



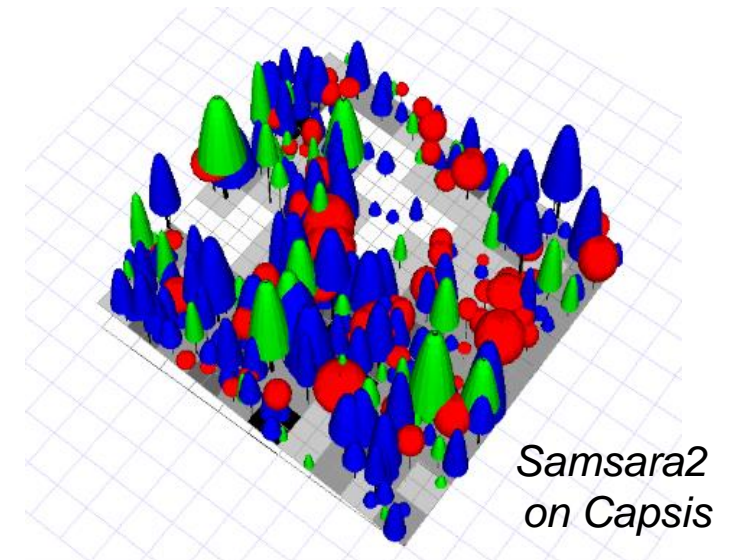
INRAE



Marteloscope of Premol

Marteloscopes as research plots : example of tree-related microhabitats

Benoit Courbaud
Laurent Larrieu



Tree-related microhabitats (TreMs) research: a need for data

Huge diversity of TreMs (47 types)

TreMs like breeding woodpecker holes are quite rare

Development time scale = tree lifetime

-> We need large data sets

TreMs are ephemeral resource patches (Finn 2001)

-> Question of dispersal and connectivity

-> We need large plots with tree coordinates



Marteloscopes constitute a significant part of the European TreM database

Harmonized TreM Data base

Total (Courbaud et al. 2021) :

2377 plots

80 000 living trees

19 species groups

Managed/ Unmanaged forests

Integrate+ Marteloscopes :
(60 plots used)

