Efficient Building of Forestry Modelling Software with the Capsis Methodology

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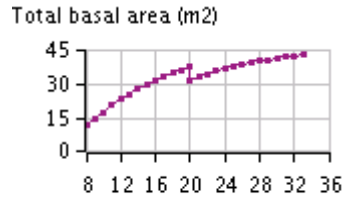
The Capsis project

Objectives: Build a **software platform** to **integrate** many forest growth, yield and dynamics models **for** forestry modellers, forestry managers and education

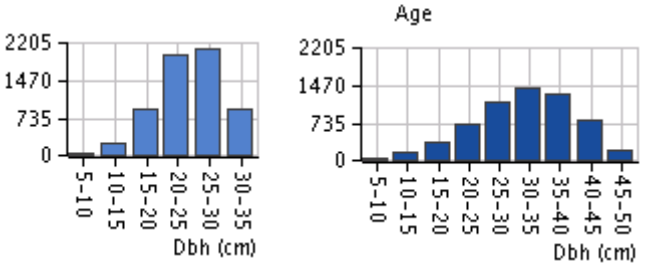
Details:
- An integration tool
- Growth / dynamics models for forests / plantations
- Various intervention to build management scenarios
- Interactive or not for long simulations
- Integrated tools to check the results
- Easy export to data analysis tools
- Possible connection to other simulation software
- Free software to ease partnerships
- Multi-OS and multi-language (french, english)

Forestry models

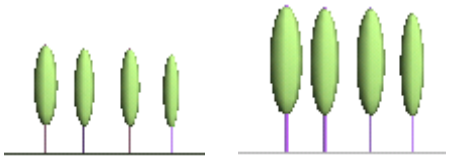
Stand level models:



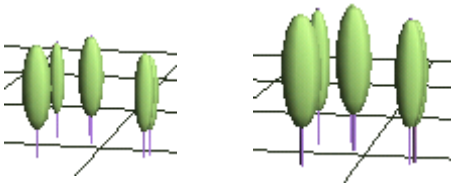
Distribution models:



Individual based models:



Spatialized models:



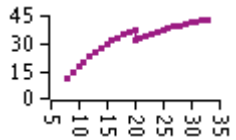
Various types of stand growth and yield models

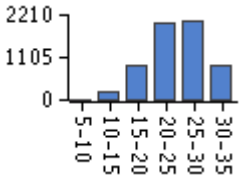
... and also Mixt models:

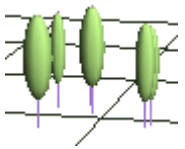
Process-based + growth and yield
Distribution + spatial structure
Individual based + genetics ...

Various representations in memory

Kind of model







Other...

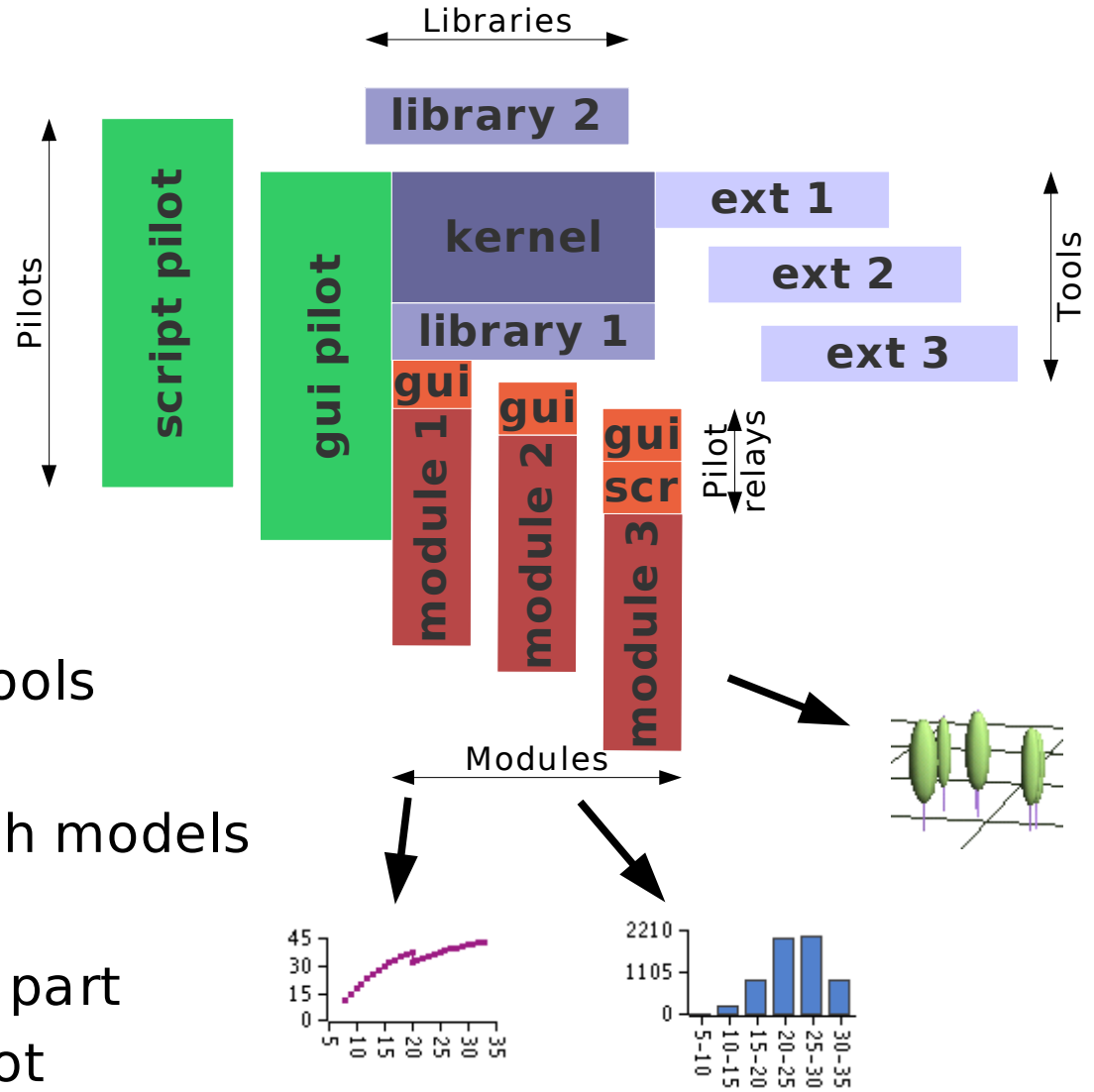
Example

Lemoine model (stand-level, plantation):
- Age
- Number of trees
- Girth (dominant, mean tree) (cm)
- Basal area (m2)
- Height (dominant, mean tree) (m)
- Volume (mean tree) (m3)

PP3 model (distribution, plantation):
A collection of bars
- Age
- Diameter (cm), Height (m), Tree volume (m3)
- Number of trees in the bar
- Crown (base height, diameter) (m)
- Other (biomass, carbon mass, leaf area, etc.)

Samsara model (individual-based, spatialized):
A collection of trees
- Age
- Diameter (cm) , Height (m)
- Location x, y, z (m)
- Species
- Crown (base height, radius) (m), Light (MJ)

Capsis Software Architecture

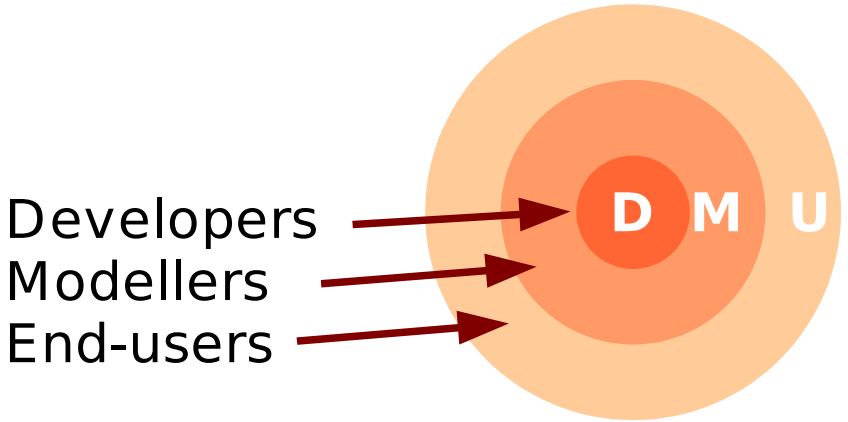


Kernel: stability
Libraries: additional tools

Modules: Stand growth models

Extensions: evolutive part
Pilots: interactive or not

The Capsis project organisation



Actors roles:

