Capsis Project Activity : 2019 - 2021

FOREM 2021 meeting – 15 June 2021

Francois de Coligny

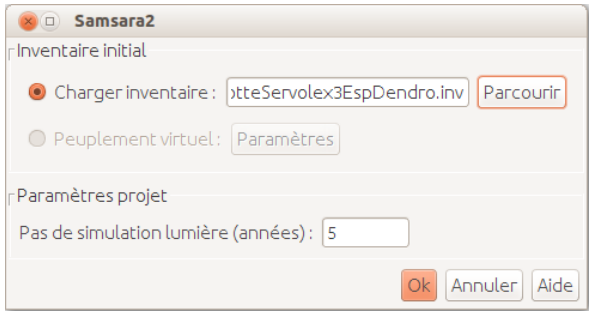
INRAE - AMAP
botany and modelling of plants architecture and vegetations

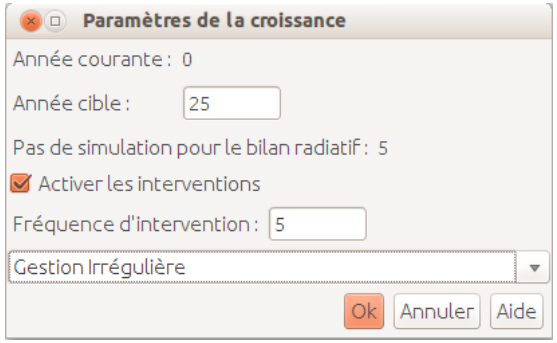
Capsis objective

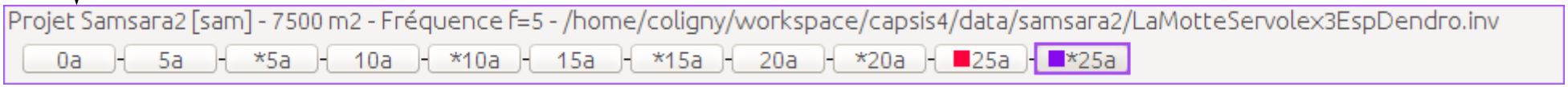
Computer-Aided Projections of Strategies In Silviculture

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

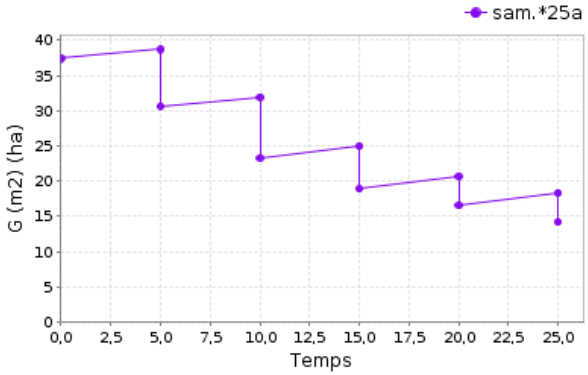
1. initialisation

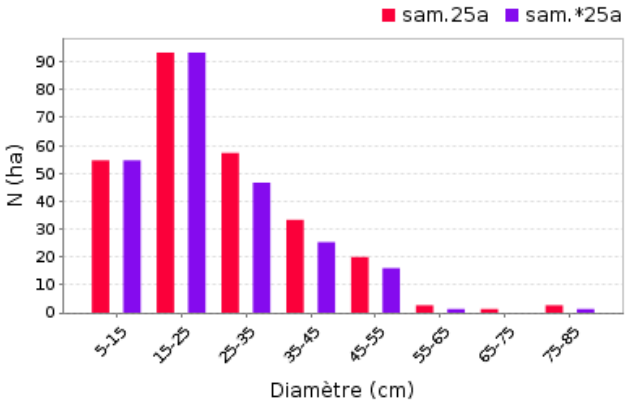






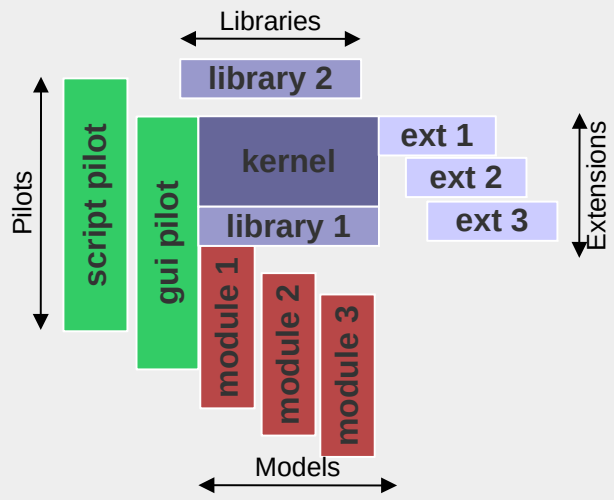
2. growth



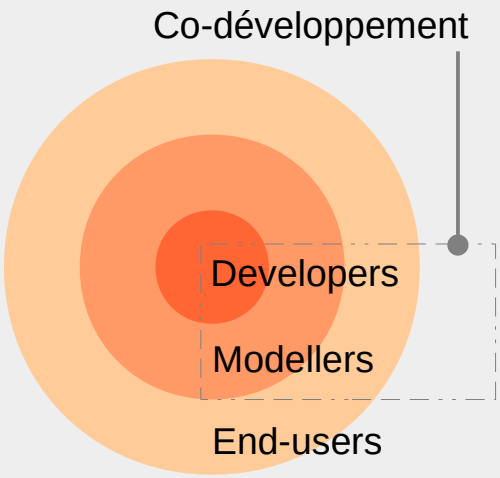


export

A co-development oriented organisation



Software architecture



Actors and roles

Free software (LGPL)

