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

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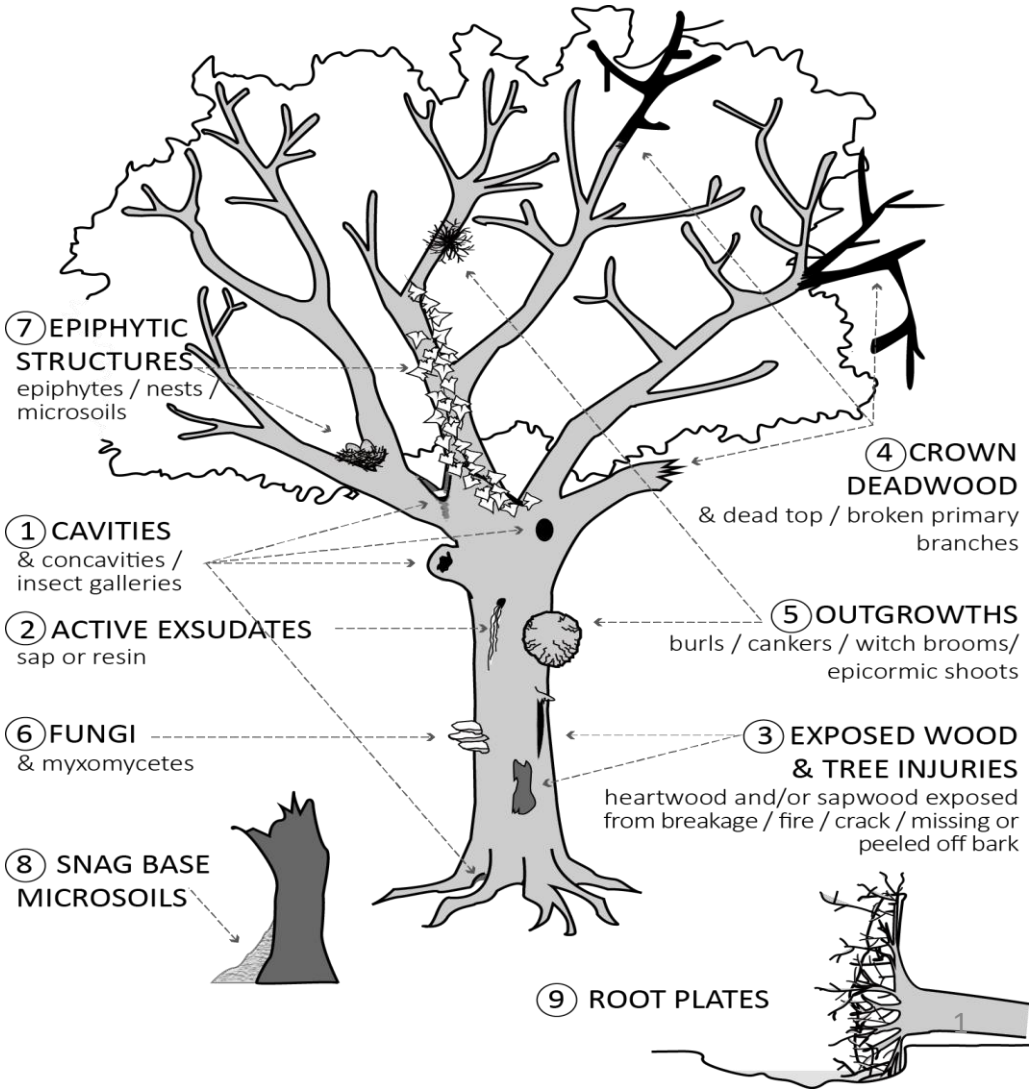