Developers: computer developers, design, training courses, assistance

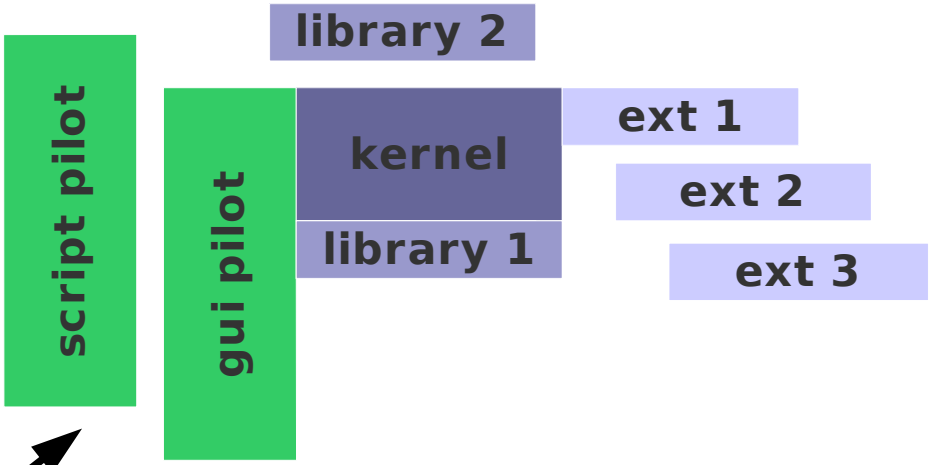
Modellers: scientists, build their models inside Capsis

End-users: interested by using the models

The Capsis Community:

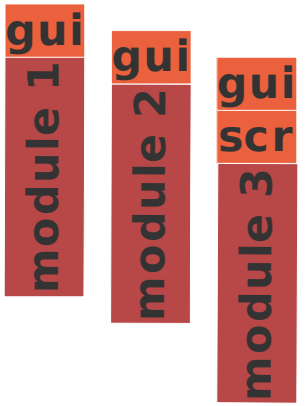
Developers + Modellers are co-developping together

Clear participation rules

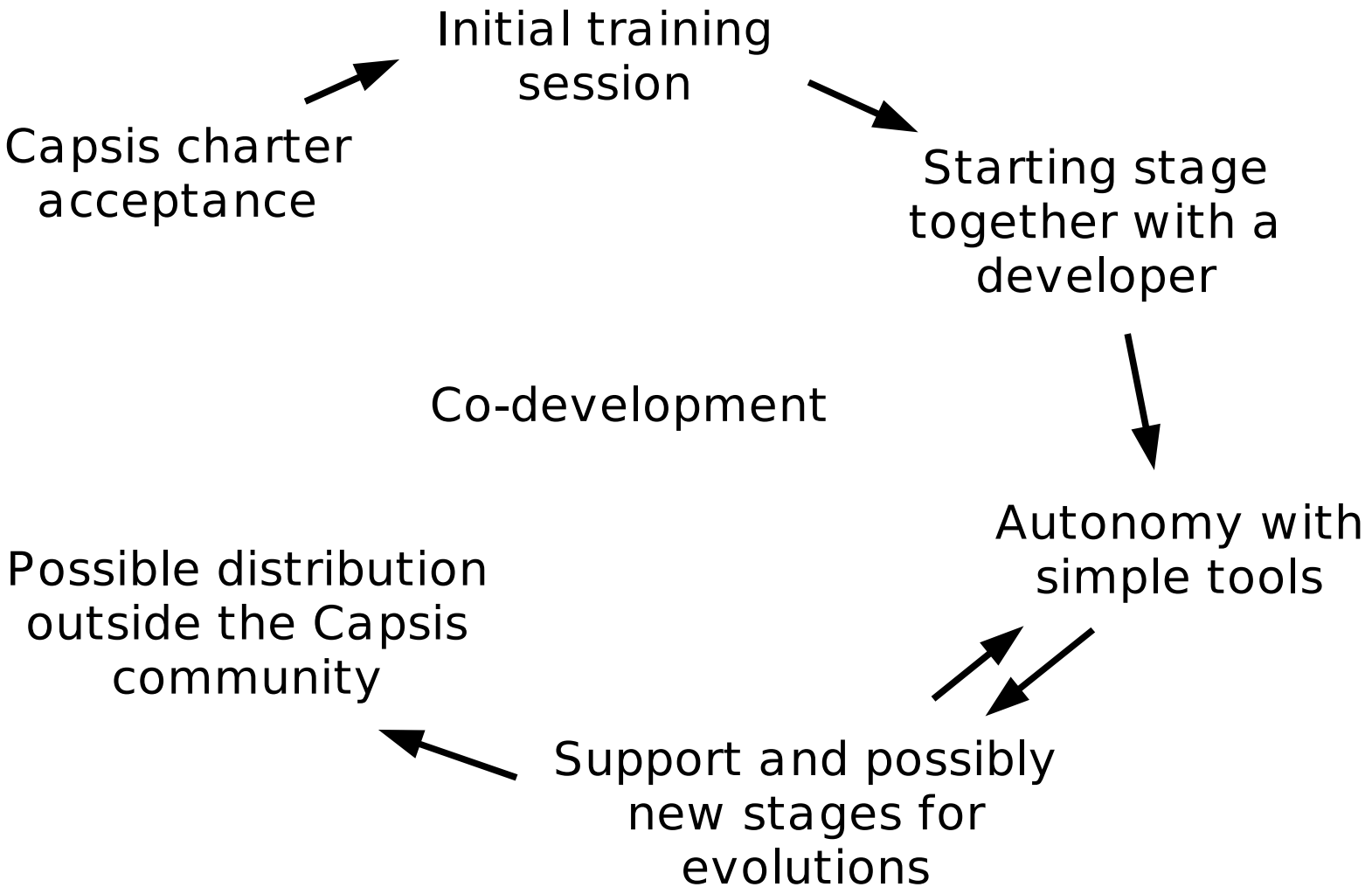


The Capsis charter:

1. **Free kernel**: the Capsis kernel is a free software (LGPL licence)
2. **Development**: the modelers are in charge of the development of their models
3. **Support**: They can have support from the developers
4. **Free access in the community**: All the source codes are freely accessible by all members in the Capsis community
5. **Respect of intellectual property**: all members respect the intellectual property of the other members
6. **Validations**: developers deal with technical validation, modelers deal with functionnal validation
7. **Distribution**: the stabilized / validated modules may be distributed when the author decides and chooses a licence
8. **Decentralization**: modelers manage directly the relations with their end-users



The Capsis methodology

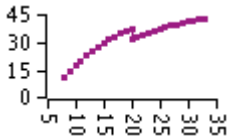


Focus: Integrated Stand Growth Model (1)

ISGM is a model by **Dr. Tang Shouzheng** (since 1994)
The **Research Institute of Forest Resource Information Techniques** (IFRIT) of the Chinese Academy of Forestry (CAF), Beijing

- Implemented in Capsis by **Hong LingXia** in june 2006 during her visit in France

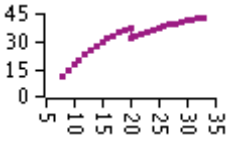
- ISGM is a Stand-level model



Tang Shouzheng, Meng ZhaoHe, Meng FanRui.1994.A growth and self-thinning model for pure even-aged stands theory and applications. Forest Ecology and Management 70(1994): 67~73.

- The structure (without equations) of the ISGM model in Capsis
→ **was reused** to begin implement the new Lemoine project in Capsis (Céline Meredieu, Thierry Labbé, INRA-EPHYSE, october 2006)

Focus: Integrated Stand Growth Model (2)



A group of correlated equations to calculate the growth of an **even-aged stand**:

- Basal area
- Density index
- Self-thinning model
- Dominant tree growth
- Mean tree growth
- Stand volume