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

Clear property rules

Method: care for the modellers

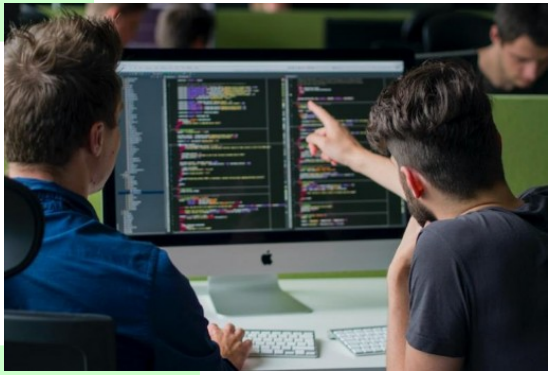
Targeted public: a modeller has designed a forestry growth model and wishes to integrate it in Capsis to get a simulator for his own objectives

- 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

New Projects (1/2)

- **SIMREG** : A non-deterministic tree-level distance independent forest model that can simulate forest growth, yield and management on a regional scale while representing the wide diversity of composition, structure and management found in forest stands
  Jérome Perin, Mikhail Pitchugin, Gauthier Ligot, University of Liège - Gembloux Agro-Bio Tech

- **C-STABILITY** : A modeling framework to leverage the continuous representation of organic matter
  Julien Sainte-Marie (1, 2), Delphine Derrien (2), Laurent Saint-André (2), Matthieu Barrandon (3) (1. AgroParisTech Silva, Nancy, 2. INRAE BEF, Nancy, 3. Université de Lorraine IECL, Nancy)

- **EsPaCe** : A growth model for young forests in Québec, connected to Artemis and Natura models
  Emmanuel Duchateau, Isabelle Auger, Dany Camirand, Thierry Kubwimana (Ministry of Forests, Wildlife and Parks of Québec, Canada)

New Projects (2/2)

- **Simcop-Qual** : A branching and nodosity model linked to the Simcop model
  Julien Sainte-Marie, Guillaume Salzet, Thomas Aiguier (UMR Silva, Nancy)

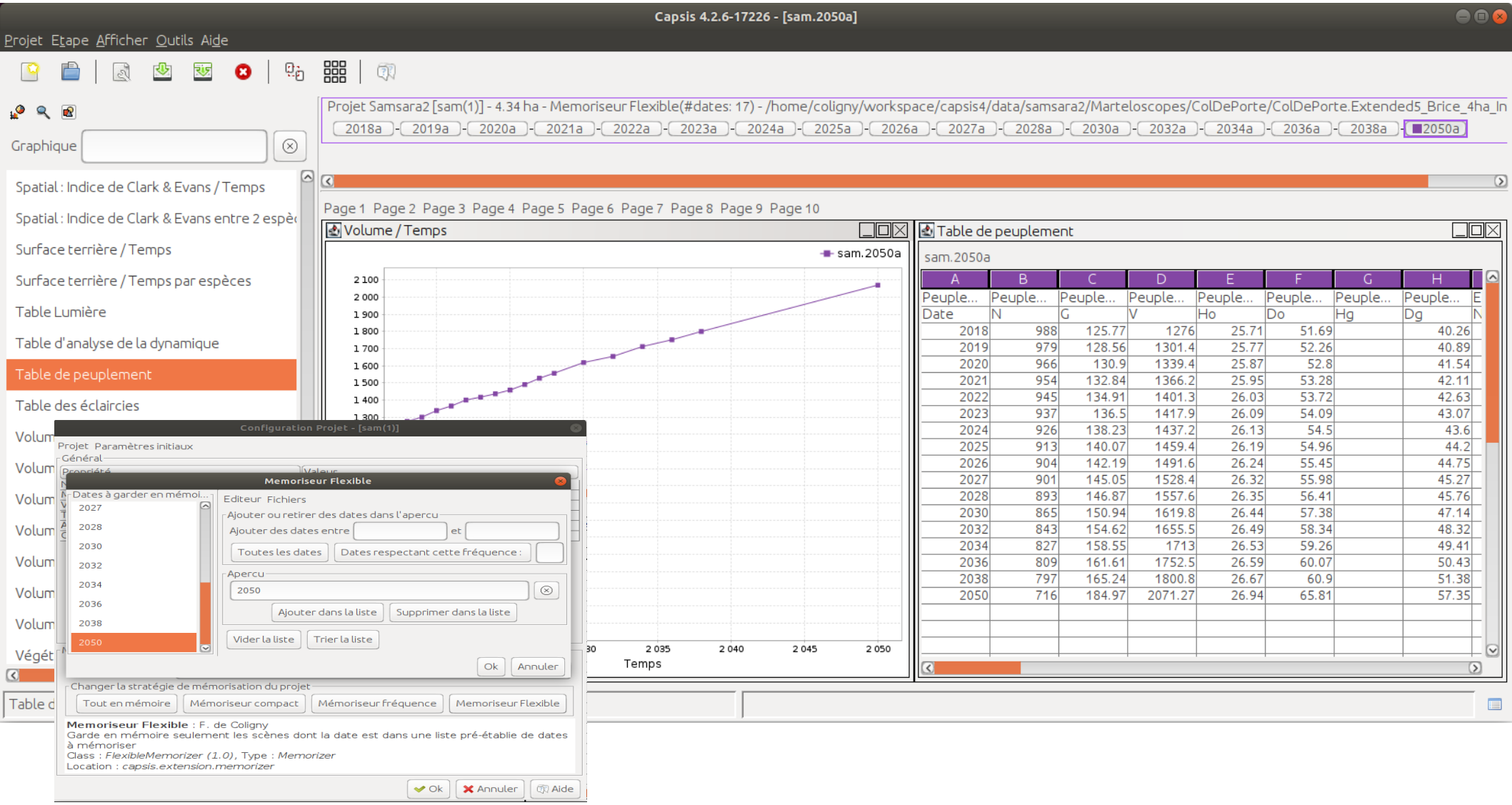
- **Poplar** : A generic bio-economic model for hybrid poplar plantations. The model was conceived to simulate the dynamics and to optimize the management of poplar plantations
  Seyed Mahdi Heshmatol Vaezin (University of Tehran, Iran)

