis installer on an ONF server for internal distribution
- upgraded each year (december) by ONF
- with the Capsis developers and modellers
- a single Capsis with 18 modules:

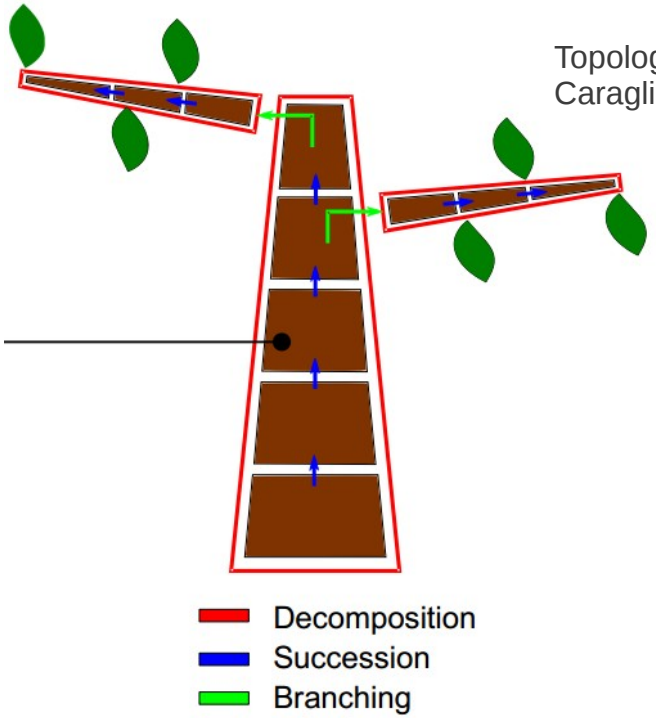
Abial (INRA)
Artemis (MRNF, Québec)
CA1 (INRA)
Fagacées (INRA)
Gymnos (Gembloux, Belgique)
Laricio (Irstea, INRA)
Lemoine (INRA)
Melies (Irstea)
NRG (INRA)
Oakpine1 et **2** (Irstea)
PiceaAbies (FCBA)
PNN2 (INRA)
Pp3 (INRA)
Pseudotsugamenziesii (FCBA)
Regix (FCBA)
Samsara (Irstea)
Sylvestris (Irstea)

Capsis helps write/update ONF silvicultural guides (about 17 since 2004)
e.g. *Massif Vosgien - Sapin, épicea et pin sylvestre*, Thierry Sardin (2012)

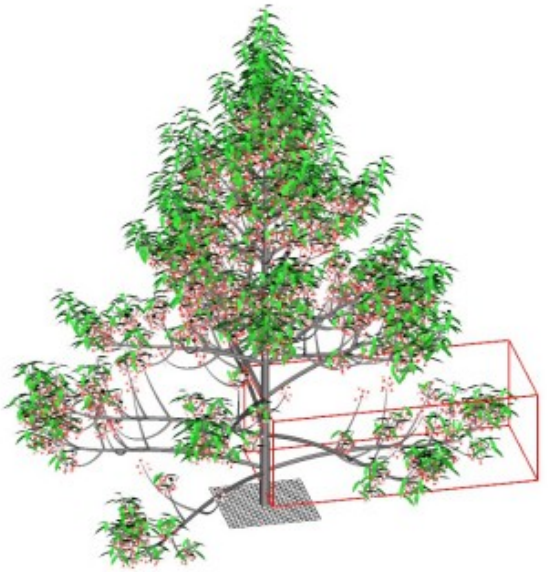
AMAPstudio: a software suite for plants architecture modelling

Objectives: Build a **software suite** to provide **editors** and **integrate simulators** for plants multi-scale architecture modelling, for the individual plant or the vegetal scene, for **modellers and teaching**

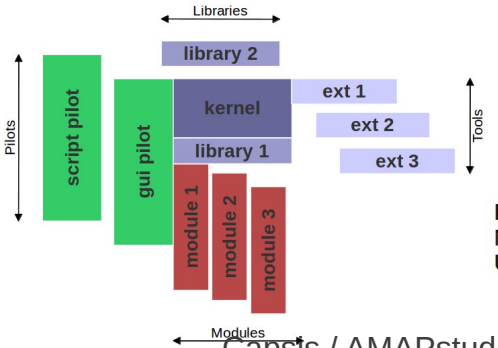
Node attributes
length
diameter
color
weight
...

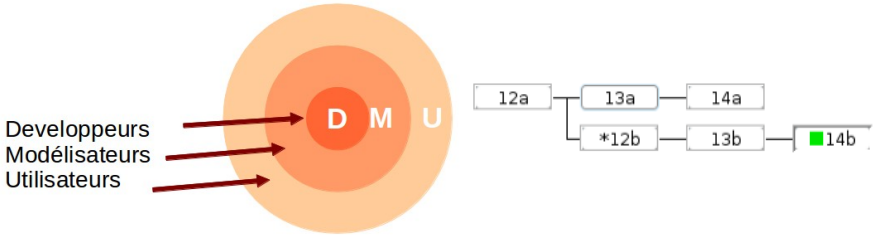


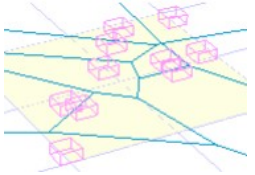
Topology based on the Multiscale Tree Graph formalism (C. Godin and Y. Caraglio, “A multiscale model of plant topological structures”, 1998)



Mutualization







AMAPstudio: Xplo + Simeo

AMAPstudio

Xplo

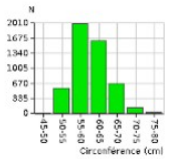
Multi-scale plant

Forest dynamics models

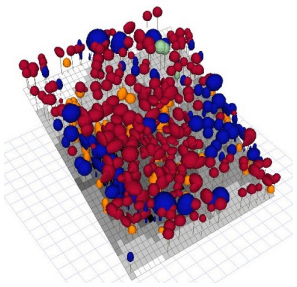
Capsis

Simeo

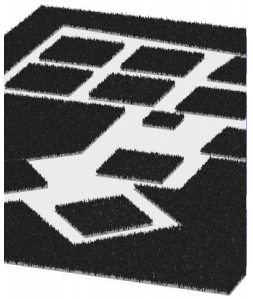
High-detailed vegetal scene



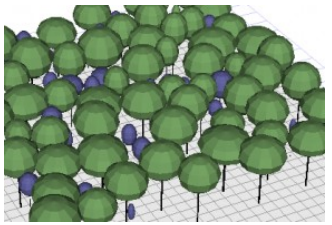
Capsis-PP3



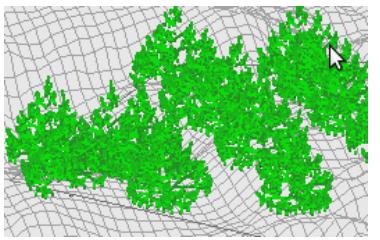
Capsis-Heterofor



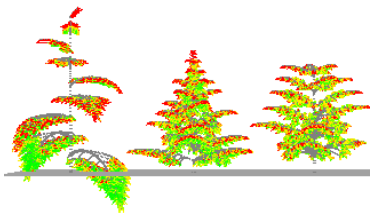
Capsis-FireParadox (800 000 trees)



Simeo-Lollymangrove



Simeo-Edito



Simeo-Archimed

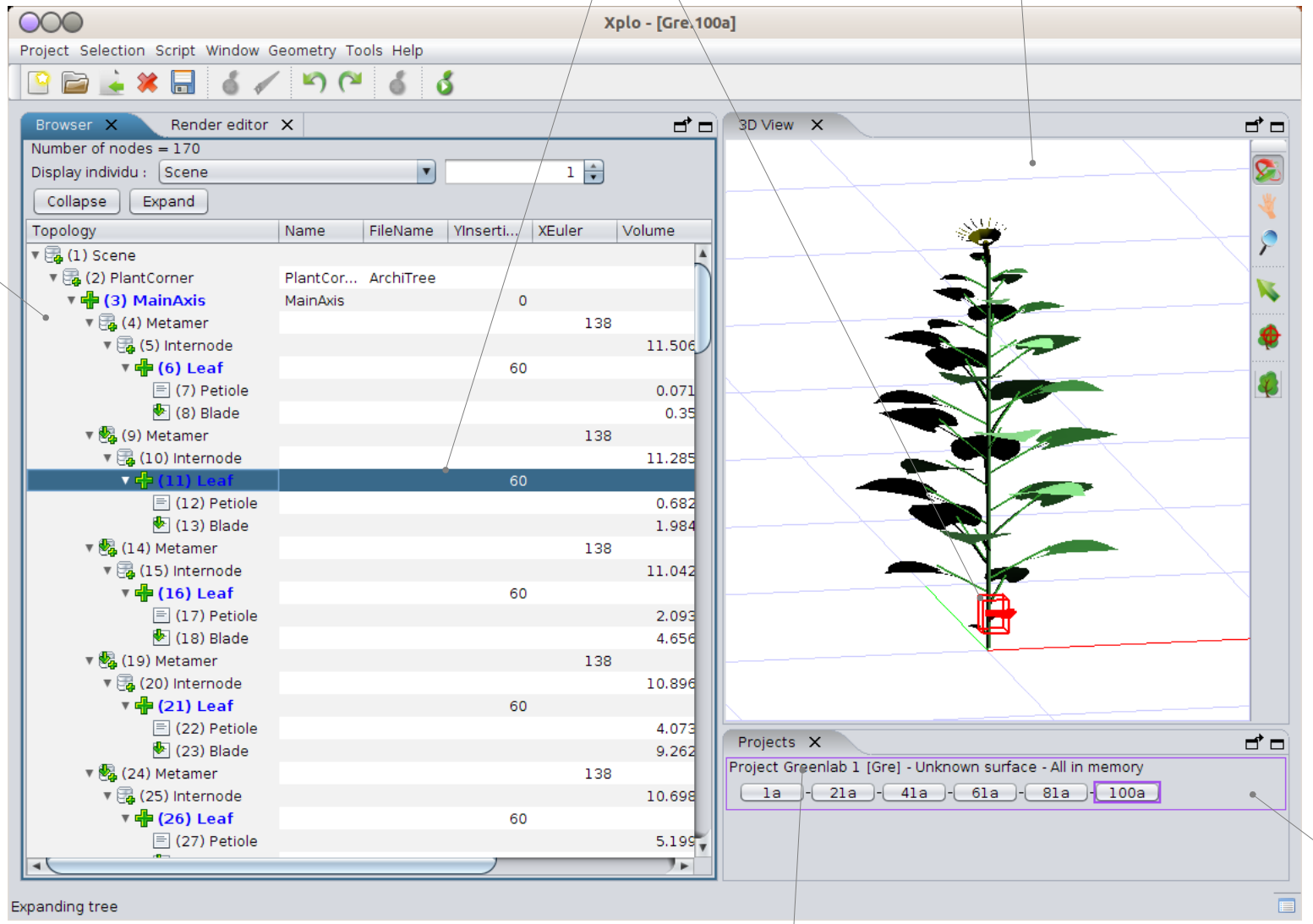
Xplo: how does it work ?

