Tree-related microhabitats (TreMs) as key elements for forest biodiversity

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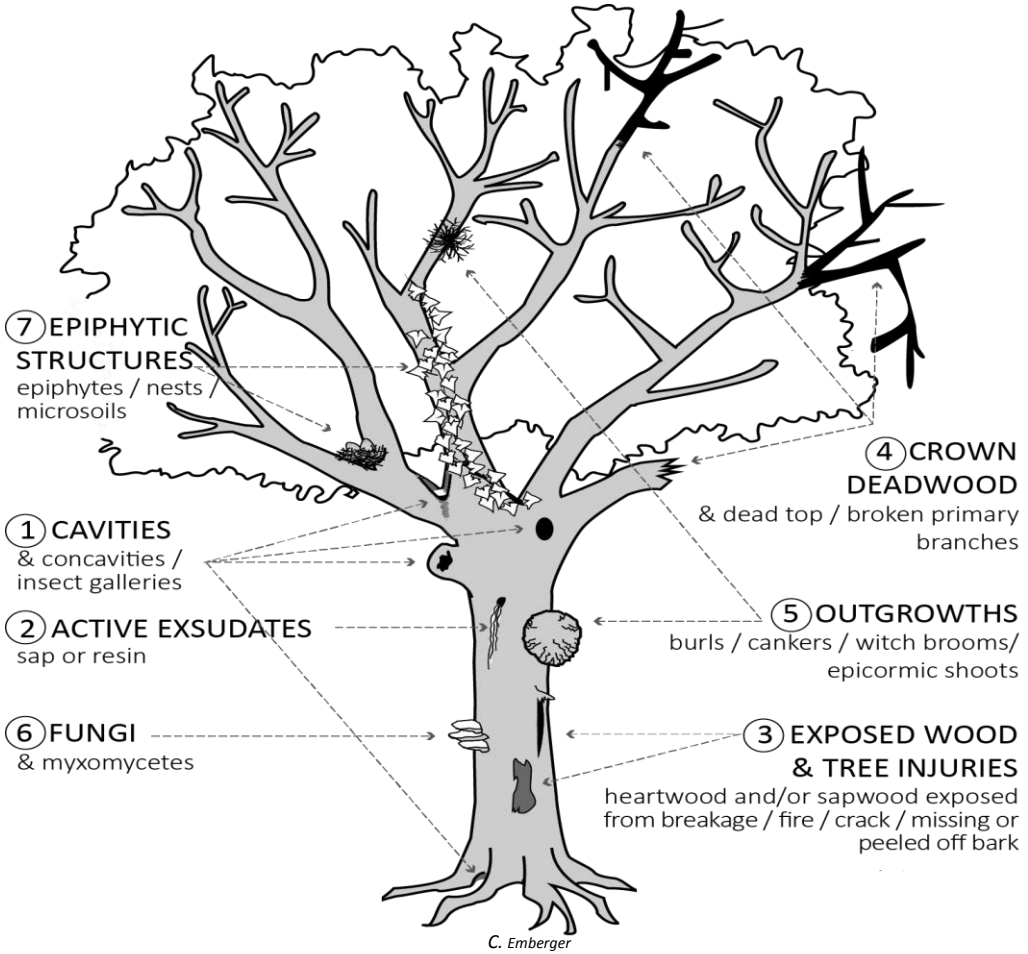
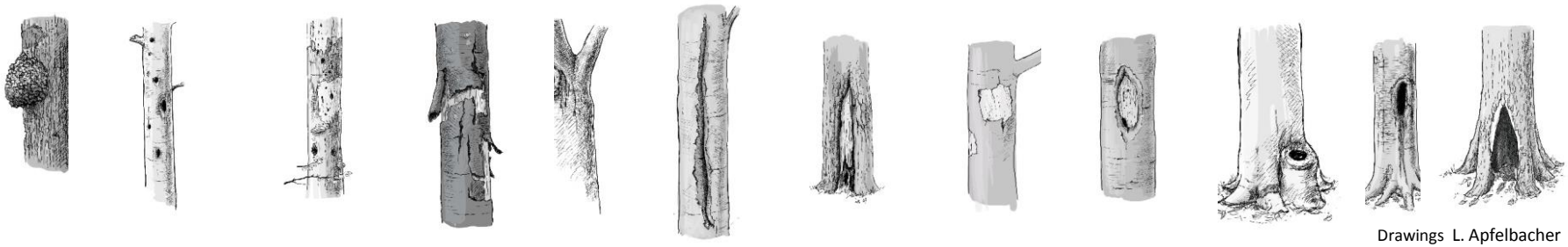


A TreM is specific above-ground tree morphological singularities

- **distinct, well delineated structure**
- **borne by standing living or dead trees**
- **essential substrate or life-site for taxa**
- **encompassing decaying wood (=saproxylic TreM) or not (=epixylic TreM)**



Drawings L. Apfelbacher

TreMs are regularly observed and are crucial issue for forest management

Forest managers

• defects that depreciate timber
• sylviculture items

➡ **As few as possible!**

Conservation biologists

• life-microsites
• ecological items

➡ **Total conservation…**

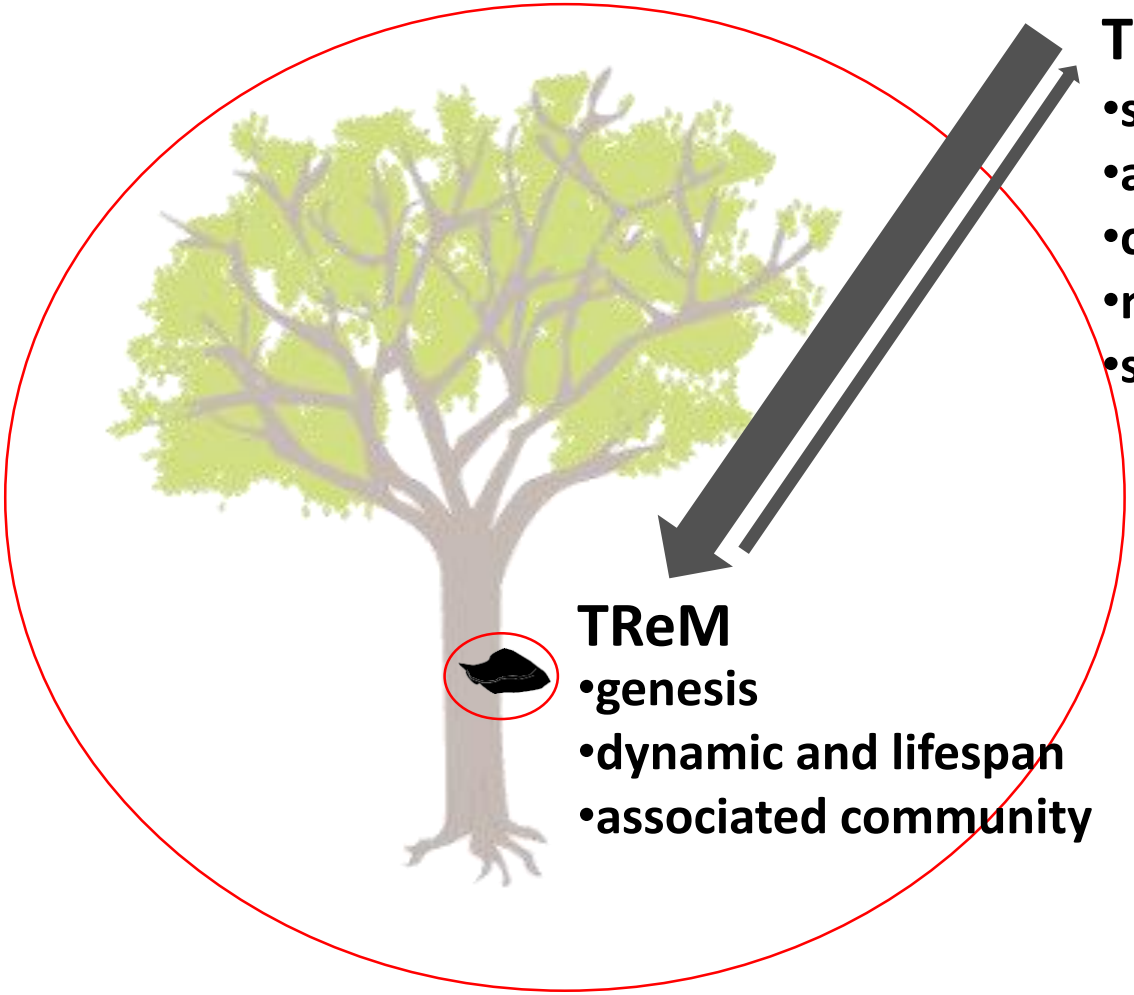
Conflict

Compromises and negotiated standards (e.g. PEFC, FSC, N2000),
but with what ecological relevance?