- **Sureau** : A plant hydraulic model that represents explicitly water flow between the soil, the plant and the atmosphere and the process of cavitation that leads to plant desiccation and mortality
  Nicolas Martin, Francois Pimont, Julien Ruffault (INRAE URFM, Avignon), Hervé Cochard (INRAE Piaf, Clermont-Ferrand)

- **Ibasam** : A metapopulation model to study salmon species population eco-evolutionary dynamics, accounting for river and marine ecosystems
  Mathieu Buoro, Amaia Lamarins, Jacques Labonne (INRAE Ecobiop)

New Features in Capsis

FlexibleMemorizer :
a way to keep only some steps in a simulation based on <u>a file of years</u> to be kept



A	B	C	D	E	F	G	H
Peuple...	Peuple...	Peuple...	Peuple...	Peuple...	Peuple...	Peuple...	Peuple...
Date	N	G	V	Ho	Do	Hg	Dg
2018	988	125.77	1276	25.71	51.69		40.26
2019	979	128.56	1301.4	25.77	52.26		40.89
2020	966	130.9	1339.4	25.87	52.8		41.54
2021	954	132.84	1366.2	25.95	53.28		42.11
2022	945	134.91	1401.3	26.03	53.72		42.63
2023	937	136.5	1417.9	26.09	54.09		43.07
2024	926	138.23	1437.2	26.13	54.5		43.6
2025	913	140.07	1459.4	26.19	54.96		44.2
2026	904	142.19	1491.6	26.24	55.45		44.75
2027	901	145.05	1528.4	26.32	55.98		45.27
2028	893	146.87	1557.6	26.35	56.41		45.76
2030	865	150.94	1619.8	26.44	57.38		47.14
2032	843	154.62	1655.5	26.49	58.34		48.32
2034	827	158.55	1713	26.53	59.26		49.41
2036	809	161.61	1752.5	26.59	60.07		50.43
2038	797	165.24	1800.8	26.67	60.9		51.38
2050	716	184.97	2071.27	26.94	65.81		57.35