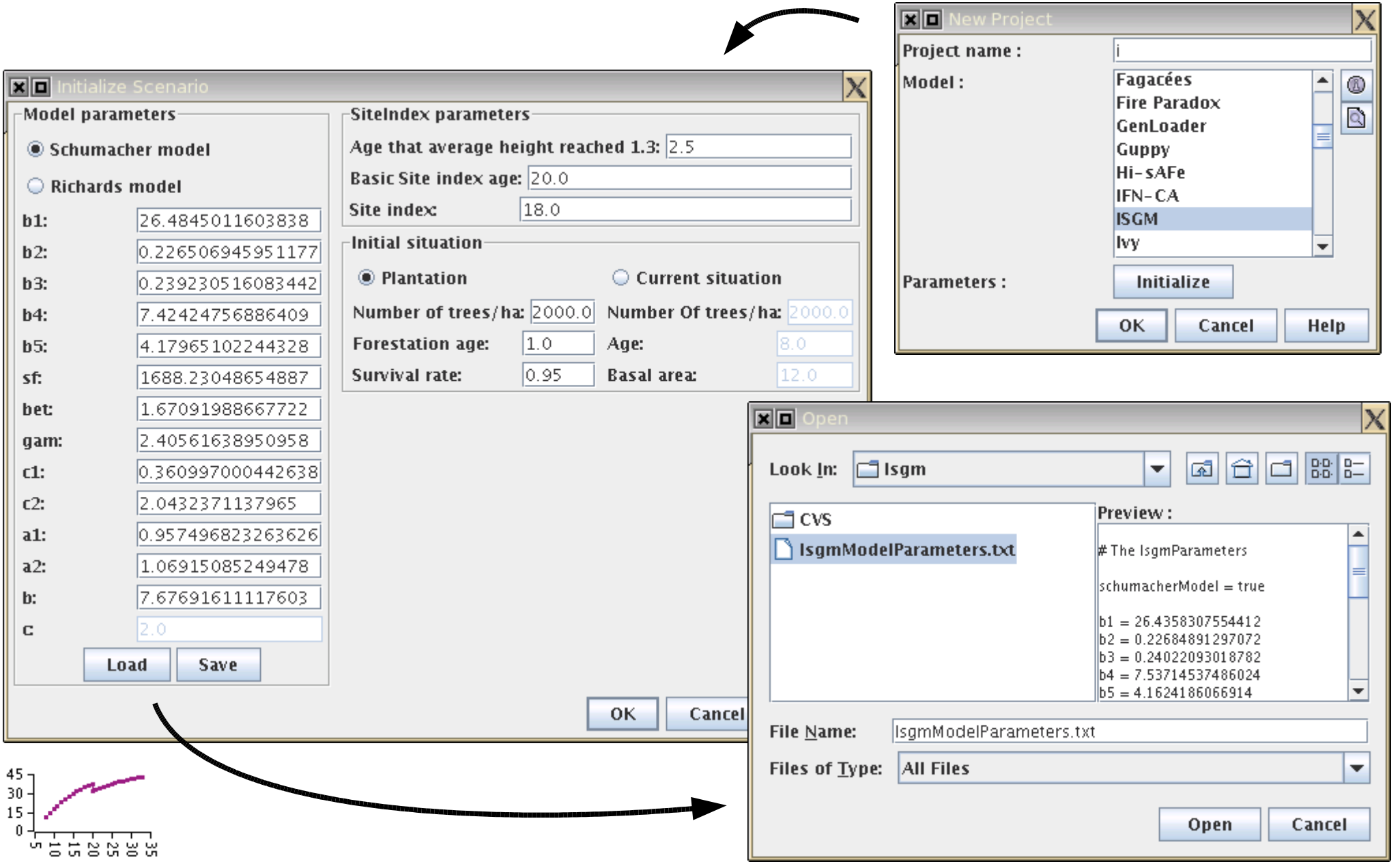
Outputs:

- different kinds of growth tables with different site index, stand density, thinning methods
- A stand density control graph

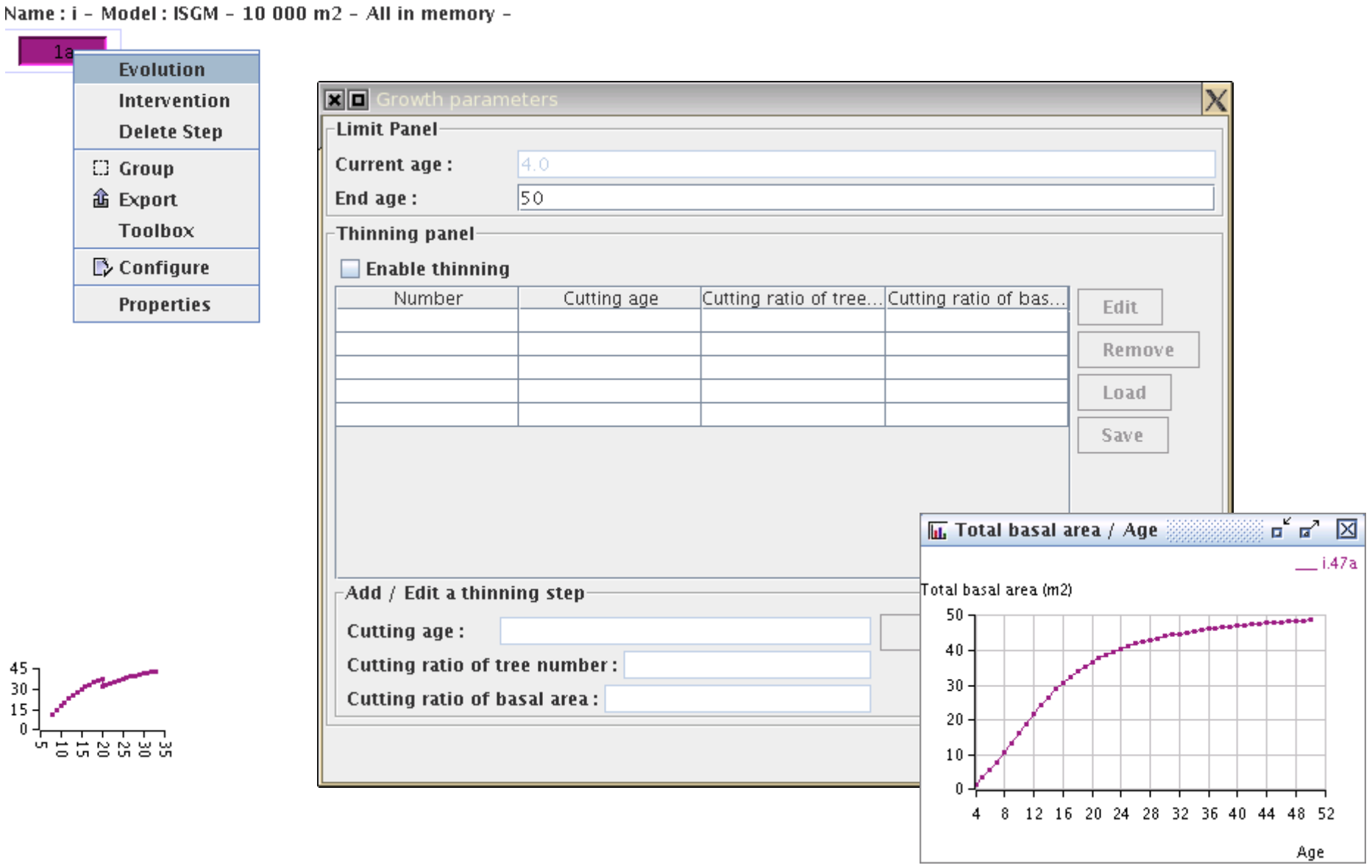
Implemented:

- in ForStat (Chinese, CAF)
- in Capsis (English, INRA-AMAP)

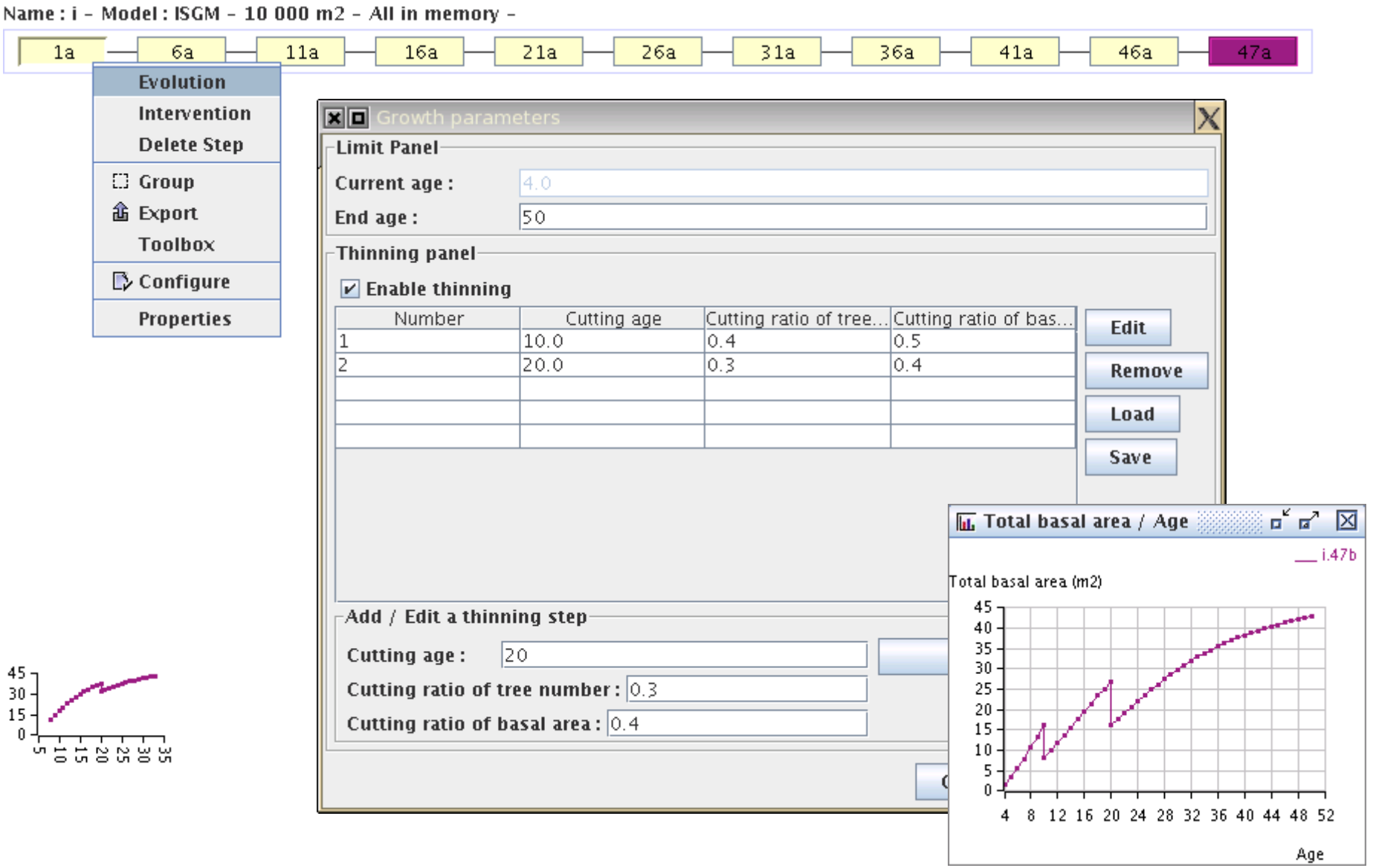
Focus: Integrated Stand Growth Model (3)