selection

3D View

export

Excel like editor

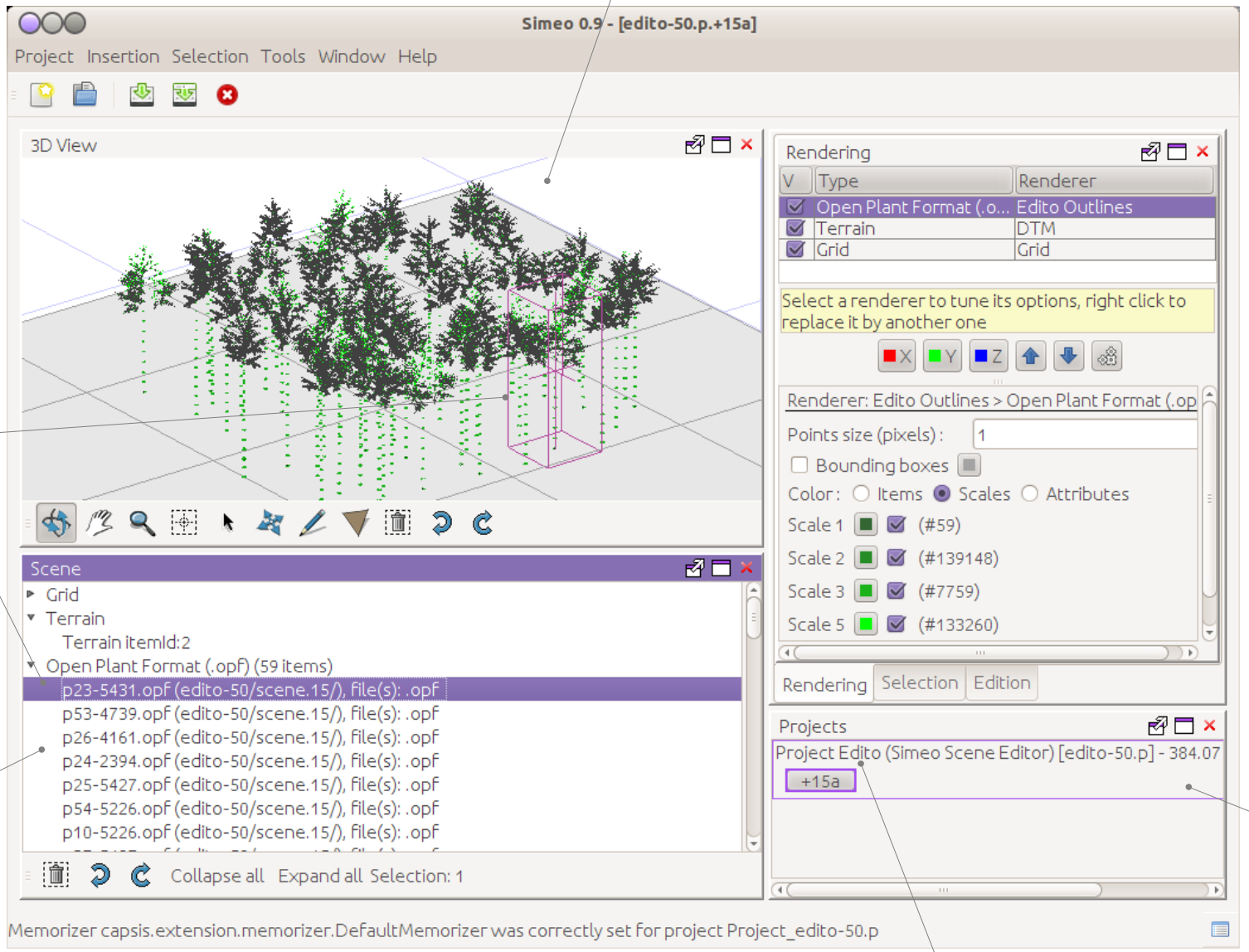


project

Xplo - Linux - Graphical user interface - English

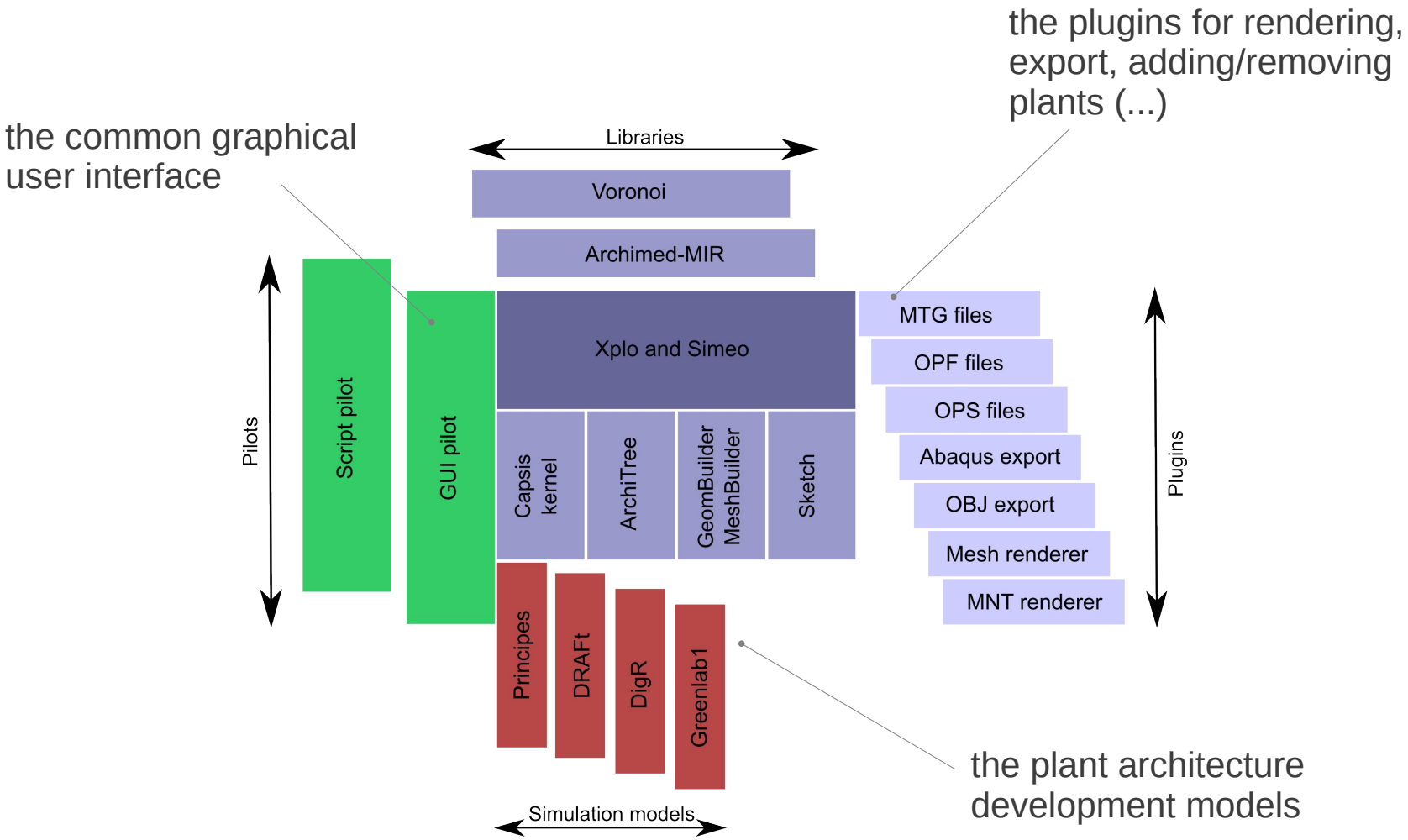
model : initialisation + time loop (optional)

Simeo: how does it work ?



Simeo - Linux - Graphical user interface - English

Xplo / Simeo: Software design

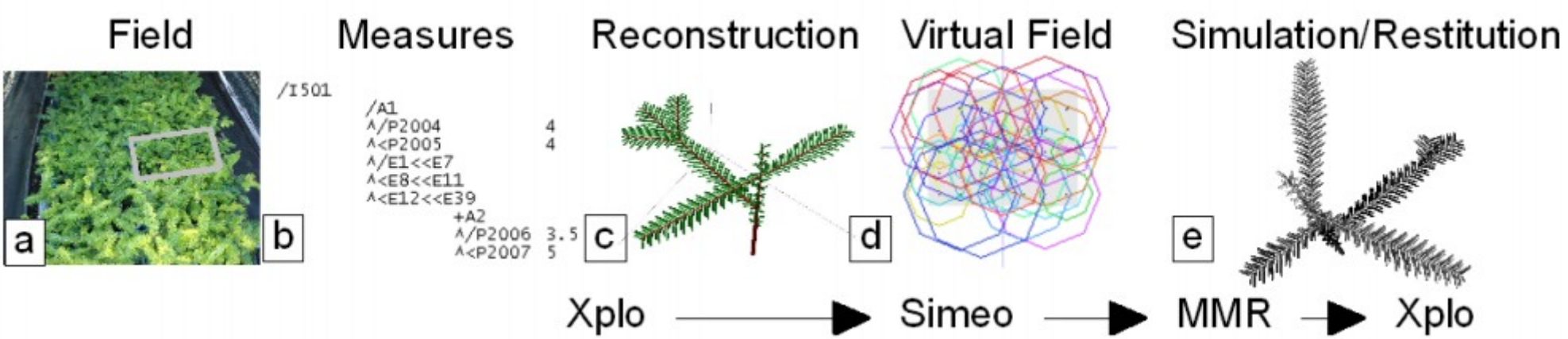


Sébastien Griffon (Cirad AMAP), Francois de Coligny (INRA AMAP)

Xplo and Simeo editors

- create plants / vegetal scenes interactively
- check and correct them, build geometry
- run biophysical simulations (e.g. biomechanics)
- load and save plant / vegetal scenes
- export to other formats

An example: Retrospective analysis of fir sapling growth vs. light interception (Taugourdeau et al. 2010)