New Features in Capsis

E.g. Samsara2, basal area / species

List of Categories

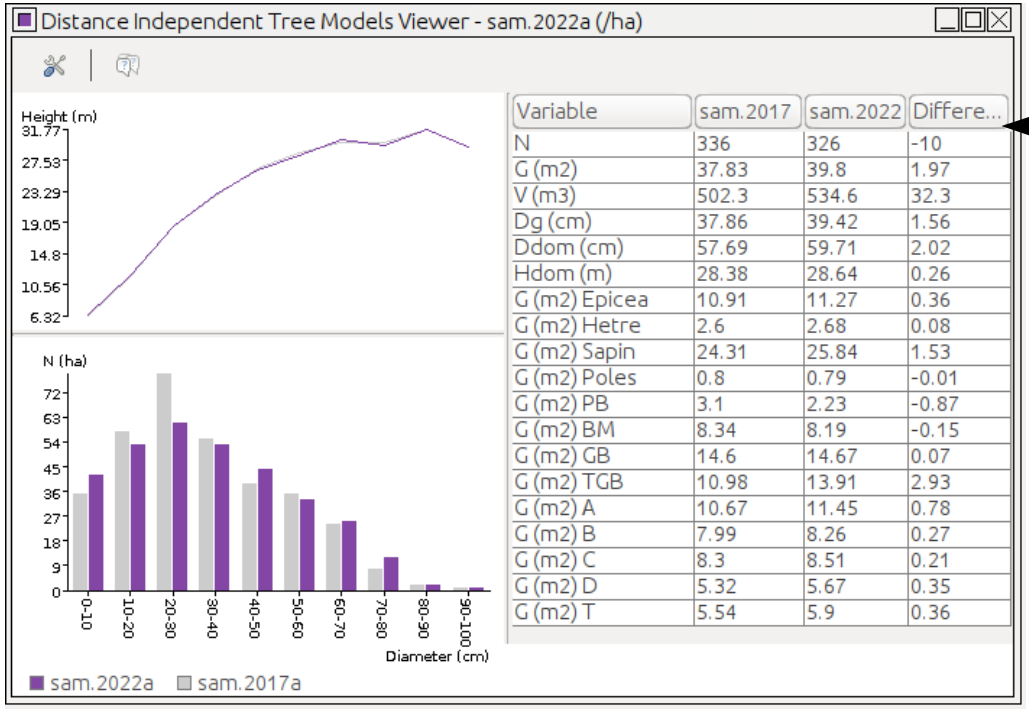
- Basal area / species
- Basal area / quality
- ...

```
/**
 * SpeciesBasalAreaProvider Returns a list of basalArea per species categories
 * for the given trees.
 */
public ListOfCategories getListOfSpeciesBasalArea(GScene stand, Collection trees) {
    if (trees == null)
        trees = new ArrayList(); // empty

    // Create a list of categories for the given trees
    Samsa2SpeciesCategories loc = new Samsa2SpeciesCategories(trees);
    // Feed the categories with the sums of basal area for the trees
    loc.applyCalculator(new Samsa2BasalAreaCalculator(), trees);

    return loc;
}
```

1. categories / species

2. apply a basal area calculator

3. show in a viewer



Variable	sam.2017	sam.2022	Differe...
N	336	326	-10
G (m2)	37.83	39.8	1.97
V (m3)	502.3	534.6	32.3
Dg (cm)	37.86	39.42	1.56
Ddom (cm)	57.69	59.71	2.02
Hdom (m)	28.38	28.64	0.26
G (m2) Epicea	10.91	11.27	0.36
G (m2) Hetre	2.6	2.68	0.08
G (m2) Sapin	24.31	25.84	1.53
G (m2) Poles	0.8	0.79	-0.01
G (m2) PB	3.1	2.23	-0.87
G (m2) BM	8.34	8.19	-0.15
G (m2) GB	14.6	14.67	0.07
G (m2) TGB	10.98	13.91	2.93
G (m2) A	10.67	11.45	0.78
G (m2) B	7.99	8.26	0.27
G (m2) C	8.3	8.51	0.21
G (m2) D	5.32	5.67	0.35
G (m2) T	5.54	5.9	0.36