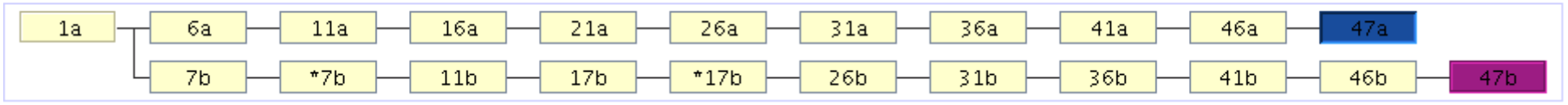
Focus: Integrated Stand Growth Model (4)

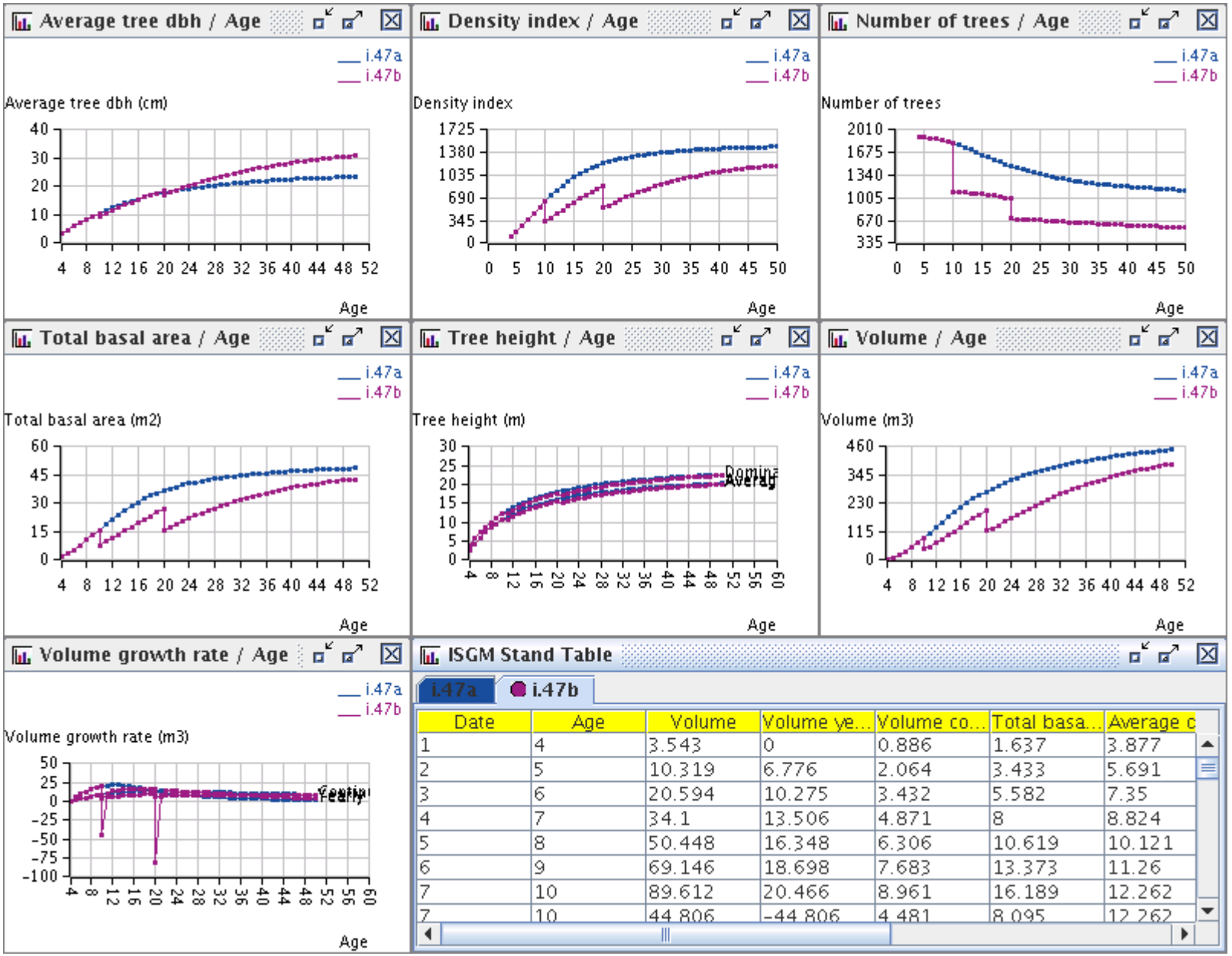


Focus: Integrated Stand Growth Model (5)



Tang Shouzheng, Hong LingXia (CAF - IFRIT)