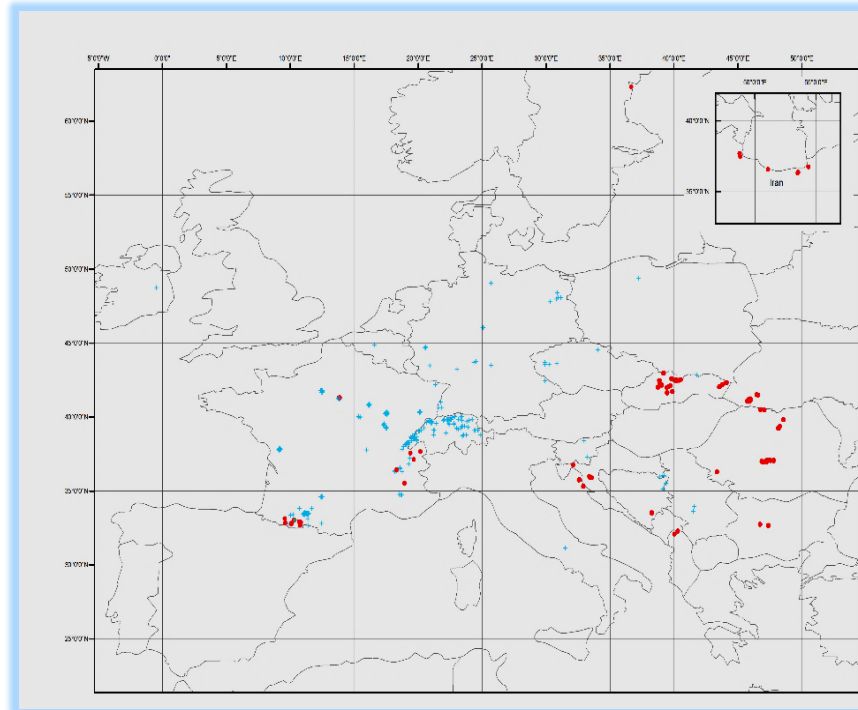
27% of the trees

8 % of the TreMs

Managed forests

Large plots with tree location

Expected end 2022 : ~ 140 000 living trees



11 TreM groups

woodpecker breeding hole

rot-hole

Dendrotelm

root concavity

bark loss

exposed heartwood

Crack

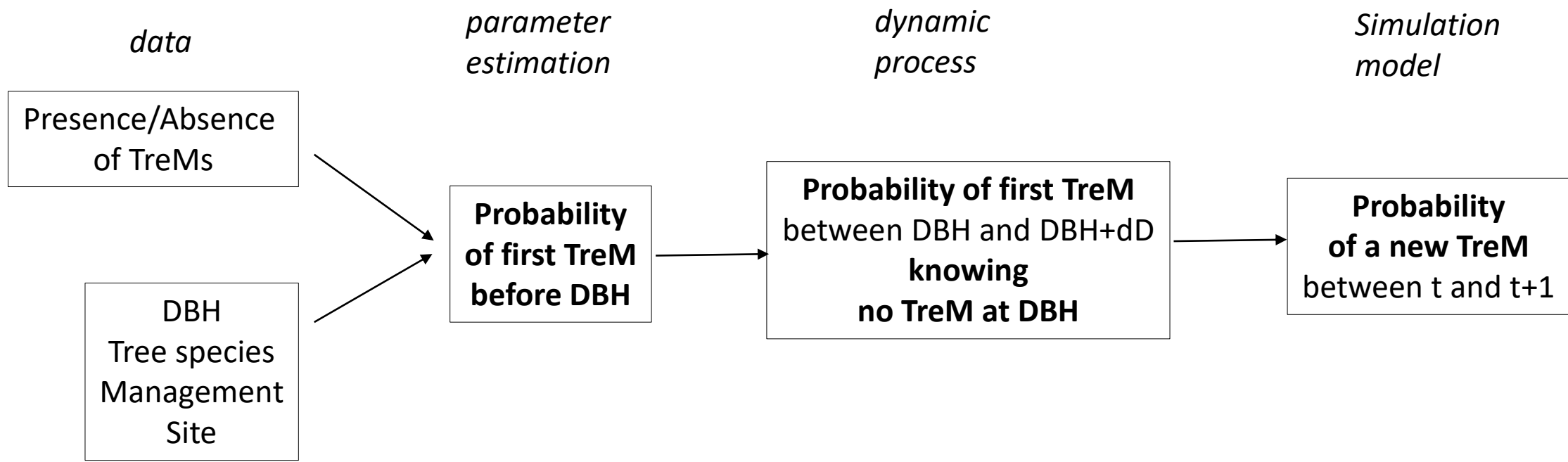
crown deadwood

burl or canker

Polypore

sap run

Estimating the probability of TreM formation

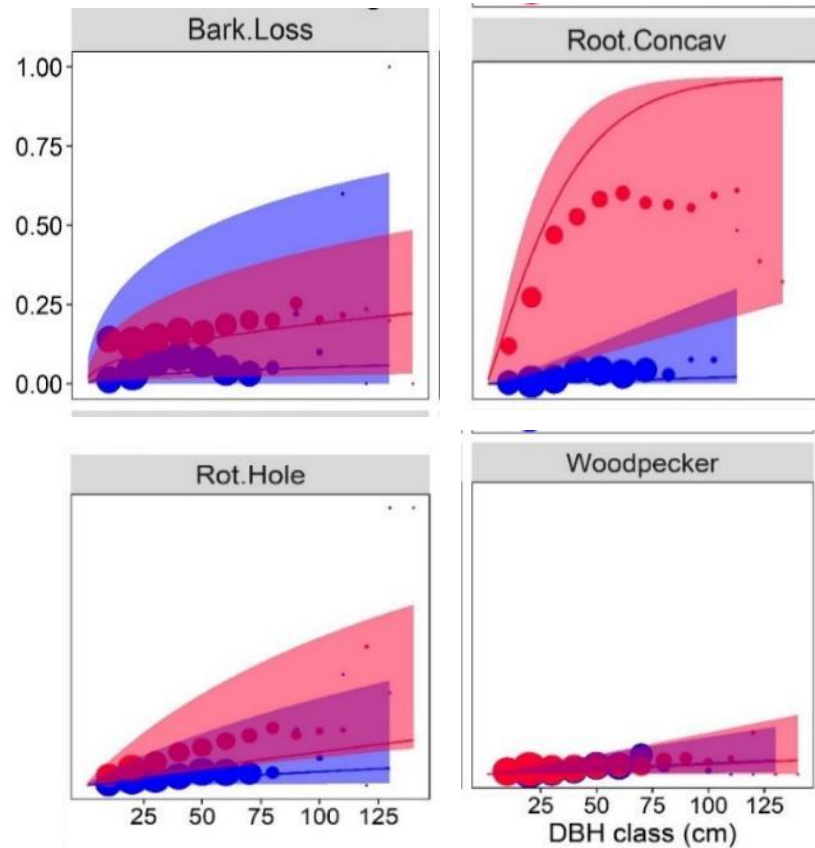


$$\text{proba} = f(\text{DBH}, \text{Tree species}, \text{Management (T/F)}, \text{Site random effect})$$

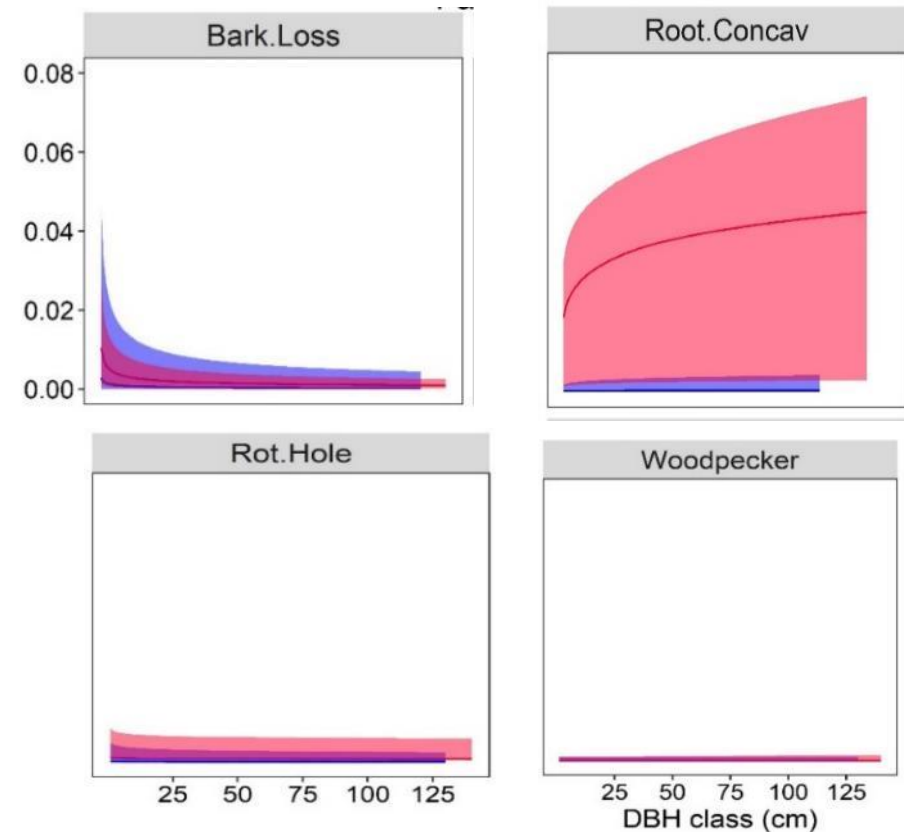
TreM formation : Differences among TreM groups