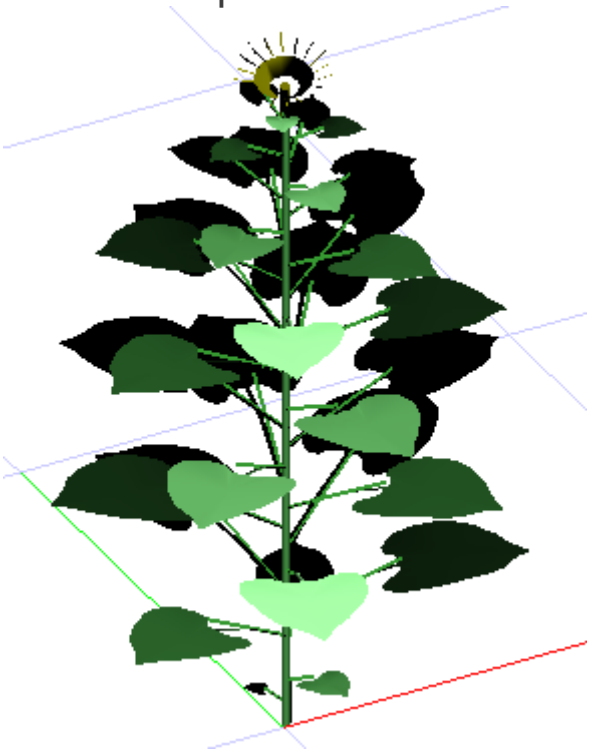
From plot to simulation, (a) view of a subplot in the dry (D) treatment, (b) plant architecture coded in accordance with AMAPMOD/MTG syntax (Godin & Caraglio, 1998), (c) topological and geometrical plant reconstruction with Xplo, (d) stand reconstruction with Simeo, (e) light interception calculated using MMR model and analyses by Xplo

Taugourdeau O., Dauzat J., Griffon S., de Coligny F., Sabatier S., Caraglio Y. & Barthélémy D., 2010. Retrospective analysis of fir sapling growth vs. light interception, Actes du 6ème colloque international sur la modélisation structure-fonction (Functional-Structural Plant Models, FSPM), 12-17/09/2010, Université de Californie à Davis (USA), pages (93-95)

Philippe de Reffye et al. (Cirad AMAP)

Greenlab 1

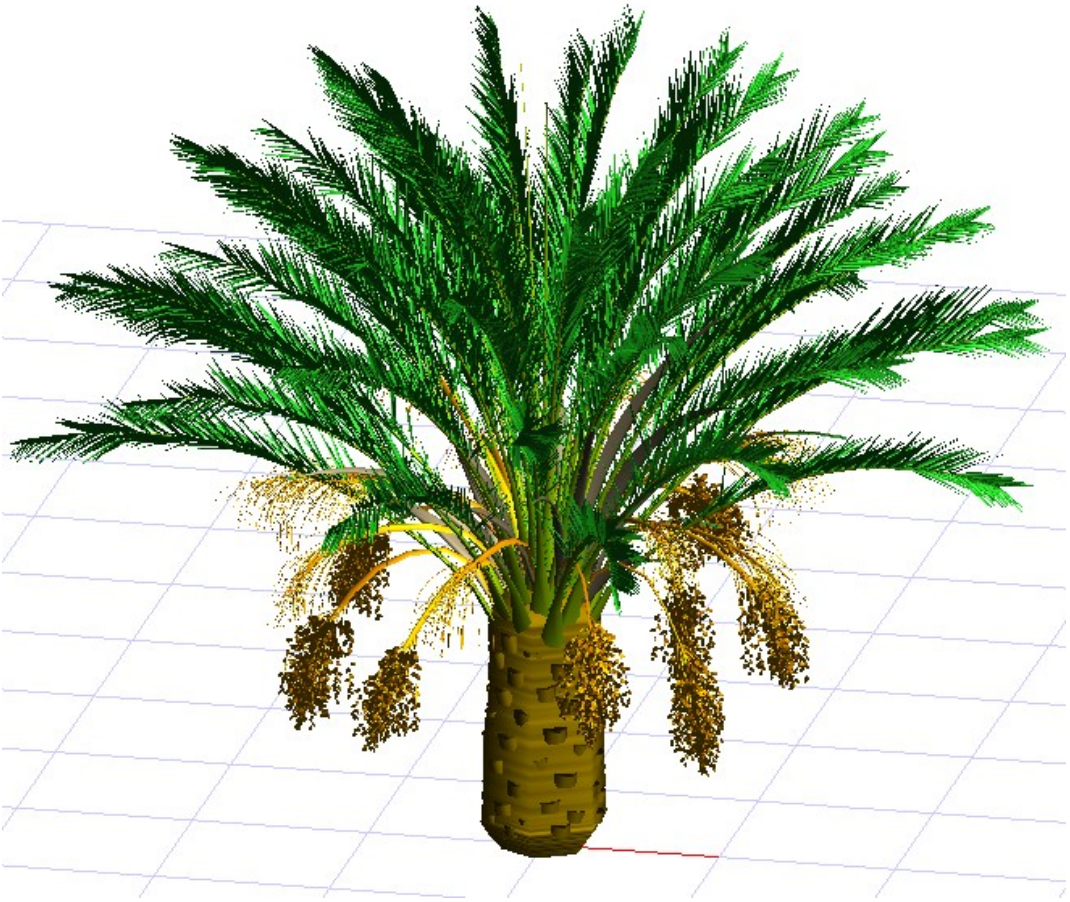
- *Greenlab* is a mathematical plant model simulating interactions between plant structure and functions
- biomass produced by organs (sources) is allocated to expanding organs (sinks) according to their relative demand
- plant parameters can be adjusted by fitting on real measurements
- Greenlab can compute the plant architecture for various species in interaction with their environment
- this model's underlying concepts can potentially predict the plant's phenotypic plasticity, for instance, pruning affects the internal competition for the resources and may lead to different leaf sizes



de Reffye P, Hu B-G. Relevant qualitative and quantitative choices for building an efficient dynamic plant growth model: GreenLab case. In: Hu B, Jaeger M, eds. Plant Growth Modeling and Applications (PMA03); Proceedings of the 2003 International Symposium on Plant Growth Modeling, Simulation, Visualization and Their Applications; Tsinghua University Press, Springer; 2003. p. 87-107

Principes

- models and simules the development and architecture of vegetative and reproductive parts of date palm (Phoenix dactylifera L.) from germination to any age
- a continuation of studies that have been carried out for almost 20 years on palm-tree architecture
- Principes brings a generic, multi-scale, structural model for palm-trees based on the organisation of the various organs
- each organ carries its own attributes (lengths, diameters, branching or deviation angles, inter organs distances, etc.)

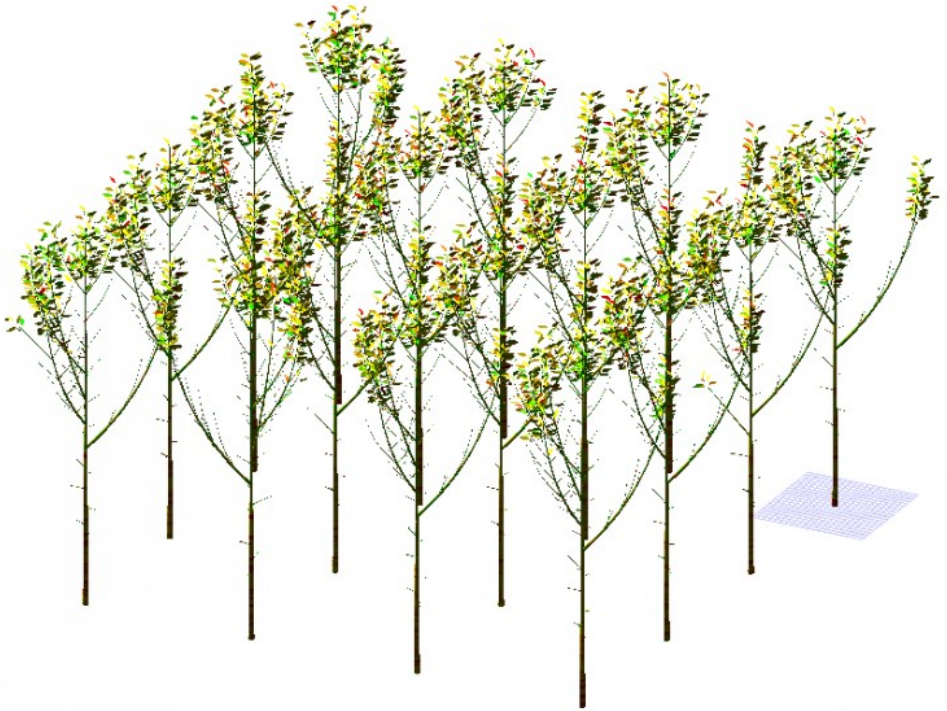


Tristan Charles-Dominique (Cirad AMAP), Francois Munoz (UM2 AMAP),
Yves Caraglio, Jean-Francois Barczi, Jean Dauzat (Cirad AMAP)

InSilEco - Architectural plasticity in ecological communities

- simulate the growth of several tree individuals in a forest stand
- the growth of an axis depends on the amount of light that it and its leaves receive
- the simulation process then combines architectural rules defined at species level (AmapSim), an illumination module used to assess light interception by leaves (MIR), and a coupling of axis growth and ramification capabilities with local light interception

The objective is to assess the effect of competition for light within and between species on the overall structure of the forest stand



Powered by AmapSim, Simeo and Archimed-MMR

Exporting to other formats / software

.ops / .opf / .mtg

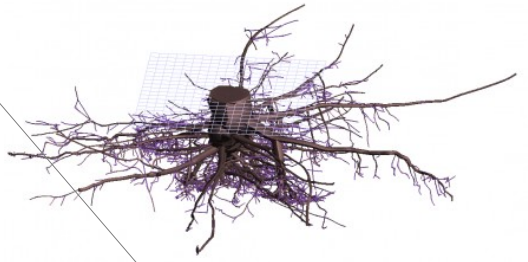
```
# Simeo OpsFormatExport: Mon Oct 15 11:46:11 CEST 2012

# Part 1: one line per plant in the scene
#sceneId        plantId plantFileName    x       y       z       scal
1       1       opf/p1-mod_Rauh_14.opf  30.862822679993986      50.(
1       3       opf/p3-mod_Scarrone_7.opf       54.86255259261524
1       4       opf/p4-mod_Massart_10.opf       45.36609940359506

# Part 2 (optional), chaining: only if scenario or project, one line
#motherId       sceneId date
-1      1       0
```

AMAPstudio

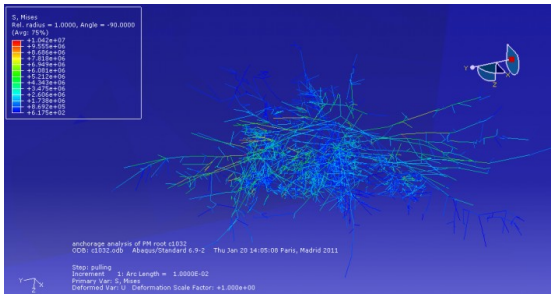
Xplo

Simeo

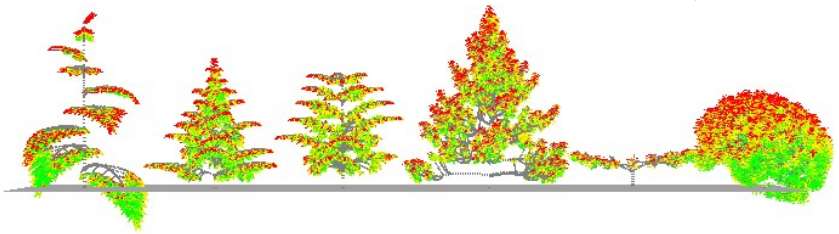
.obj (Blender...)