➡ **A challenge for research**

TreMs as ecological items

TreMs depend on tree characteristics



And tree vitality and life-span sometimes depends on the TreM it bears…

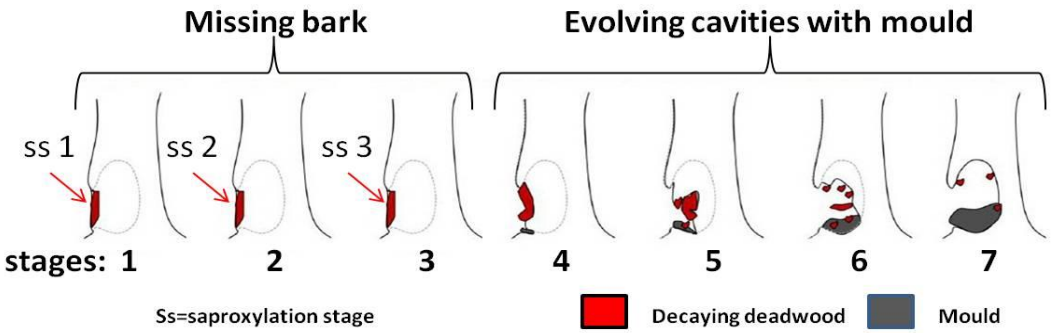
TReMs are « ephemeral resource patches (Finn 2001) »

- high quality site → Dependence gradient
- spatially limited → Small size (limited by the tree size)
- temporary → TReM type "X"

Disappearance
(tree removed)

Development/change

❑ Type "X" → Type "Y" (=lifespan)



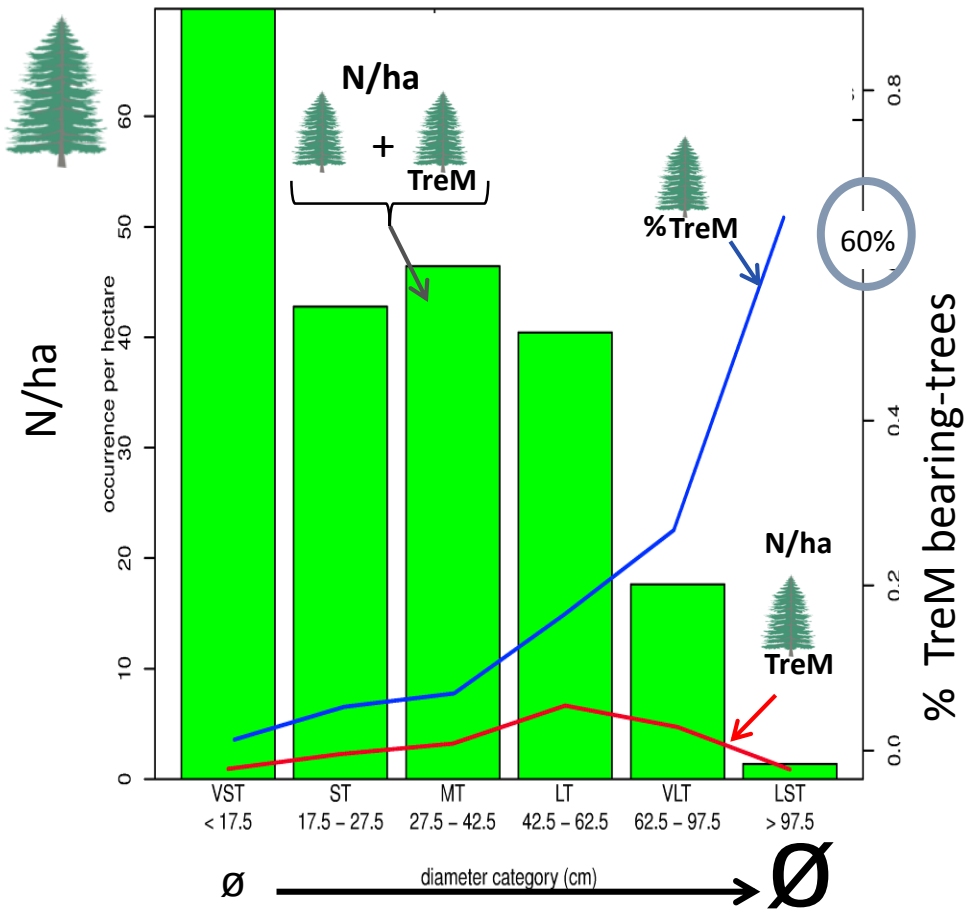
❑ Living tree → Dead tree

Unavailability
(="useful" period)

Which trees bear TreMs within old-growth forests?

The largest trees play a pivotal role in TreM supply

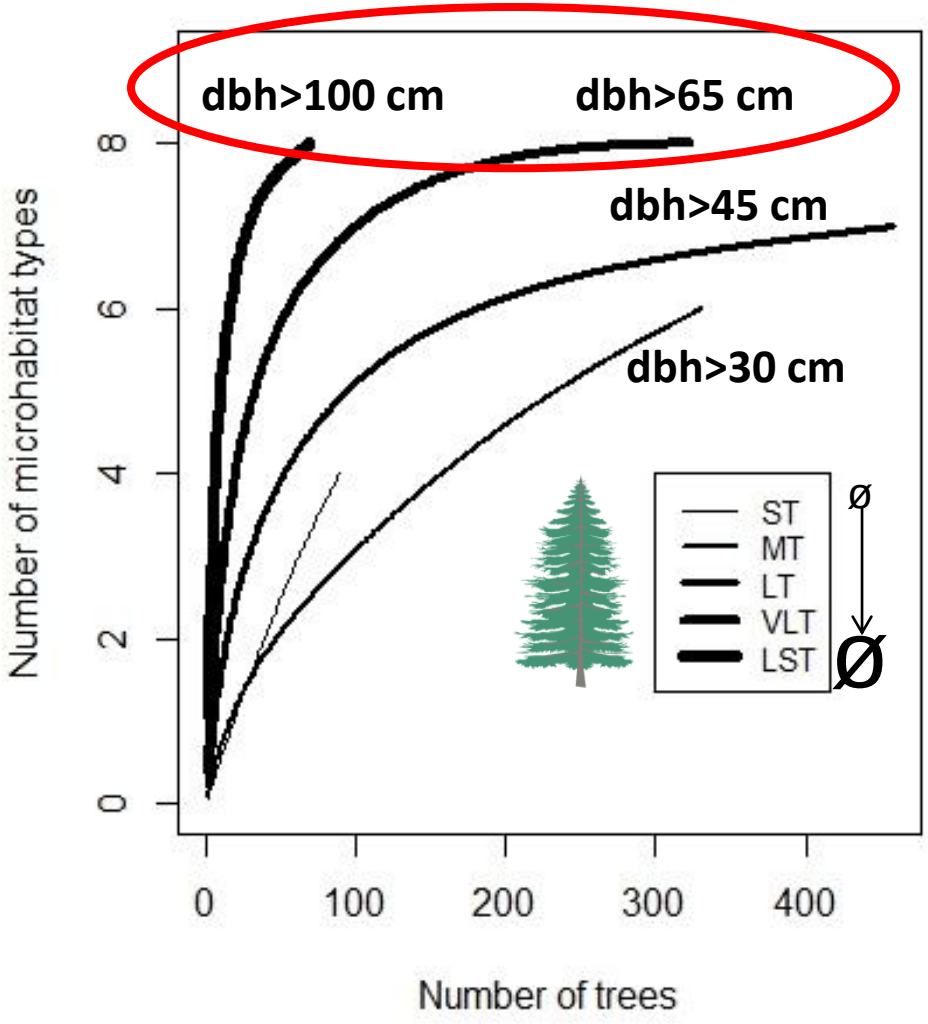
(Larrieu et al. EJFR 2014)



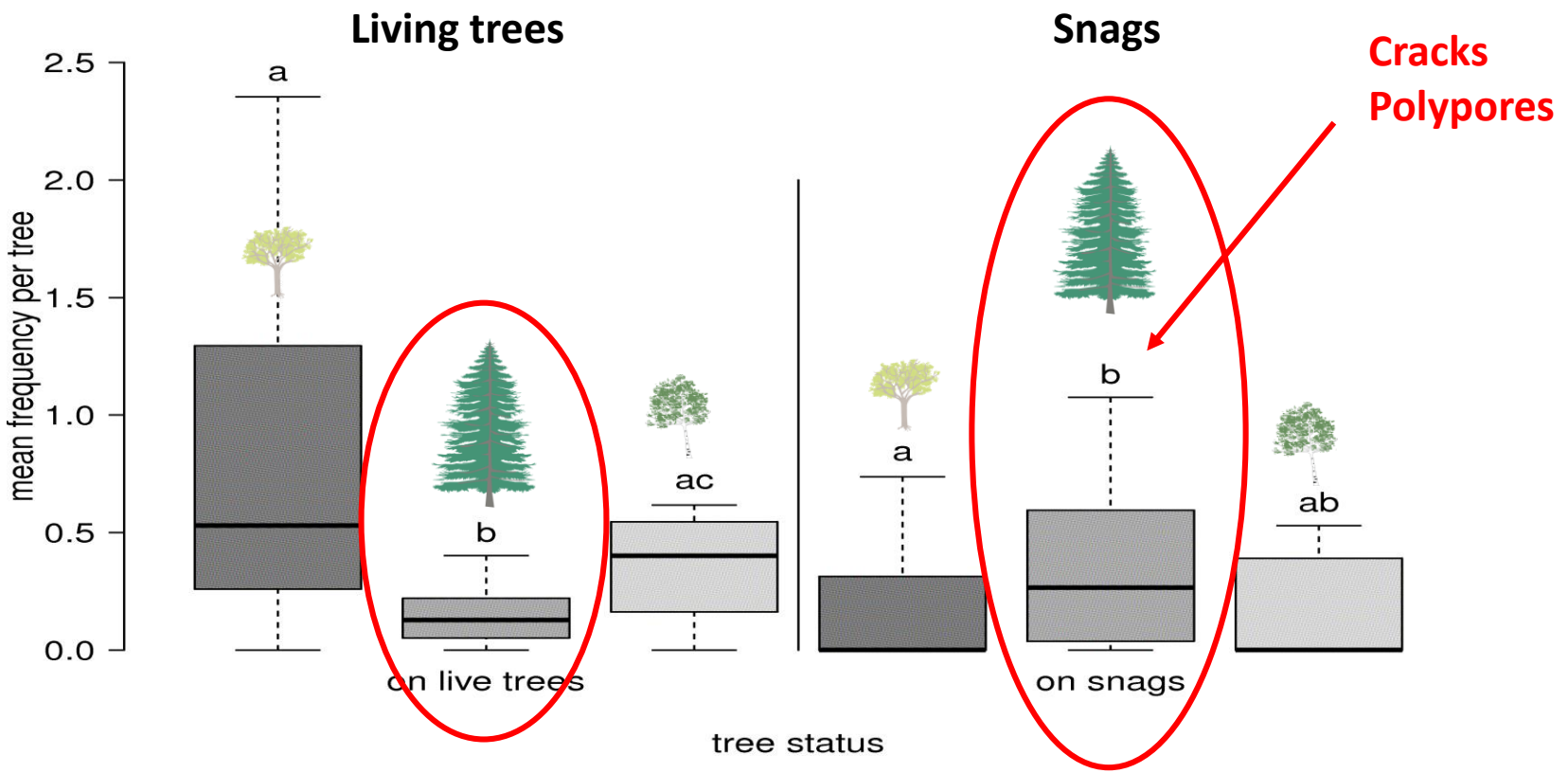
(See also: Michel et al. CJFR 2011; Vuidot et al. BC 2011; Regnery et al. FEM 2013)

