Capsis Project Activity 2023 - 2024

FOREM 2024 meeting
2-4 April 2024 - Nancy

Francois de Coligny

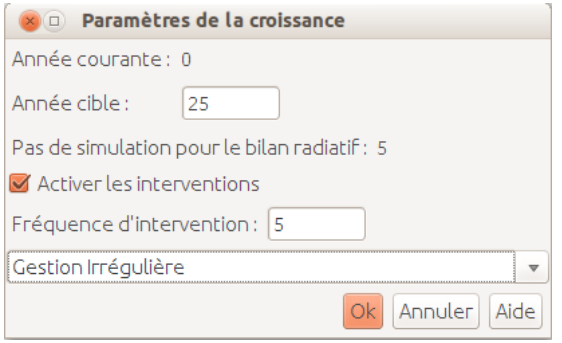
INRAE - AMAP
botany and modelling of plants architecture and vegetations

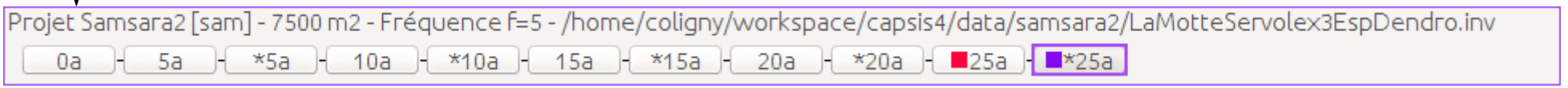
Capsis objective

Computer-Aided Projections of Strategies In Silviculture

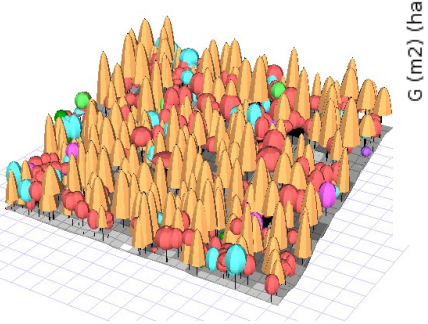
Build **a software platform** to integrate **forest growth and dynamics models** for **modellers, forest managers and training**

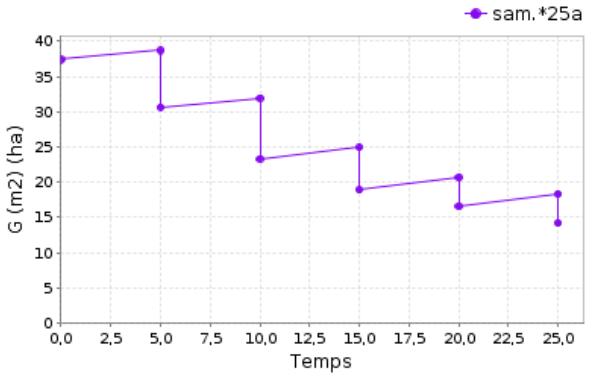
1. initialisation

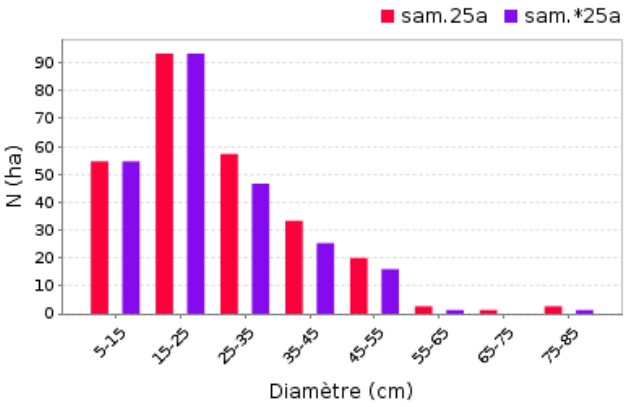




2. growth

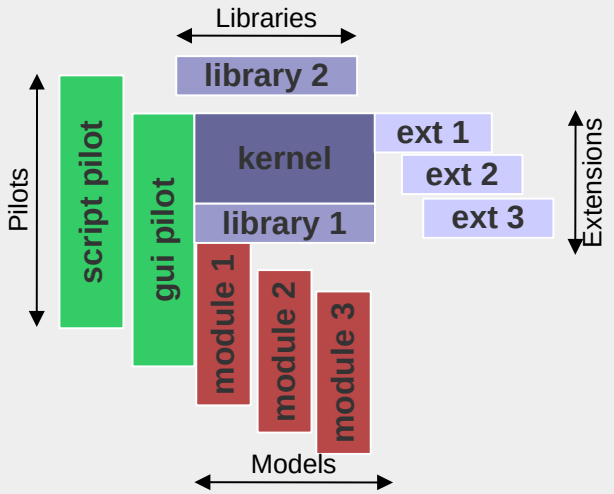




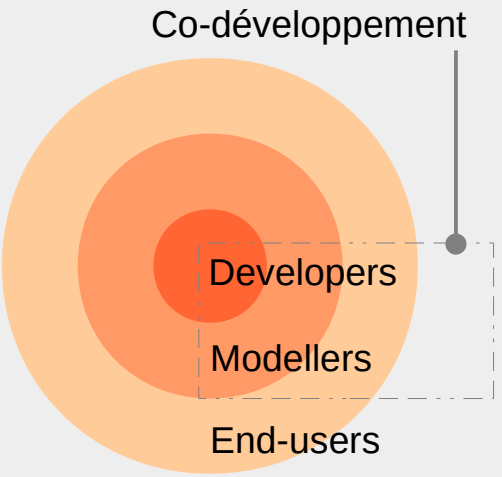


export

A co-development oriented organisation



Software architecture



Actors and roles

Free software (LGPL)

Capsis charter :
- property
- sharing with other co-developers

Clear property rules

Capsis charter

Accepted by all members

- aims at sharing and intellectual property respect
- compatible with academic and private field partners

http://www.inra.fr/capsis/charter

Capsis Charter

Main points

1. **Free kernel**: the Capsis4 kernel is a free software (LGPL licence) : kernel + generic pilots + extensions + libraries (all the capsis.* packages)
2. **Development**: the modellers are in charge of the development of their models into Capsis
3. **Support**: They can have support from the developers : training sessions, design, starting help, further assistance
4. **Free access in the community**: All the source codes are freely accessible by all members in the Capsis community, modules may become the base for new modules, code can be shared…
5. **Respect of intellectual property**: all members respect the intellectual property of the other members.
6. **Validations**: developers deal with technical validation, modellers deal with functionnal validation.
7. **Distribution**: the stabilized / validated modules may be distributed when the author decides and chooses a licence (LGPL free license suggested), possible download from a ftp site.
8. **Decentralization**: modellers manage directly the relations with their end-users: financing, training, assistance, models documentation, contracts…

To comply with the charter, the modellers may **distribute** the Capsis platform with their own modules but **NOT with the modules of the other modellers**. The modules (i.e. the growth models) are indeed not free and belong to their authors who may decide to distribute them with the license they choose. The section 4 of the charter grants access on all the modules to the modellers of the Capsis community but only to them, resulting in this distribution restriction.

