Modelling the occurrence of tree-related microhabitats in managed uneven-aged forest stands over time

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Introduction

Tree-related Microhabitats (TreMs)
are **morphological singularities** on trees
that **constitute a substrate or life sites suporting forest biodiversity**
(cavities, bark losses, cracks, fungi …)

Previous works show that (Lindenmayer 1993, Vuidot 2011, Larrieu 2012, 2014)

- TreMs are **more frequent on large trees**
- TreMs are **more frequent on broadleaves** than conifers
- TreM density is **influenced by forest management**

We know little about the **dynamic process** of TreM formation

Modelling TreM formation would make possible to
include TreMs in forest dynamics and management simulators







Introduction

Hypotheses :

- **The rate of TreM formation**
  - **(i) increases during tree growth ?**
  - **(ii) is higher for broadleaved species than conifers ?**

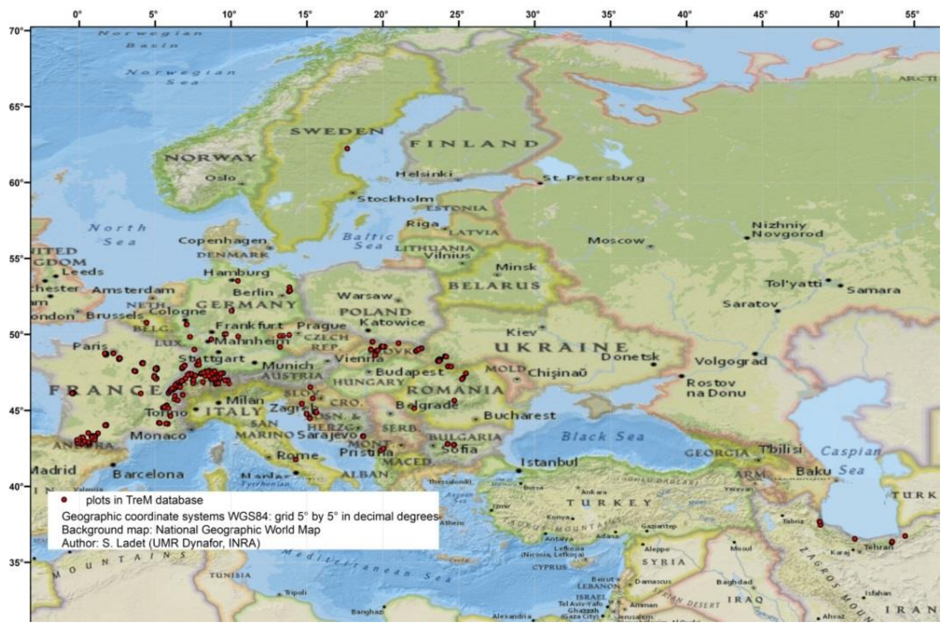
- **TreM density can be increased in uneven-aged stands**
  - **(i) by habitat-tree retention ?**
  - **(ii) by higher harvesting DBH ?**

Approach:
- Model TreM formation rates from observations of TreM presence on trees
- Make simulation experiments

Step1: Collecting and harmonising TreM observations at an international scale

- Observations of TreM presence on trees
- A network of 8 research groups / 70 000 living trees

- 11 simplified TreM groups
- Harmonizing observations made with different field protocols (TreM definitions, size thresholds)



Step 2: Estimating TreM formation rates (Courbaud et al., 2017)