Only the largest trees bear all TreM types

(Larrieu et al. EJFR 2014)



Cracks and fungus sporophores are rather borne by snags than by living trees (Larrieu & Cabanettes CJFR 2012)



Complementarity of living and dead trees

(See also: Regnery et al. FEM 2013; Vuidot et al. BC 2011)

Effect of forest management on TreM profile

Distribution patterns are very different in old-growth forests or in managed stands (Larrieu et al. EJFR 2012)

TreMs

Harvested stands →

- wide range of density, but often low
- low diversity
- relative proportions dramatically impacted

"favoured" by harvesting *vs* **"unfavoured" by harvesting**

Dendrotelms

Bark losses

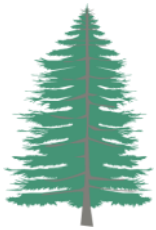
Cracks

Cavities

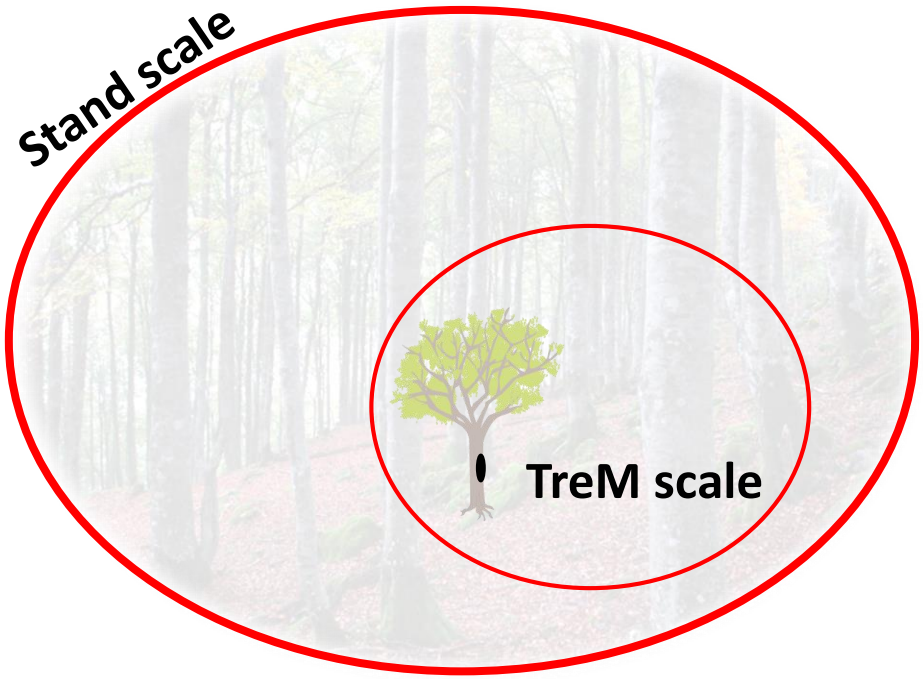
Fungus sporophores

(See also Winter & Möller FEM 2008)

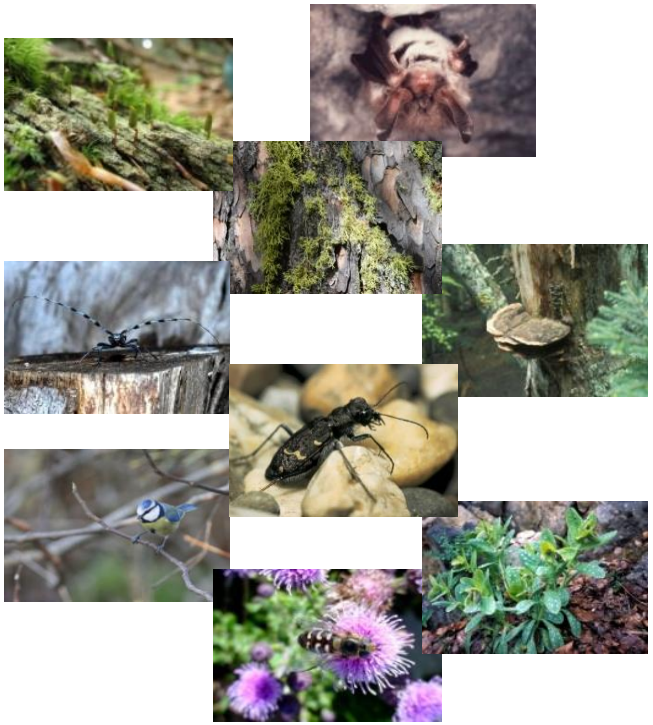
Decrease in the density of TreM-bearing trees is mainly due to tree-selection for broadleaves and a too low harvesting diameter for conifers (Larrieu et al. EJFR 2014)

	Harvesting dbh= 70 cm	Tree-marking
	-16% (ns)	-39%***
	-30% (ns)	0%

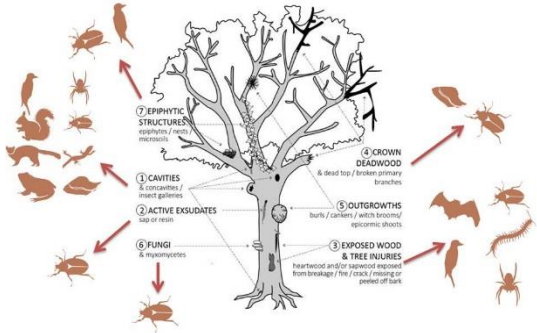
Relationships between TreMs and associated taxa



?



TreMs host a wide diversity of taxa and play a wide range of pivotal biological roles



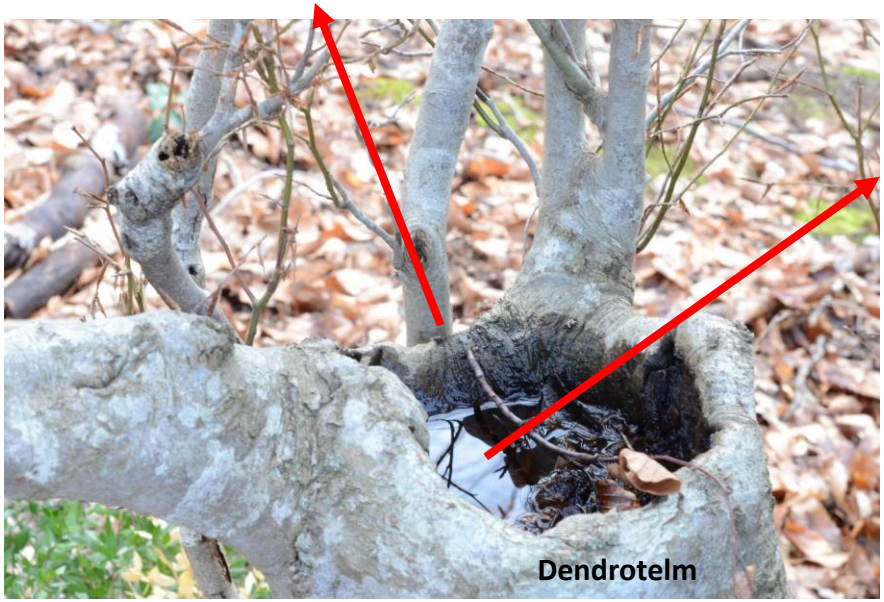
Dependence gradient: - (top) to + (bottom)

- **Shelter** → ➢ Simple shelter; ➢ Regulation Hygrometry / T°; ➢ Wintering site
- **Foraging site** → ➢ Nutrition
- **Reproduction site** → ➢ Several functions?
- **Full life cycle** → ➢ All vital functions

Certain Trems host poor but very specific species assemblages

❑ **Mosses**

- *Zygodon forsteri*
- *Anacamptodon splachnoides*



❑ **Insects** (about 15 species in Europe)
- Mainly Diptera
- Coleoptera (*Prionocyphon serricornis*)