new column : difference between the two steps

basal area / species : Epicea, Hetre, Sapin

basal area / wood large categories
Poles, PB, BM, GB, TGB

basal area / quality : A, B, C, D, T

New Features in Capsis

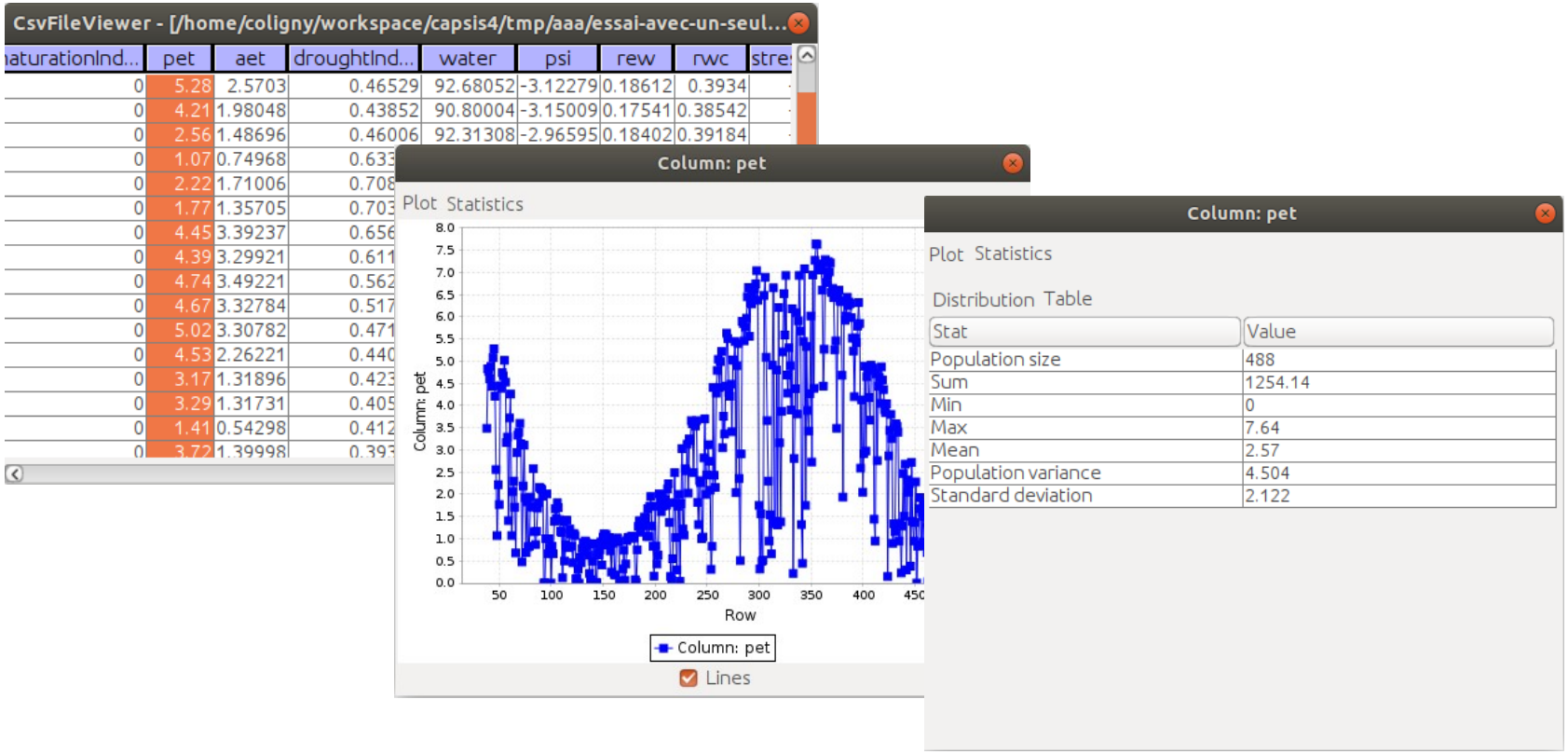
List of Values

A way to get easily statistics
on a list of values

Programmatically

```
// fc-9.3.2021
ListOfValues lov = new ListOfValues(treesSupDbhMin) {
    @Override
    public double getValue(Object o) {
        Samsa2Tree tree = (Samsa2Tree) o;
        return tree.getDbh();
    }
};

lov.getFormattedStatistics(lov.ARITHMETIC_MEAN, nf, "NA")
lov.getFormattedStatistics(lov.STANDARD_DEVIATION, nf, "NA")
lov.getFormattedStatistics(lov.SKEWNESS, nf, "NA")
...
```

E.g. in a Capsis table > Plot a column > Statistics



New Features in Capsis

Log headers

In Capsis, it is easy to write in log files with a chosen name, e.g. **SureauComputeCFL.log**

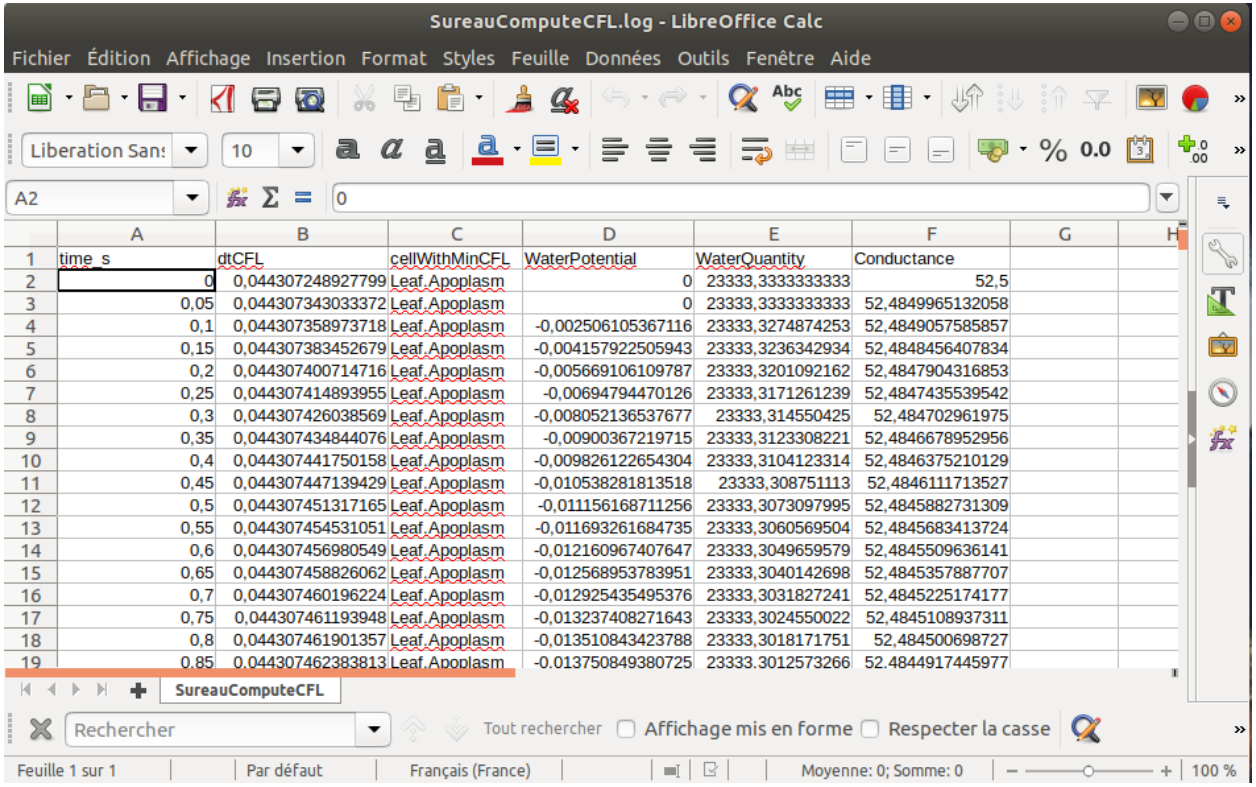
New : prepareHeader (...)