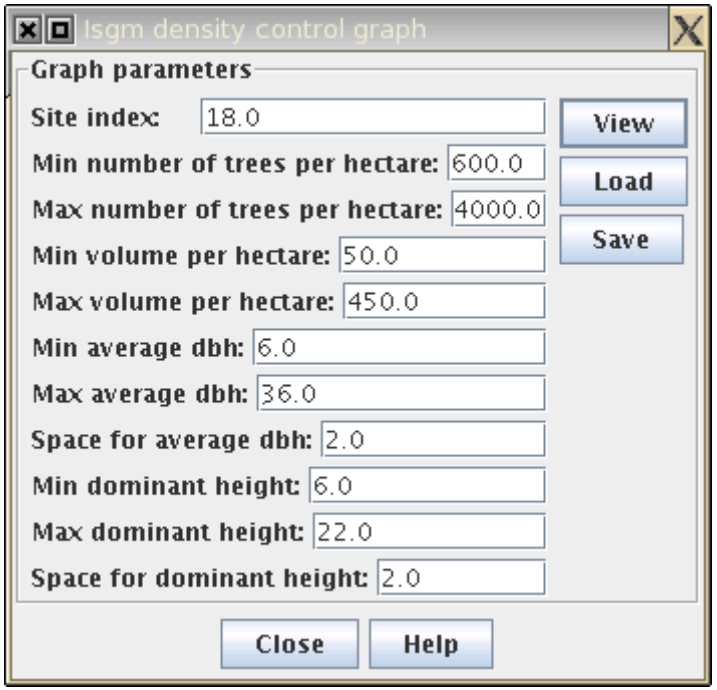


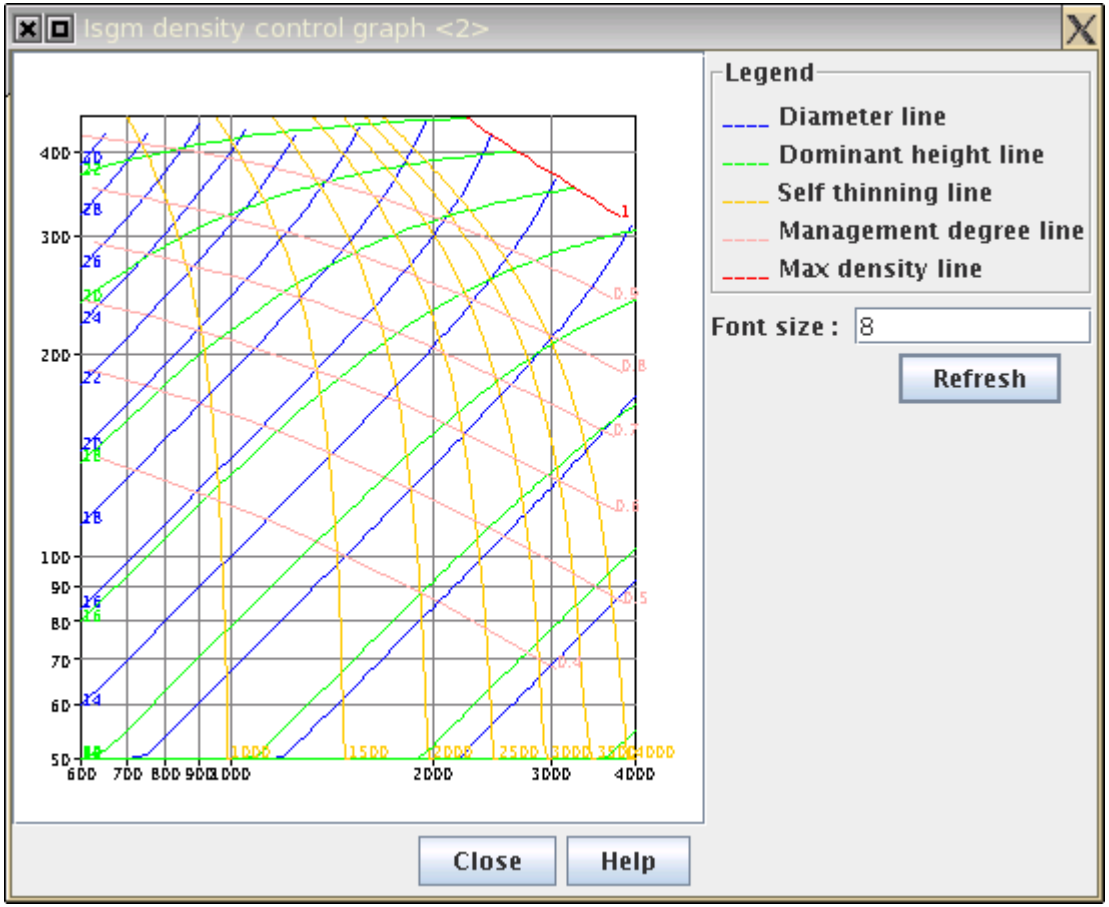


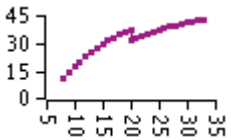
Date	Age	Volume	Volume ye...	Volume co...	Total basa...	Average c
1	4	3.543	0	0.886	1.637	3.877
2	5	10.319	6.776	2.064	3.433	5.691
3	6	20.594	10.275	3.432	5.582	7.35
4	7	34.1	13.506	4.871	8	8.824
5	8	50.448	16.348	6.306	10.619	10.121
6	9	69.146	18.698	7.683	13.373	11.26
7	10	89.612	20.466	8.961	16.189	12.262
7	10	44.806	-44.806	4.481	8.095	12.262

Focus: ISGM (6)

Focus: Integrated Stand Growth Model (7)







A specific tool: the ISGM density control graph

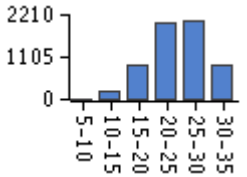
A distribution model: Sylvestris (1)

Sandrine Perret[(1)], **Thomas Pérot**[(1)], **Céline Meredieu**[(2)]
[(1)] Cemagref - Forest ecosystems
[(2)] INRA - EPHYSE

- Scientific purpose: studying and modelling **Scots Pine growth in pure and even-aged stands**

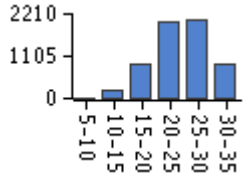
- Applied purpose: helping forest managers to **build various silvicultural scenarios** adapted to different stand structure, site fertility or management purpose.

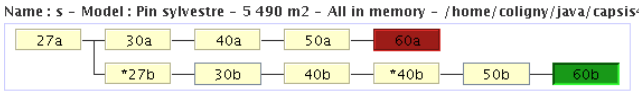
5 equations:
- Dominant height – age – fertility model
- Diameter increment model
- Height-diameter model
- A self-thinning model (Hynynen, 1993)
- Volume table (Goupil, 1981)

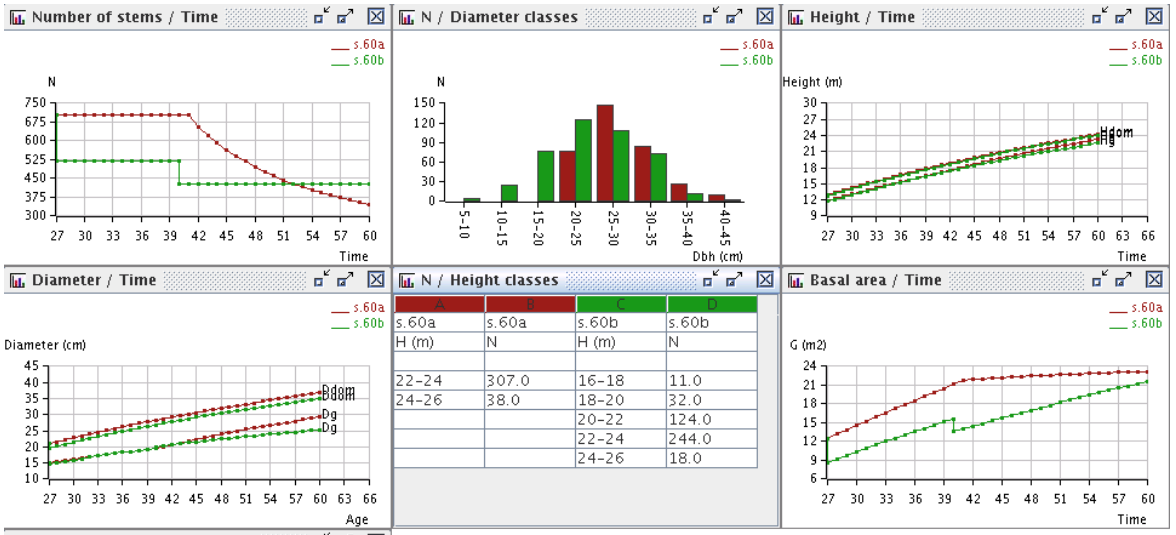


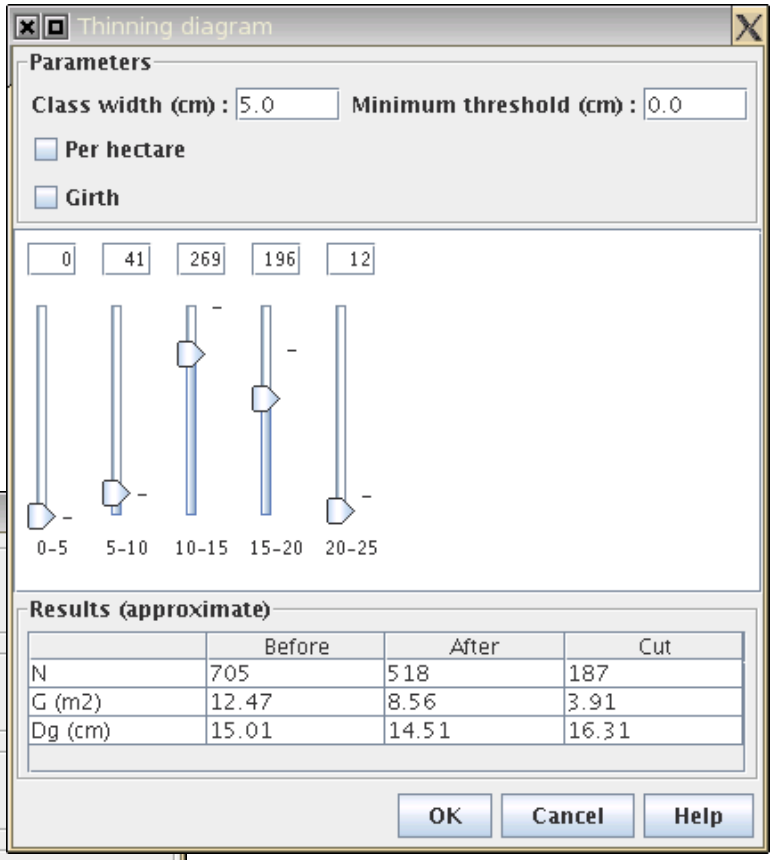
Sandrine Perret, Thomas Perot (Cemagref), Céline Meredieu (INRA)

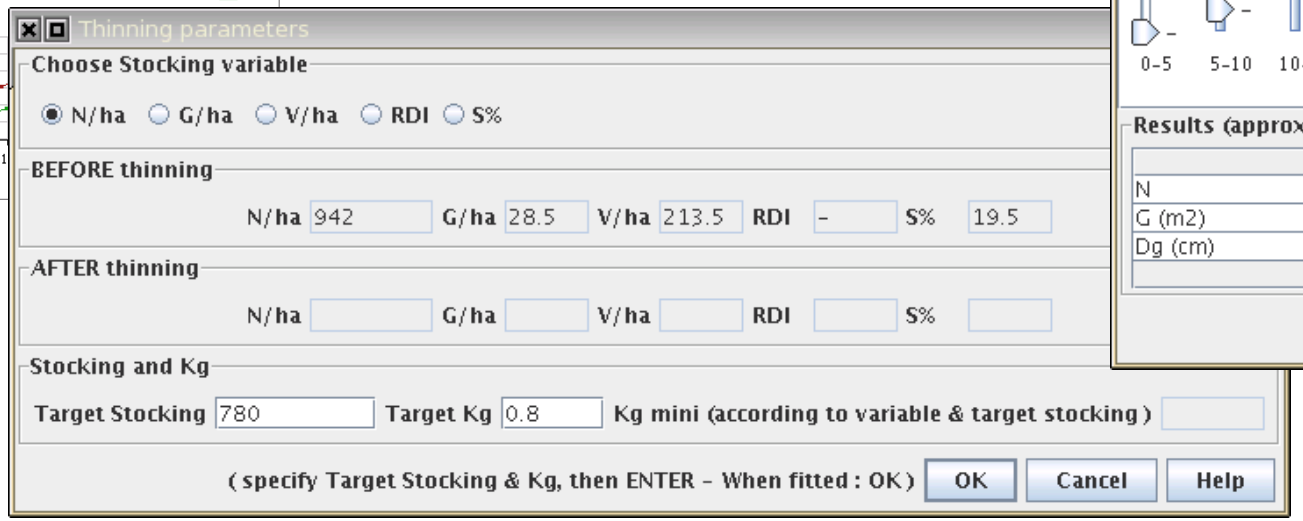
A distribution model: Sylvestris (2)