Method: take care of the modellers

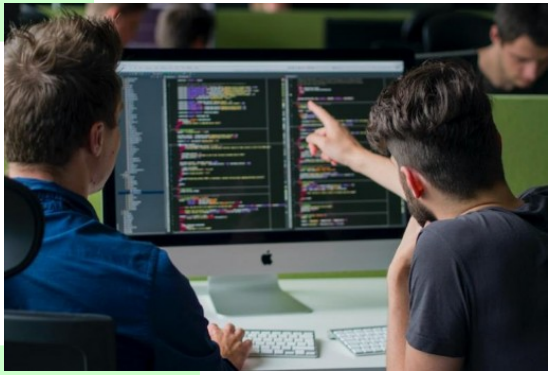
Targeted public: a modeller has designed a forestry growth model and wishes to integrate it in Capsis to get a simulator for his own objectives

- discussion
- accept the charter
- training
- immediate working session to start together
  (never start alone)

Or in video conference...

Goal: get quickly a running prototype
-> often in few days / during few weeks

Start in 'pair programming' on the same machine
-> the developer masters the technique
-> the modeller masters his model
-> the simulator is valid technically and fonctionally



The modeller can then continue by himself with simple tools...

... and a Long term support

Main activity in 2023-2024

No new project in Capsis this year

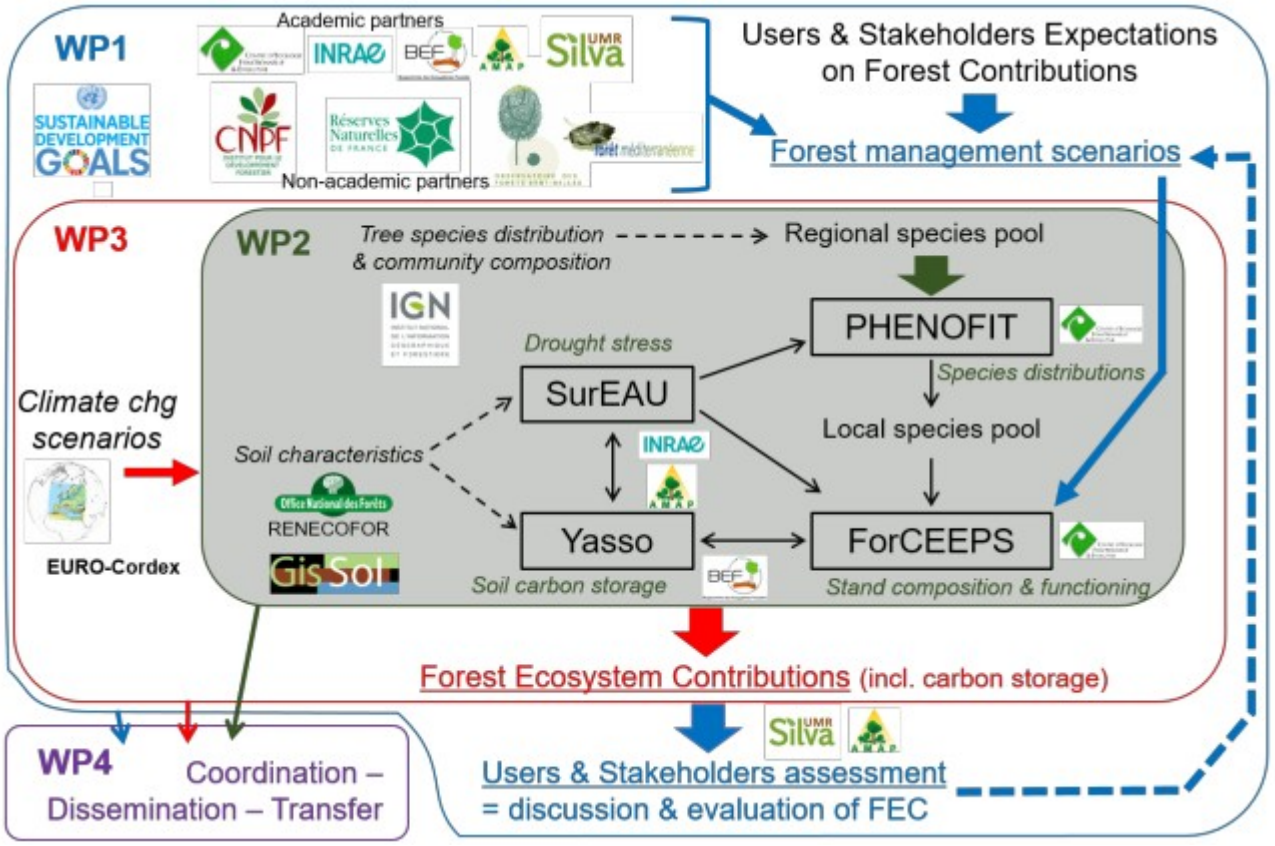
Main support actions on existing projects, in decreasing number of days:

- **Forceps + Sureau + Yasso** : Nicolas Martin (INRAE URFM Avignon), Louis Devresse, Tanguy Postic, Xavier Morin (CNRS CEFE Montpellier), Florian Mézerette (INRAE BEF, Champenoux), Zhun Mao (INRAE AMAP, Montpellier)
- **Samsara2** : Benoit Courbaud, Nathéo Beauchamp, Lilou Thill (INRAE Lessem, Grenoble)
- **Ecoaf** : Frédérique Santi (INRAE Biofora, Orléans), Fabien Liagre, Pierrick Gouhier, Ambroise Martin-Chave, Camille Beral (Agroof, Anduze), Gauthier Ligot (U Liège Gembloux, Belgium)
- **Heterofor** : Arthur Guignabert, Matt Willecome, Frédéric André, Mathieu Jonard (UCL, Louvain la Neuve, Belgium)
- **Poplar** : Seyed Mahdi Heshmatol Vaezin (Univ Tehran, Iran)
- **C-Stability / SimcopQual** : Julien Sainte-Marie (AgroParisTech, Nancy)
- **Luberon2** : Victor Fririon, Francois Lefèvre (INRAE URFM, Avignon)
- **ModisPinaster** (optimisation) : Gilles Le Moguedec (INRAE AMAP), Teresa Fonseca, Adelaide Cerveira (UTAD, Vila Real, Portugal)
- **Regeneration** (roots distribution in soil) : Mostafa Moradzadeh (INRAE FONA, Nogent sur Vernisson), Philippe Balandier (INRAE PIAF, Clermont-Ferrand)
- **Sydy2** : Timothée Audinot (ONF R&D, Avignon)
- **Ibasam** : Amaia Lamarins (Univ Helsinki, Finland), Mathieu Buoro (INRAE Ecobiop, St Pée / Nivelle)
- ...