❑ **Fungi** (Hyphomycetes)

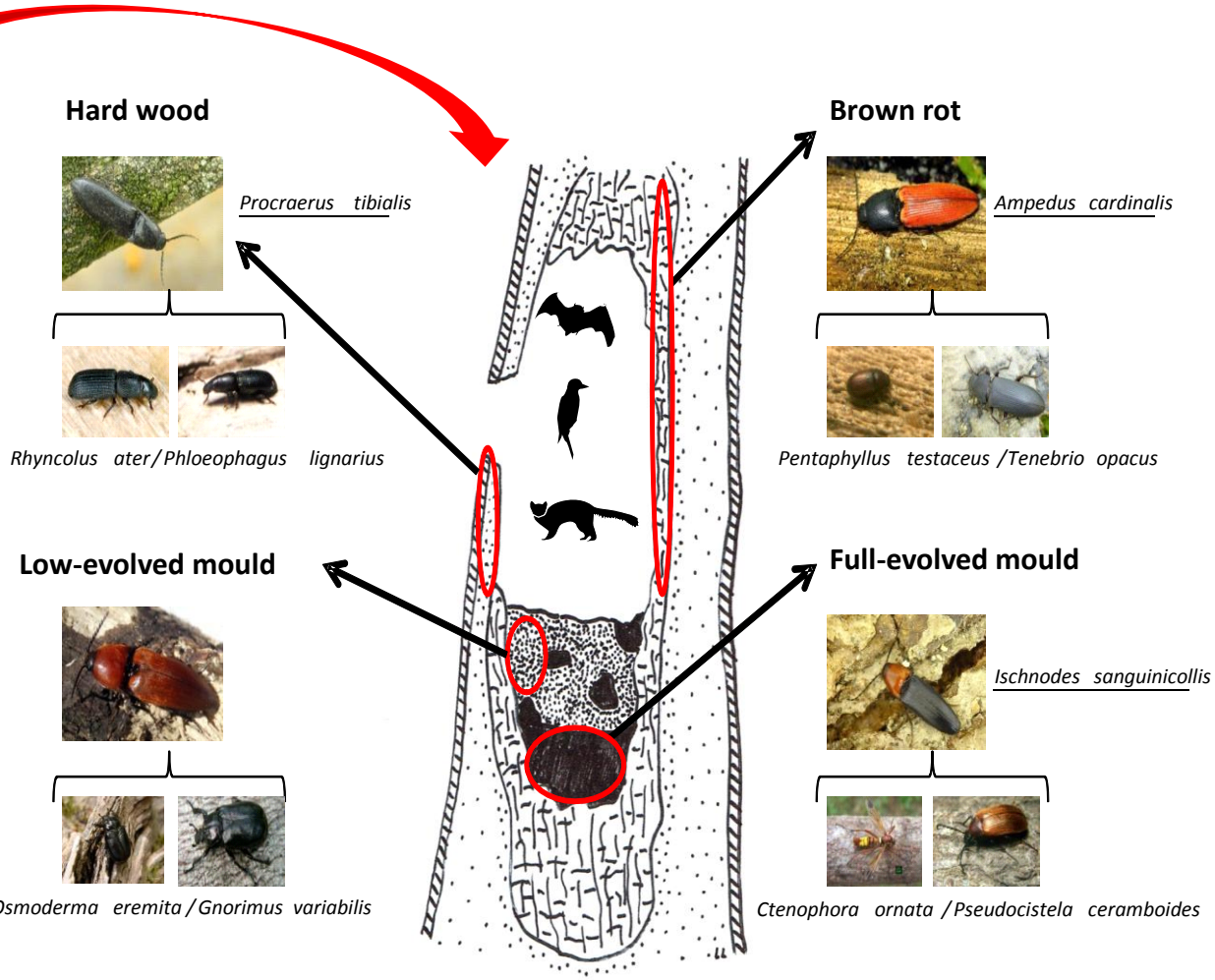
❑ **Flagellates, Rotifers, Nematodes**

❑ **Microcrustaceans**

50 % of the dendrotelm-dwelling insects are strictly associated with this TreM type (Dajoz 1998)

Certain are composite habitat and hosts several communities

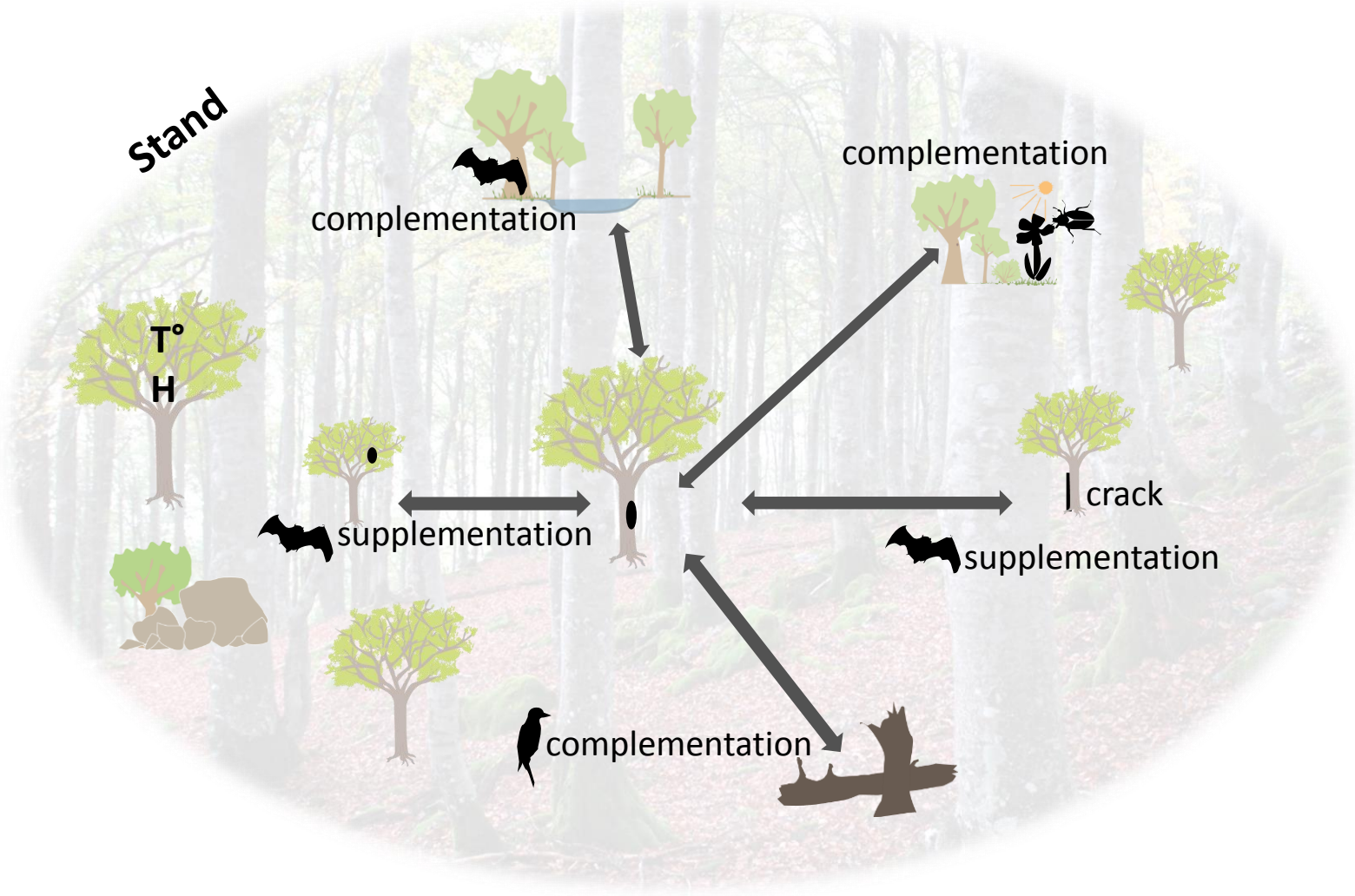
A woodpecker breeding cavity



Elateridae and their main preys

(from Stokland et al. 2012 and Brustel pers. com.)