Abacus



Archimed MMR / ART / Lidar

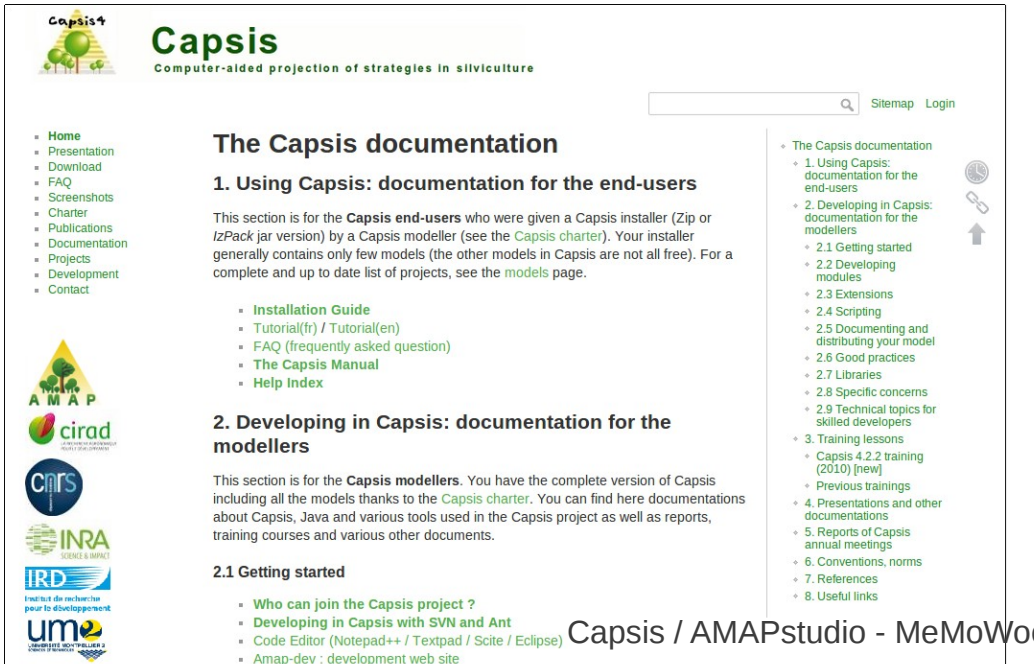


Perspectives

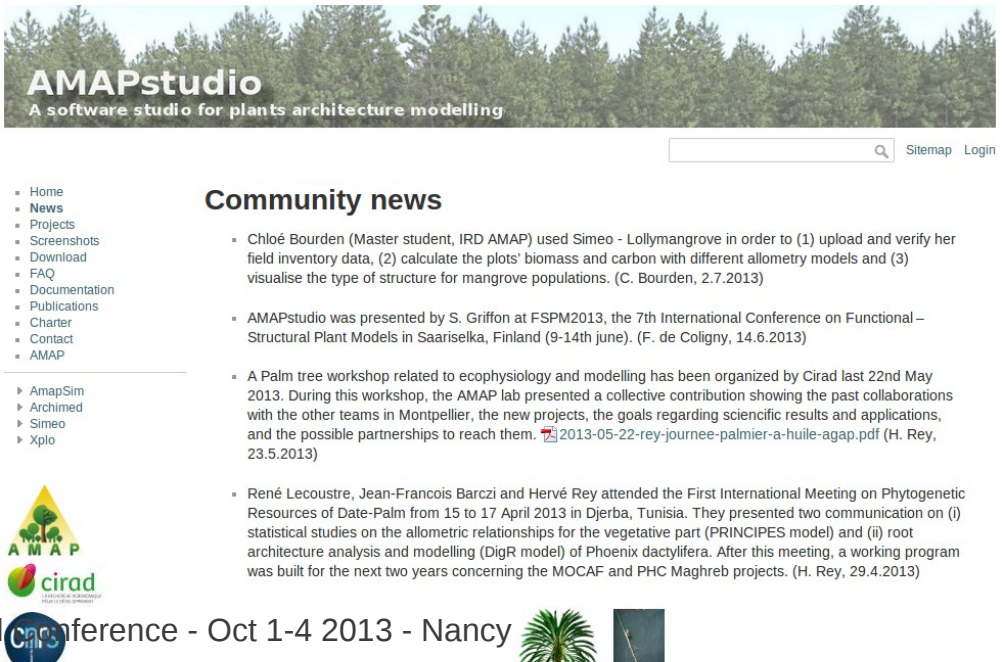
Capsis is in production: 60 models integrated since 1999
- support new projects starting
- training courses, starting sessions
- permanent support
- annual meeting

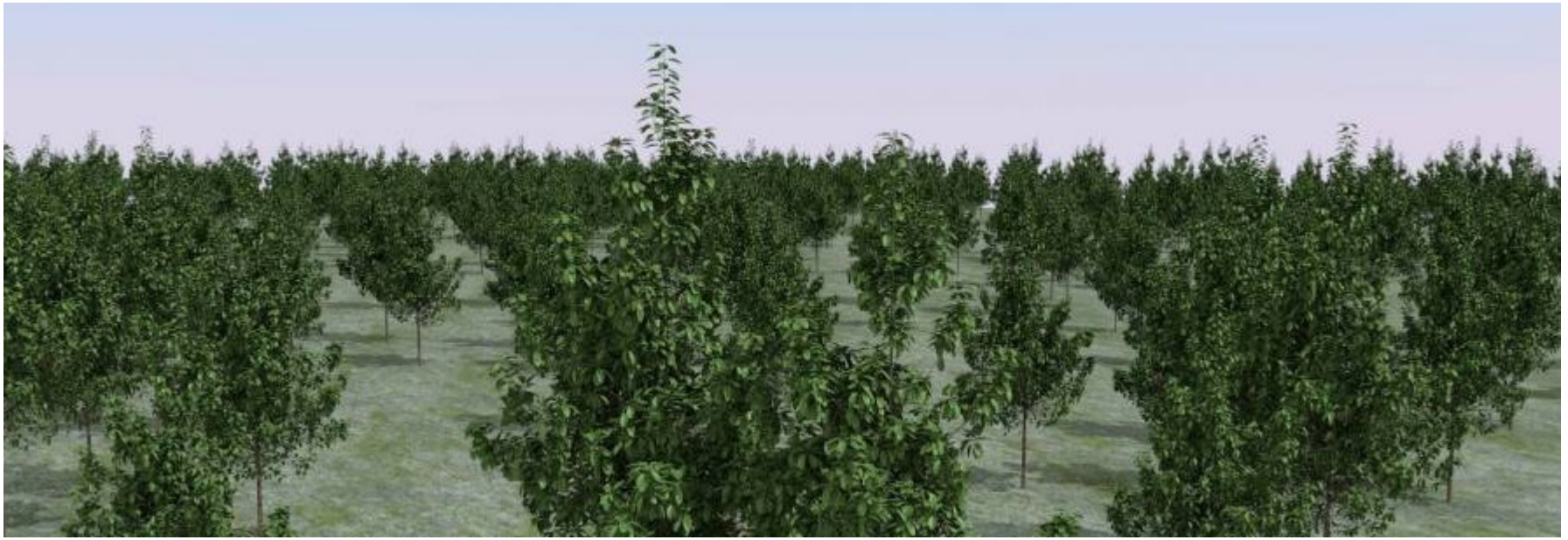
AMAPstudio is younger
- improve our software
- support medium / big size projects like Capsis (ANR, European project...)
- find partners outside the lab
- support simulation models for high detailed vegetation scenes

http://www.inra.fr/capsis



http://amapstudio.cirad.fr





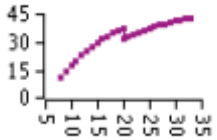
Thank you for your attention

Dufour-Kowalski S., Courbaud B., Dreyfus P., Meredieu C., de Coligny F., 2012. Capsis: an open software framework and community for forest growth modelling. Annals of Forest Science (2012) 69:221–233

Griffon S., de Coligny F. 2012. AMAPstudio: a Software Suite for Plants Architecture Modelling. In: Kang M., Dumont Y., Guo Y., eds. Plant Growth Modeling, Simulation, Vizualization and Applications. Proceedings of PMA12. Shanghai, China: IEEE press, pp. 141:147

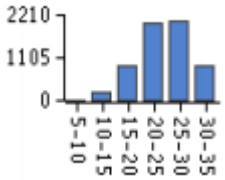
Céline Meredieu, Thierry Labbé (INRA Biogeco, Bordeaux)

Models for maritime pine in the *Landes de Gascogne*



Lemoine model (stand level, plantation):

- age
- number of trees
- girth (dominant, mean)
- basal area
- height (dominant, mean)
- volume (mean)



PP3 model (distribution model, plantation):

a list of trees

- age
- diameter, Height, volume of each tree
- number of trees in each category
- crown (Height, diameter)
- other information (biomass, carbon, etc.)