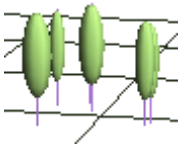


Thinning extensions

Samsara: individual-based, spatialized (1)

Benoît Courbaud - Cemagref

- A model of forest dynamics designed for the study of stand structure / stand dynamics and silviculture interactions



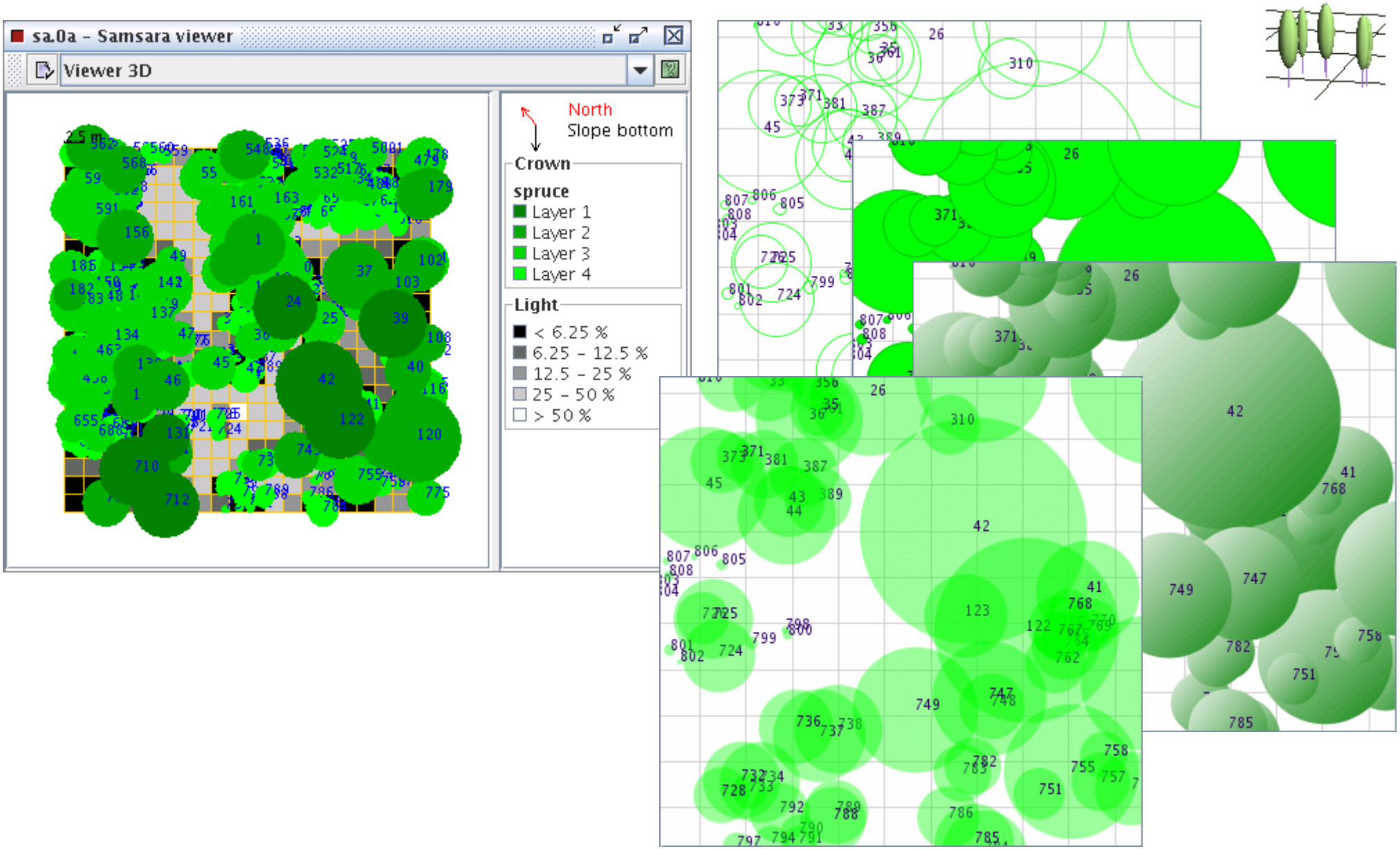
- To **compare thinning strategies** and to understand how demographic processes at the tree level (regeneration, growth, death) generate patterns at the stand level

- Trees: location (x, y, z), height, diameter at breast height, crown base height and crown base radius

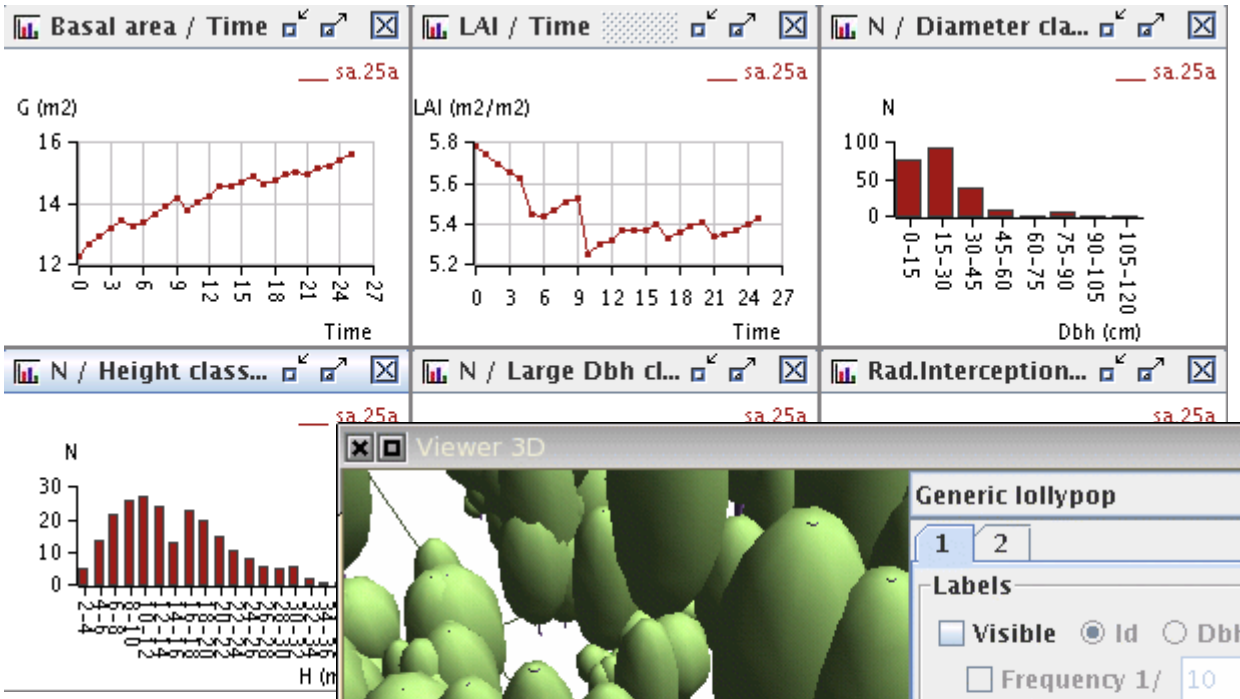
- **Light interception** is calculated for every tree and every cell, **growth, death and competition** are modelled at the tree level for every individuals higher than 1.30 m. **Regeneration** is modelled at the ground cell level

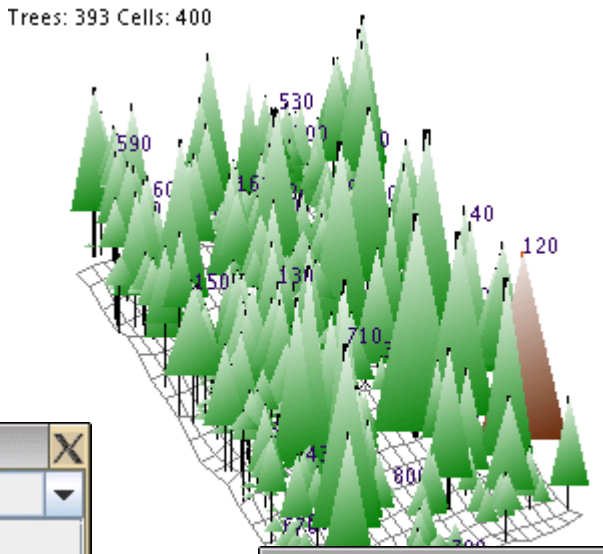
Courbaud, B., Goreaud, G., Dreyfus, Ph., Bonnet, F.R., 2001 : Evaluating thinning strategies using a Tree Distance Dependent Growth Model: Some examples based on the CAPSIS software "Uneven-Aged Spruce Forests" module. Forest Ecology and Management.