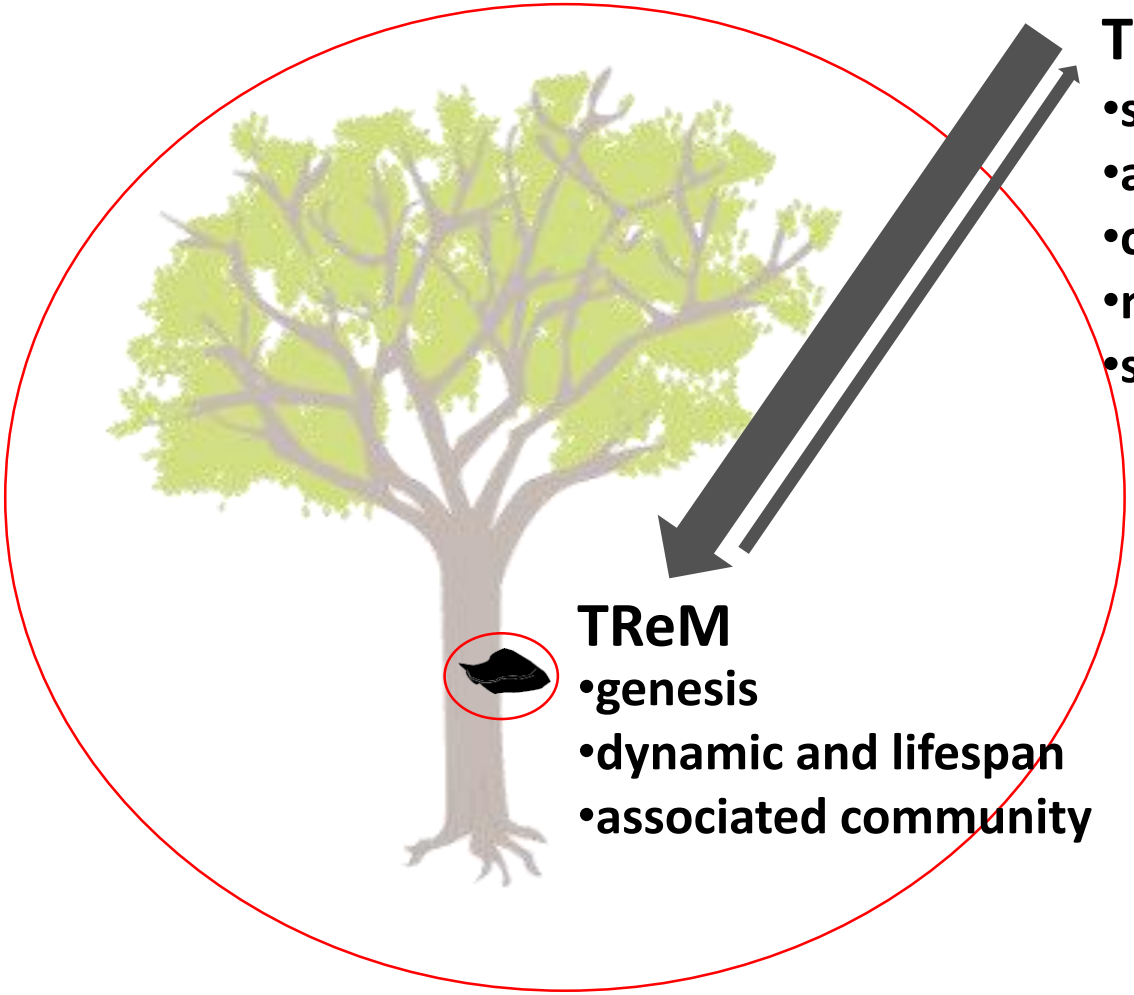
TReMs are morphological singularities borne by trees; they host a wide range of taxa

- **Borne by above ground parts of a tree, dead or living: base, trunk and crown**
- **Small to mid-sized (cm/cm³ → m/m³)**
- **Encompassing decaying wood (=saproxylic TreMs) or not (=epixylic TreMs)**
- **Hosting preferentially-associated taxa**

Drawings from L. Apfelbacher

I-TreMs as ecological items

TreMs depend on tree characteristics



TREE
- species life-traits
- age/diameter
- close environment
- management
- stochastic events

TReM
- genesis
- dynamic and lifespan
- associated community

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

TReMs are « ephemeral resource patches (Finn 2001) »

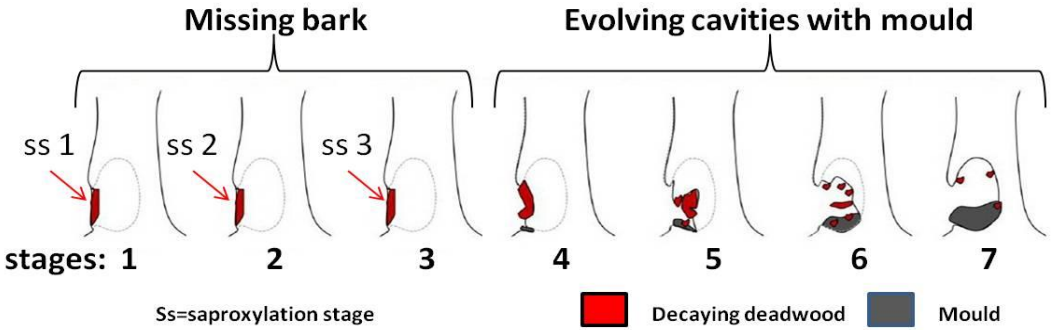
≈

- 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)

TreMs play a wide range of pivotal biological roles

Dependence gradient

-

Shelter →

- **Simple shelter**
- **Hygrometry/temperature regulation**
- **Wintering site**