Examples of *Fagus silvatica*

Proba of 1rst TreM before DBH



Proba of new TreM between DBH and DBH+dDBH



Nb_Trees • 100 • 500 • 1000 Management Managed Unmanaged

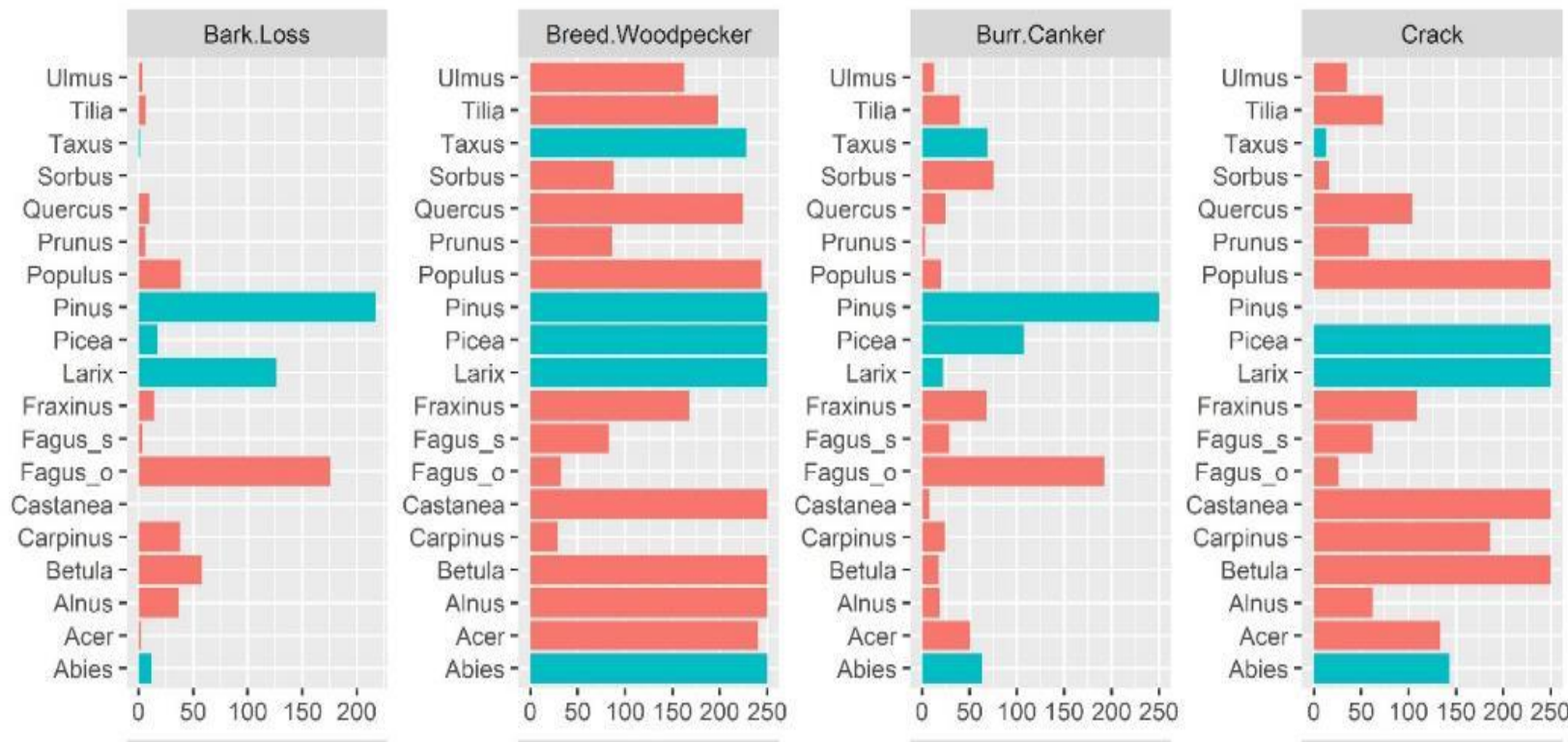
Large variation among TreM groups
Increasing vs. Decreasing relations

TreM formation : Differences among tree species

Unmanaged forests > 100 yrs

Difficult to find general patterns

Tree species with High formation rates for six TreM groups or more



- Abies*
- Alnus*
- Betula*
- Fagus*
- Prunus*
- Quercus*
- Sorbus*
- Tilia*
- Ulmus*

DBH at which 50% of the trees have at least a TreM

■ Broadleaf ■ Conifer

TreM bearing trees show more regular spatial distributions than other trees

Interactions between TreM-bearing trees and other trees

Attraction between trees -> Clumped spatial distribution

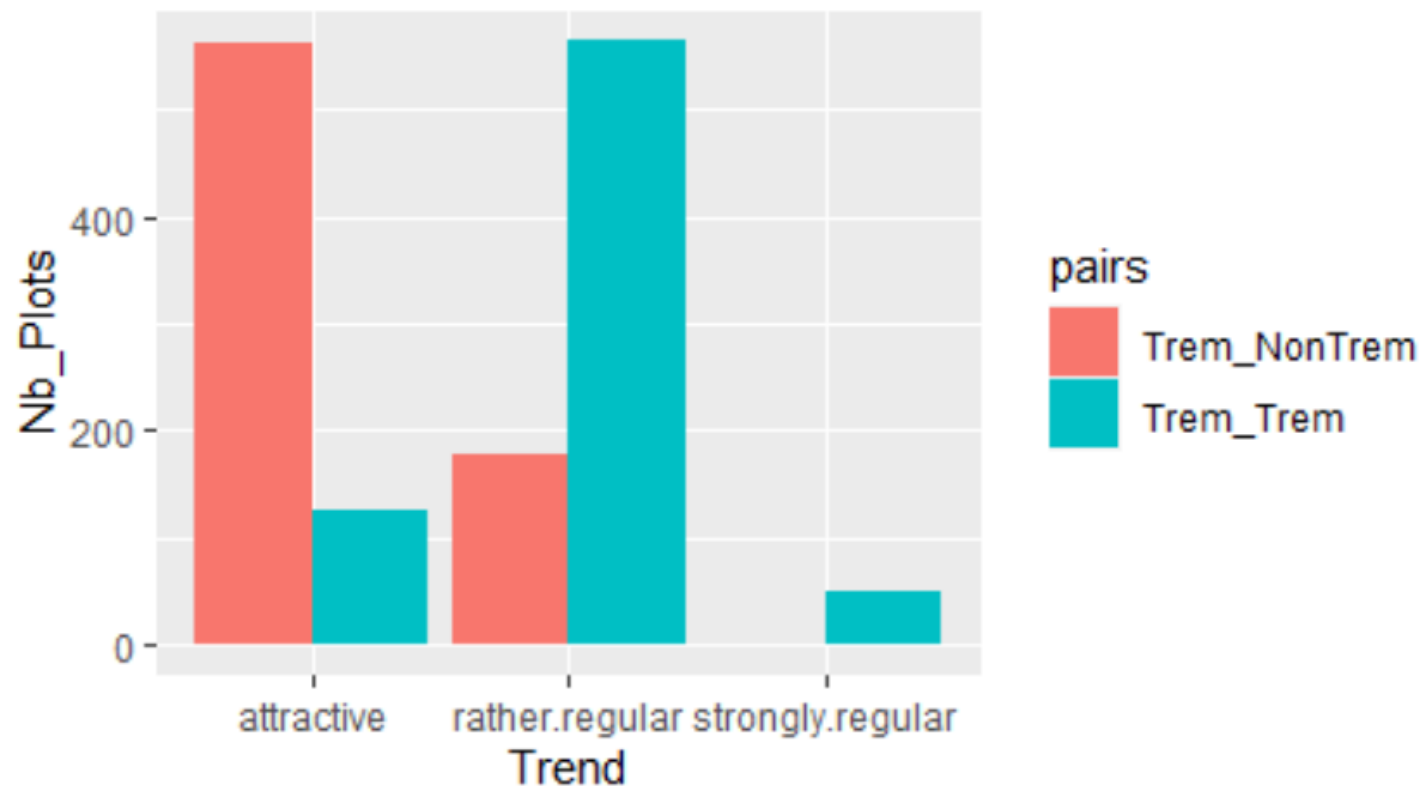
Repulsion between trees -> Regular spatial distribution