Xavier Morin, Tanguy Postic, Isabelle Chuine (CNRS CEFE, Montpellier), Nicolas Martin (INRAE URFM, Avignon), Florian Mézerette (INRAE BEF, Champenoux)

FISSA - linking Forceeps, Sureau, Phenofit... and Yasso

- Forecasting forest Socio-ecosystems' Sensitivity and Adaptation to climate change
- Coupling several simulators in Capsis
- Phenofit for phenology: preliminary simulations / file reading
- Forceeps - Sureau : internal link each year or for the driest years
- **Yasso (soil carbon storage)**



Rewriting of Yasso20 in Java
-> a library in Capsis
-> still under progress

+ micro climate
+ new soil conductance equation
+ tuned periodic writing system
...

Viskari et al. 2022

Forceeps Regional Scale

- Run Forceeps on **several regions** with several sites
- Each year, for each site, manage regeneration coming from other sites in the same region and from other regions
- **Added a new adaptive mode**
- Can manage any trait from Forceps or from Sureau

Sureau

Forceps

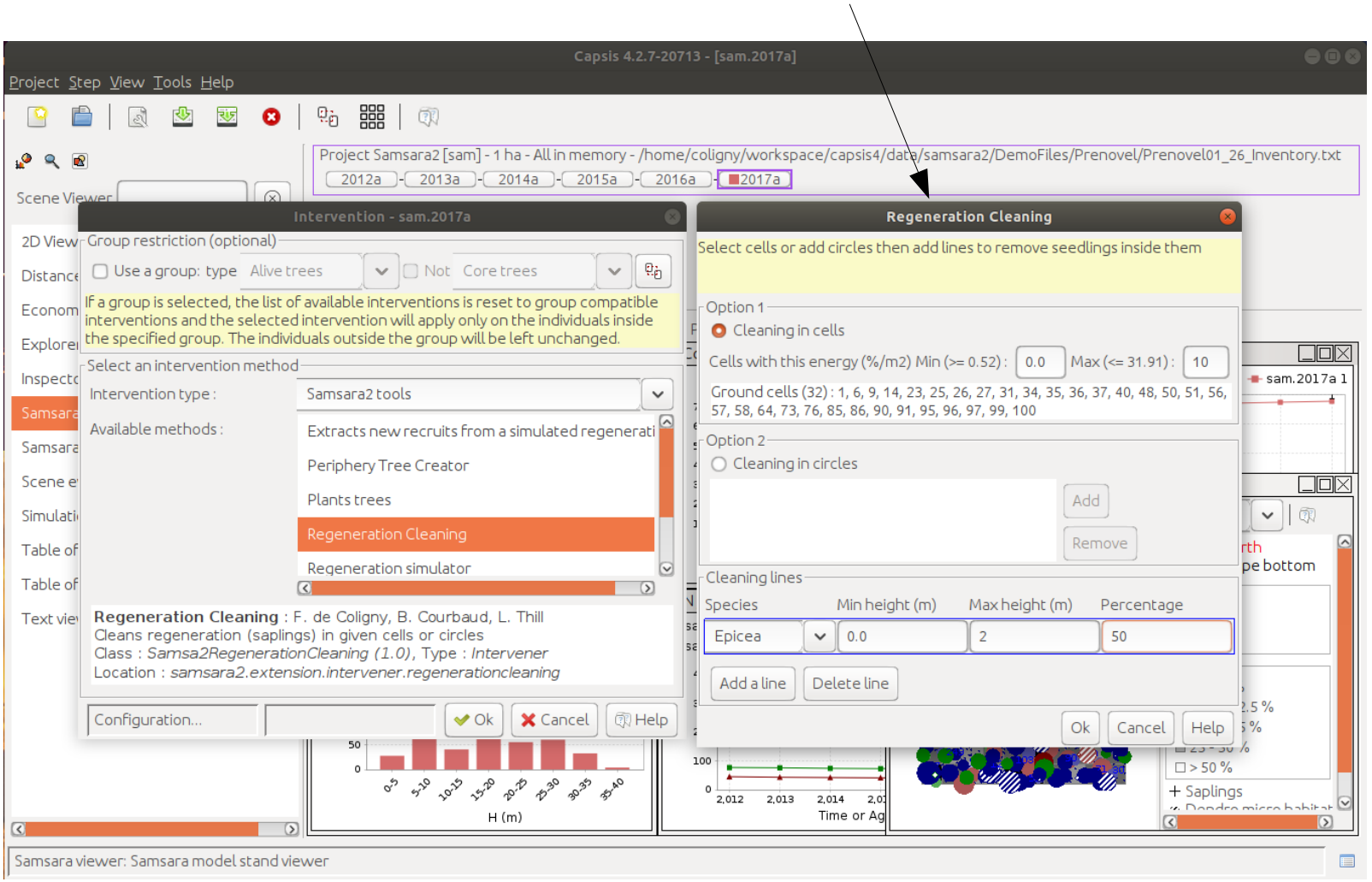
```
#Forceps File for adaptiveMode2 Louis Devresse 22.01.2024

# Trait table
# minValue and maxValue accept NA if there is no min or max bound
# traitName sd  h2  minValue    maxValue
TRAIT   P50_VC_Leaf 0.4 0.7 -20 0
TRAIT   P50_VC_Stem 0.4 0.8 -20 0
TRAIT   la  0.1 0.2 1   9
TRAIT   PiFullTurgor    0.3 0.2 -15 0
TRAIT   g   11  0.2 0   NA
TRAIT   hmax    1.5 0.4 0   NA

# Traits correlation matrix
# TraitName P50_VC_Leaf ; P50_VC_Stem ; la ; PiFullTurgor ; g ; hmax
P50_VC_Leaf 1 ; 0.9 ; 0.25 ; 0 ; 0 ; 0
P50_VC_Stem 0.9 ; 1 ; 0.25 ; 0 ; 0 ; 0
la  0.25 ; 0.25 ; 1 ; 0 ; 0 ; 0
PiFullTurgor    0 ; 0 ; 0 ; 1 ; 0 ; 0
g   0 ; 0 ; 0 ; 0 ; 1 ; 0
hmax    0 ; 0 ; 0 ; 0 ; 0 ; 1

# Traits mean
# SpId: Forceps speciesId
# SpId  SpName  TraitName   TraitMean
0   Abies alba  P50_VC_Leaf -3.79
0   Abies alba  P50_VC_Stem -3.79
0   Abies alba  la  1
0   Abies alba  PiFullTurgor    -1.22
0   Abies alba  g   350
0   Abies alba  hmax    50
17  Fagus sylvatica P50_VC_Leaf -3.79
17  Fagus sylvatica P50_VC_Stem -3.79
17  Fagus sylvatica la  1
17  Fagus sylvatica PiFullTurgor    -1.8
17  Fagus sylvatica g   260
17  Fagus sylvatica hmax    50

# If shiftConductionTraitsFromTlp is true, PiFullTurgor must be provided in the adaptive2
# traits upper (TLP will be calculated from PiFullTurgor) AND the TLP coefficient table
# must be provided below (about P88_gs and P12_gs)
shiftConductionTraitsFromTlp = true

# TLP coefficient table
# SpId: Forceps speciesId
# SpId  P88_gsCoefA P88_gsCoefB P12_gsCoefA P12_gsCoefB
0   1   0   1   0
17  1   0   1   0
```

```
/**
 * Returns the value (type double) of the given trait. First searches in
 * adaptive2 variables (priority), then in CepsSpecies variables. Only available
 * for numeric variables (int, double...), else writes in the Log and throws an
 * exception. If value not found (tRaitName error...) throws an exception.
 */
public double getTraitValue(String traitName) {
    // fc+ld-23.2.2024 This method was added late in Forceps, throws
    // RuntimeExceptions for easier code adaptation

    // In case of trouble...
    String errorMessage = "Could not get value of this trait (check its name): " + traitName;

    // --- Adaptive2Mode has priority if activated
    if (isAdaptive2TraitAvailable(traitName))
        return adaptive2TraitMap.get(traitName); // found

    // --- If not found, search in the instanceVariables of CepsSpecies

    // Get all the fields in CepsSpecies (and not in its superclasses)
    Collection<Field> fields = AmapTools.getFields(CepsSpecies.class, "all");

    for (Field f : fields) {

        if (f.getName().equals(traitName)) {
            // traitName found in the list of instanceVariables of CepsSpecies
            try {
                Object v = f.get(this); // get its value

                // fc-7.3.2024
                if (v instanceof Double)
                    return (Double) v;
                else if (v instanceof Integer)
                    return (Integer) v;

            } catch (Exception e) {
```