Now just before the writing in the Log with println()

```
// fc-nm-30.4.2021 Big detailled trace for debugging
// This header will only be written once in the log
Log.prepareHeader("SureauComputeCFL", "time_s" + "\t" + "dtCFL" + "\t" + "cellWithMinCFL" + "\t"
        + "WaterPotential" + "\t" + "WaterQuantity" + "\t" + "Conductance");
Log.println("SureauComputeCFL",
        "" + time_s + "\t" + dtCFL + "\t" + cellWithMinCFL.getName() + "\t" + cellWithMinCFL.getWaterPotential()
                + "\t" + cellWithMinCFL.getWaterQuantity() + "\t" + cellWithMinCFL.getConductance());
```

The header is written just once

Same location than println () : easier to keep up to date



	A	B	C	D	E	F
1	time_s	dtCFL	cellWithMinCFL	WaterPotential	WaterQuantity	Conductance
2	0	0,044307248927799	Leaf.Apoplasm	0	23333,3333333333	52,5
3	0,05	0,044307343033372	Leaf.Apoplasm	0	23333,3333333333	52,4849965132058
4	0,1	0,044307358973718	Leaf.Apoplasm	-0,002506105367116	23333,3274874253	52,4849057585857
5	0,15	0,044307383452679	Leaf.Apoplasm	-0,004157922505943	23333,3236342934	52,4848456407834
6	0,2	0,044307400714716	Leaf.Apoplasm	-0,005669106109787	23333,3201092162	52,4847904316853
7	0,25	0,044307414893955	Leaf.Apoplasm	-0,00694794470126	23333,3171261239	52,4847435539542
8	0,3	0,044307426038569	Leaf.Apoplasm	-0,008052136537677	23333,314550425	52,484702961975
9	0,35	0,044307434844076	Leaf.Apoplasm	-0,00900367219715	23333,3123308221	52,4846678952956
10	0,4	0,044307441750158	Leaf.Apoplasm	-0,009826122654304	23333,3104123314	52,4846375210129
11	0,45	0,044307447139429	Leaf.Apoplasm	-0,010538281813518	23333,308751113	52,4846111713527
12	0,5	0,044307451317165	Leaf.Apoplasm	-0,011156168711256	23333,3073097995	52,4845882731309
13	0,55	0,044307454531051	Leaf.Apoplasm	-0,011693261684735	23333,3060569504	52,4845683413724
14	0,6	0,044307456980549	Leaf.Apoplasm	-0,012160967407647	23333,3049659579	52,4845509636141
15	0,65	0,044307458826062	Leaf.Apoplasm	-0,012568953783951	23333,3040142698	52,4845357887707
16	0,7	0,044307460196224	Leaf.Apoplasm	-0,012925435495376	23333,3031827241	52,4845225174177
17	0,75	0,044307461193948	Leaf.Apoplasm	-0,013237408271643	23333,3024550022	52,4845108937311
18	0,8	0,044307461901357	Leaf.Apoplasm	-0,013510843423788	23333,3018171751	52,484500698727
19	0,85	0,044307462383813	Leaf.Apoplasm	-0,013750849380725	23333,3012573266	52,4844917445977

New Features in Capsis

Parallel scripts

- Based on the standard command file driven script in Capsis
- This runs a simulation for each line of a command file
- Introduction of a parallel loop to run several simulations in parallel
- The simulations must be completely separated
- A check of the model structure may be required
- -> if many simulations to be ran, faster

Used in Forceeps, Salem...