Foraging site →

- **Nutrition**

Reproduction site →

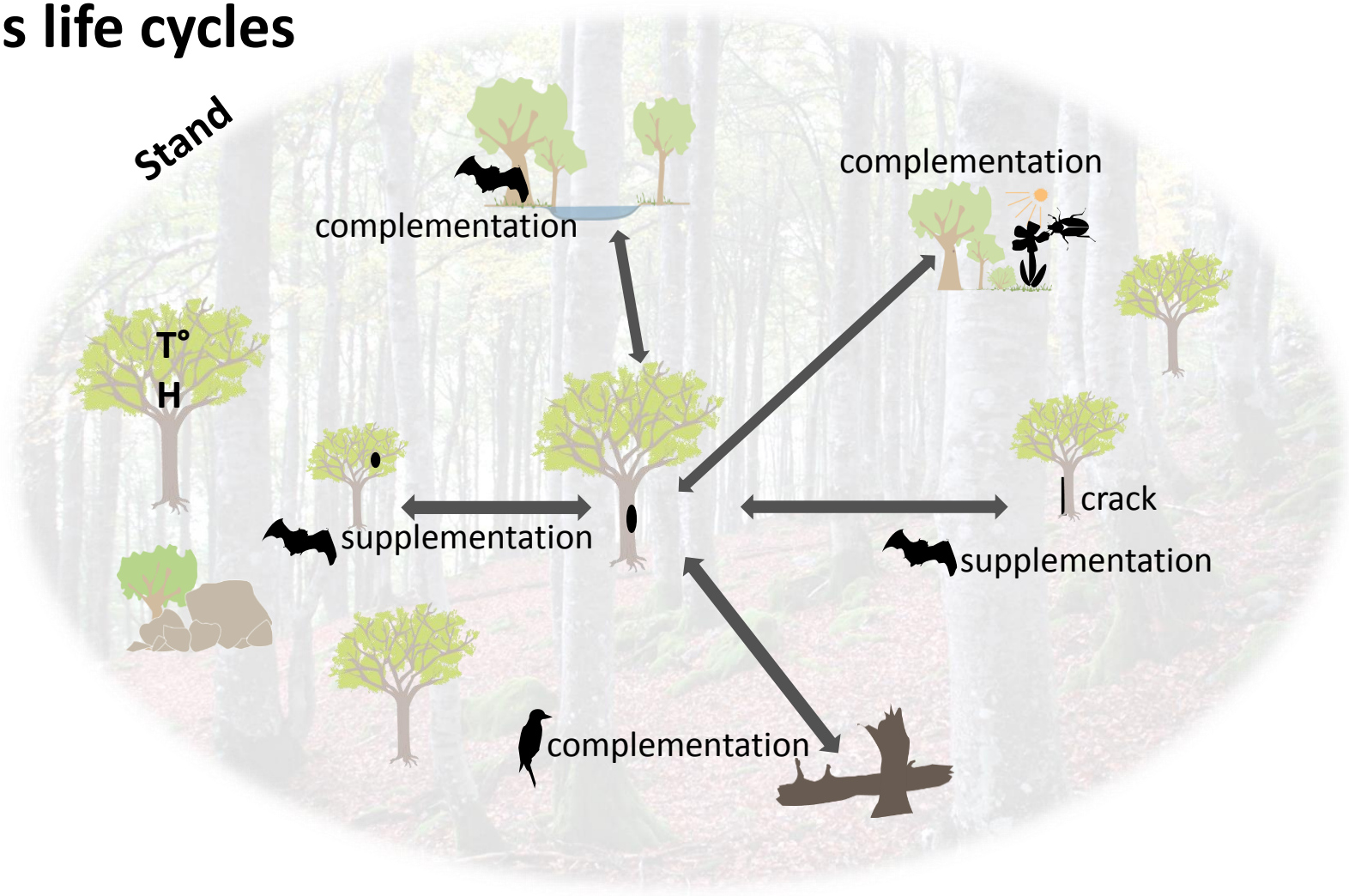
- **Several functions?**

+

Full life cycle →

- **All vital functions**

TReMs participate in a functional habitat network in species life cycles



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

TReMs are key elements for complexity of forest ecosystems

Dimensions of complexity (from Cadenasso et al. 2006)

Structural heterogeneity

- Broad scale
  - Trees
  - Eco-units
  - Sylvigenetic phases
  - Sylvigenetic cycle
- Fine scale
  - **TreM density**
  - **TreM diversity**
  - **Substrate diversity within a TreM**

