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

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Integrate+ conference, Ebrach (Bavaria), October 26-28th, 2016
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 (=saproyxlic TReMs) or not (=epixylic TReMs)
- Hosting preferentially-associated taxa
I-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
- spatially limited
- temporary

TReM type “X”

Disappearance (tree removed)

Development/change

- Type “X” → Type “Y” (=lifespan)

Unavailability (=“useful” period)

Missing bark

Evolving cavities with mould

stages: 1, 2, 3

Ss=saprophytation stage

Decaying deadwood

Mould

Living tree → Dead tree
TreMs play a wide range of pivotal biological roles

- 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
  - Taxa:
    - Bats
    - Fungi

Significant and positive relationships:
- \( p < 0.05 \)
- \( p < 0.001 \)
**TreM-bearing tree density significantly drives saproxylic beetles diversity in many forest contexts** (Bouget et al. El 2014)

**Introduction**

TreMs and taxa relationships
TreM scale / Stand scale

Further research

**Mould cavities**

**Saproxylic fungi**

SR=species richness
AB=abundance

TreMs and taxa relationships
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17 forest regions, harvested or not, France
How TReM contribute to local biodiversity depends both on forest type and taxon conservation status \((Bouget\ et\ al.\ BC\ 2013)\)

<table>
<thead>
<tr>
<th>Common species</th>
<th>Rare species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oak forest</td>
<td>5(^{th}) rank</td>
</tr>
<tr>
<td>Beech forest</td>
<td>ns</td>
</tr>
</tbody>
</table>

Contribution of TReM-bearing tree density to species richness of saproxylic beetles
Positive relationships between TReM density and local species richness are sometimes thresholded (Bouget et al. El 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

Number of cavity-bearing trees/ha

Species richness

Further research
The positive effect of increasing TReM density on saproxylic beetle diversity is affected by stand openness (Bouget et al. El 2014)

Likely effects of:
- increase of complementation resource amount (flowers,...)
- best microclimate conditions within saproxylic substrates
- beetles more active in warmer environments
III-Research perspectives

Spatial distribution

Modelling

Fungi bearing trees

Exponential

Rayleigh

Weibull

Species

Abies alba

Fagus sylvatica

(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

Catalogue of tree microhabitats

Reference field list

e-applications

- TreM assessment
- learning in the field
- marteloscopes
Thanks for your attention!

I’d like to bear TReMs like you...

You have to be patient, kid!

Thanks for your attention!