Samsara2

- connection with capsis.lib.**regeneration** (particular work on the saplings)
- **SylvaRock** indices to evaluate the ability of a forest to stop rock falls
- growth and mortality processes updated
- new tools to plant new saplings and **clean regeneration**

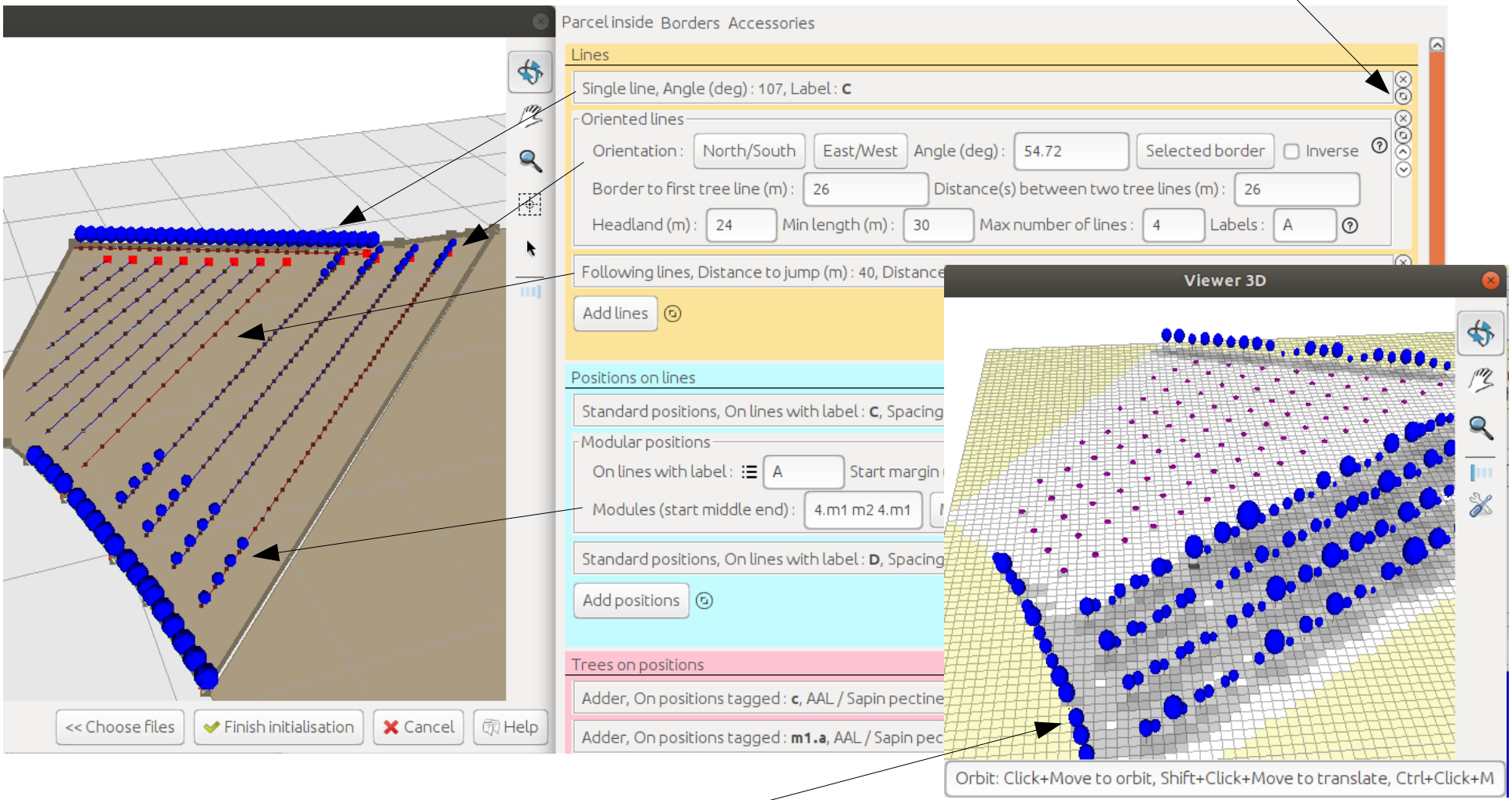
...



Frédérique Santi (INRAE Biofora, Orléans), Fabien Liagre, Pierrick Gouhier, Ambroise Martin-Chave, Camille Beral (Agroof, Anduze), Gauthier Ligot (U Liège, Gembloux, Belgium)

EcoAF

- An Agroforestry model: tree lines in parcels
- added **Single line**, **Following lines**, **reusable layout scenarios**, **expand / collapse**
- reviewed crown radius, height model,