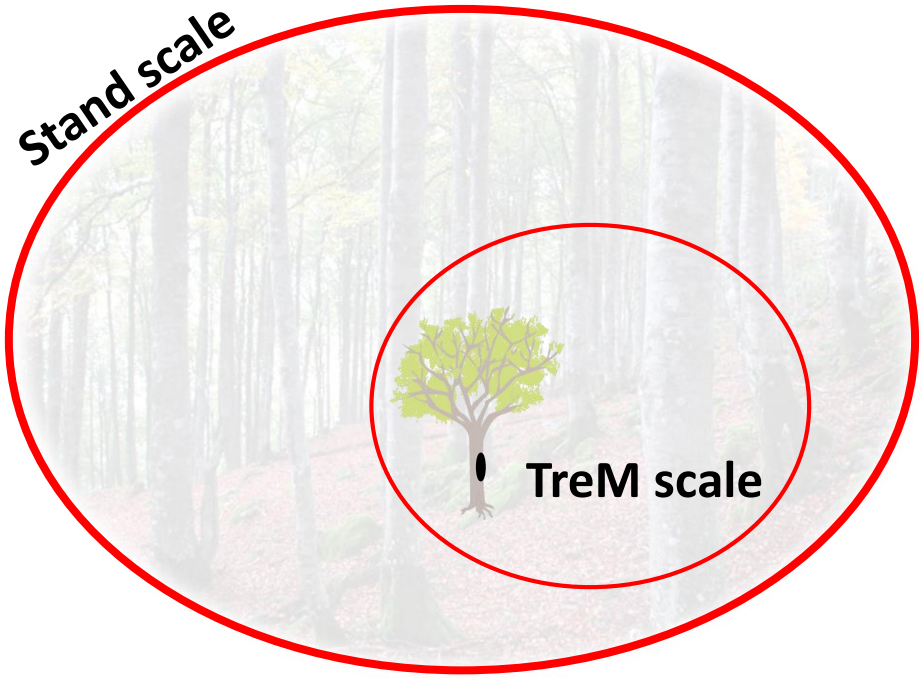
Spatial connectivity

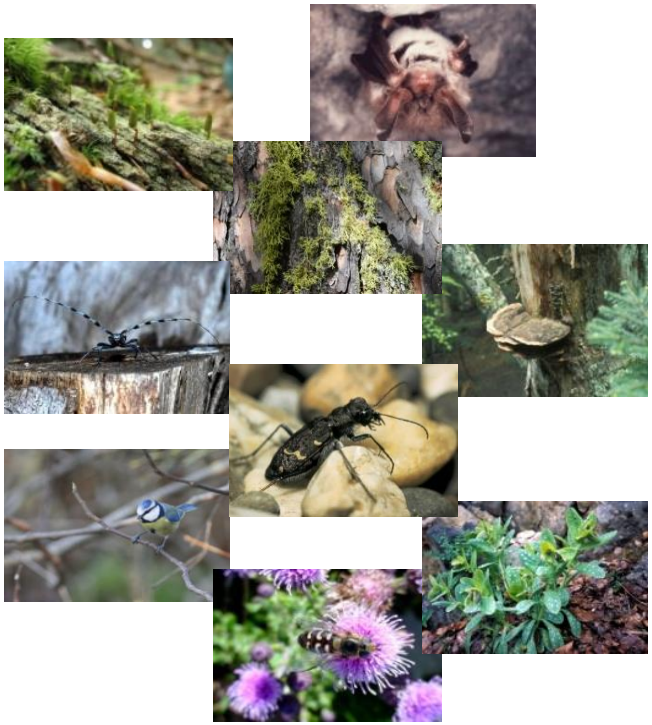
- **TreM spatial distribution**
- **TreMs as complementation/supplementation resources**
- **Changes in TreM profile**

Historical contingencies

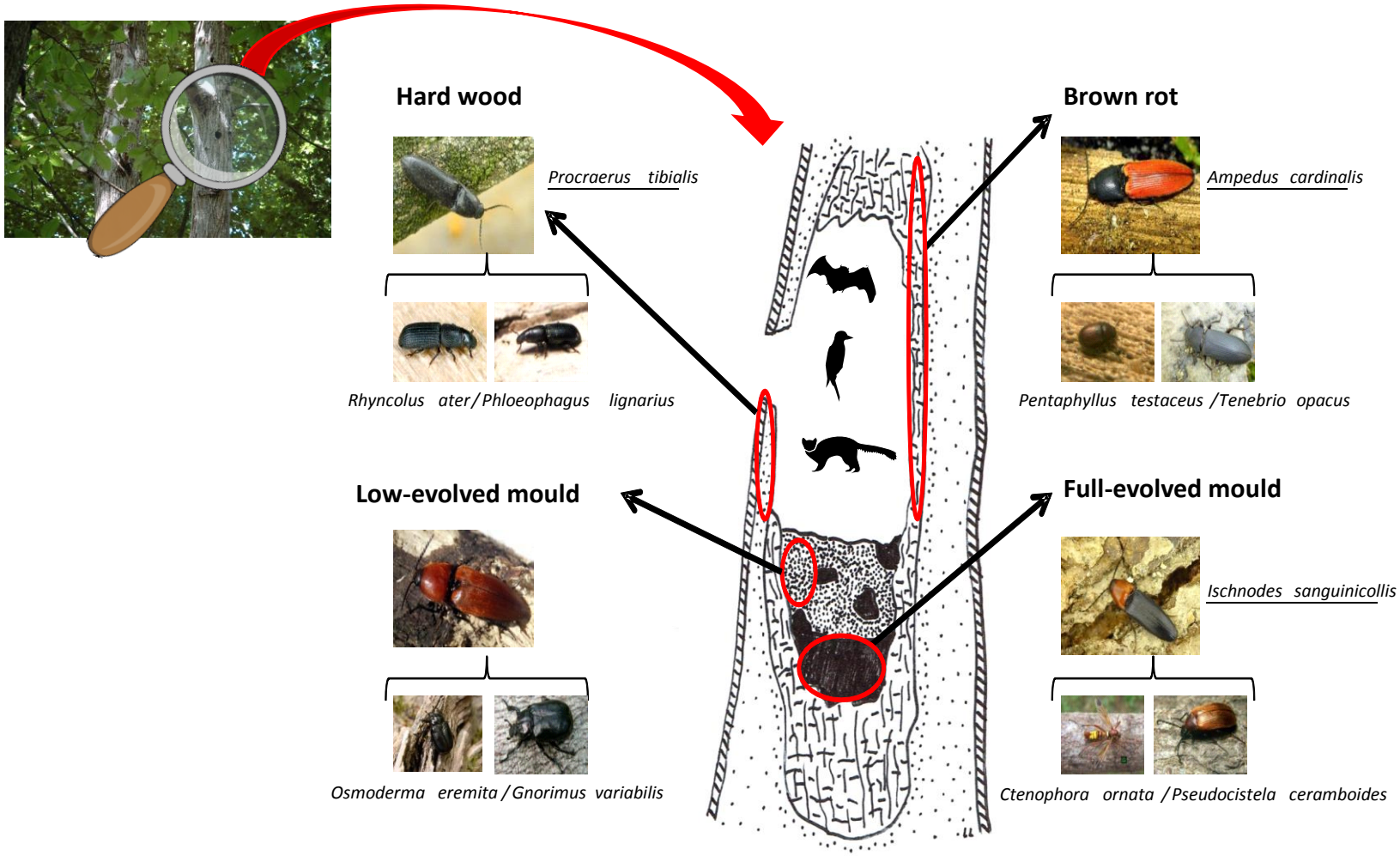
- Legacies
- Resource gaps
- Time-lagged taxon response