Analysis at the plot scale



Fagus sylvatica > 50%

Unmanaged
Forests



Key factors

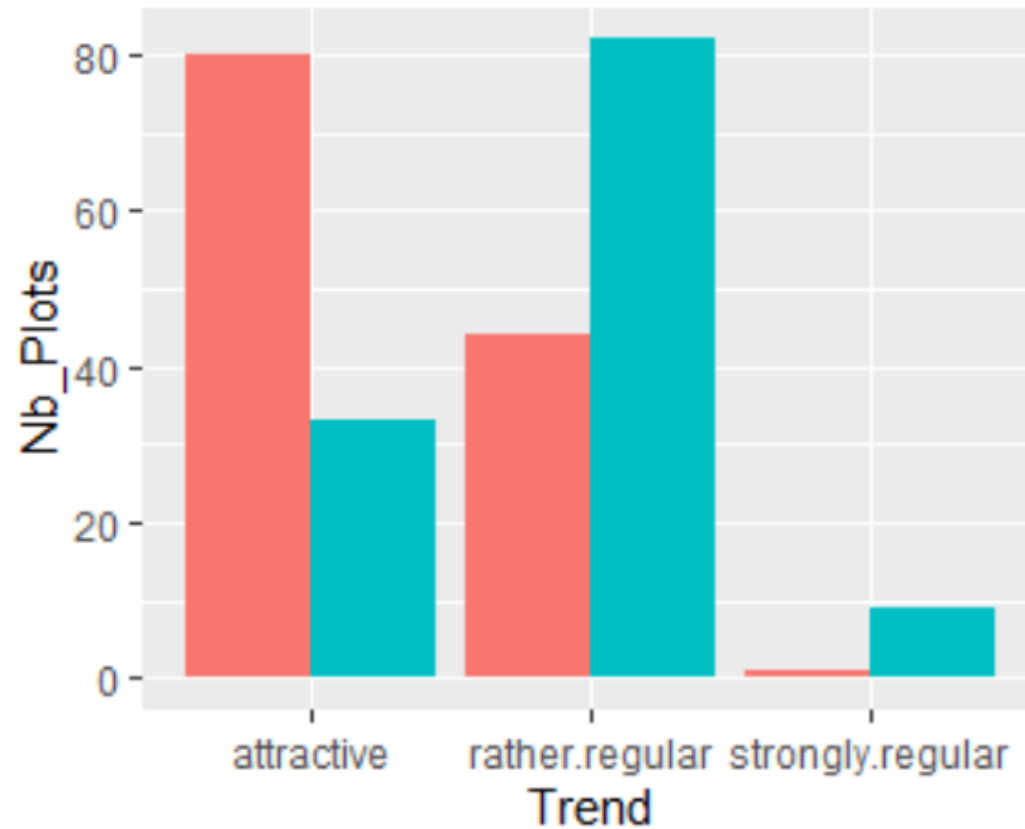
1. DBH
2. Snag
3. Fagus

Less contrast between spatial distributions in managed forests

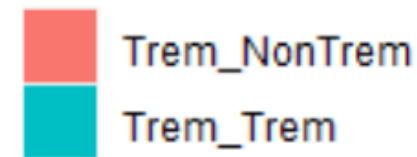


Fagus sylvatica > 50%

Managed
Forests



pairs



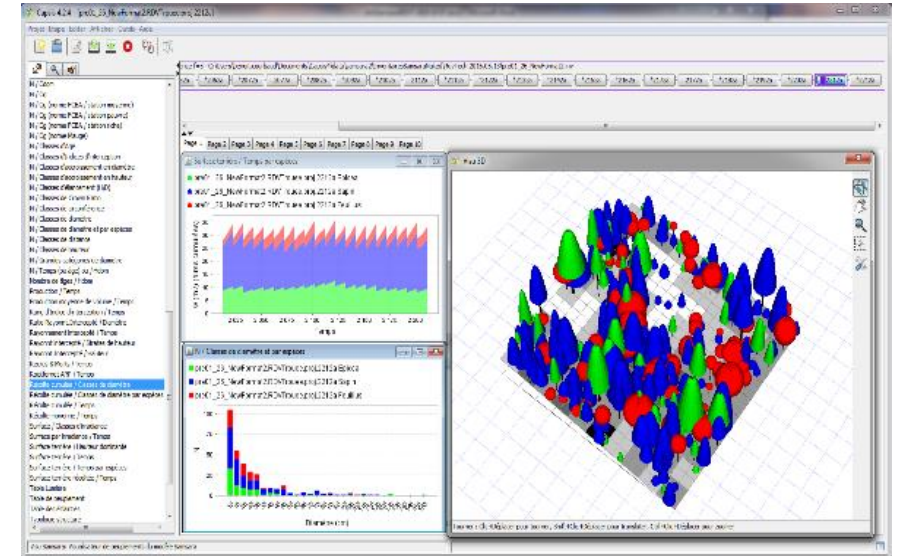
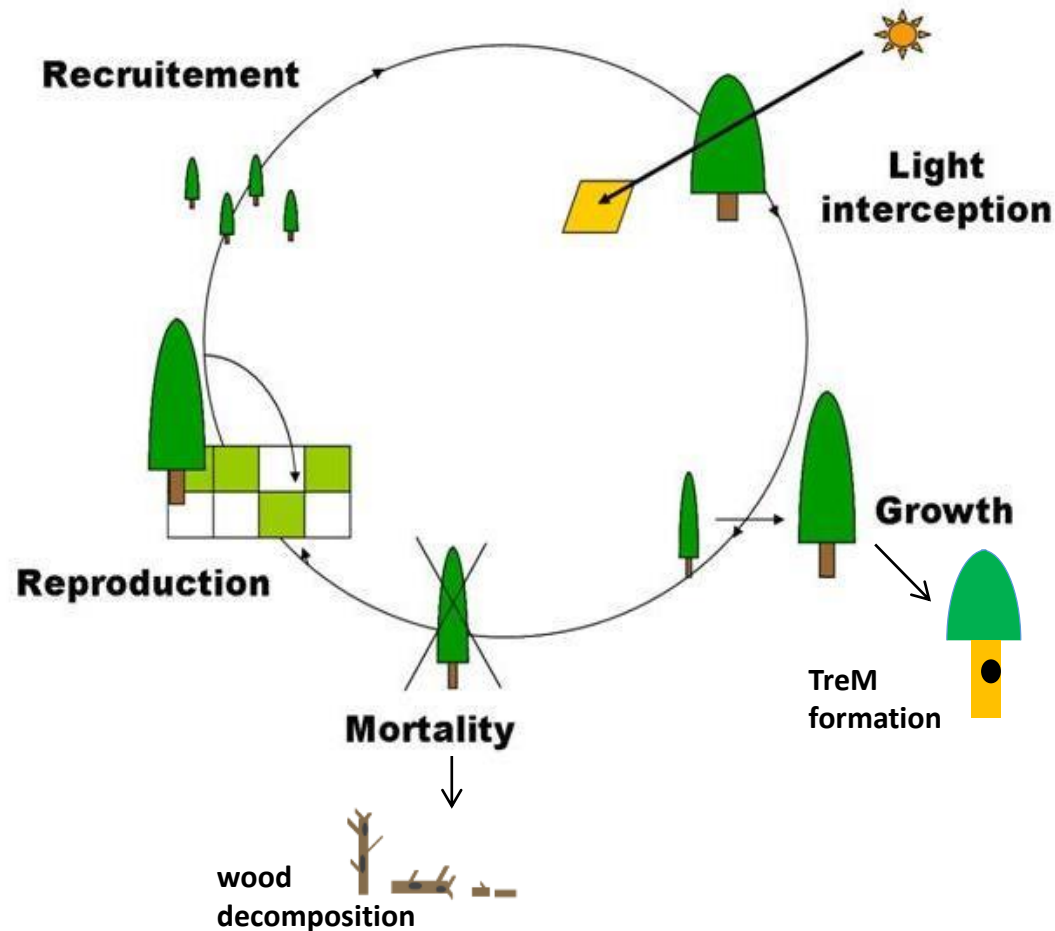
Key factors

1. Fagus
2. DBH

We need more data