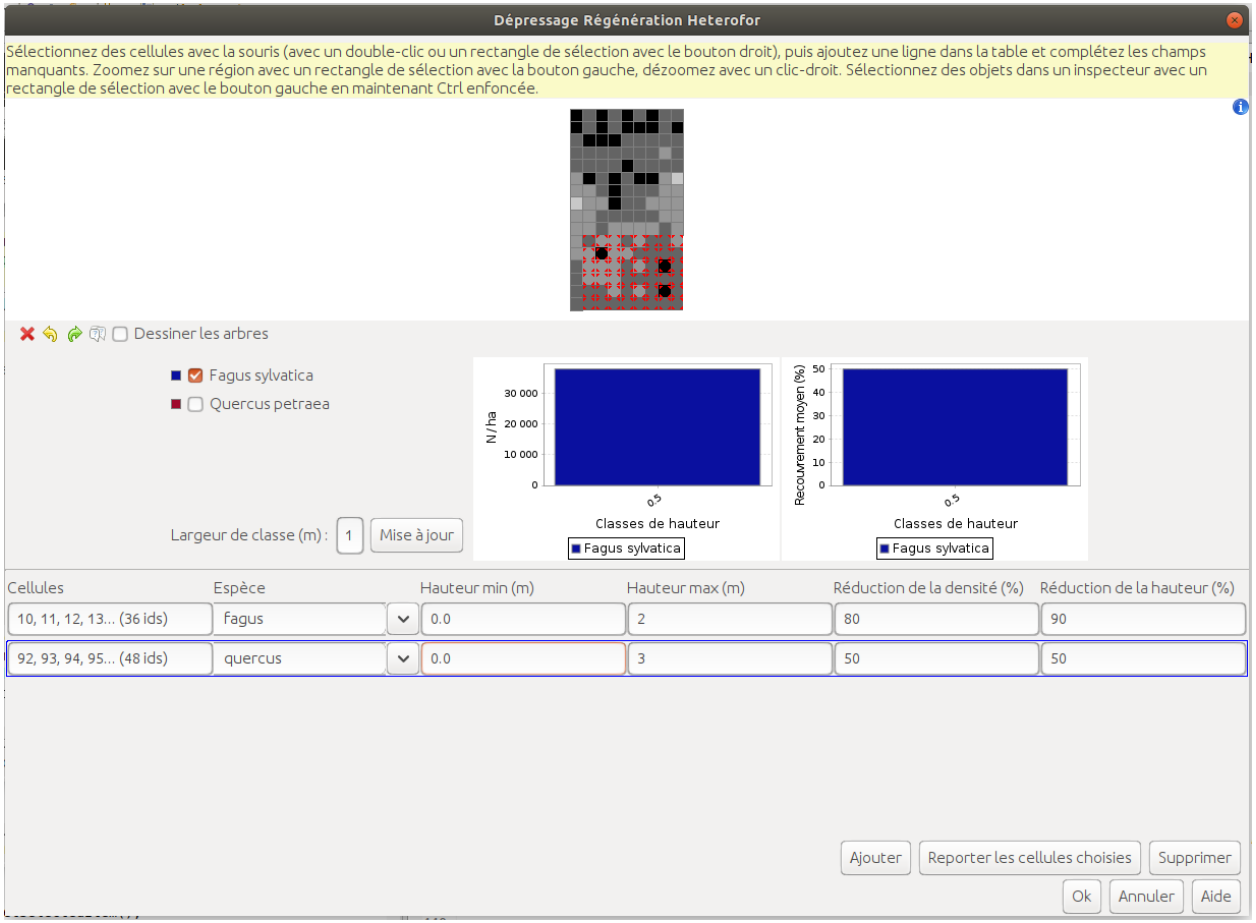


- added **border trees** in radiative balance

Heterofor

Heterofor is a spatially-explicit and individual-based model. The objective is to elaborate a model describing tree growth and resource use (solar radiation, water and nutrients) in heterogeneous forests (mixed and uneven-aged)

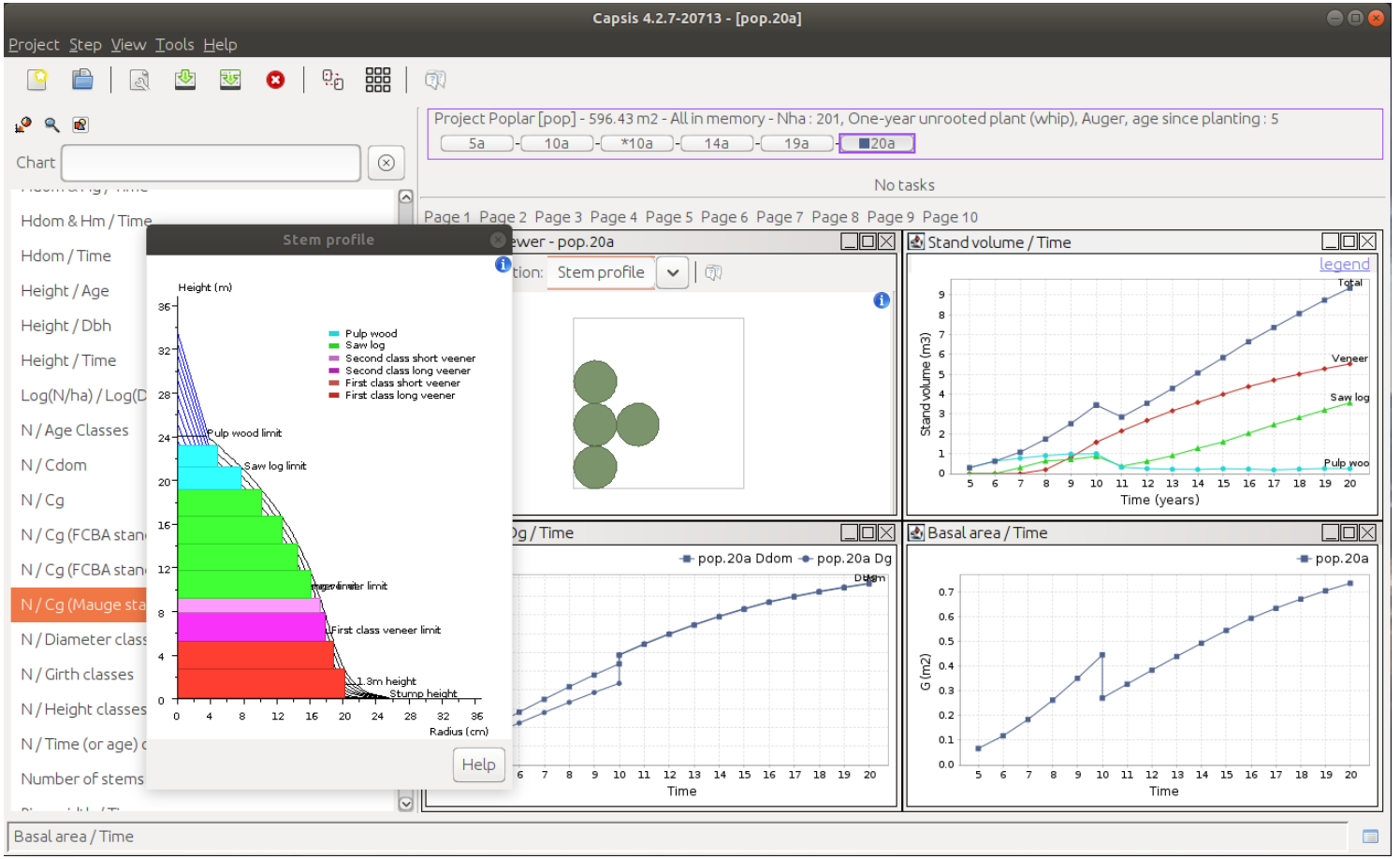
- **Regeneration clearing**, hourly meteo file, initial dialog reorganization...
- **Carbon balance module** / soil carbon dynamics
- Decaying compartments (dead wood, litter)
- ...



Poplar

A generic bio-economic model for hybrid poplar plantations. The model was conceived to simulate the dynamics and to optimize the management of poplar plantations.

- 2 visits in November 2023 / February 2024
- updated the **diameter and height sub-models**
- thinning and other improvements



Luberon2

Luberon2 is an individual-based forest dynamics model for even-aged (or even-aged per patch) monospecific stands with heritable trait variation and stochastic disturbance.