Standard loop :

```
// Run a simulation per line in commandFileReader
int k = 0;
for (SimulationCommandReaderDivProd.SimulationLine line : commandReader.simulationLines) {
    k++;
    runOneSimulation(k, commandReader.setupFileName, commandReader.numberOfYearsToBeJumped,
            commandReader.exportTimeStep, line);

}
```

Parallel loop (I can help for the syntax) :

```
// fc-29.4.2020 Run the simulations in parallel
// with nThreads threads
forkJoinPool.submit(() -> indexedLines.parallelStream().forEach((line) -> {

    // k++; // fc-29.4.2020 Can not be used with parallelStream

    runOneSimulation(line.index, commandReader.setupFileName, commandReader.numberOfYearsToBeJumped,
            commandReader.exportTimeStep, line.simulationLine);

})).get(); // This makes it an overall blocking call
// fc-29.4.2020: end of parallel processing
```

J4R by Mathieu Fortin

- J4R is a technology developed by REpicea (Mathieu Fortin and Jean-Francois Lavoie) to call Java programs from R.
- It tries to be simpler to use than other technologies including rJava.
- J4R is based on a client/server architecture, with a server running transparently Java on your local machine.
- Can help run Capsis scripts from R scripts (sensitivity analysis, optimisation...)

https://sourceforge.net/p/repiceasource/wiki/J4R/

Preview:

Calling Java methods

Calling a method on a Java object

In this example, the value of 15 is added to the ArrayList instance that was previously created. The method add returns a boolean. Then we call the method .get(0) on the same object. The value of 15 is then returned to R.

```
> callJavaMethod(mySimpleJavaObject, "add", 15)
[1] TRUE
> callJavaMethod(mySimpleJavaObject, "get", as.integer(0))
[1] 15
>
```

Because mySimpleJavaObject is an instance of a Java object, the $ operator can also be used instead of the callJavaMethod as in the following example:

```
> mySimpleJavaObject$add(15)
[1] TRUE
> mySimpleJavaObject$get(as.integer(0))
[1] 15
>
```

Fortin (2020), PeerJ Comput. Sci., DOI 10.7717/peerj-cs.300

Capsis Training Sessions

15 - 16 January 2020 : 8 people
28 - 29 Sep 2020, Québec, video conference, 3 people
22 Jan 2021, Québec, video conference, 1 person
3 - 4 Feb 2021, video conference : 7 people

Capsis
Computer-aided projection of strategies in silviculture

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The Capsis training online

fc-January 2021

This is an online version of the supervised exercises within the Capsis training, built to better fit the training by video conference.

- The Capsis training online
- Installation, video links and organisation
- The java exercises online (first afternoon)
- The Capsis exercises online (second afternoon)

Note: this training online material is part of the annual session of the Capsis training course, for registered modelers or students.

Installation, video links and organisation

Before d-day, please see the installation section below:

- 0. Installation

On d-day, video conference links (will be updated):

- **Foxtrot** video (**F**rancois), click or copy this link in your browser: https://meet.google.com/quf-jrru-uxw
- **Papa** video (**P**hilippe) click or copy this link in your browser: https://meet.google.com/ces-eznb-mbi
- **Golf** shared document (**G**oogle Doc) editable by all (hopefully) click here

In the morning, **everybody connects to the Foxtrot** video conference for the courses. In the afternoon, we will start on Foxtrot, then some may switch to Papa.

Problems:

- I'm lost, I don't remember where to go… → go to the Foxtrot video link upper, will always stay open (hopefully)
- I can not connect to this video link
  - try with **another browser** (Chrome, Firefox…)
  - try **from your phone** (if it is smart enough), you might join us this way and you could download the presentation pdfs on your computer to follow the courses

AMAP
cirad
cnrs
INRAE
IRD

The java exercises online (first afternoon)

- 1. Create a minimal program
- 2. Create a Tree class
- 3. Create a SpatializedTree class
- 4. Add instance variables in the tree
- 5. Add methods in the tree
- 6. Write a method to create a list of trees
- 7. Write the trees in a file
- 8. Pass parameters on the command line

The Capsis exercises online (second afternoon)

- 10. Create a new module in Capsis called training
- 11. Random regeneration
- 12. Mortality
- 13. Add a geometrical plot made of square cells
- 14. Make a graph: N / Time
- 15. Script
- 16. Regeneration around the mothers

Transfert

A new page on the Capsis web page : http://capsis.cirad.fr/capsis/transfer

Distribution annuelle ONF (Christine Deleuze)

Office National des Forêts

Direction Forêt et Risques Naturels – D

Tel : 06 10 33 10 47, Mél : christine.