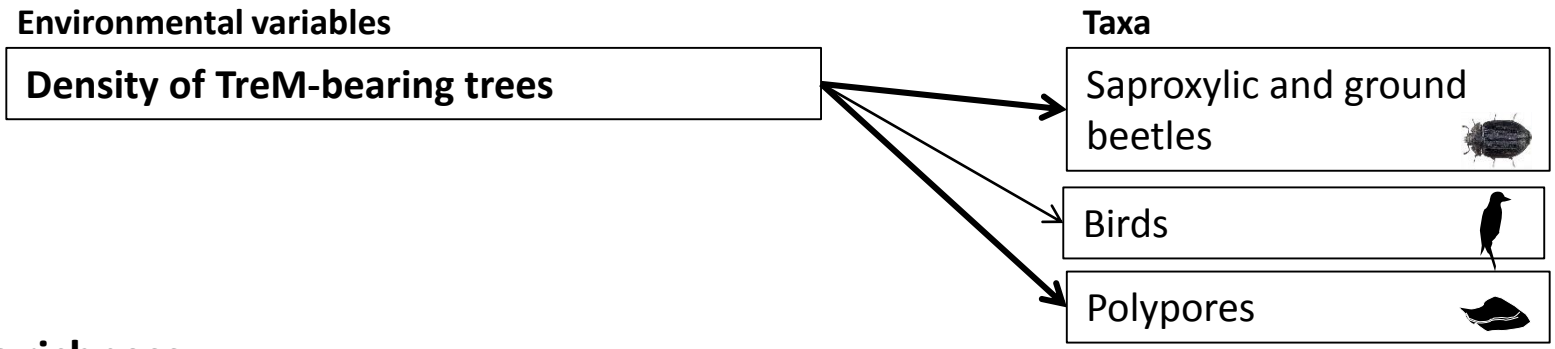
TReMs participate in a complex functional habitat network in species life cycles



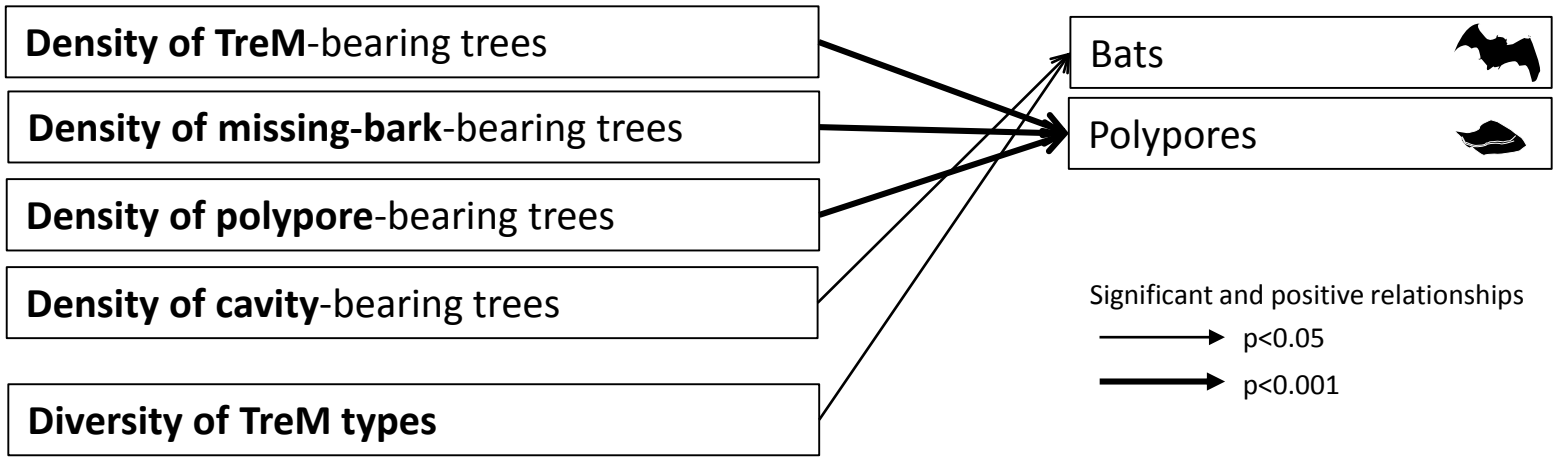
Examples of complementation/supplementation resources for woodpeckers ( ), bats ( ), saproxylic beetles ( )

TReM density and diversity contribute significantly to species diversity (Larrieu et al. in prep.)

❑ **Species composition** (CAP)



❑ **Species richness** (GLMM)



(See also: Winter & Möller FEM 2008; Regnery et al. EI 2013)

102 forests, harvested or not, France

How TReMs contribute to local biodiversity depends both on forest type and taxon conservation status (Bouget et al. Biodiv. Cons. 2013)

Contribution of TReM-bearing tree density to species richness of saproxylic beetles

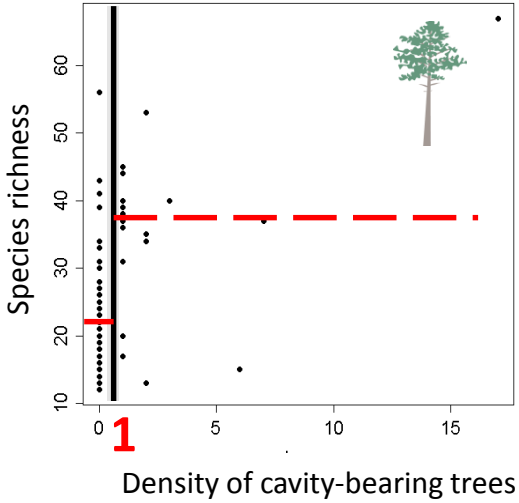
	Common species	Rare species
 **Oak forest**	5th rank	ns
 **Beech forest**	ns	1st rank

7 forests, harvested or not, France

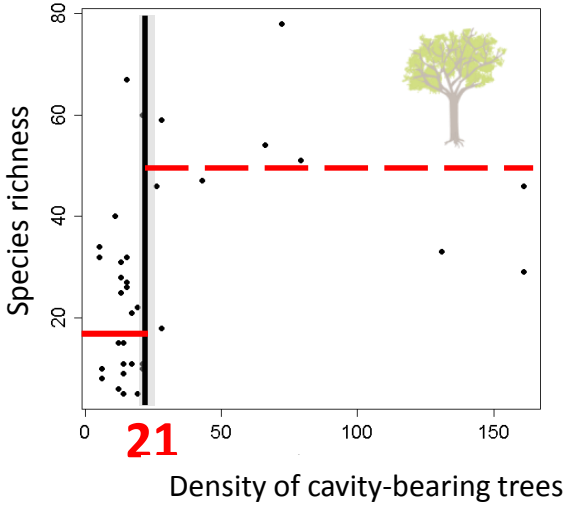
Positive relationships between TReM density and local species richness are sometimes thresholded (Bouget et al. EI 2014)

Local <u>species richness</u> of <u>saproxylic beetles</u> was, on average, higher above the thresholds

1 cavity-bearing tree/ha in lowland **pine** stands



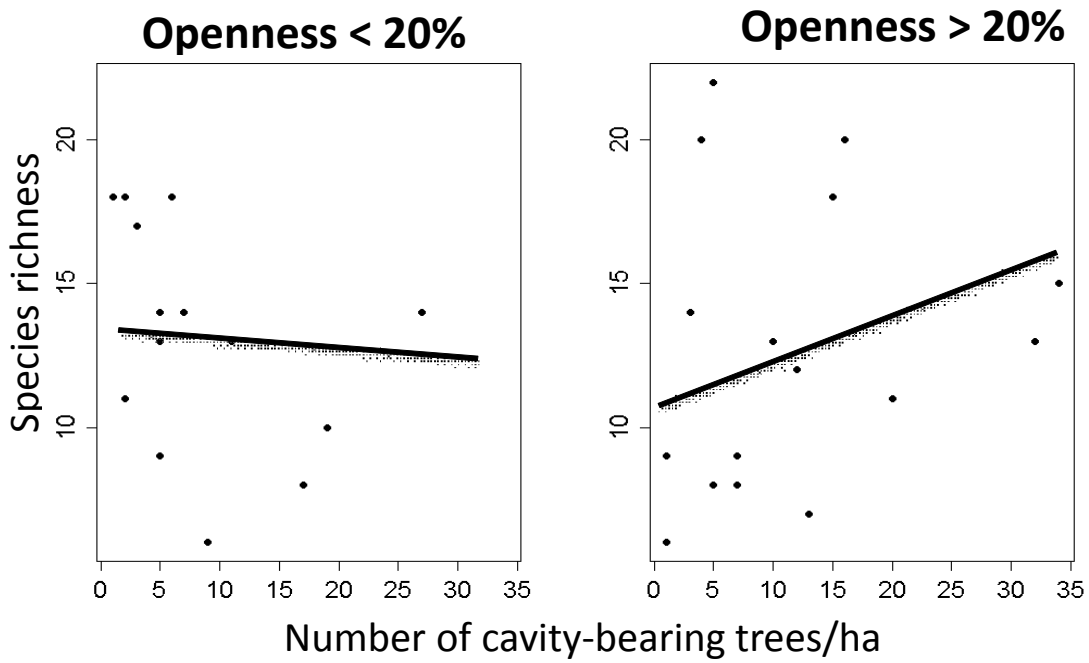
21 cavity-bearing trees/ha in **beech** stands



46 forests, harvested or not, France

The positive effect of increasing TReM density on saproxylic beetle diversity is affected by stand openness

(Bouget et al. EI 2014)



Likely effects of :

- **increase of complementation resource amount (flowers,…)**
- **best microclimate conditions within saproxylic substrates**
- **beetles more active in warmer environments**