→ Added **Picea abies** species

Luberon2 user manual

a forest demo-genetic simulation software on Capsis

Version : Capsis 4.2.7-19850 [20 July 2023]

Luberon2 was developed by Claire Godineau[*1], Victor Fririon[*1], Nicolas Beudez[2], François de Coligny[2], François Courbet[1], Gauthier Ligot[3], Sylvie Oddou-Muratorio[1,4], Leopoldo Sanchez[5], François Lefèvre[1§]

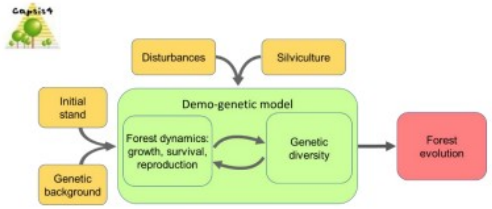
[*]co-first authors; [1]INRAE, URFM, France; [2]INRAE, AMAP, France; [3]KU Leuven, Gembloux Agro-Bio Tech, Belgium; [4]INRAE, ECOBIOP, France; [5]INRAE, BIOFORA, France; [§]contact: francois.lefevre.2@inrae.fr

***Citation of the model**: Godineau C., Fririon V., Beudez N., de Coligny F., Courbet F., Ligot G., Oddou-Muratorio S., Sanchez L., Lefèvre F. (2023). A demo-genetic model shows how silviculture reduces natural density-dependent selection in tree populations. Evolutionary Applications, doi: 10.1111/eva.13606*

The project received financial support from the Réseau Mixte et Technologique RMT AFORCE, project IGS, and from the European Union's HORIZON 2020 Research and Innovation programme under grant agreement No 773383, project B4Est.

Summary

Luberon2 is a forest dynamics model with heritable trait variation to simulate the joint effects of natural evolutionary processes including stochastic disturbance, thinning and cutting, and genetic diversity in monospecific stands: it is a demo-genetic agent-based model (Oddou-Muratorio et al, 2020; Lamarins et al, 2022). The current version runs either for cedar (*Cedrus atlantica*), Douglas fir (*Pseudotsuga menziesii*), Norway spruce (*Picea abies*), and larch (*Larix sp.*). Fir species (*Abies sp.*) are planned. Using a graphical interactive environment or a script mode, it can be used with various levels of expertise for communication, teaching, training or research purposes. The model is developed on the Capsis modeling platform[1], available upon request. This user manual contains a synthetic presentation of the model and more detailed documentation on the model. Some sections can be skipped depending on the level of use of the model: (1) simple simulations using pre-existing input files; (2) development of ad-hoc input files for personalized simulations; (3) advanced use of all parameters' flexibility; (4) extension of the model or re-use of parts of the code. Luberon2 is continuously evolving, the latest version of the user-manual and a quick tutorial to the graphical interface are available on the Capsis website[2].



[1] https://capsis.cirad.fr/
[2] https://capsis.cirad.fr/capsis/help_en/luberon2

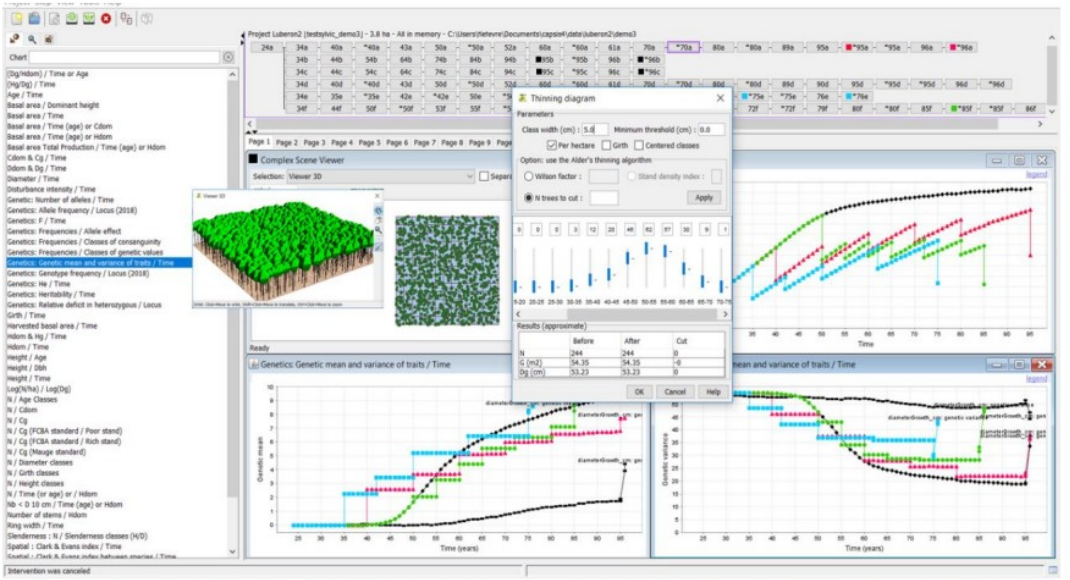
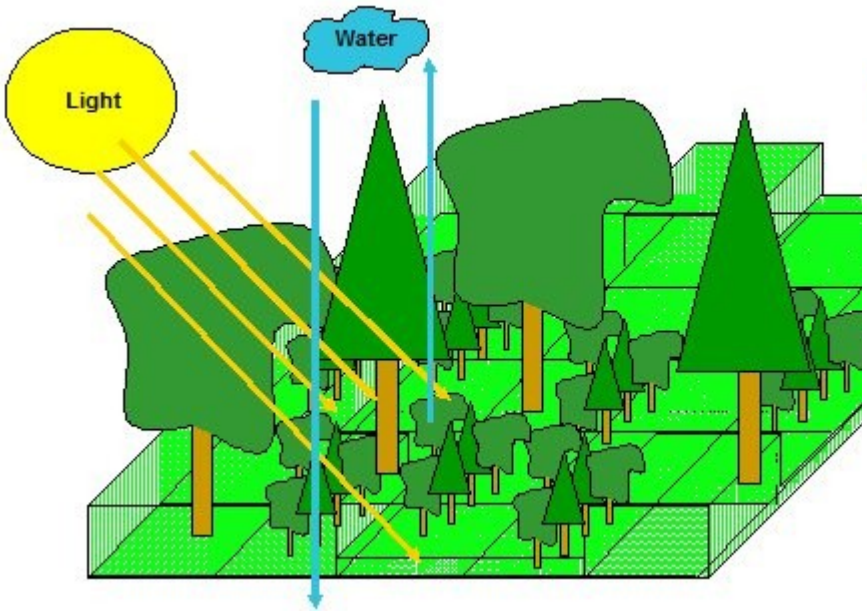


***Figure 2**: screen-shot of Luberon2. Chrono-sequences at the top show the different scenarios of events (interventions, regeneration, with or without disturbances); left panel shows the choice of graphic representations; first front pop-up window is an interactive tool to proceed selective thinning based on the distribution of individual diameters; panels behind show 2D and 3D representations of the stand, graphical comparison of different thinning scenarios in terms of the evolutions of total basal area, genetic mean and variance of vigor during the simulation.*

Mostafa Moradzadeh (INRAE FONA, Nogent sur Vernisson), Philippe Balandier (INRAE PIAF, Clermont-Ferrand)

Regeneration

The simulated scene is a 1 ha plot divided into square cells of a chosen size (a few meters). **Adult trees** are explicitly spatialised on the plot, whereas **understorey** vegetation and regeneration are considered as a multi-species layer whose characteristics vary at the cell level. Vegetation is described by its height and cover. Tree regeneration, i.e. seedlings and saplings, are initialised as cohorts characterized by a diameter and height distribution. The overstorey and understorey growth time step is annual, whereas within this annual loop, the **light interception** and **water cycle** (interception, evapotranspiration and soil water content) processes are simulated, respectively, monthly and daily.