To analyse all Trem groups

Integrating a TreM submodel into a forest dynamics simulator

Individual-based, spatially-explicit Model Samsara



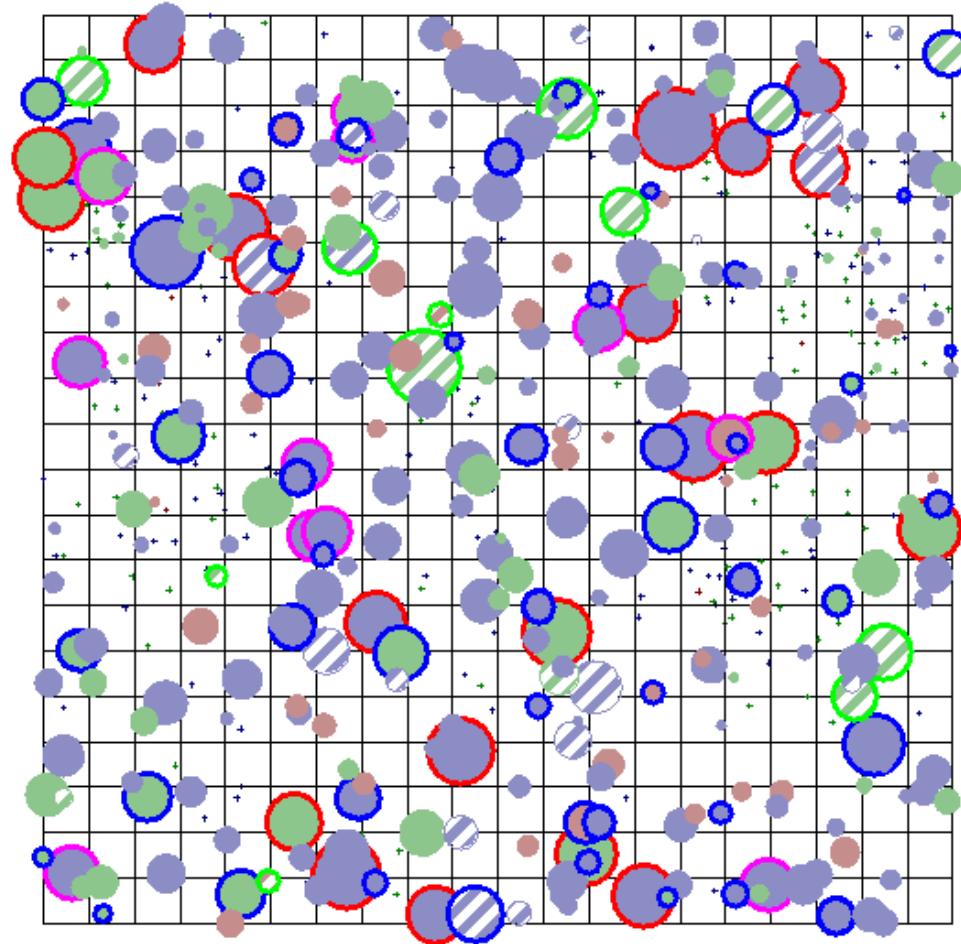
Development platform CAPSIS

Courbaud et al., 2015
Dufour-Kolawski et al., 2012

Simulating integrative management

An algorithm to simulate tree cutting

-  *Fagus sylvatica*
-  *Picea abies*
-  *Abies alba*
-  TreM
-  Retention
-  Focal
-  Harvest
-  Thinning