16 mountain forests, harvested or not, France

Some practical considerations for forest management integrating TreMs







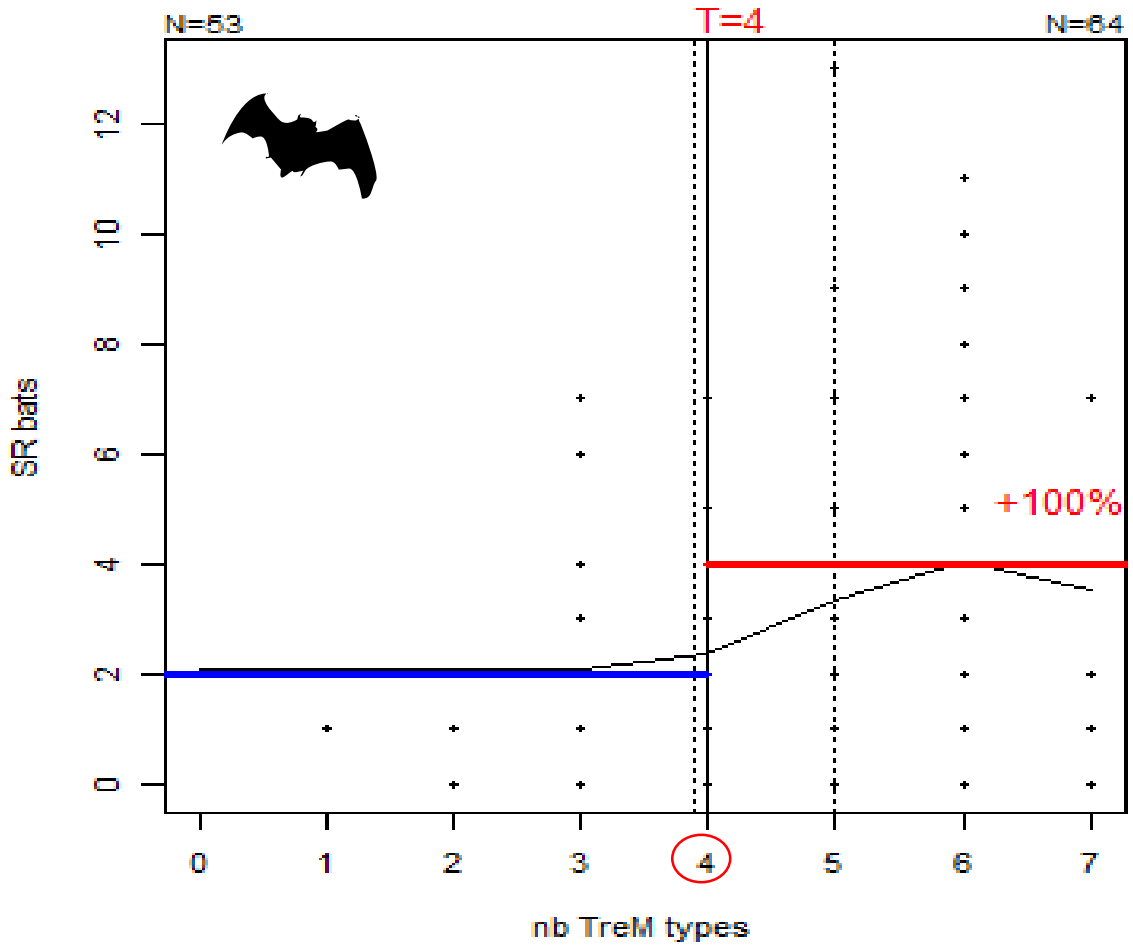




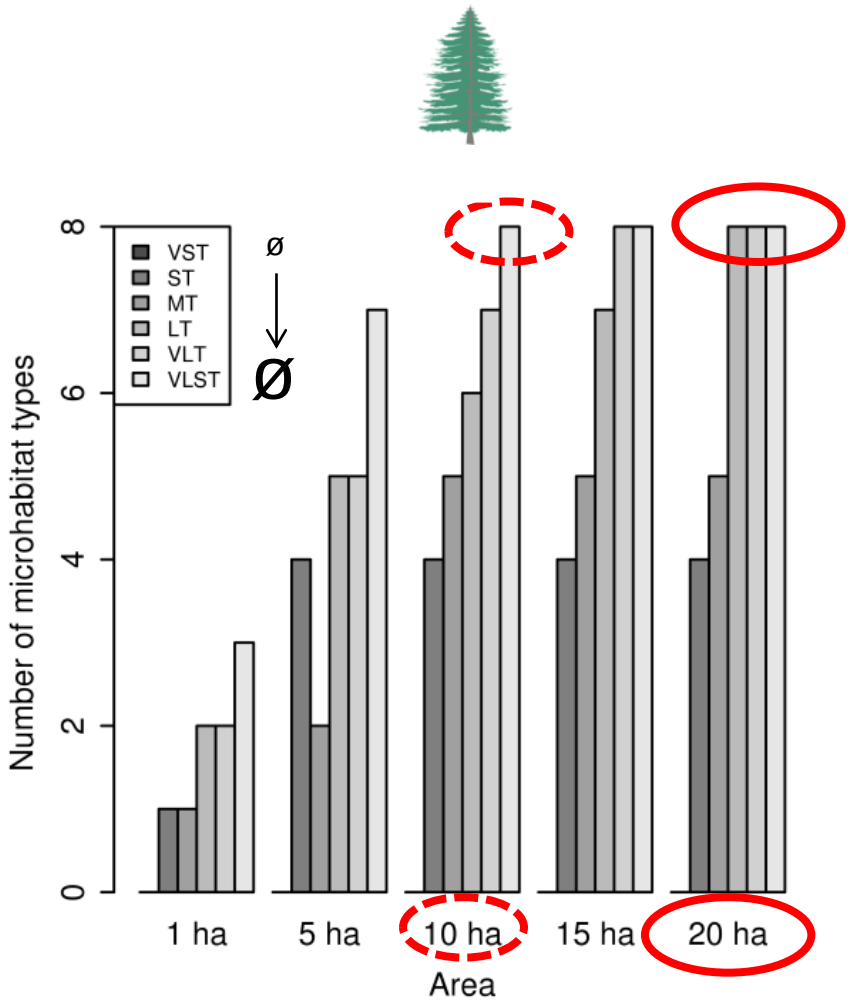



Toward more number-thresholds as practical tools to help forest managers taking TreM-associated taxa into account

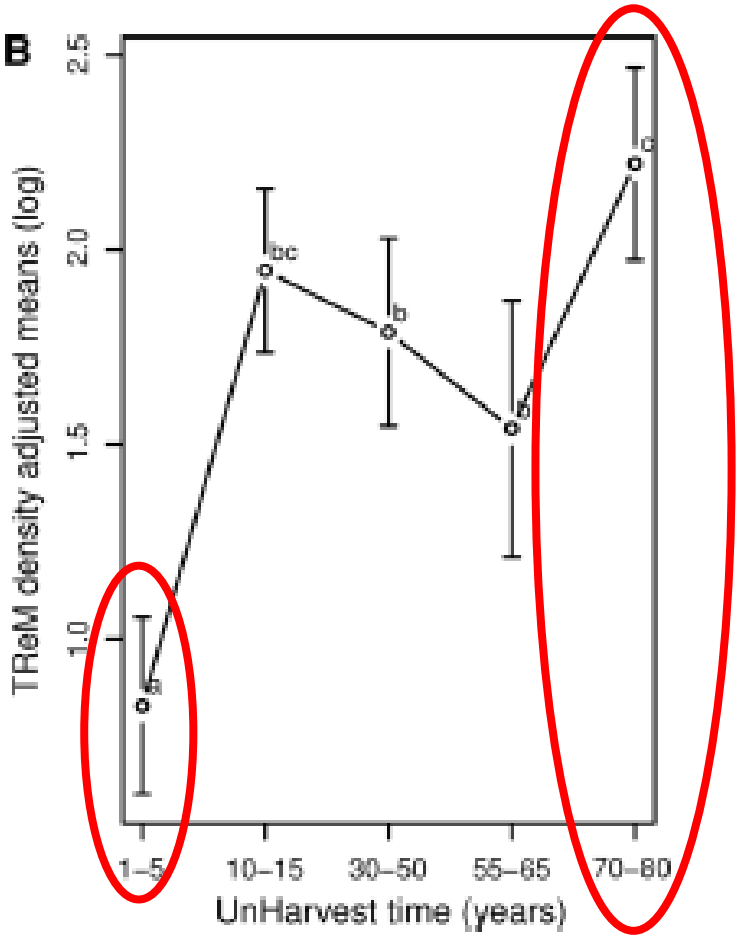
(Larrieu et al. in prep)



Set-aside areas: 20 ha are needed in mixed forest to conserve TreM diversity (Larrieu et al. EJFR 2014)



After a drastic harvesting, recovery of TreM community need decades (Larrieu et al. EJFR 2017)



>80y without harvesting needed to reach a "natural" TreM density

Furthermore, TreM-associated taxa have a time-lag response…
(Bouget et al. AC 2014)

Coppice-with-standards, 24 forests, SW France

It can exist a strong observer effect on TreM recording

(Paillet et al. EI 2015)