Samsara: individual-based, spatialized (2)



Samsara: individual-based, spatialized (3)

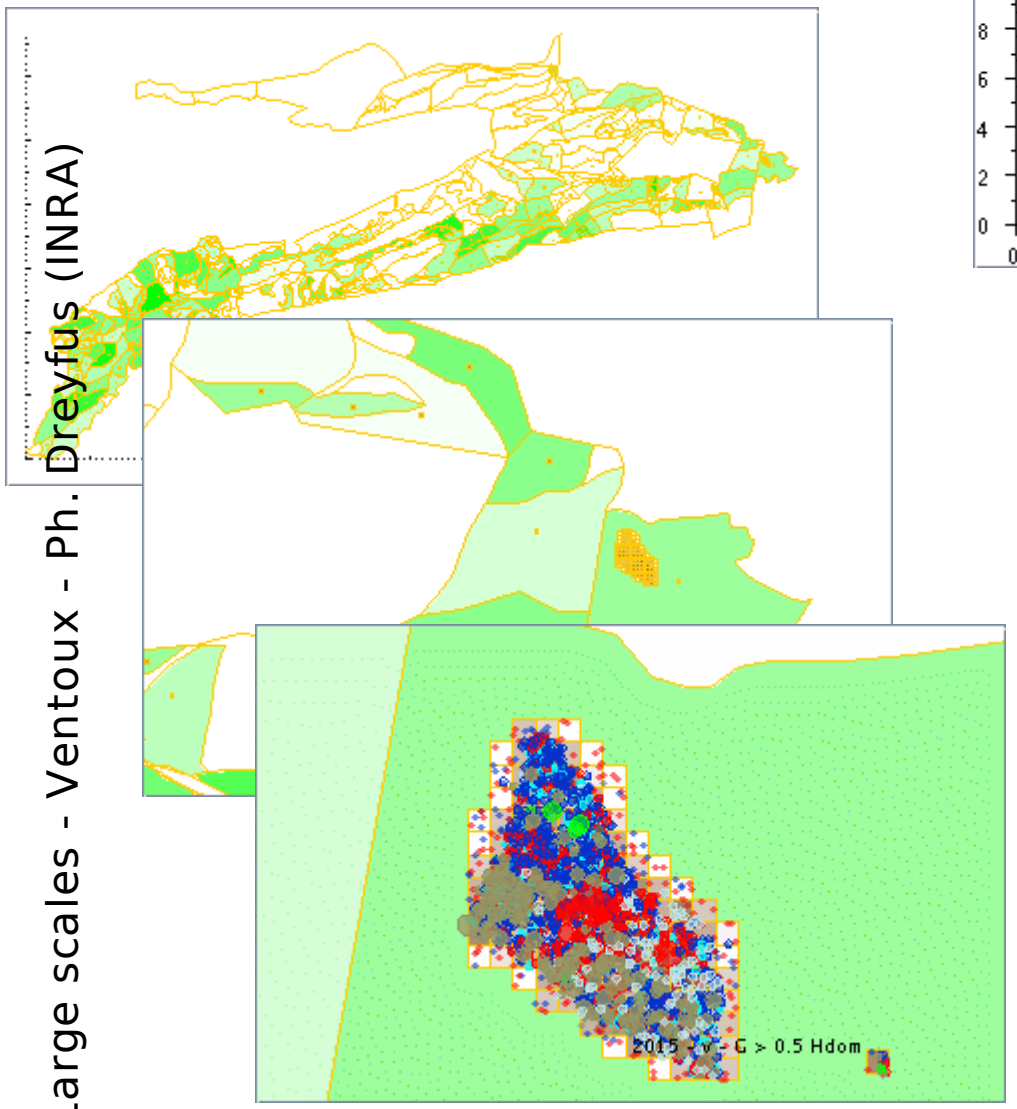




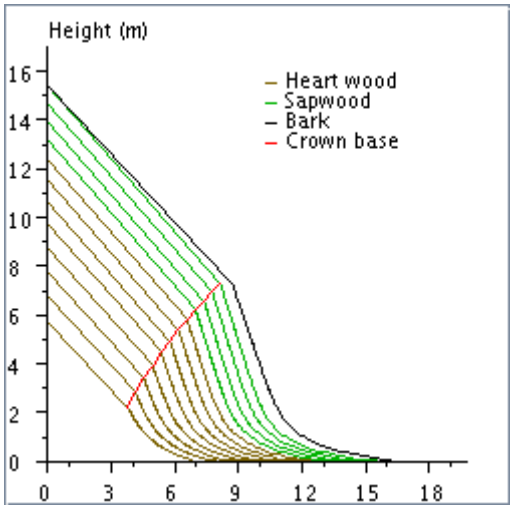
SamsaTree

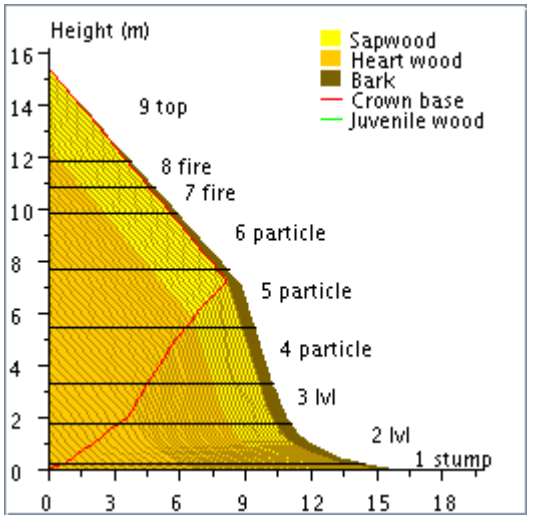
Field	Value
Age	182
CONIC	1
Cell	SquareCell_[15, 1...
CrownBaseHeight	1.62144255638...
CrownBaseHeight...	0.23
CrownColor	java.awt.Color[r=...
CrownRadius	6.18205928802...
CrownShape	P
CrownType	1
CrownVolume	1578.35340897...
Dbh	72.7588653564...
DbhIncrement	0.53916931152...
DiameterClass	6
Energy	281898.75
Height	27.9131050109...
HeightIncrement	0.10319919139...
Id	120
ImpactNumber	15344

Other examples

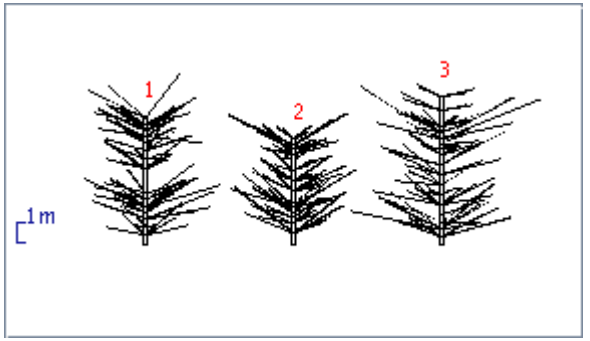


Large scales - Ventoux - Ph. Dreyfus (INRA)

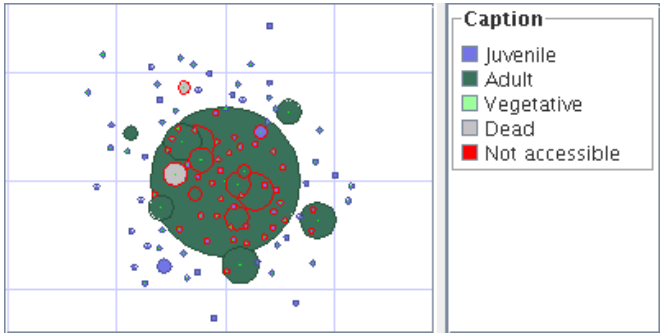




Wood quality - Fagacées - F. Mothe (INRA)