II-Relationships between TreMs and associated taxa





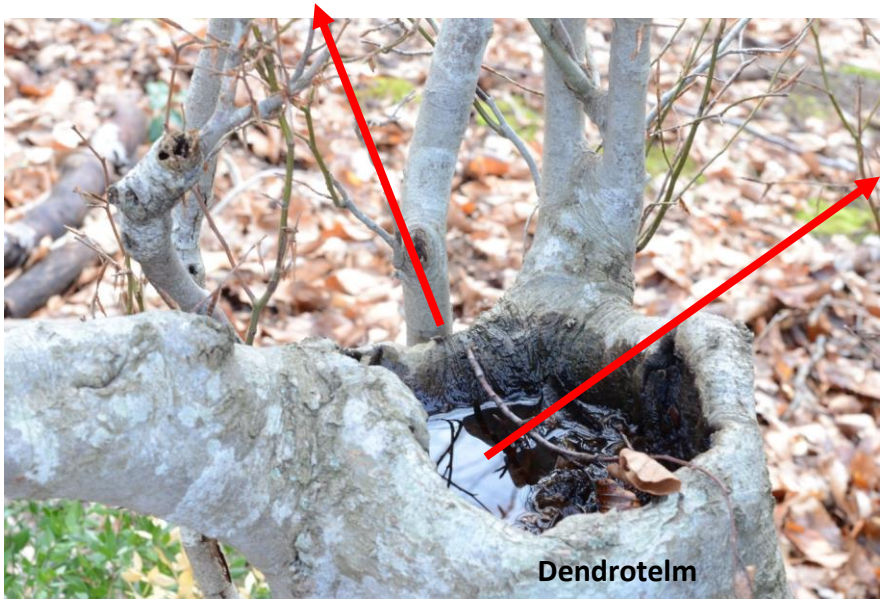
A TreM is often a composite habitat and hosts several communities



Elateridae and their main preys; from Stokland et al. 2012 and Brustel pers. com.

Certain Trems host 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)

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

❑ Species composition (CAP)

Environmental variables

Density of **TreM-bearing trees**

Taxa

Saproxylic beetles

Birds

Fungi

❑ Species richness (GLMM)