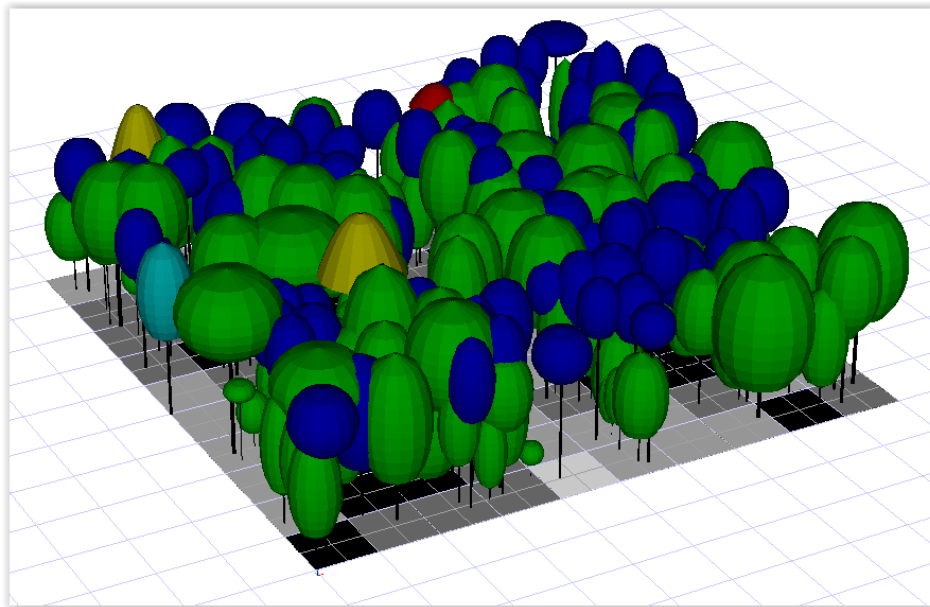


1ha plot / circles proportional to DBH

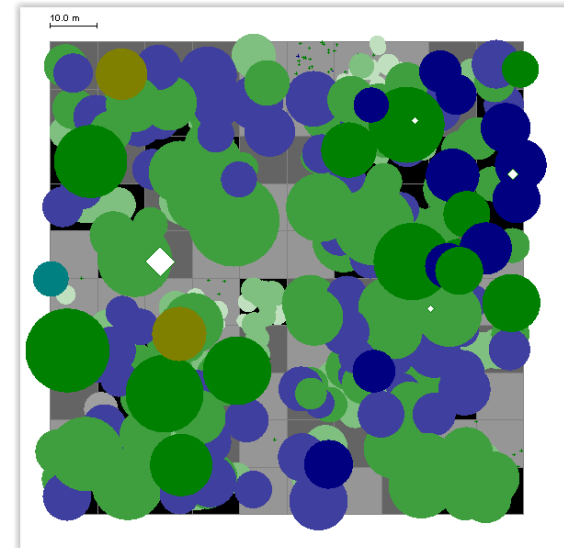
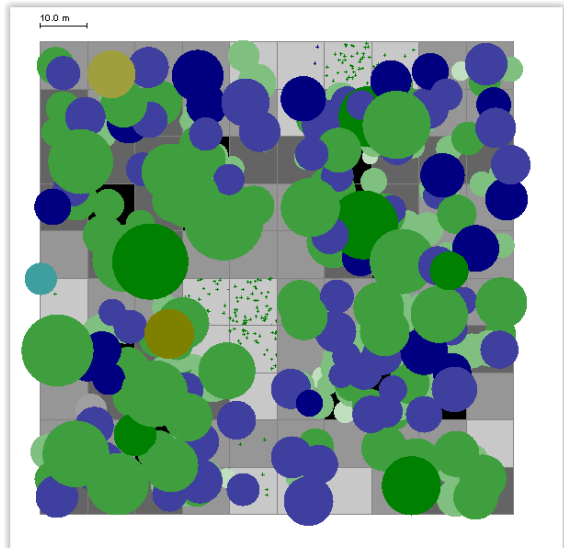
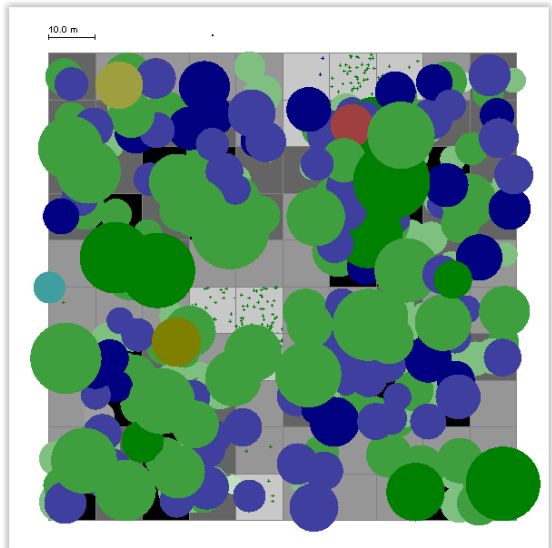
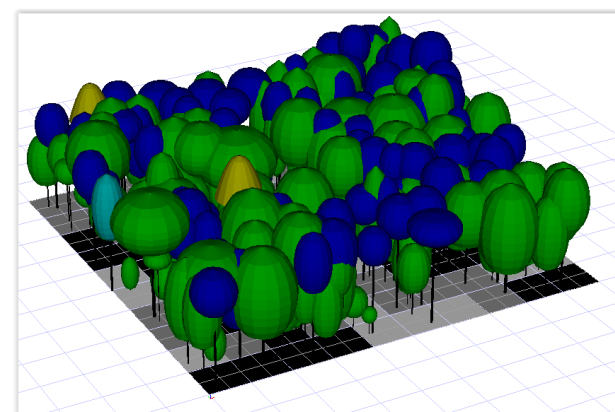
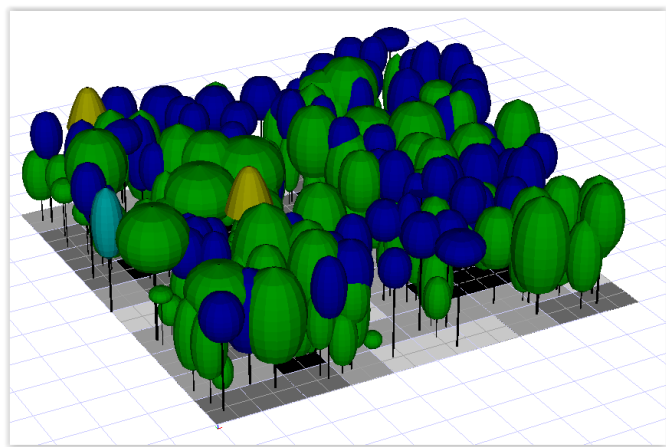
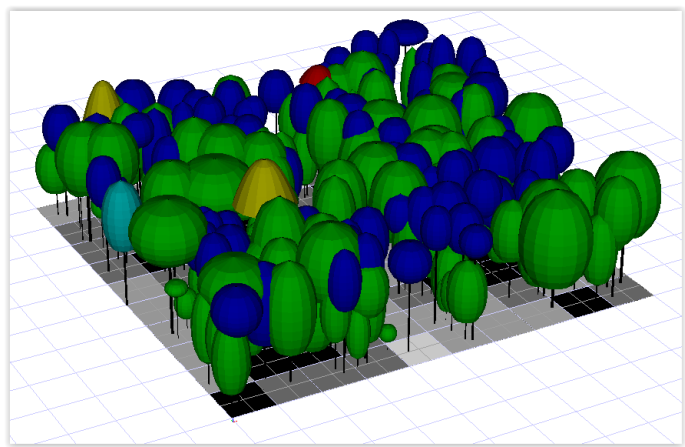
Multicriteria Selection
of four different trees groups