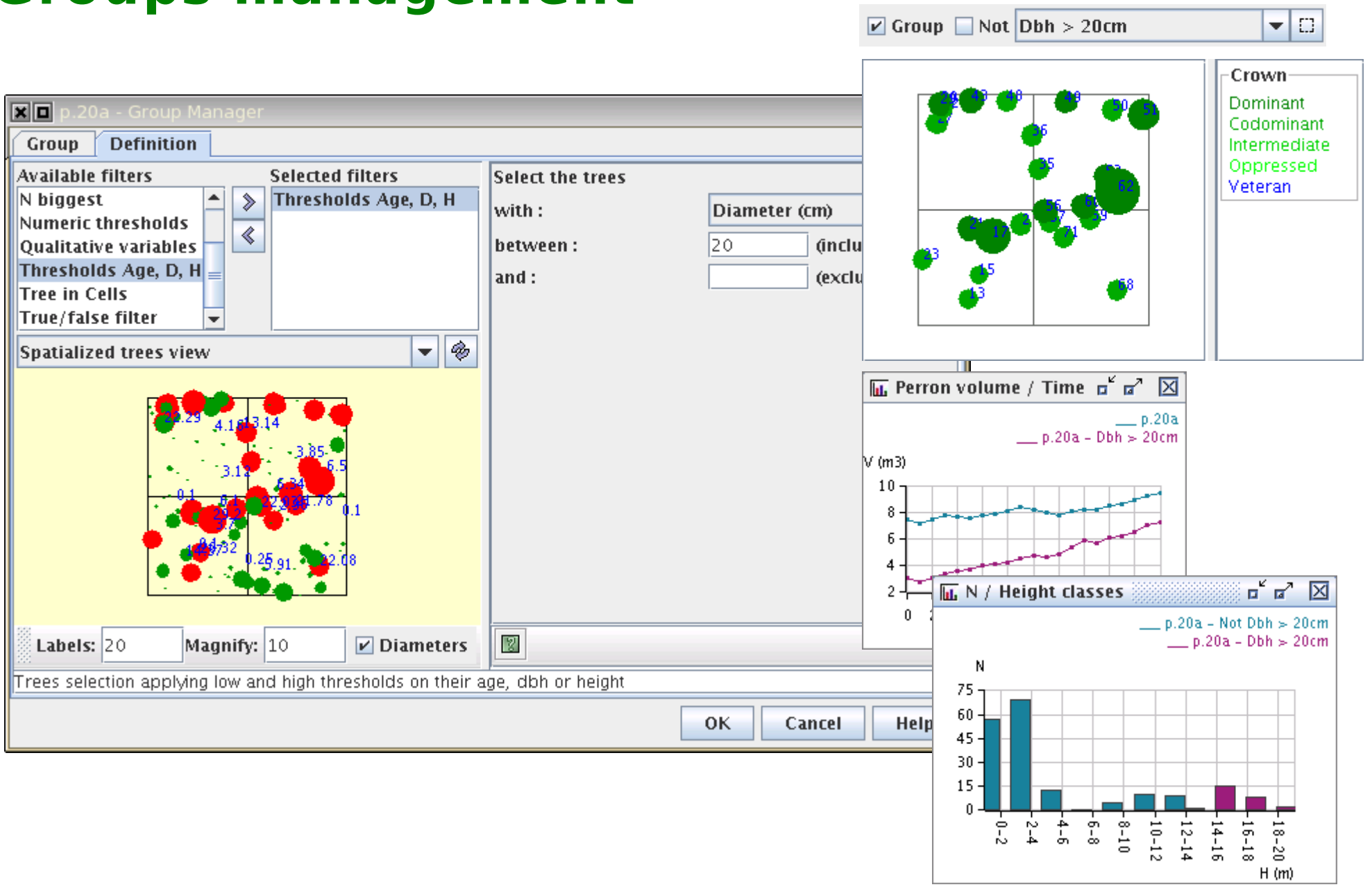


Branches - NZ1 - D. Pont (ENSIS NZ)



Dispersion - Cytisus - E. Chambon-Dubreuil (INRA)

Groups management

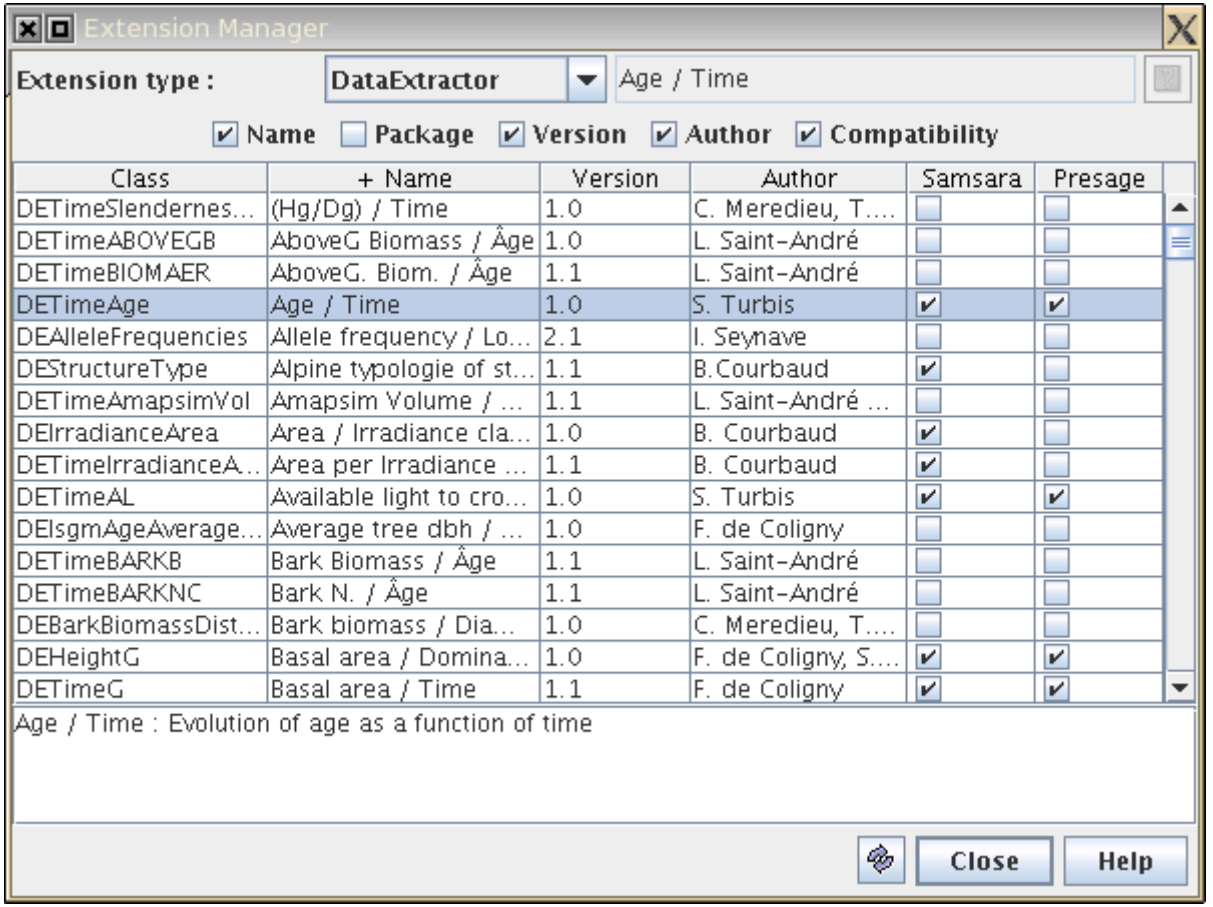


Extensions

Capsis kernel

Extension manager (390)

- Data extractor (182)
- Data Renderer (6)
- Economic function (7)
- Filter (12)
- Generic tool (6)
- Grouper display (3)
- Intervener (26)
- Ioformat (71)
- Lollypop (1)
- Memorizer (4)
- Model tool (18)
- Object viewer (24)
- Stand viewer (30)



About 400 extensions in Capsis, either generic or specific to one model

Main reusable libraries

Biomechanics - Philippe Ancelin (Cemagref)

Calculates wind effects, considered as a natural disturbance, on forest stands managed by a tree-based forest growth or dynamics model

Economics - Christophe Orazio (IEFC)

Economic balance of a scenario by allocating expenses and incomes to the interventions

Genetics - Christian Pichot et al. (INRA)

Genetics information and processus to study interactions between gene flows and trees demography

Spatial - Francois Goreaud (Cemagref)

Generation and characterization of spatial structures

Integrated modules: various types

IBM
Fagacées
Fasy
OakPine1 (*new*)

IBM + Spatialized
Cytisus
Fiesta / NRG
Mountain
Paletuviers
Presage
Quercus
Regelight
Samsara
Selva
Sexi
Simsys
TranspopRege

Diameter class
CA1, Luberon
Eucalypt
IfnCa
Laricio
NZ1
PNN
PP3
QS1
Sylvestris
Transpop

Diameter class + Spatialized
Alisier
Dynaclim
Ventoux, Ventoug

Fish
Bidasoa
Dynet
Guppy

Stand level
ISGM
Lemoine (*new*)

AgroForestry
HiSafe

Recent publications

Goreaud F., de Coligny F., Courbaud B., Dhôte J.-F., Dreyfus P., Pérot T., **2005**. La modélisation : un outil pour la gestion et l'aménagement en forêt. Vertigo 6 (2).

de Coligny F., Meredieu C., Labbé T., Vallet P., Dreyfus P., **2005**. Using Capsis for connection with wood quality. In Proceedings of the fifth Workshop "Connection between Forest Resources and Wood Quality : Modelling Approaches and Simulation Software", Waiheke Island, New Zealand, 20-27 November 2005. In press.

Goreaud F., Courbaud B., de Coligny F., **2005**. How long does the spatial structure of an initial state influence the dynamics of a forest growth model ? A simulation study using the Capsis platform. In Proceedings of the Open International Conference on Modeling and Simulation - OICMS 2005, 13-15 june 2005, Clermont Ferrand (France), pp 217-230.

de Coligny F., **2005**. Capsis: Computer-Aided Projection for Strategies In Silviculture, a software platform for forestry modellers. Workshop on Information Science for Agriculture and Environment (ISAE). 3-4 june 2005, GuiZhou Normal University, GuiYang, P.R. China.

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Perspectives

- Integration of new projects
- Progress on the common parts
- Better documentation -> for self-training
- More connections with AMAP plant architecture simulators
- Support for other european projects
- More partnerships with european / other foreign countries
- Web site completely in english

http://**capsis.free.fr**