Density of **TreM-bearing trees**

Diversity of TreM types

Density of **missing-bark**-bearing trees

Density of **fungus**-bearing trees

Density of **cavity**-bearing trees

Bats

Fungi

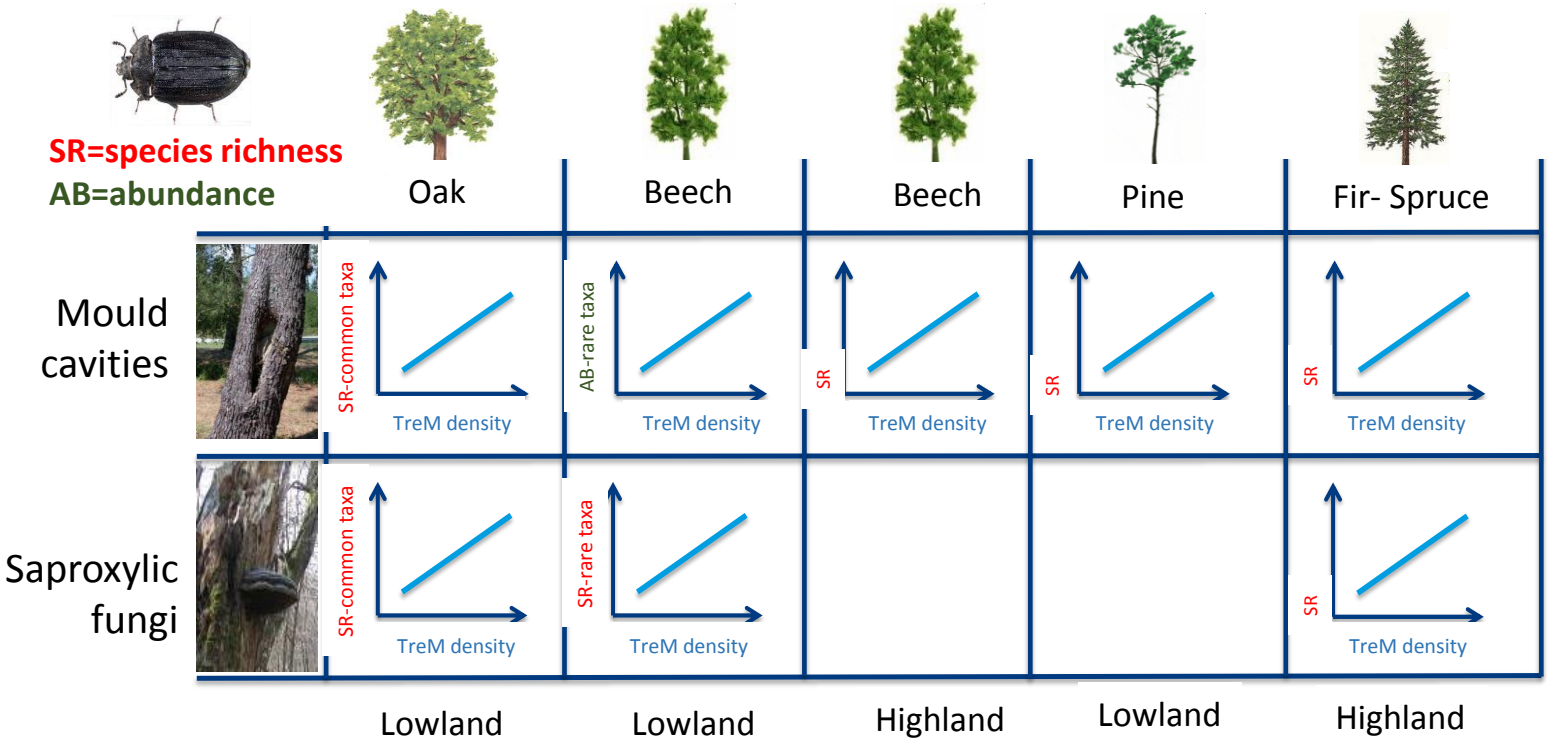
Significant and positive relationships

→ p<0.05

→ p<0.001

102 forests, harvested or not, France

TreM-bearing tree density significantly drives saproxylic beetles diversity in many forest contexts (Bouget et al. EI 2014)



17 forest regions, harvested or not, France

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

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

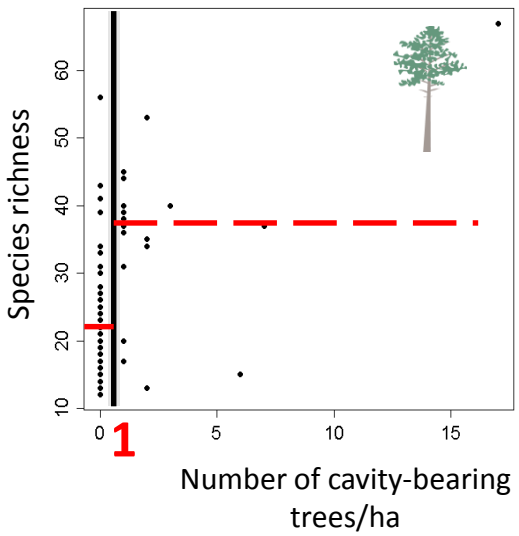
	Common species	Rare species
Oak forest	5th rank	ns
Beech forest	ns	1st rank

7 forests, harvested or not, France

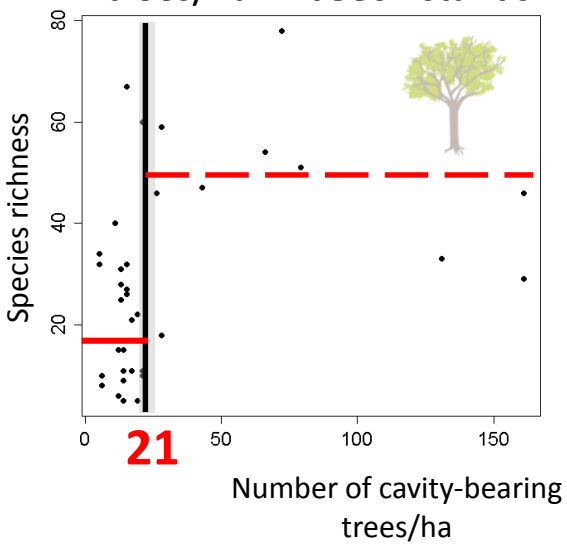
Positive relationships between TReM density and local species richness are sometimes thresholded (Bouget et al. EI 2014)

Local species richness of saproxylic beetles was, on average, higher above the thresholds