X = DBH at which a tree forms its first TreM

$F_X(D)$: Proba of forming the first TreM before having a DBH of D

Proportions of trees bearing at least 1 TreM at D

Calibrated on observations

h(D) : Hazard Rate Function

Proba for a tree without TreM at D to have one at D + dD

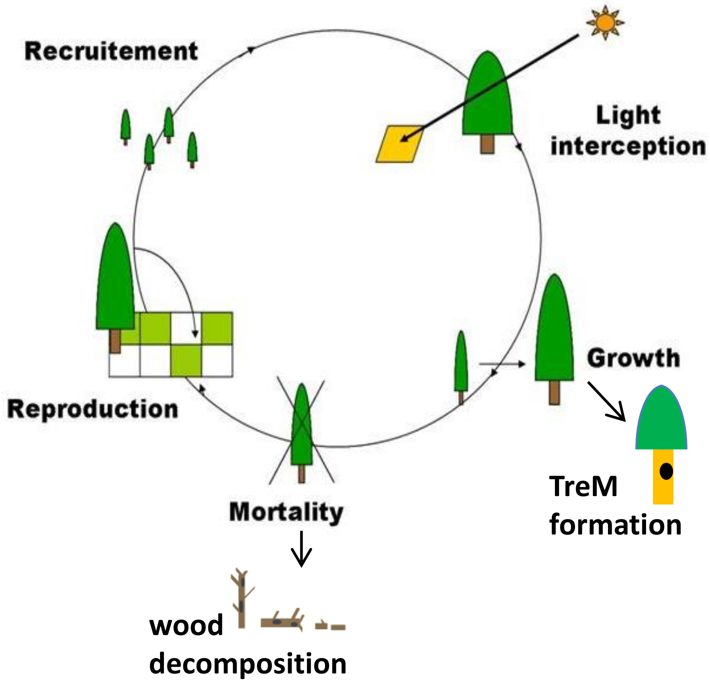
P(t) : Annual Rate of TreM formation

Proba of forming a new TreM between t and t+1

$$P(t) = f(D, \Delta D)$$

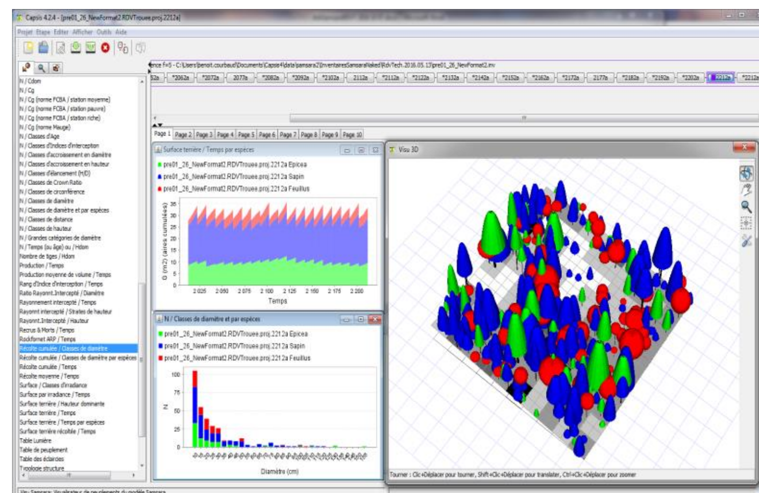
Method

Step 3: Simulating TreM formation in a forest stand



Model Samsara
Development platform CAPSIS

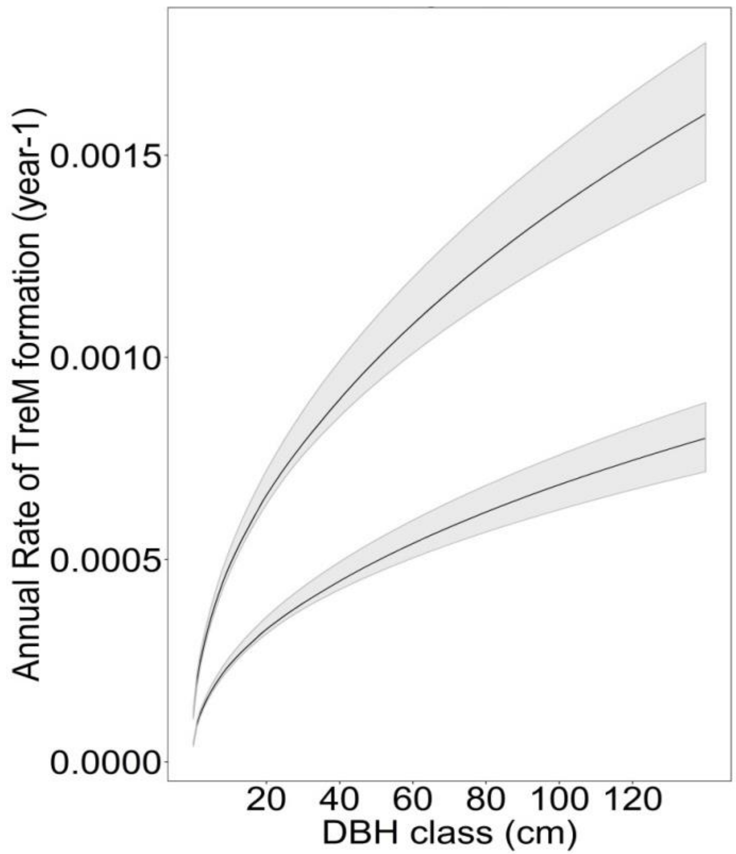
Individual-based
Spatially explicit
Mixed, uneven-aged stands