Need

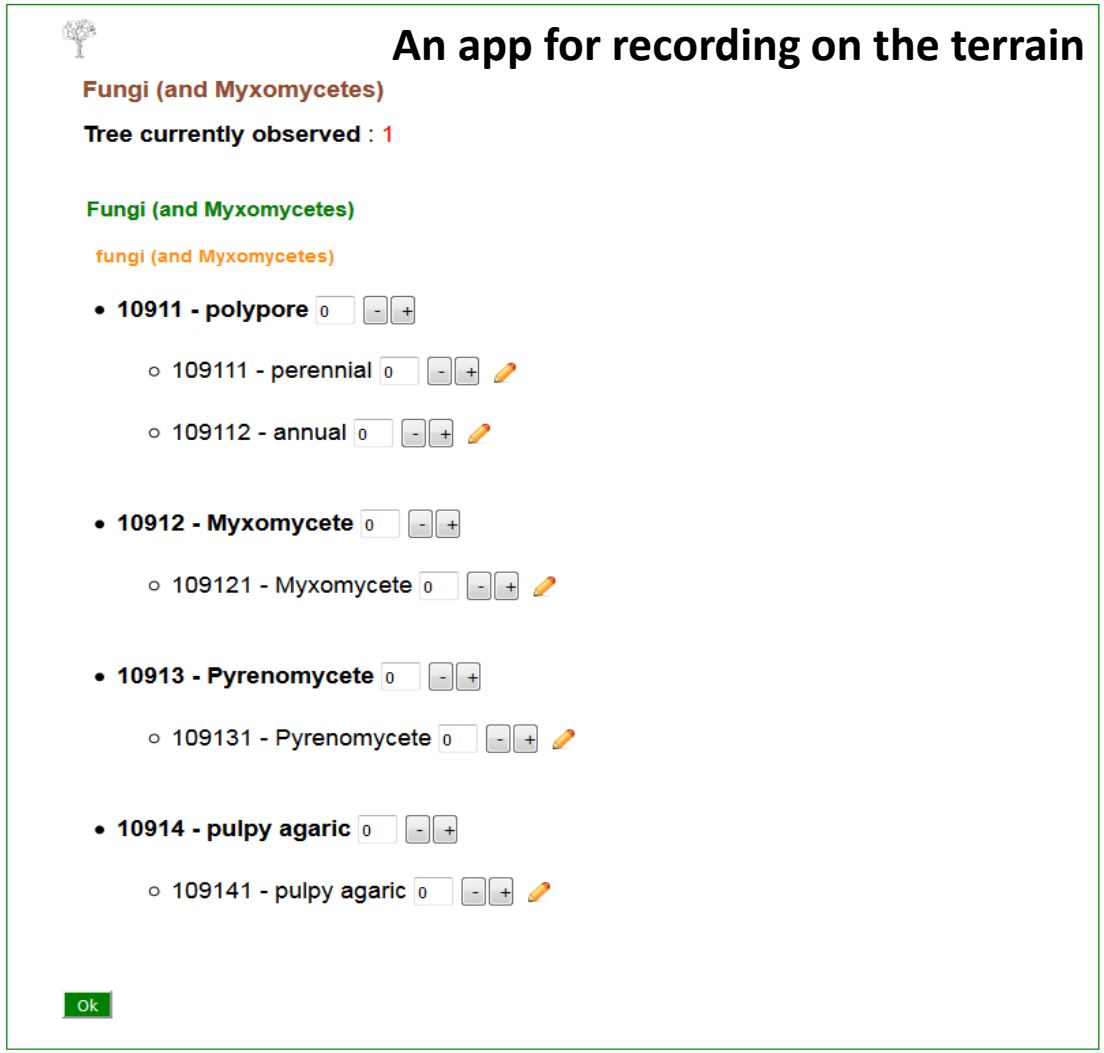
- **Using the same TreM definition**
- **Clear procedures**
- **Observer training**
- **Accurate definition of the tree-part where TreMs are observed**

A hierarchical typology is now available as a reference for TreM recording in temperate and Mediterranean European forests

(Larrieu, Paillet, Winter et al. EI 2018)

Table 5
Illustrations of the TreM types

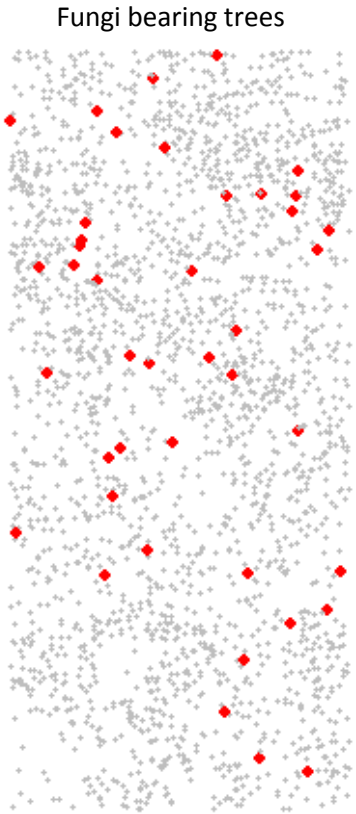
Form	Group	
Cavities l.s.	Woodpecker breeding cavities	Small wood Entra 
	Rot-holes	Trunk h (closed top Open 
	Insect galleries	Insect galler Hole ø >2cr 