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

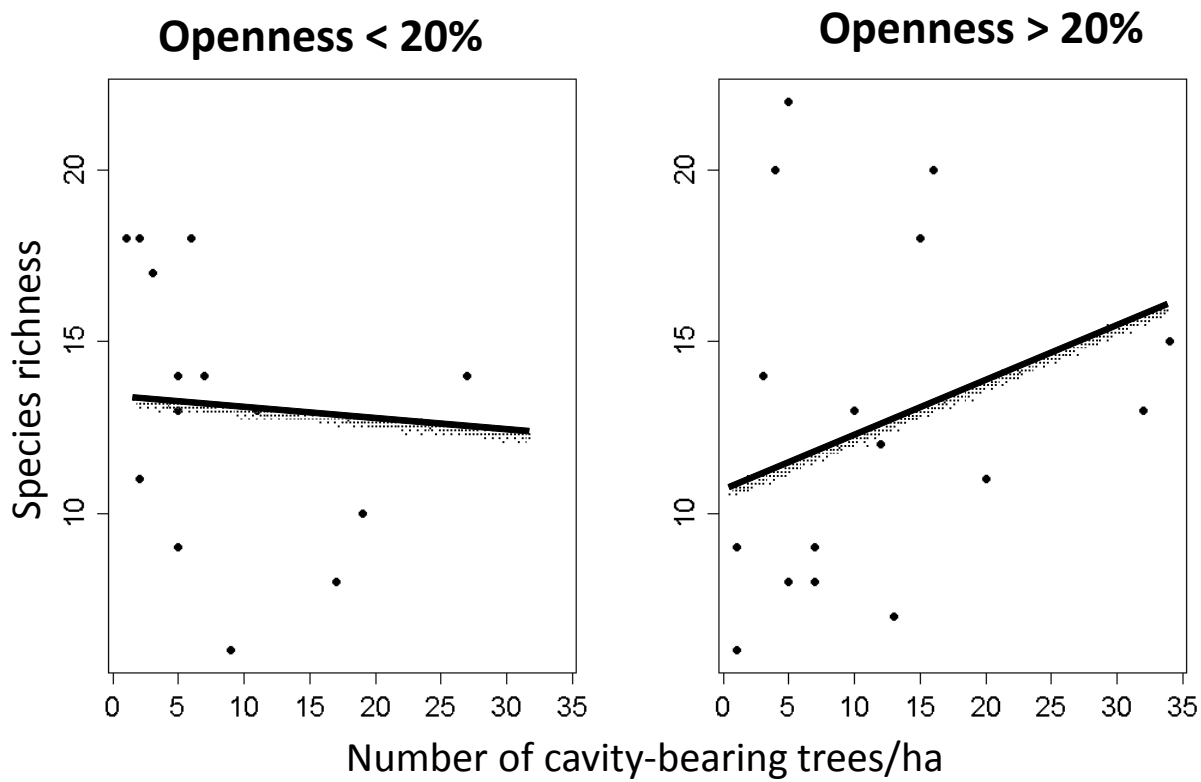


21 cavity-bearing trees/ha in **beech** stands



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 :

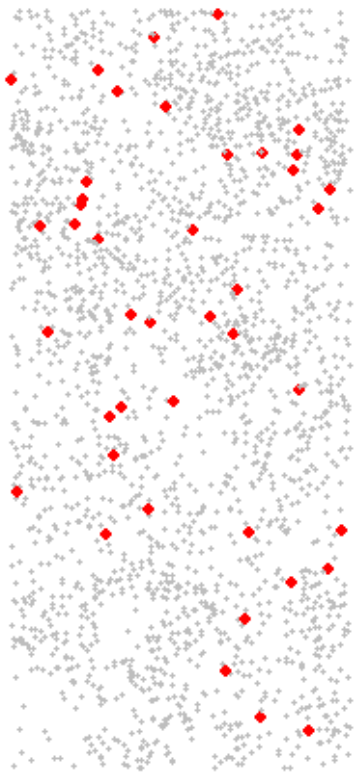
- **increase of complementation resource amount (flowers,…)**
- **best microclimate conditions within saproxylic substrates**
- **beetles more active in warmer environments**