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

The annual rate of TreM formation increases with DBH and with DBH increment

Breeding woodpecker holes on *Fagus sylvatica*



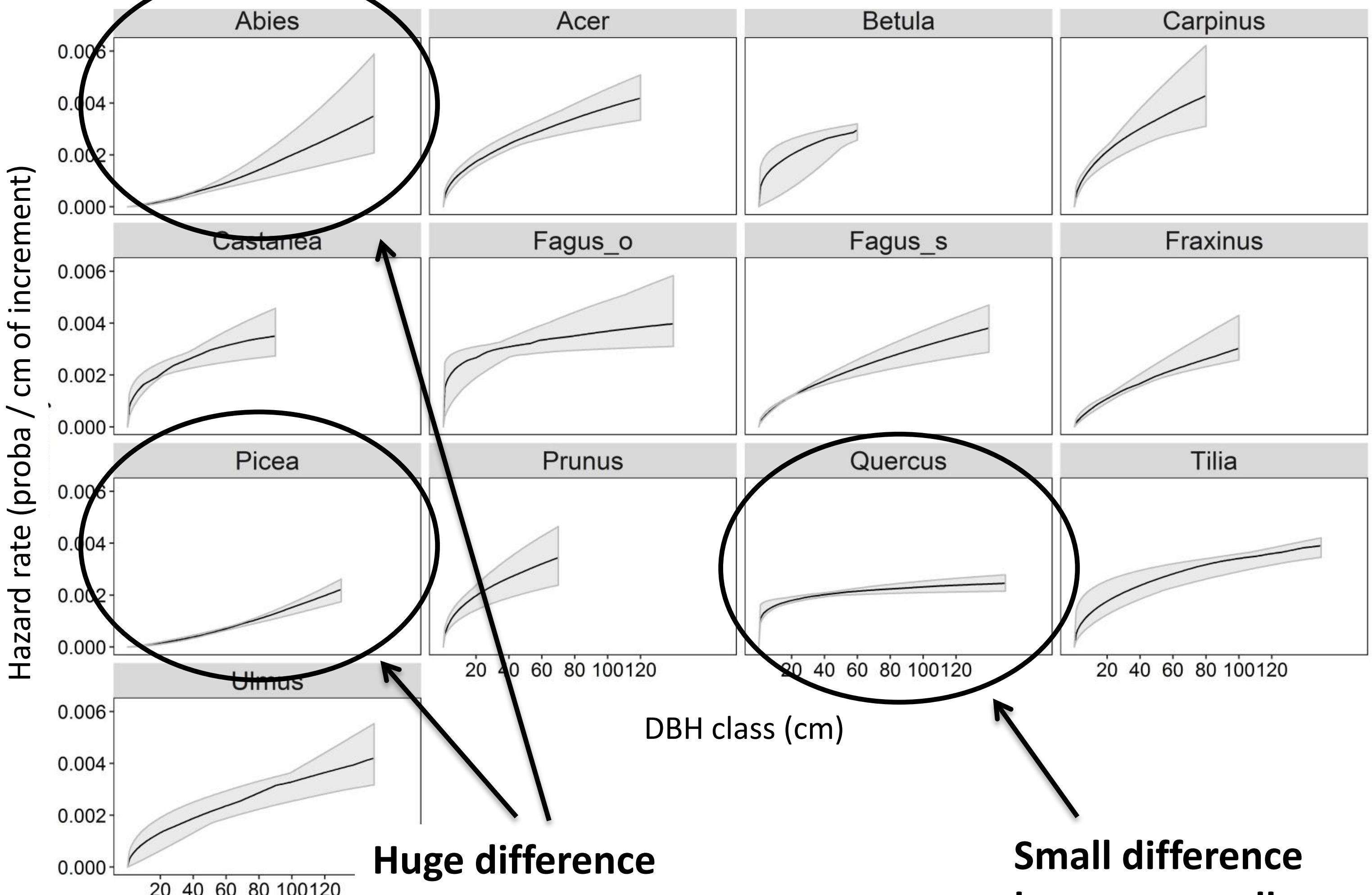
DBH increment 1cm/year

DBH increment 0.5 cm/year

Results

The effect of DBH on TreM formation rate varies among tree species

Ex: Rot holes



Huge difference between small and large trees

Small difference between small and large trees

Results

Annual TreM production for DBH =50 cm and ΔDBH=1 cm/yr

SpGroup/ TreM	Rot Hole	Breed Wpeck	Bark Loss	Exposed HeartW	Crack	Crown DeadW	Polypore	Root Concav	Burr
Abies	0.0007	0.0009	0.0031	0.0005	0.0009	0.0016	0.0028	0.0020	0.0014
Picea	0.0006	0.0006	0.0028	0.0006	0.0009	0.0026	0.0003	0.0057	0.0013