Applications, further works:

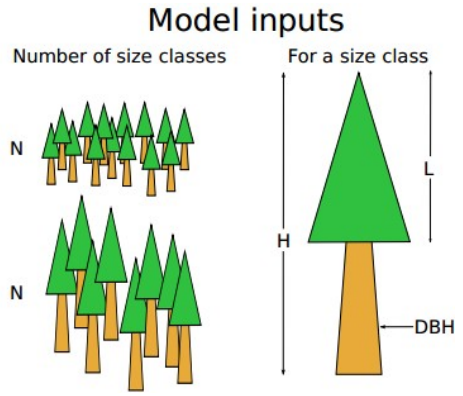
- a permanent resource analysis system (with IFN - National Forest Inventory)
- dead wood modelling and biodiversity
- models transfer to the silviculture prescribers

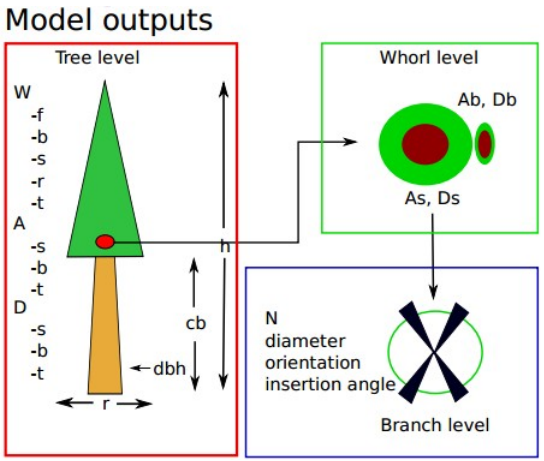
Robert Schneider (UQAR, Québec)

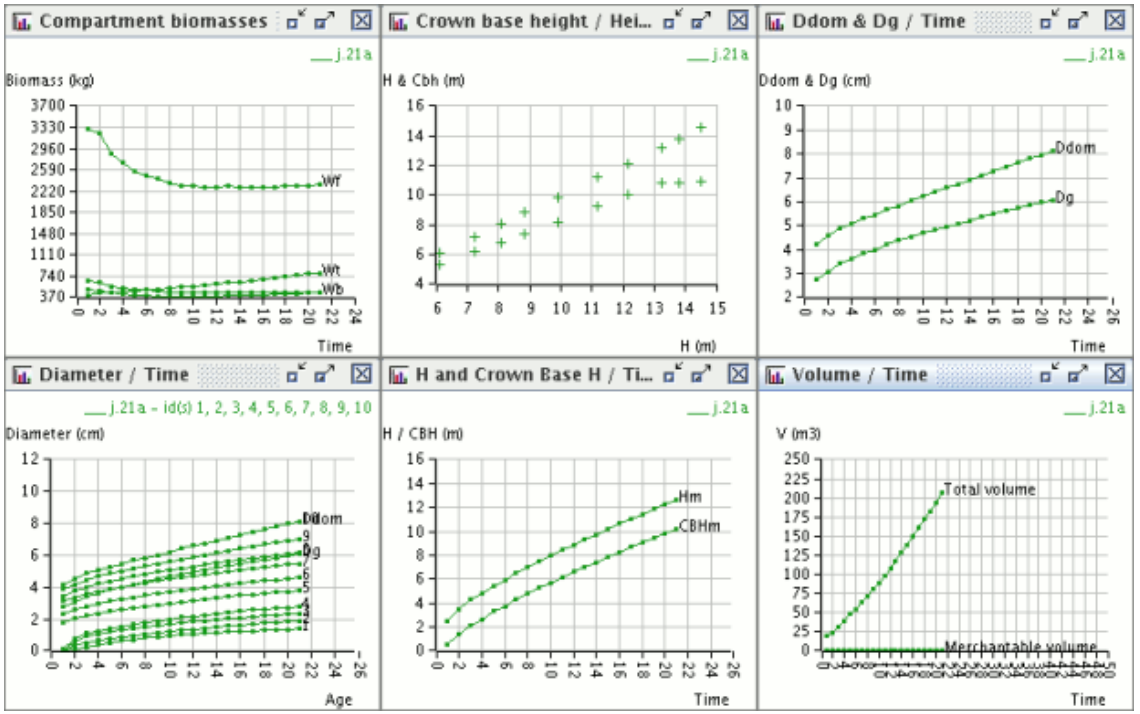
Jackpine

Predict the effect of different scenarios on the growth and wood quality of jack pine, black and white spruce in Québec.

The Crobas - PipeQual model by Annikki Makela (University of Helsinki, Finland), a reusable library for Crobas was added in Capsis







http://www.mrn.gouv.qc.ca/publications/forets/connaissances/recherche/Fortin-Mathieu/Memoire156.pdf

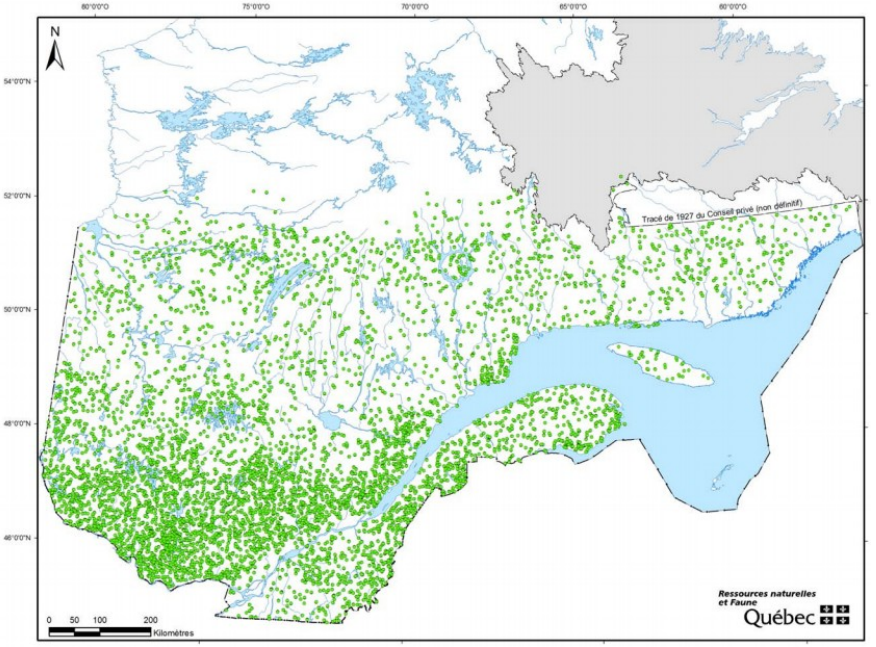
Mathieu Fortin, Luc Langevin (MRNF Québec), Jean-Francois Lavoie (Arcane Technologies)

Artemis-2009

A distance-independent tree model for the main potential vegetations in the province of Québec

Objectives, at the provincial level:
- develop silvicultural strategies
- update sample plots
- calculate the allowable cut

Six sub-models to forecast (i) the temporal change of mortality, (ii) diameter growth at breast height (dbh) of surviving stems, (iii) the number of recruits, (iv) their diameters, (v) height and (vi) volume using dbh.



The permanent plots of the MRNF-DIF in Québec: 12001 plots, from 1970

Other Capsis models by the Québec MRNF since 2002:

Présage (Daniel Mailly, Sylvain Turbis): a model of production and evaluation of scenarios to help management of forests in Québec

SaMARE (Sadi Aid, Sylvain Turbis): a distance-independent tree model for sugar maple- dominated stands (sugar maple, yellow birch, American beech and other broadleaved species)

Natura (Sadi Aid, Isabelle Auger): a whole-stand model for the province of Québec

Succès (Mathieu Fortin, Luc Langevin): a succession model for the main forest types in Québec

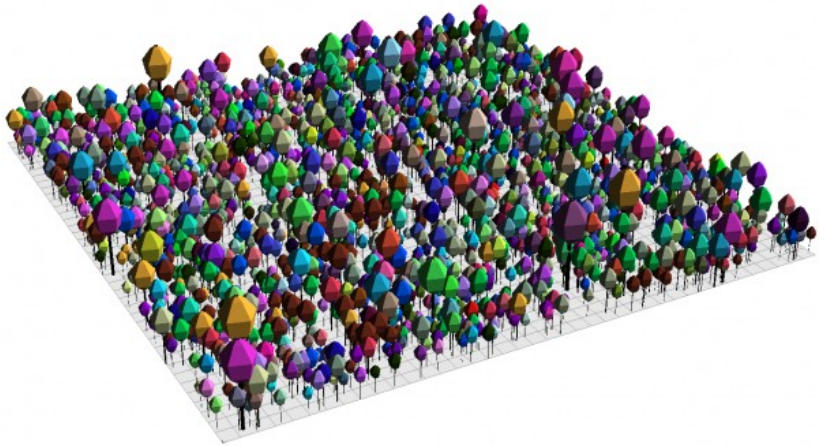
Ghislain Vieilledent (Cirad BSEF, Montpellier)

twoe: tropical forests

twoe (2e) is a software that can be used for modelling and simulating multispecies tropical forest dynamics from permanent plot data

Two packages:

- an R package to estimate the demographic parameters of tropical tree species from permanent forest plot data
- a Capsis module to simulate forest dynamics



More details on http://twoe.org/

Philippe Dreyfus (INRA URFM, Avignon)

Ventoux: modelling a forested massif

Realistic sylvicultural scenario and evolution over 100 years

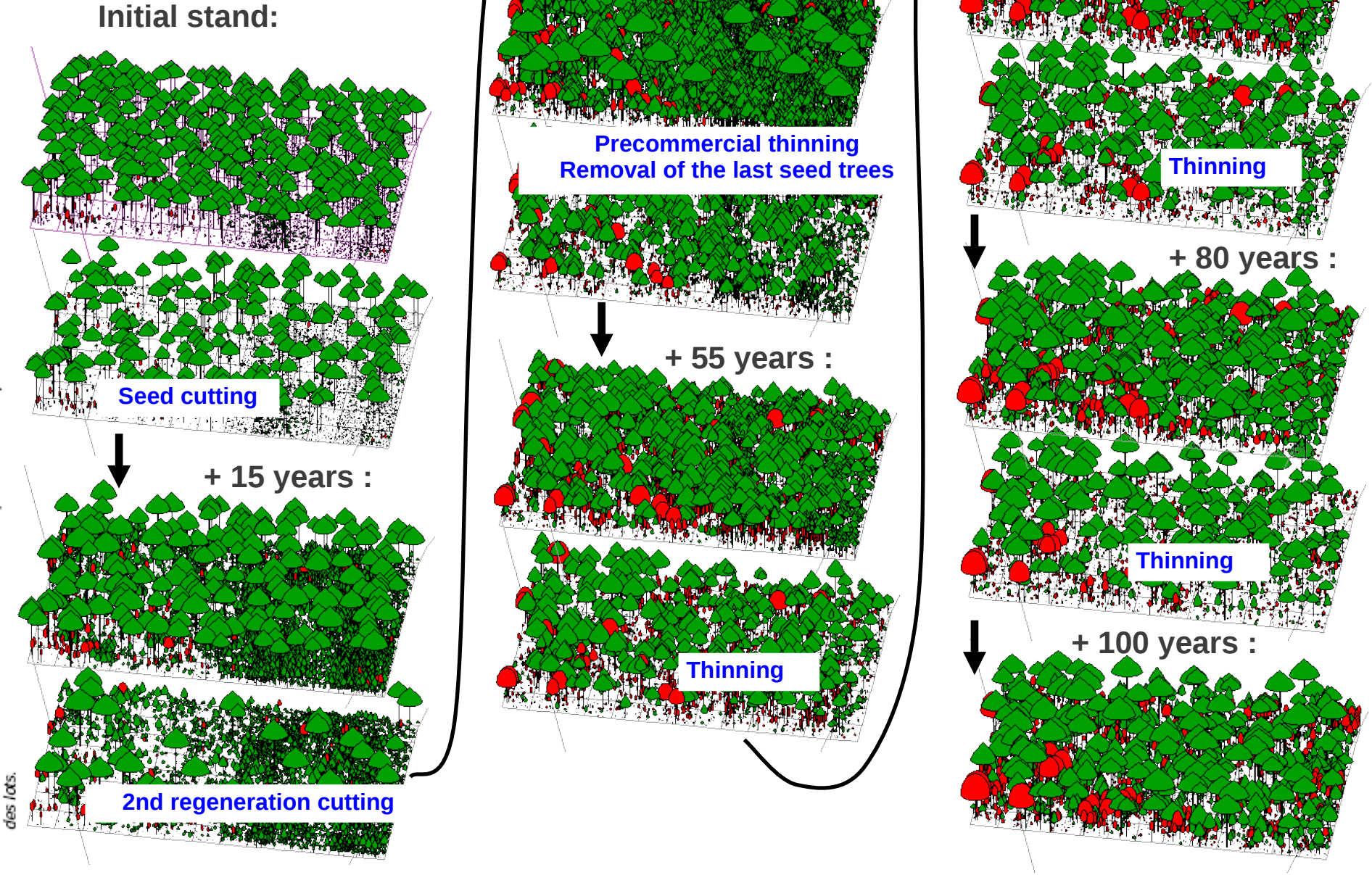
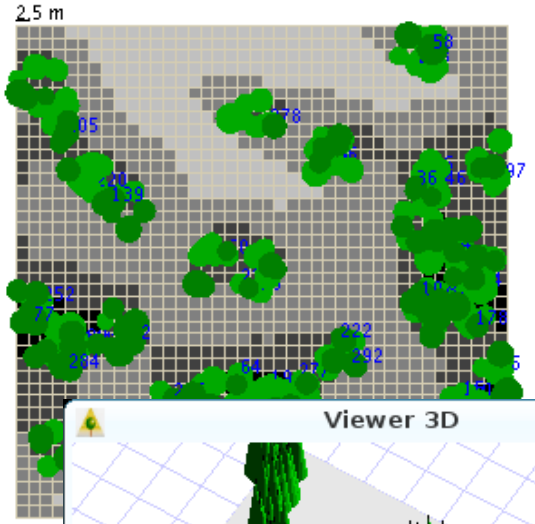