Example of simulation on the marteloscope Steinkreuz (Bavaria)

- *Fagus sylvatica*
- *Quercus robur*



Example of simulation on the marteloscope Steinkreuz



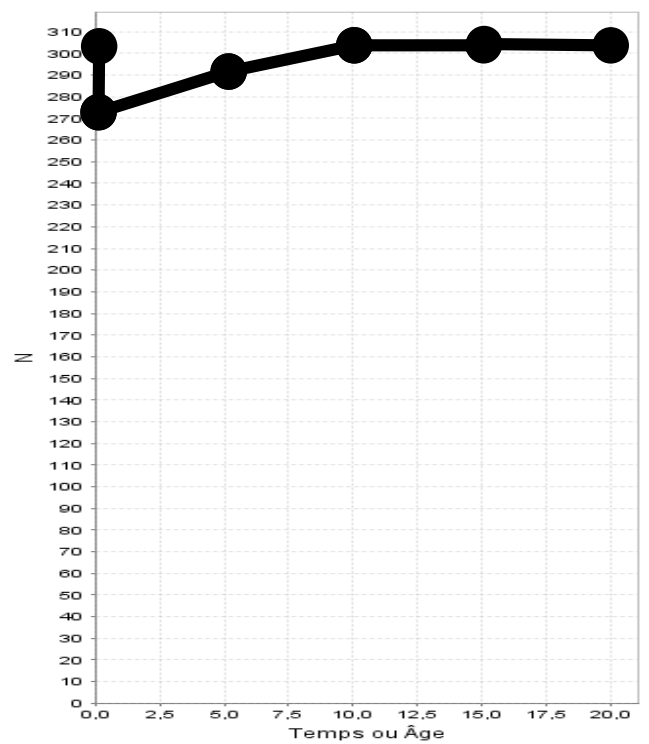
Initial stand

After cut

After 20 years

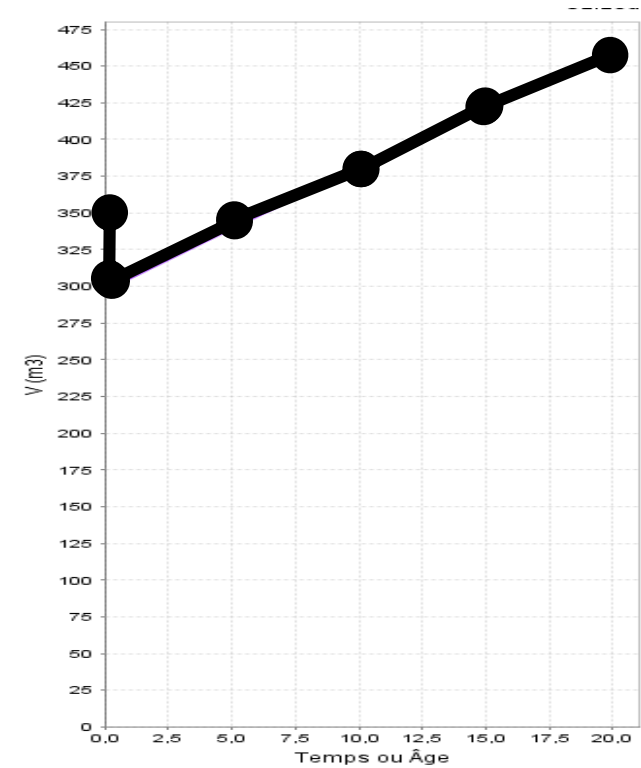
Example of simulation on the marteloscope Steinkreuz

Density
(nb trees / ha)



Time (yr)

Volume
(m³/ha)