Root cone intersection with the soil layers:

the root cone is cut into **successive cylinders** superimposed according to the depth of the soil layers. Then the **layers of soil** in each cell are also **assimilated to cylinders** (of the same surface area as the cube), which allows us to return to the (relatively simple) calculation of the intersection surface of two disks

Cone-shaped root pattern

Figure 1 illustrates the distribution of roots and their uptake patterns in trees. As evident from the figure, as we approach the end of the root system, the distribution of root patterns decreases.

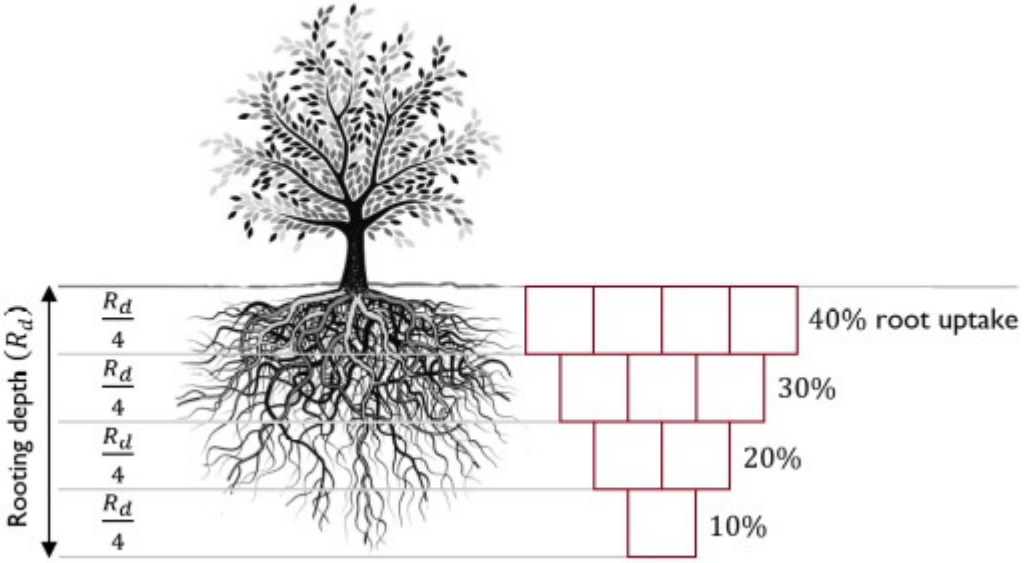
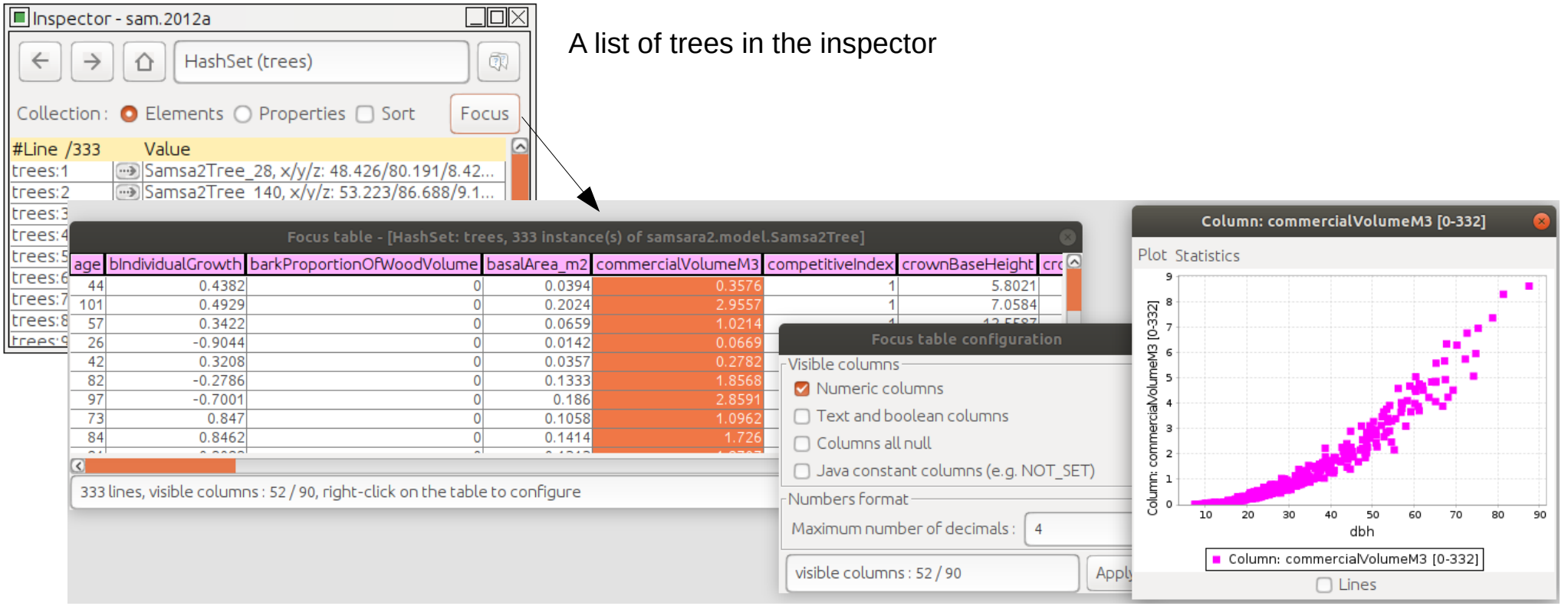


Fig 1. Root distribution and uptake patterns.

Recent Features in Capsis

Reviewed in 2023

Focus table: to view a list of objects from the inspector



A list of trees in the inspector

Focus table: a tree per line, its properties in columns

Configuration : which columns, number of fraction digits

Right click on a column > plot the values

Capsis web site

Capsis

Computer-aided projection of strategies in silvicultu

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- **Screenshots**
- Charter
- Publications
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- Transfer/Teaching
- Development
- FOREM
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AMAP

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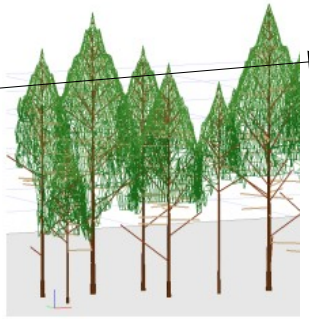
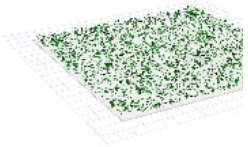
IRD

Screenshots

A set of 25 years old douglas trees
(Guillaume Salzet, Thomas Aiguier,



A forest growing during 1000 years



Simulation with Phenofit4 of Querc
(Victor van der Meersch, Novembe

5. Reports of Capsis / FOREM annual meetings

The Capsis annual meetings take place each year during the **FOREM meeting** (formerly CAQSIS). All the members are invited to talk together about the current / active / short term beginning projects. Every meeting results in a report that you can find below.