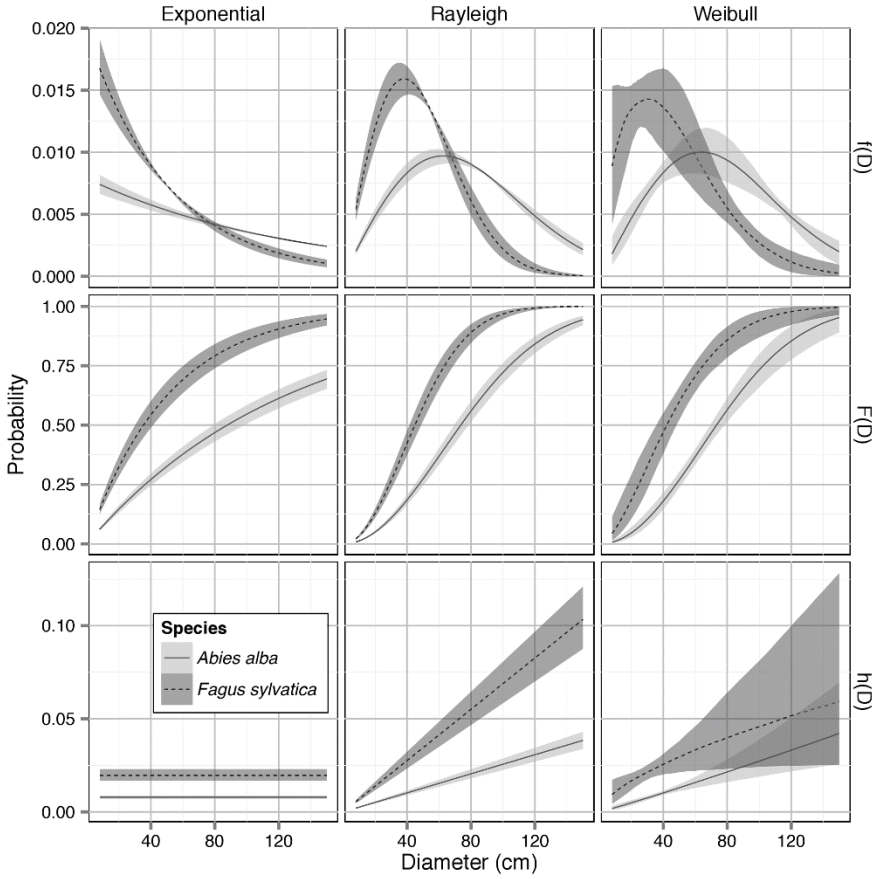
, 47 types

Ongoing research

Spatial distribution

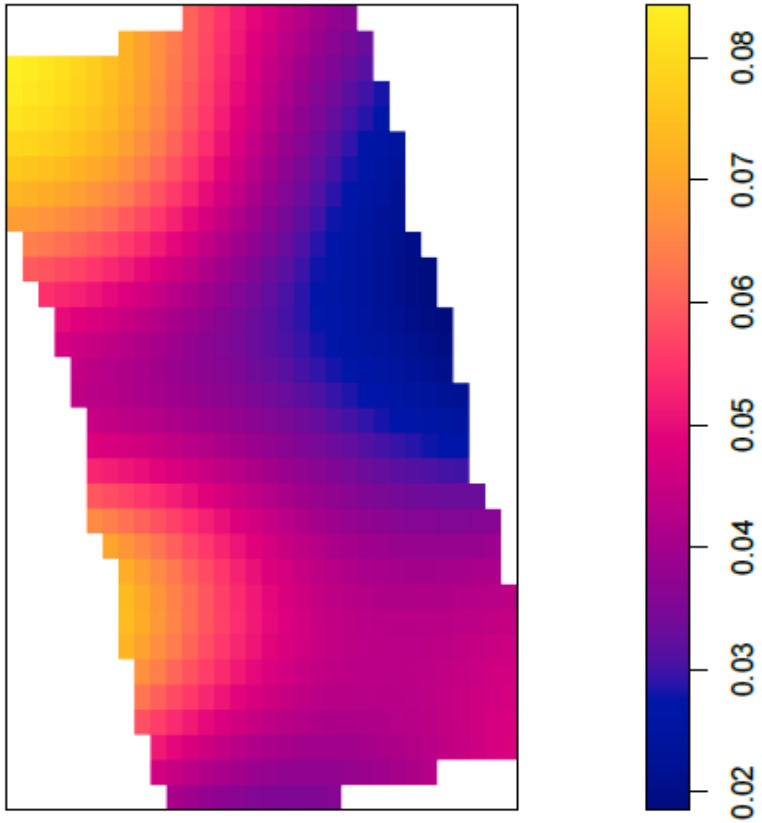


Modelling

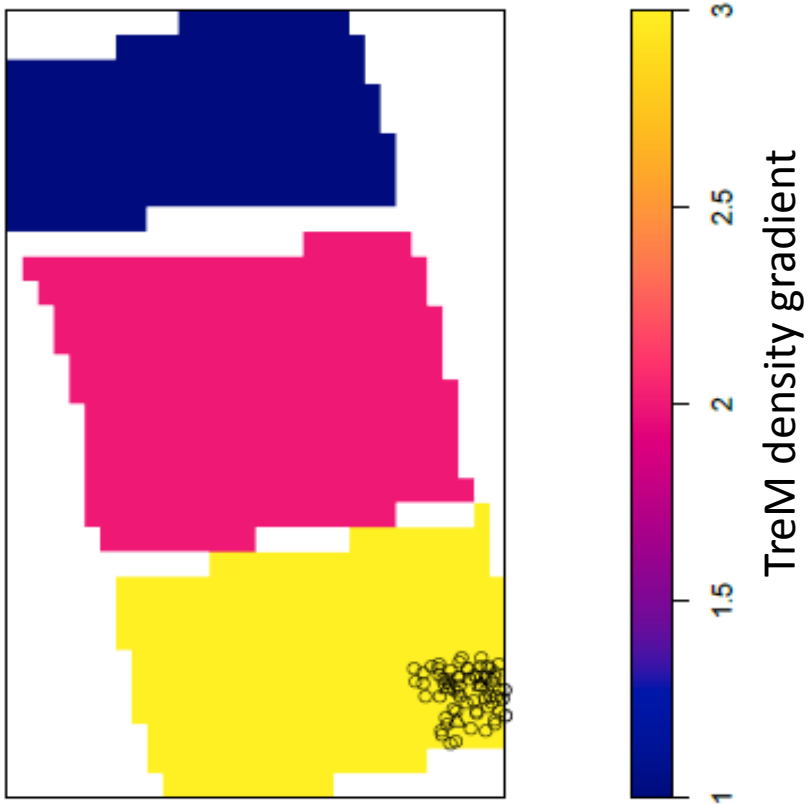


TreM spatial distribution patterns in old-growth forests and harvested stands and effects on associated taxa

Rot-holes



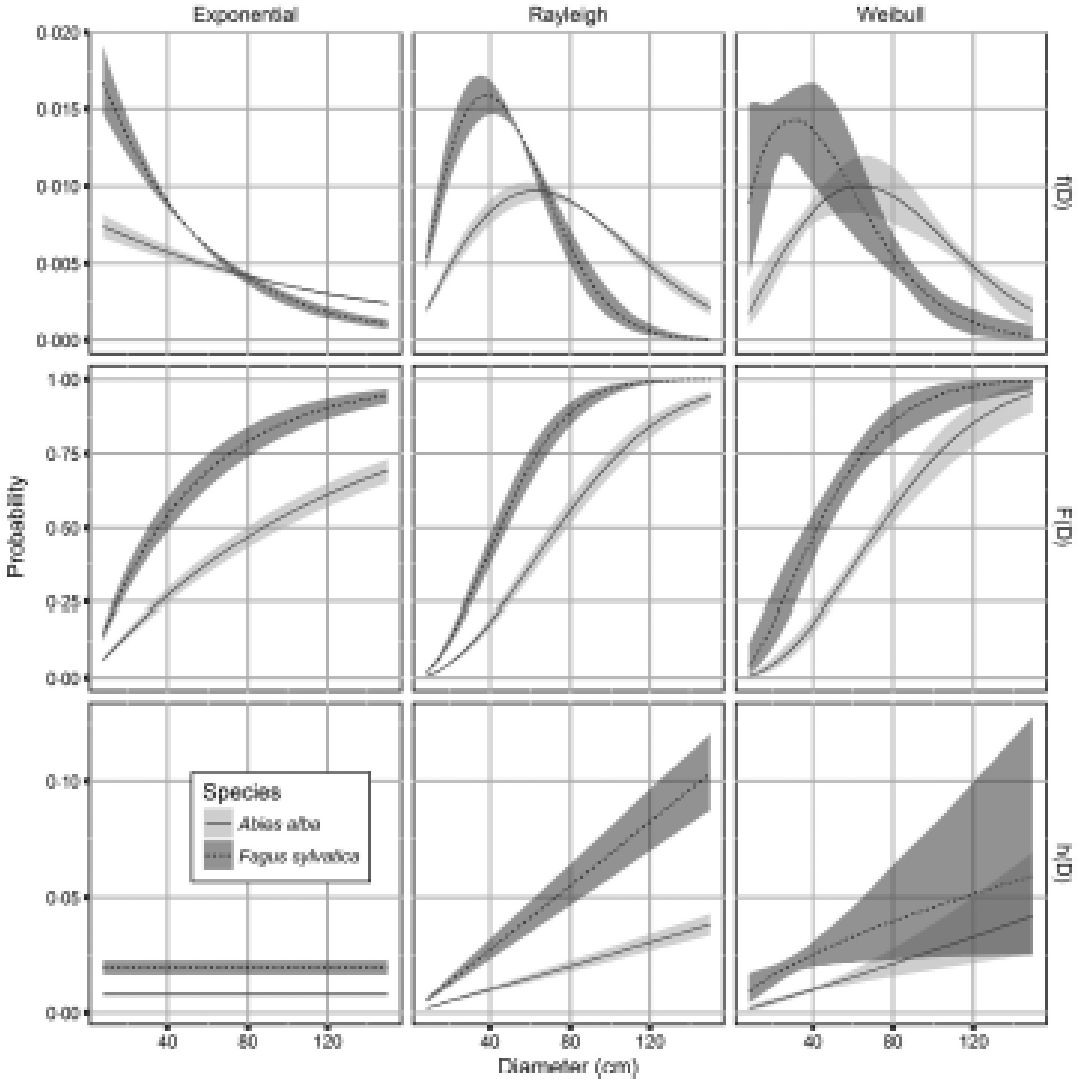
Dendrotelms



Need of spatial data…

10-ha plot Uholka primeval forest

Modelling the probability of TreM formation (Courbaud et al. MEE 2017)

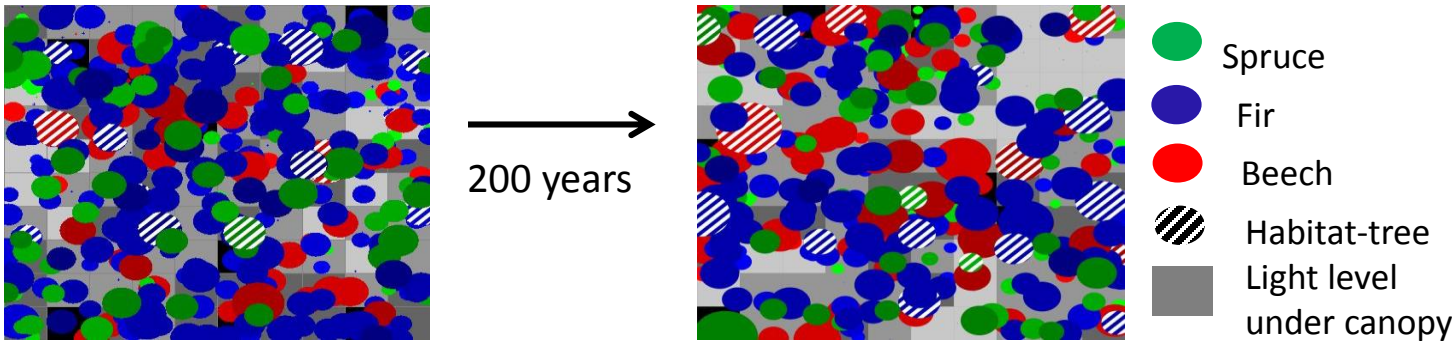


Current targets:

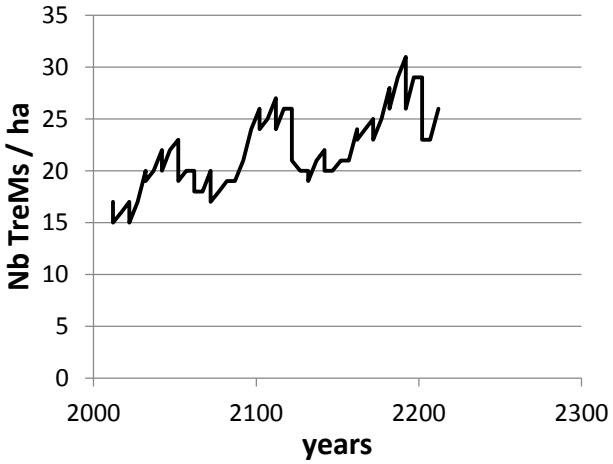
- **10 tree-species**
- **10 TreM types**

Then using a simulation model to evaluate long-term effects of a range of management senarii

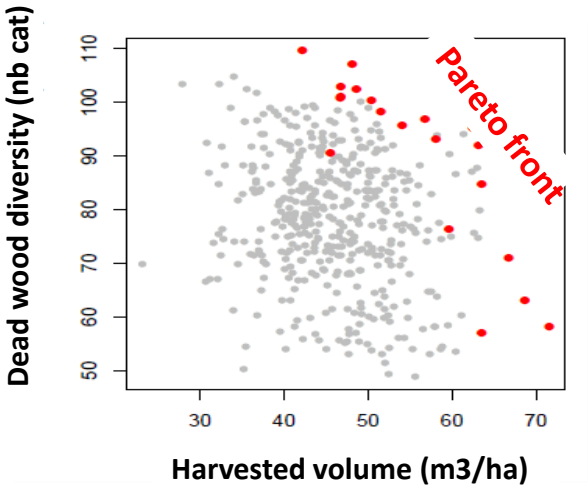
(Courbaud et al. 2003, 2015; Coligny et al. 2003, Dufour-Kowalski et al. 2012; Lafond et al., in press)



Evolution of TreM density



Production/biodiversity trade-offs



Be patient, kid, and come back about 2118…

Thanks for your attention !