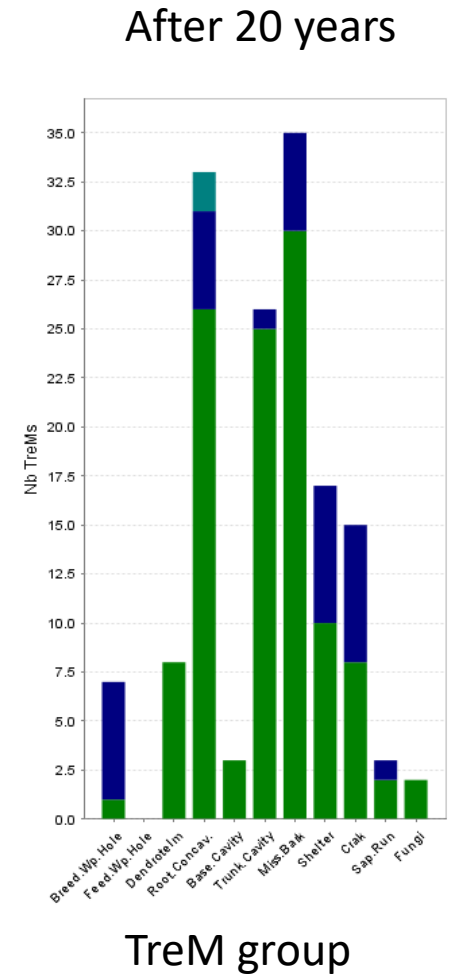
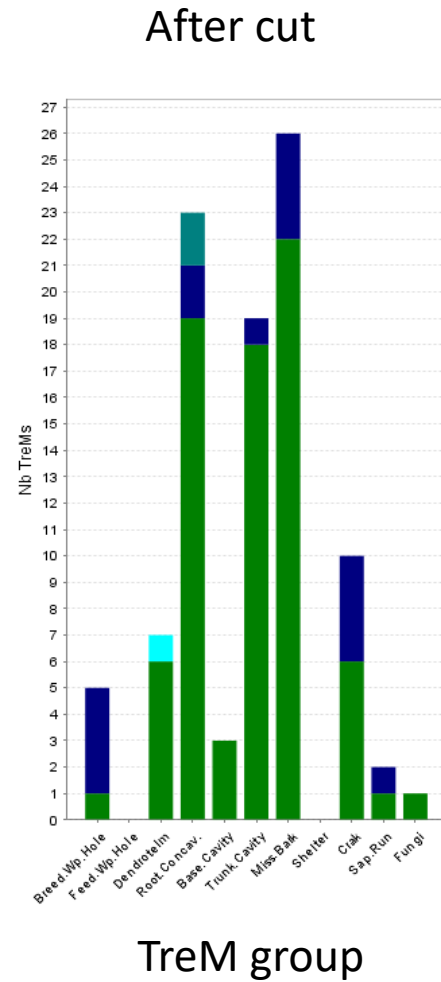
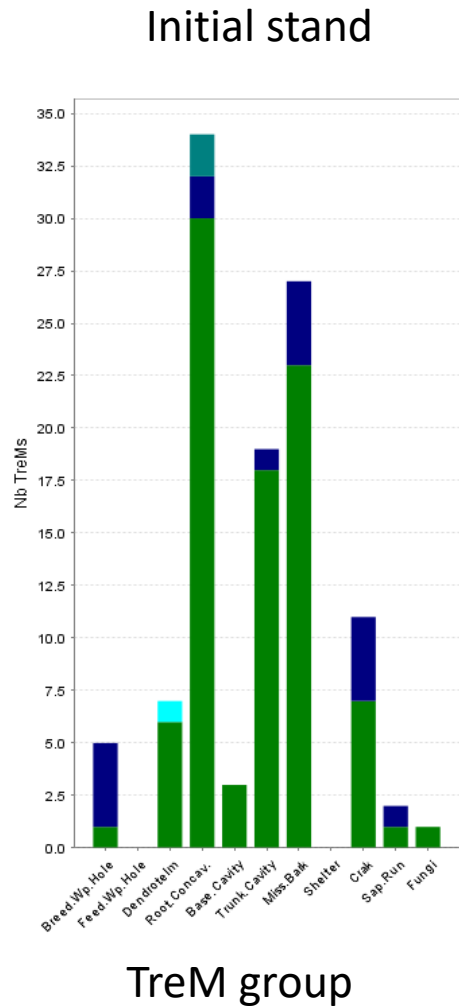


Time (yr)

Tree density, has recovered after 8 years
Volume has recovered after 6 years

Example of simulation on the marteloscope Steinkreuz

TreM density
(Nb TreMs/ha)



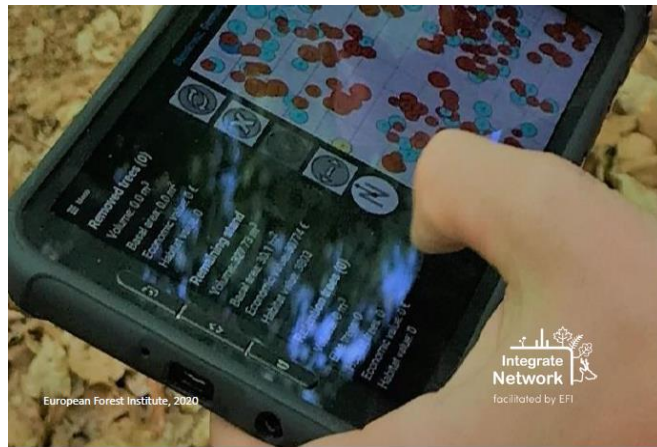
In this simulation
Most TreMs have been preserved thanks to habitat-tree retention
TreM densities have increased after 20 years

Simulating stand dynamics during marteloscope exercises

complementarity

I+ Trainer (Zudin & al.)

Help to tree-marking :Stand / tree information
Interactive tool



Final report:

Stand before cut
Stand after cut

Individual + references

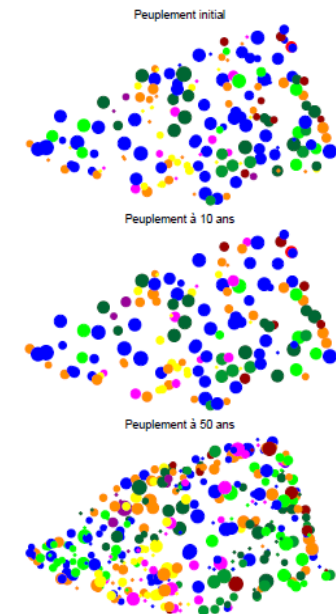
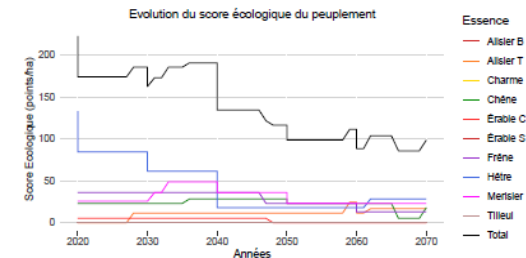
Samsara on a marteloscope

A-posteriori analysis tool

Not interactive : participants enter their data on Excel

- Marking data
- Marking rules

The facilitator makes the simulations on his computer



Final report:

Stand before cut
Stand after cut

Stand after 10 years

Stand after 50 years

Individual + group results

Marteloscopes could provide other interesting data for research

Examples of complementary data that could be interesting for research

DBH increments



Seed production



Sapling growth and survival



Mortality



Wood decomposition



TreM Evolution



Discussion: Value of marteloscopes for research

Advantages

- Large plots with the location of each tree
- Standard protocol
- A wide network
- A person in charge of each plot
- Wide range of contexts (stands types, climate...)

Limits

- No real stand sampling strategy at the European scale
- Difficult to put heavy instrumentations
- No experimental loggings

-> Marteloscopes can be used for observational studies, not for destructive sampling or experimental studies

Develop the use of marteloscopes as permanent research plots

Develop the continuum research – teaching – practice

Develop collaboration networks

Easier to maintain long-term
funding and monitoring
on multipurpose plots



*Thank you
for your attention*

Marteloscope of Hêches