Objet :	**CR d'installeur Capsis ONF 2019 versic**
Date :	9 janvier 2020
Rédacteur :	Christine Deleuze
Destinataires :	DFRN-RDI, Thierry Sardin, Médéric A Maréchal, Paul Del-Rey, Francis Maug Xavier Mandret, Sébastien Laguet, Eric M tous les développeurs CAPSIS participants

Dossier partagé : PartageRDI\04-Outils\06-Capsis\Capsis_ON

CAPSIS ONF 2019

En 2018-19, 23 modules étaient accessibles, le module De module Luberon2 a été ajouté, soient 24 modules cette ann fagacees, forceps, gymnos, heterofor, laricio, luberon2, mathil 2, organon, picea-abies, pseudotsuga menziesii, PNN2, regix,

Le module Simcop pourra être disponible dans un second tem

Office National des Forêts

Direction Forêt et Risques Naturels – Département RDI

Tel : 06 10 33 10 47, Mél : christine.deleuze@onf.fr

Objet :	**CR d'installeur Capsis ONF 2020 version 4.2.6**
Date :	10 décembre 2020
Rédacteur :	Christine Deleuze
Destinataires :	DFRN-RDI, Thierry Sardin, Médéric Aubry, Fabrice Coq, Marie-Claire Maréchal, Paul Del-Rey, Francis Maugard, Denis Feuillerat, Pauline Delord, Xavier Mandret, Sébastien Laguet, Eric Mermin, Michel Chartier, Simon Martel, tous les développeurs CAPSIS participants et François de Coligny !

Dossier partagé : PartageRDI\04-Outils\06-Capsis\Capsis_ONF2020

CAPSIS ONF 2020

En 2020, 26 modules sont accessibles : abial, artémis, CA1, castaneaonly, economics, fagacees, forceps, gymnos, heterofor, laricio, lemoine, luberon2, mathilde, modispinaster, oakpine 1 et 2, organon, picea-abies, pseudotsuga menziesii, PNN2, pp3, regix, salem, samsara2, sydy, sylvestris. Nous retrouvons les deux modules pin maritime : pp3 et lemoine, et avons ajouté le module castaneaonly.

Le module Simcop pourra être disponible dans un second temps en fonction des demandes.

Publication

The Capsis Publication page, 2020, extract :

Morin X., Bugmann H., de Coligny F., Martin StPaul N., Cailleret M., Limousin J.-M., Ourcival J.-M., Prevosto B., Simioni G., Toigo M., Vennetier M., Catteau E., Guillemot J., 2021. Beyond forest succession: A gap model to study ecosystem functioning and tree community composition under climate change. Functional Ecology, 2021;00:1–21, doi:10.1111/1365 2435.13760

Régolini, M., Meredieu, C., Jactel, H., Arias-González, A., Branco, M., Cantero, A., Castro, A., Fraysse, J., Gardiner, B., Hevia, A., Lario, F., Steffy-Pater, C., Rodríguez-Soalleiro, R., Soares, P., & Orazio, C. 2020. Multi-criteria analysis to compare multiple risks associated with management alternatives in planted forests. Forest Systems, 29(2), e004. doi:http://dx.doi.org/10.5424/fs/2020292-15660

Schneider R., Franceschini T., Duchateau E., Bérubé Deschênes A., Dupont Leduc L., Proudfoot S., Power H, de Coligny F. 2020. Influencing plantation stand structure through•close to nature silviculture. European Journal of Forest Research, https://rdcu.be/cdtAQ

Perin J., Pitchugin M., Hébert J., Brostaux Y., Lejeune P., Ligot G., 2020. SIMREG, a tree-level distance-independent model to simulate forest dynamics and management from national forest inventory (NFI) data. Ecological Modelling, Volume 440, 2021, 109382, https://doi.org/10.1016/j.ecolmodel.2020.109382

Chevalier L., de Coligny F., Labonne J. 2020. A demogenetic agent based model for the evolution of traits and genome architecture under sexual selection, bioRxiv, 2020.04.01.014514, ver. 4 peer-reviewed and recommended by Peer Community in Evolutionary Biology. https://www.biorxiv.org/content/10.1101/2020.04.01.014514v4

Morin X., Damestoy T., Toigo M., Castagneyrol B., Jactel H., de Coligny F., Meredieu C., 2020. Using forest gap models and experimental data to explore long-term effects of tree diversity on the productivity of mixed planted forests. Annals of Forest Science (2020) 77: 50. https://doi.org/10.1007/s13595-020-00954-0

de Wergifosse L., André F., Beudez N., de Coligny F., Goosse H., Jonard F., Ponette Q., Titeux H., Vincke C., Jonard M., 2020. HETEROFOR 1.0: a spatially explicit model for exploring the response of structurally complex forests to uncertain future conditions. II. Phenology and water cycle. Geosci. Model Dev., 13, 1459–1498, https://doi.org/10.5194/gmd-13-1459-2020, 2020.

Jonard M., André F., de Coligny F., de Wergifosse L., Beudez N., Davi H., Ligot G., Ponette Q., Vincke C., 2020. HETEROFOR 1.0: a spatially explicit model for exploring the response of structurally complex forests to uncertain future conditions. I. Carbon fluxes and tree dimensional growth. Geosci. Model Dev., 13, 905–935, https://doi.org/10.5194/gmd-13-905-2020, 2020.

Conclusions

- Nicolas Beudez left Capsis in October 2020 (mobility, back to Avignon - EMMAH, Virtual Soil platform)
- A request has been made to replace him, but the lab has several priorities
- Work in visio with the modellers on a routine basis, 2 to 4 days per week
- Video training with online support for the exercises

Thanks for your attention