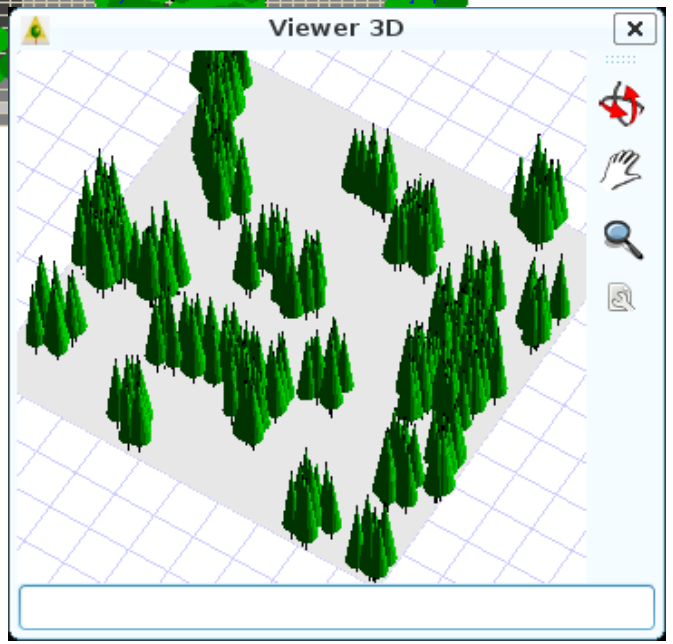
Figure 7 : Simulation d'un scénario sylvicole complet réaliste et évolution sur 100 ans d'une plantation de Pin noir (en vert) en cours de colonisation par le Hêtre (en rouge) : régénération par coupes progressives du couvert de Pin, qui bénéficie autant au Hêtre qu'aux semis de Pin ; dépressage unique, à l'occasion duquel la proportion des deux essences peut être en partie modifiée (mais le dynamisme du Hêtre et sa faculté à rejeter ne permettent pas de l'éliminer, même si on souhaite favoriser au maximum le Pin) ; éclaircies, en nombre limité compte tenu de la nécessité d'offrir un volume suffisant à chaque intervention pour favoriser la vente des lots.

Philippe Ancelin, Benoit Courbaud (Irstea, Grenoble), Thierry Fourcaud (Cirad AMAP)

Foreole: individual-based wind risk

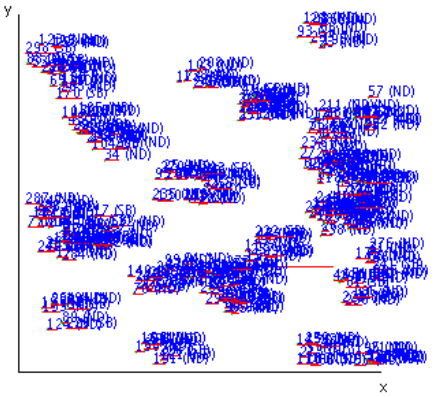
An integrated library
- assess the risk
- simulate trees removal



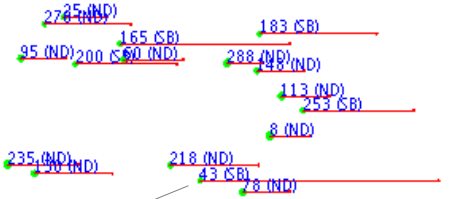


Mountain growth model (Spruce)

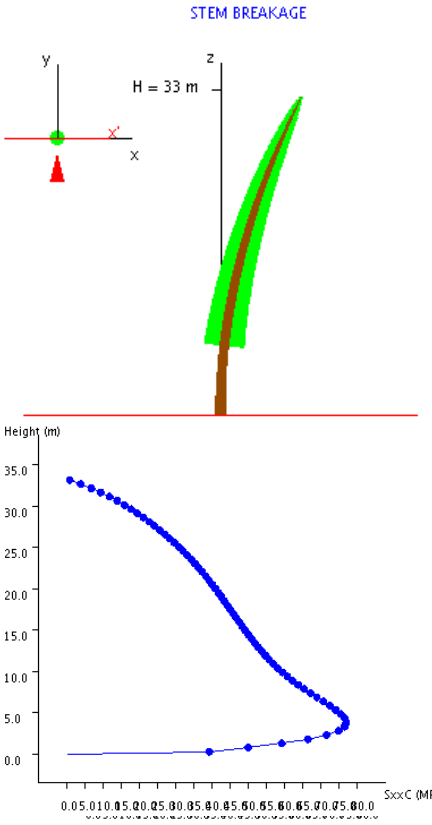
Foreole



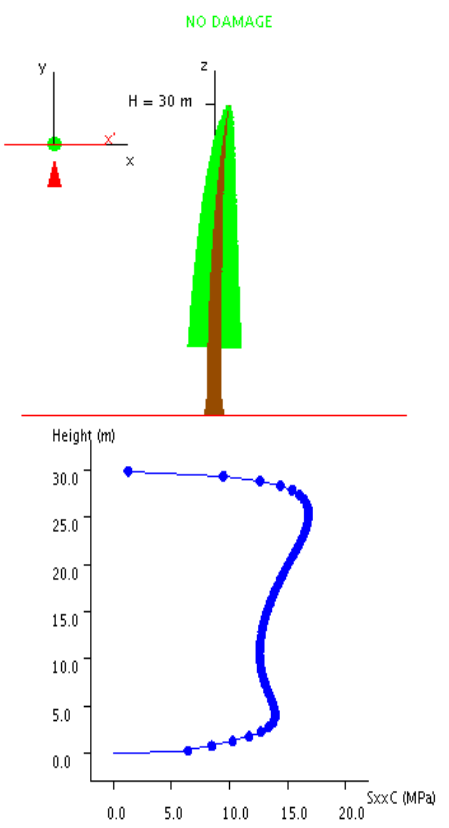
Zoom



Tree 43



Tree 113



Dufour-Kowalski S., Courbaud B., Dreyfus P., Meredieu C., de Coligny F., 2012. Capsis: an open software framework and community for forest growth modelling. Annals of Forest Science (2012) 69:221–233

Results 1/2

Table 2 Modules in Capsis: scope and main characteristics (see also Online resource 1)

Climatic zone	Stand composition[a]	Stand structure	Simulation levels[b]	Main processes[c]	Specific features[d]	Species[a]	Module name
Temperate	Pure	Regular	Average tree, stand	Gr (DI), Mo, Re, Di		*Cytisus scoparius*	Cytisus
			Average tree, stand	Gr (DI), Mo	Phy	*Abies alba, Fagus sylvatica*	Dynaclim
			Average tree, stand	Gr (DI), Mo	Phy, Ge	*A. alba, F. sylvatica*	PhysioDemoGenetics
			Average tree, stand	Gr (DI)	Th	*Pinus pinaster*	Lemoine
			Average tree, stand	Gr (DI)		Many species	Natura
			Average tree, stand	Gr (DI)		*Eucalypt* ssp., *Populus* ssp.	Regix
			Tree, stand	Gr (DI), Mo	Th	*A. alba*	Abial
			Tree, stand	Gr (DI), Mo		*Picea alba*	Afocelpa
			Tree, stand	Gr (DI), Mo		*P. pinaster*	Afocelpp
			Tree, stand	Gr (DI), Mo		*Cedrus atlantica*	CA1
			Tree, stand	Gr (DI), Mo		*Pseudotsuga menziensii, Larix* spp., *Picea abies*	Douglas
			Tree, stand	Gr (DI), Mo	Th	*Quercus petraea, F. sylvatica*	Fagacees
			Tree, stand	Gr (DI), Mo	Br	*Pinus halepensis*	Fiesta/NRG
			Tree, stand	Gr (DI), Mo		*Pinus nigra laricio*	Laricio
			Tree, stand	Gr (DI), Mo		*Abies balsamea*	Matapedia
			Tree, stand	Gr (M/D), Mo	Th	*P. pinaster*	ModisPinaster
			Tree, stand	Gr (DI)	Br	*Pinus radiata*	NZ1
			Tree, stand	Gr (DI), Mo	Br	*Pinus nigra nigra*	PNN/Pnn2
			Tree, stand	Gr (DI)		*P. pinaster*	PP3
			Tree, stand	Gr (DI), Mo		*Q. petraea*	QS1
			Tree, stand	Gr (DI), Mo		*Pinus sylestris*	Sylvestris
			Average tree, stand, forest	Gr (DI)	Th	2 virtual species	Mustard
			Tree, stand, forest	Gr (M/D)	Th	Many species	IFNCA
			Tree, stand, forest	Gr (DI), Mo, Re, Di	Ge	*C. atlantica*	Luberon
			Tree, stand, forest	Gr (DI), Mo		*Pinus contorta*	MPB
			Tree, stand, forest	Gr (DD), Mo, Re		Many species	Presage
			Tree, stand, forest	Gr (DI), Mo, Re	Ge	*Q. petraea*	Quercus
			Tree, stand, region	Gr (DI), Mo		*Pinus sylvestris, Quercus* sp.	Simmen
			Tree, stand, region	Gr (DI)	Th	*P. pinaster*	Sylvogene
		Irregular	Tree, stand	Mo, Re, Di	Ge	*Prunus mahaleb*	Prunus
			Tree, stand, forest	Re, Di		*C. atlantica*	Abccedrus
			Tree, stand, forest	Gr (DI), Mo, Re, Di		*A. alba*	Migration
			Tree, stand, forest	Gr (DD), Mo, Re		*P. abies*	Mountain