16 mountain forests, harvested or not, France

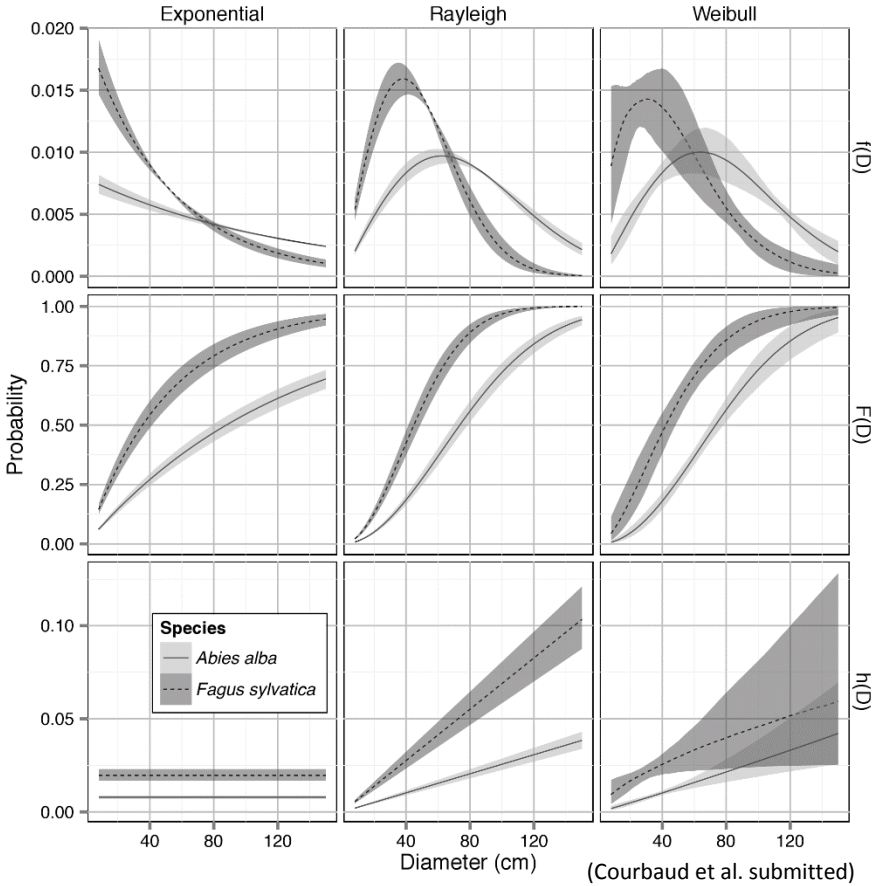
III-Research perspectives

Spatial distribution

Fungi bearing trees



Modelling



(Courbaud et al. submitted)

Ongoing research on TreM spatial patterns will take a tremendous step forward in TreM knowledge

Main objectives

- **Mid-term: patterns of TreM spatial distribution and role on TreM-associated biodiversity**
  - In subnatural forests: TreM spatial distribution as a proxy of dispersion capacities of the TreM associated taxa
  - In managed forests: disentangle the effects of changes in both TreM density and TreM spatial distribution on TreM-associated biodiversity changes

- **Long-term: TreM dynamics**
  - TreM types genesis and co-occurrences (using distribution of environmental features)
  - TreM life-spans (diachronic studies)

The modelling of TreM dynamics may help generalize results and improve practical recommendations

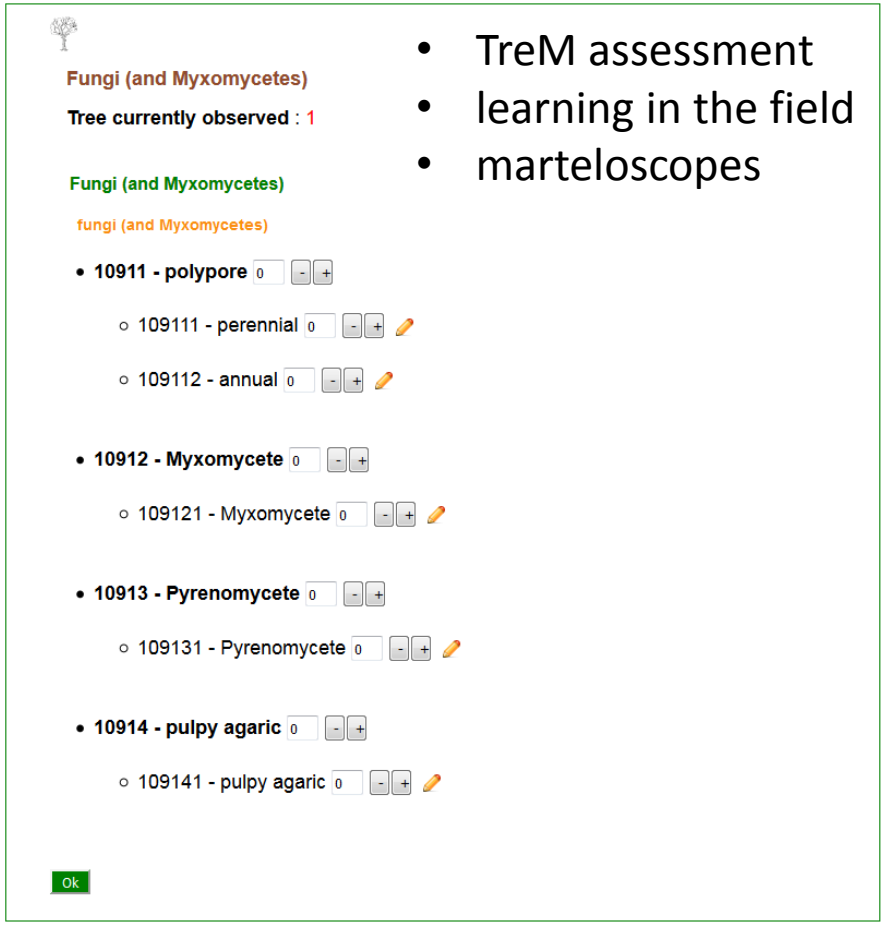
- **Modelling the probability of TreM formation using survival analysis methods**
- **Using tree life-history traits to understand differences of TreM dynamics among species and generalize for groups of tree species**
- **Implementing TreM dynamics in Samsara2, an individual-based model of forest dynamics**

→ **Prediction of TreM flows within stands, managed or not**

IV-Related tools already available

Typologies

e-applications



- TreM assessment
- learning in the field
- marteloscopes

I'd like to bear TReMs like you…
You have to be patient, kid!
JG
Thanks for your attention !