FOREM : Forest And Modeling

FOREM is the animation network of French-speaking researchers and developers involved in the modeling of forest-wood systems in their environments.

Its objective is to create opportunities for meetings and exchanges around the study of forest dynamics and the genetic, environmental and silvicultural factors that control it. Topics also cover interactions with the socio-economic sphere: forest-wood sector, ecosystem services, risk management, territories. Thesis and job offers are regularly sent to the network's mailing list.

The members of the Capsis project, a simulation platform for forest growth and dynamics models, meet within the framework of this network.

The FOREM network is an inter-organism and multidisciplinary scientific animation tool supported by INRAE's ECODIV department (formerly INRA's EFPA department). From 1999 to 2019, this network was called the CAQ network and then CAQSIS.

FOREM

*The Capsis platform modellers have been meeting each year since 1999, first in a dedicated **Capsis meeting** around April, then since 2011, it joined with the annual meeting of the CAQ network (Gérard Nepveu - INRA Lerfob, Nancy) to become **the CAQSIS meeting** (Céline Meredieu, Mathieu Fortin (until 2015), Francis Colin (2016-2017), Thiéry Constant and Francois de Coligny), itself turned into the **FOREM meeting** in 2020.*

Reports of the meetings :

- **April 9-11 2023, FOREM 2023, INRAE Lessem Grenoble (fr)**
- March 22-23 2022, FOREM 2022, INRAE BioforA Orléans (fr)
- June 15 2021, FOREM 2021 meeting in videoconference
- [CANCELLED] The FOREM 2020 meeting will be held in Orléans next March 31 - April 2, 2020, hosted by INRAE BioForA.
- March 26-28 2019, IRSTEA Recover Aix-en-Provence - CAQSIS 2019
- March 27-29 2018, INRA PIAF Clermont-Ferrand - CAQSIS 2018
- March 28-30 2017, FCBA Bordeaux - CAQSIS 2017 *(24.4.2017 - cm, fc)*

Capsis Training Sessions

The Capsis annual training session took place on 20-21 June 2023 in Montpellier

5 people attended the session

Capsis 4.2.6 training (January 2020)

- Java introduction LibreOffice file pdf file
- Java exercises LibreOffice file pdf file
- Capsis training LibreOffice file pdf file
- Capsis exercices LibreOffice file pdf file

Publication

The Capsis Publication page, 2024, extract :

Metsaranta J.M., Fortin M., White J.C., Sattler D., Kurz W.A., Penner M., Edwards J., Hays-Byl W., Comeau R., Roy V. **2024**. Climate sensitive growth and yield models in Canadian forestry: Challenges and opportunities. **The Forestry Chronicle**. 26 February 2024. doi

Barrere J., Ligot G., Boulanger V., Collet C., Courbaud B., de Coligny F., Mårell A., Saïd S., Balandier P., **2023**. Oak regeneration facing deer browsing: Can competition between saplings offset the diversion effect? A simulation experiment. **Ecological Modelling**, volume 489, March 2024, 110608, doi

Godineau C., Fririon V., Beudez N., de Coligny F., Courbet F., Ligot G., Oddou-Muratorio S., Sanchez L., Lefèvre F. **2023**. A demo-genetic model shows how silviculture reduces natural density-dependent selection in tree populations. **Evolutionary Applications**, 16, 1830–1844. doi

Fririon, V., Lefèvre, F. **2023** Simulation data with the demo-genetic forest model Luberon2: random thinning and disturbance scenarios in Cedrus atlantica. doi, Recherche Data Gouv, V1

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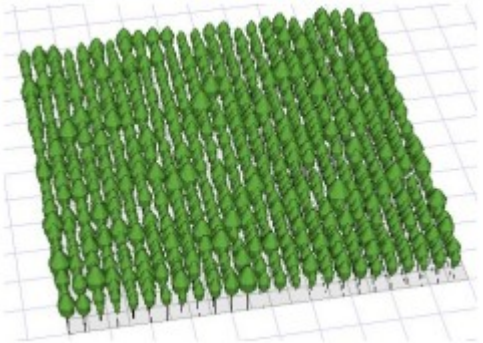
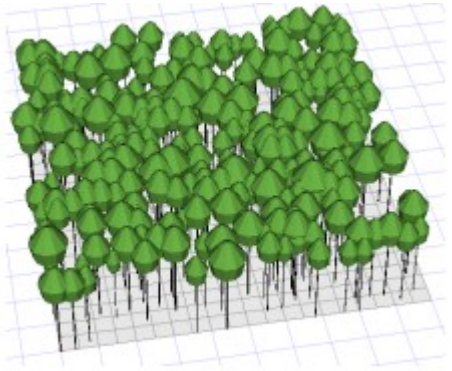
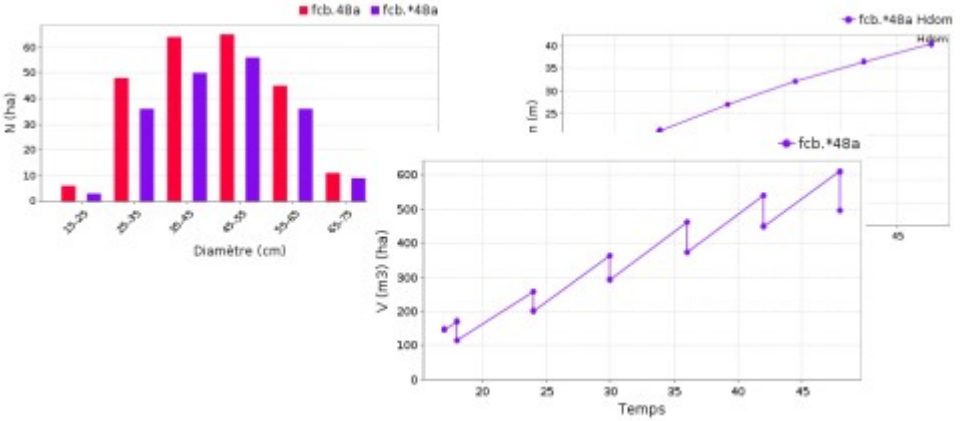
Conclusions

- Capsis is going through a period of deepening
- Less new projects but more model coupling (climate, soil, roots, litter, dead wood, carbon...)
- More optional features in the models
- Model coupling results in more complex code
- Still working in video conference with the modellers on a routine basis, 2 to 4 days per week
- A request ro replace Nicolas Beudez is resent every year







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Thanks for your attention