[a] "Pure" with a list of species means that the model either works with a pure stand of one of these species at a time or can simulate concurrently several pure stands of different species in the same forest

[b] Scale levels at which the model works or the module gives outputs (with more or less details depending on the model)

[c] Forest dynamics processes: growth (diameter and, possibly, height) (Gr), mortality (Mo), recruitment/regeneration (Re), dispersal (seeds/seedlings) (Di). Details for growth submodel: distance-independent tree growth (Gr (DI)), distance-dependent tree growth (Gr (DD)), growth submodel relying on a transition matrix or a diameter distribution curve (Gr (M/D))

[d] Genetics (Ge), ecophysiological processes (Phy), branching model (Br), automated thinning (in addition to Capsis' interactive intervention tools) (Th)

Dufour-Kowalski S., Courbaud B., Dreyfus P., Meredieu C., de Coligny F., 2012. Capsis: an open software framework and community for forest growth modelling. Annals of Forest Science (2012) 69:221–233

Results 2/2

Table 2 (continued)

Climatic zone	Stand composition[a]	Stand structure	Simulation levels[b]	Main processes[c]	Specific features[d]	Species[a]	Module name
	Mixed	Regular	Average tree, stand	Gr (DI)		*P. abies, A. alba*	Melies
			Tree, stand	Gr (DI), Mo		*Q. petraea, F. sylvatica, P. sylvestris*	Fagacees–Sylvestris
			Tree, stand	Gr (DD)		*Q. petraea, F. sylvatica, P. sylvestris*	Oakpine1
			Tree, stand	Gr (DI)		*Q. petraea, F. sylvatica, P. sylvestris*	Oakpine2
			Tree, stand	Gr (M/D), Mo	Th	*Larix olgensis, Picea jezoensis, Abies nephrolepis*	LSFMGM
			Tree, stand, forest	Gr (DI), Mo		*Pinus banksiana, Picea glauca, Picea mariana*	JackPine
			Tree, stand, region	Re		Many species	Succes
		Irregular	Tree, stand	Gr (DD)		*Populus* spp., *Juglans nigra x regia, Prunus avium*, crops	Hi-sAFe
			Tree, stand	Re		Broadleaved species of north-eastern France	Regelight
			Tree, stand	Gr (DD), Mo, Re		*Quercus* sp., *P. sylvestris*	RReShar
			Tree, stand	Gr (DD), Mo, Re		*Acer saccharum, Betula alleghaniensis, Fagus grandifolia*, other broadleaves	Samare
			Tree, stand	Gr (DD), Mo, Re		*P. abies, A. alba*, other species	Samsara
			Tree, stand, forest	Gr (DI), Mo, Re, Di	Ge	*Sorbus torminalis, Q. petraea, F. sylvatica*	Alisier
			Tree, stand, forest	Gr (DI), Mo, Re, Di	Ge	*F. sylvatica*, virtual species	TranspopRege
			Tree, stand, forest/ landscape	Gr (DI), Mo, Re, Di	Ge, Th	*A. alba, F. sylvatica, P. nigra nigra, P. sylvestris, Pinus uncinata*	Ventoux/VentouG
			Tree, stand, forest	Gr (DI), Mo	Th	*P. halepensis, P. sylvestris, P. pinea, P. pinaster, P. nigra laricio, P. nigra nigra*	FireParadox
			Tree, stand, region	Gr (DI), Mo, Re	Th	Many species	Artemis
Subtropical	Pure	Regular	Average tree, stand	Gr (DI)	Th	*Pinus massoniana*	ISGM
Tropical	Pure	Irregular	Tree, stand	Gr (DI)		*Eucalyptus* spp.	Eucalypt
			Tree, stand	Gr (DD)		*Rhizophora* spp.	Mangrove
			Tree, stand	Gr (DD), Re		*Avicennia* spp., *Rhizophora* spp.	Paletuviers
			Tree, stand, forest	Gr (DI), Re	Ge	*Vitellaria paradoxa*	Karite
	Mixed	Irregular	Tree, stand	Gr (DD), Mo, Re		Many species	Selva
			Tree, stand	Gr (DD), Mo, Re	Br	Many species	Stretch

[a] "Pure" with a list of species means that the model either works with a pure stand of one of these species at a time or can simulate concurrently several pure stands of different species in the same forest

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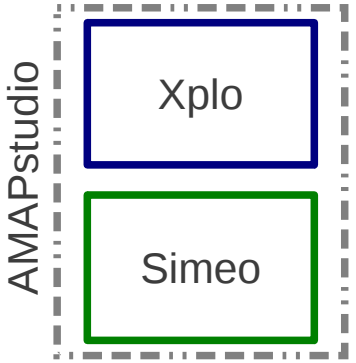
[c] Forest dynamics processes: growth (diameter and, possibly, height) (Gr), mortality (Mo), recruitment/regeneration (Re), dispersal (seeds/seedlings) (Di). Details for growth submodel: distance-independent tree growth (Gr (DI)), distance-dependent tree growth (Gr (DD)), growth submodel relying on a transition matrix or a diameter distribution curve (Gr (M/D))

[d] Genetics (Ge), ecophysiological processes (Phy), branching model (Br), automated thinning (in addition to Capsis' interactive intervention tools) (Th)

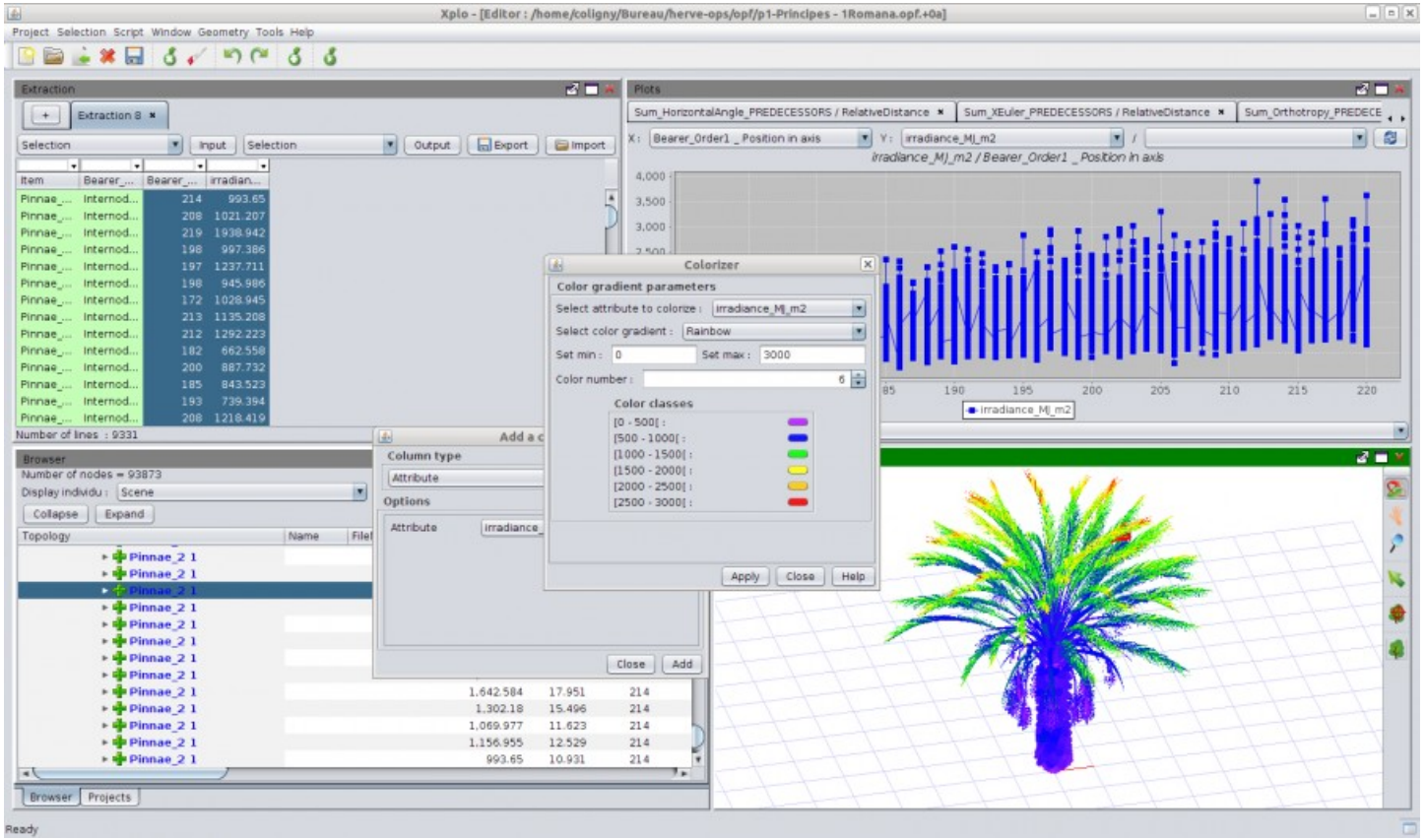
AMAPstudio: a software suite for plants architecture modelling

AMAPstudio contains applications and models
- to rebuild, explore, analyse and study the growth of plants from an architectural point of view
- at the individual or vegetal scene level