Acer	0.0026	0.0008	0.0057	0.0012	0.0029	0.0029	0.0007	0.0033	0.0007
Betula	0.0026	NA	0.0053	NA	NA	NA	NA	NA	NA
Carpinus	0.0030	0.0013	0.0081	0.0011	0.0027	0.0020	0.0018	0.0026	0.0009
Castanea	0.0027	NA	0.0060	NA	0.0012	0.0034	NA	NA	0.0021
Fagus_s	0.0021	0.0010	0.0028	0.0013	0.0010	0.0026	0.0009	0.0043	0.0016
Fraxinus	0.0020	0.0009	0.0032	0.0013	0.0022	0.0033	NA	0.0025	0.0003
Prunus	0.0027	0.0015	0.0036	NA	0.0016	0.0019	0.0028	0.0028	0.0020
Quercus	0.0020	0.0007	0.0105	0.0007	0.0052	0.0032	0.0011	0.0024	0.0008
Tilia	0.0027	NA	0.0042	NA	0.0022	0.0036	NA	0.0043	NA
Ulmus	0.0022	NA	0.0047	NA	0.0021	0.0033	NA	0.0034	NA

Higher than 1.25*mean

Lower than 0.75*mean

***Abies and Picea* have low production rates for most TreMs**

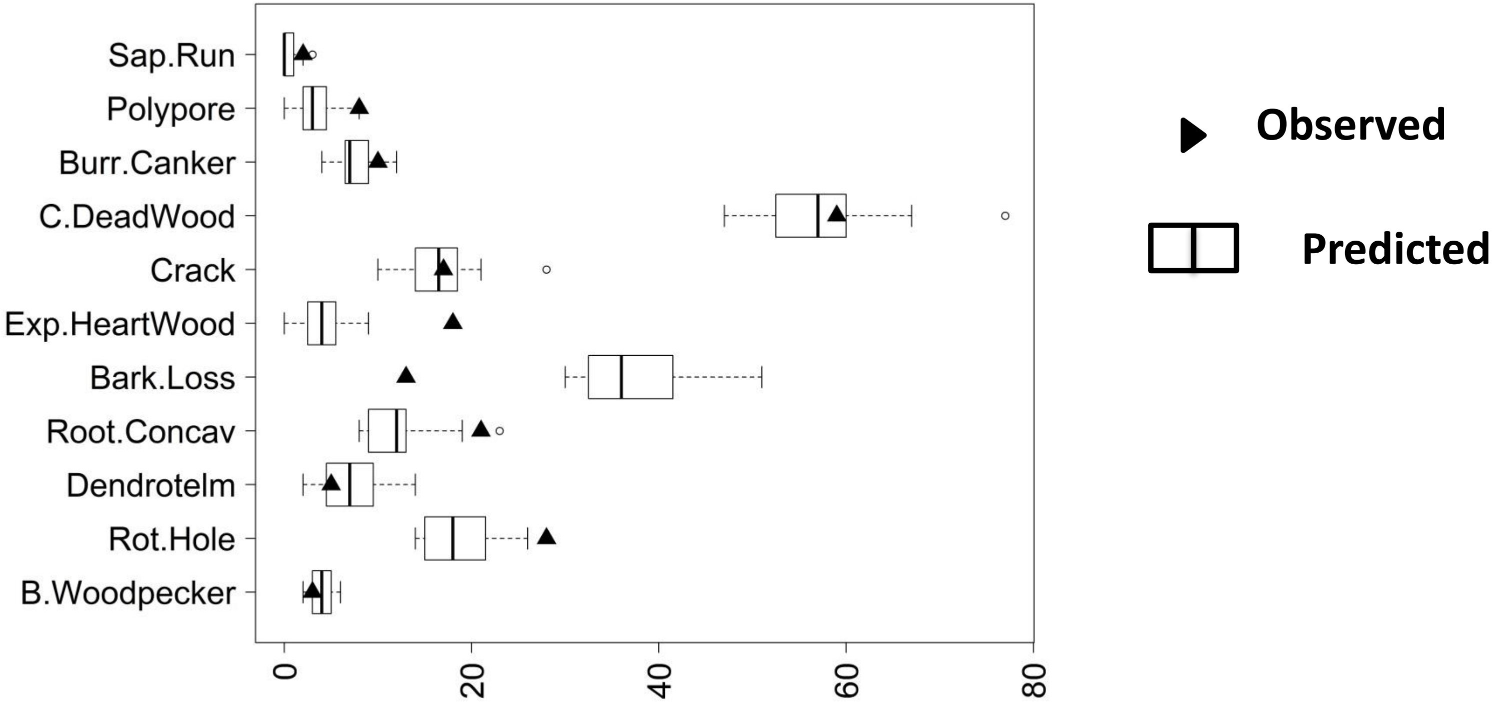
Huge heterogeneity among broadleaved species