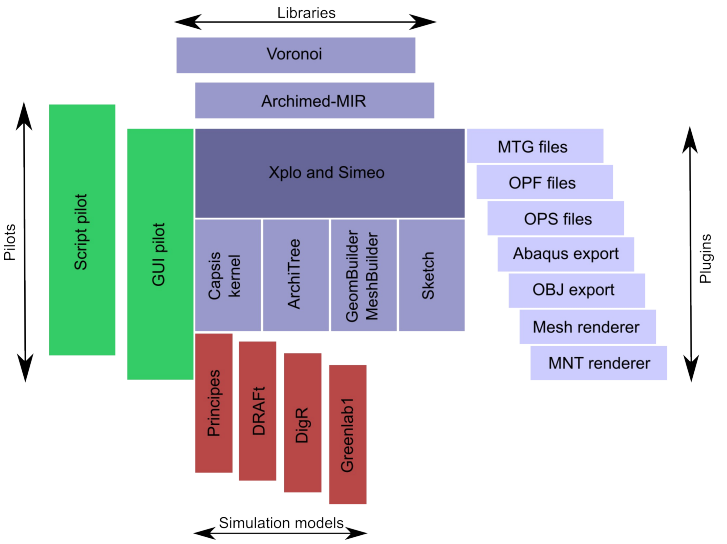
Multi-scale plant

High-detailed vegetal scene



A palm-tree 3D mock-up under inspection in Xplo (Hervé Rey, Cirad AMAP)

AMAPstudio: the Charter



Clear participation rules

All the common parts are free software (LGPL), they are reusable by everyone
-> all **except the workspace/, xplo/module/ and simeo/module/ directories**

- **Free kernel**: the AMAPstudio kernel is a free software (LGPL licence) : **kernels** + **generic pilots** + **extensions** + **libraries**
- **Development**: the modellers are in charge of the development of their models in AMAPstudio
- **Support**: They can have support from the developers : training sessions, design, starting help, further assistance
- **Free access in the community**: All the source codes are freely accessible by all members in the AMAPstudio community, modules may become the base for new modules, code can be shared…
- **Respect of intellectual property**: all members respect the intellectual property of the other members
- **Validations**: developers deal with technical validation, modellers deal with functionnal validation
- **Distribution**: the stabilized / validated modules may be distributed when the author decides and chooses a licence (LGPL free license suggested)
- **Decentralization**: modellers manage directly the relations with their end-users: financing, training, assistance, models documentation, contracts…

Hervé Rey, Jean-Francois Barczi (Cirad AMAP)

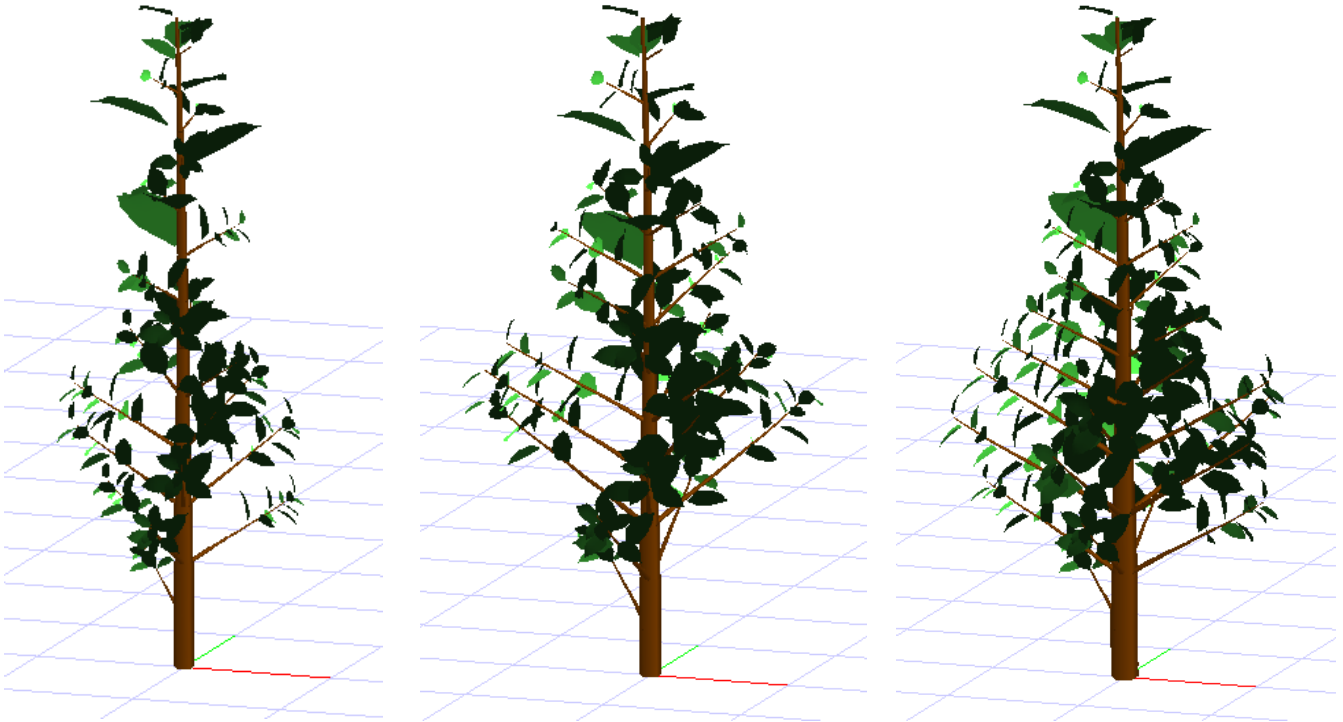
DigR

- *DigR* (Rey et al., 2011) is a root architectural model and simulator
- it relies on topological concepts as apical growth, lateral branching, senescence and death, and geometrical features as secondary growth and axes spatial positioning
- each of these properties are sorted into a root typology
- the current version runs without functional processes, however AMAPstudio will help developing further versions including functional – structural interactions during growth simulation and dealing with environmental influence (i.e. soil properties or aerial part contribution)

Olivier Taugourdeau, Jean-Francois Barczi (Cirad AMAP)

DRAFt (Demand, Resource, Architecture and Functioning at discrete time)

- a minimal FSPM designed to simulate emerging plants morphogenetical gradients
- tree architecture gradients is an emerging property of the interplay between structure function and iterative development
- DRAFt simulates the development and functioning of the tree aerial part at a yearly step
- it is based on biomass allocation, and relies on a 6 parameters equations system
- minimalist approach -> possible to use analytical tools to study the model sensitivity and behaviour

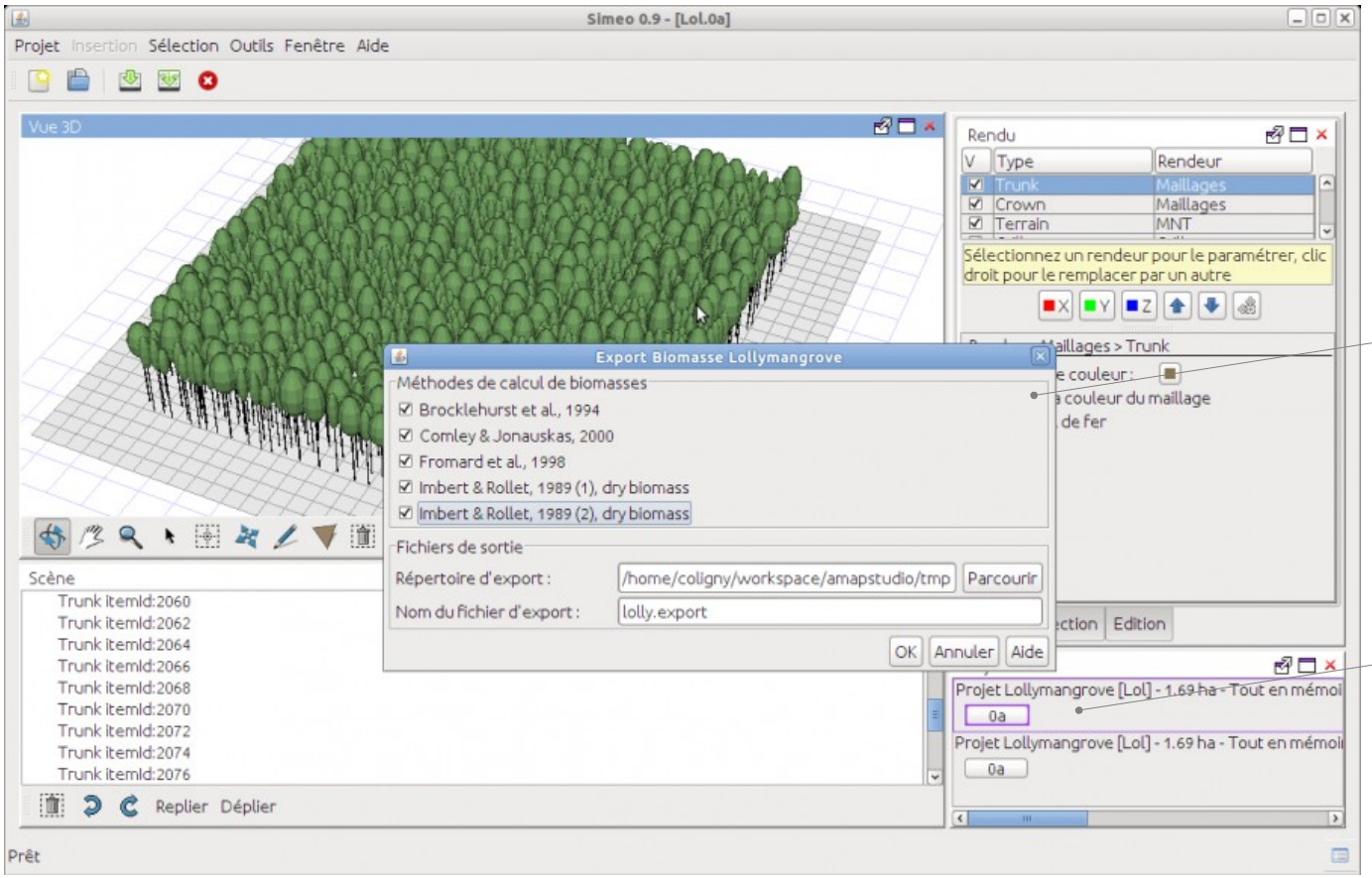


Taugourdeau O, Barczi J-F, Caraglio Y. Simulation of Morphogenetical Gradients Using a Minimal Functional-Structural Plant Model (FSPM). In: Kang M., Dumont Y., Guo Y., eds. Plant Growth Modeling, Simulation, Vizualization and Applications. Proceedings of PMA12. Shanghai, China: IEEE press; 2012. p. 379-387.

Christophe Proisy, Chloé Bourden (IRD AMAP)

Lollymangrove

- develop a standardized protocol for describing mangrove stands from forest inventories
- integrate allometric relationships between DBH, crown dimension, tree height and tree biomass to make possible the visualization of lollypop-like mangrove stands
- compute biomass at both the tree and stand scales
- provide a robust and easy-to-use interface allowing data exportation into various formats directly usable by other simulation tools (e.g. the DART model, a 3D radiative transfer model able to simulate optical remote sensing images)



biomass export

no growth model