High production rates of different TreMs are found on different tree species

Model validation at the stand level

Predicted vs observed TreM occurrence
Large variations among TreMs and among stands

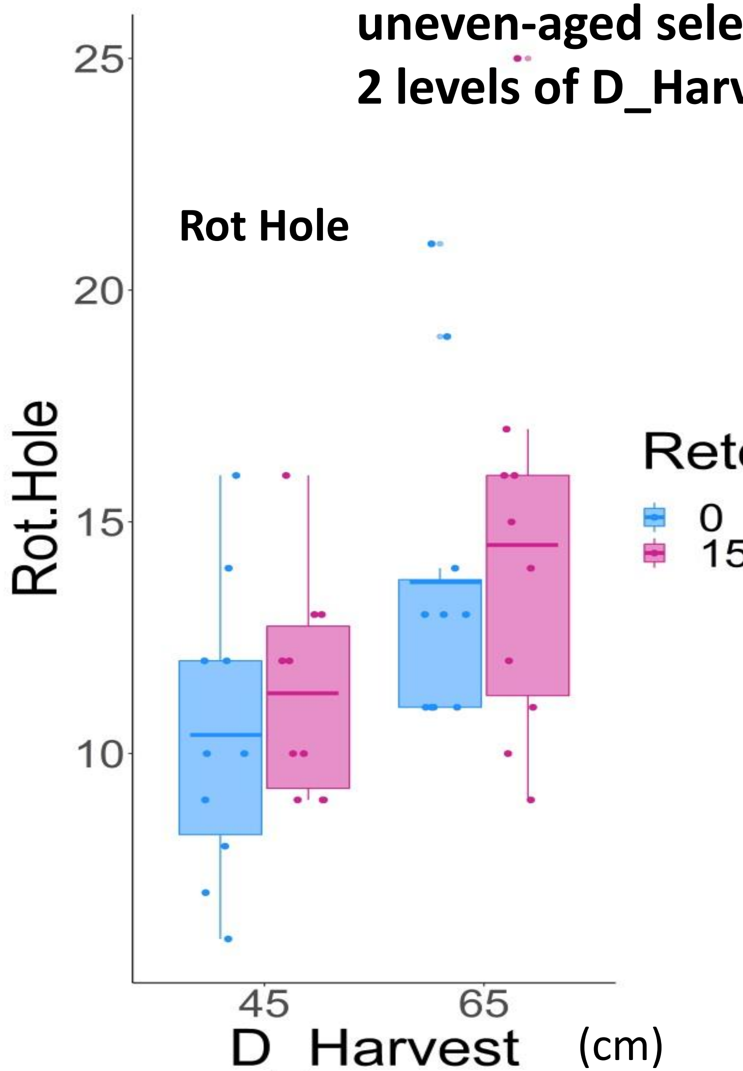
Ex: forest stand « Betchat »



Preliminary simulation result: Rot hole density after 50 years

uneven-aged selection system

2 levels of D_Harvest x 2 levels of Retention



(hab.trees /ha)

(cm)

1 initial stand
spruce-fir-beech
uneven-aged
4 ha plot
10 replications

ANOVA 2 factors
D_harvest : **
Retention : NS

Consistent effect of
Harvest limit diameter

Conclusion

TreM formation rates

increase with DBH and DBH increment

are usually higher for Broadleaves

High formation rates of different TreMs

are found on different tree species

Habitat-tree retention is not the only way to promote TreMs

Harvest limit diameter

or species composition are important

In forest dynamics simulations, TreMs can be used as indicators of **management effect on habitat quality for biodiversity**

Field observations should be made using a standard TreM typology
In order to build **data sets large enough** to estimate the formation rate of **rare TreMs**
ex: Sandardized hierarchical typology (Larrieu & al., 2018)


Thank you for your attention
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