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Laurent Larrieu, Benoit Courbaud, Goulard Michel, Wilfried Heintz, Daniel Kraus, Thibault Lachat, Sylvie Ladet, Fabien Laroche, Jörg Müller, Yoan Paillet, et al.

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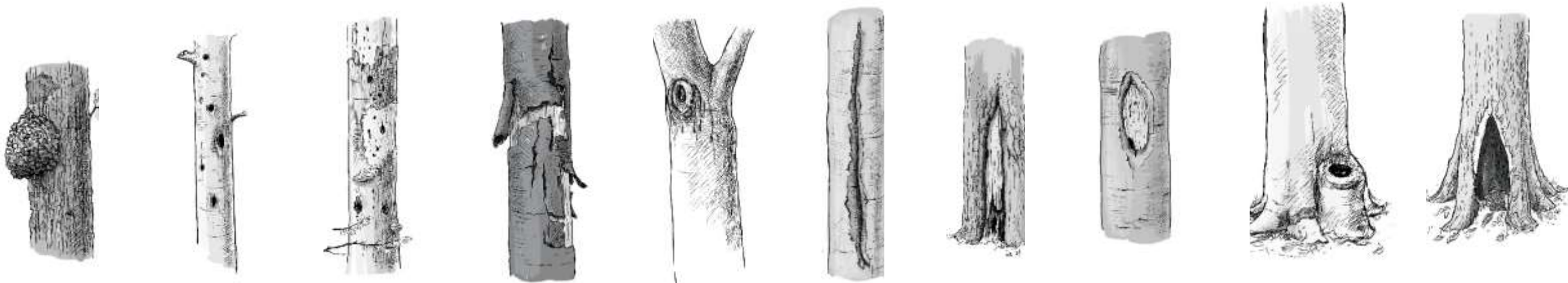
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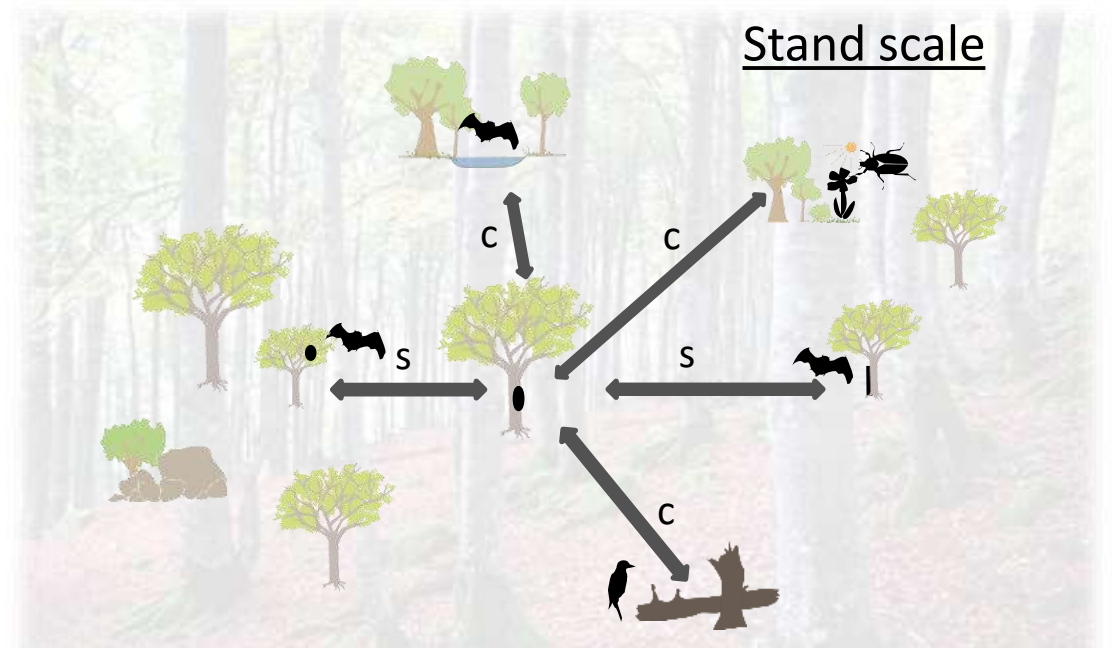
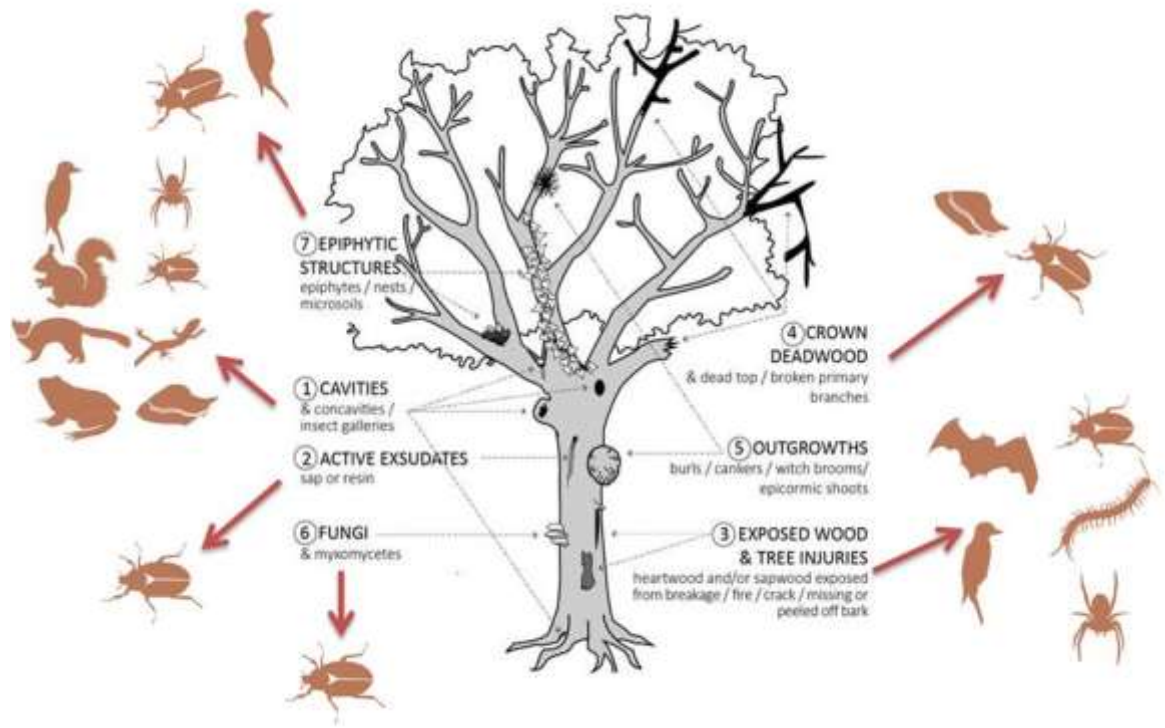
# A TreM is a specific above-ground tree morphological singularity

- **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 key features for many taxa and participate in a complex functional habitat network in species life cycles



Examples of supplementation (s) and complementation (c) resources

- By harvesting TreM-bearing trees, **management impacts both TreM density and diversity** (e.g. Larrieu & Cabanettes 2012)
- We observe **poorer communities of TreM-dwelling taxa in managed stands** (e.g. Bouget et al. AC 2014)
- Is this lower biodiversity due to a lower TreM supply only or also to **changes in spatial distribution pattern?**

# **Are spatial distribution patterns of TreMs different in harvested stands compared to unharvested ones?**

**Hypothesis 1: TreM distribution is spatially structured in old-growth forests (>100 years)**

**Hypothesis 2: The spatial distribution of TreMs is mainly driven by the spatial distribution of tree dbh**

**Hypothesis 3: Management affects these patterns by controlling dbh range, density and location of TreM-bearing trees**



# An analysis focusing on beech-dominated stands, recently harvested or not

International standardized TreM database: 267 sites, 1492 plots, 86 754 trees, 17 TreM groups



- **Beech-dominated** (>50% trees) stands

Tree coordinates

>20 trees/plot

>10 TreM/plots

- **2 time categories since the last harvest**

< 50 y: managed forest

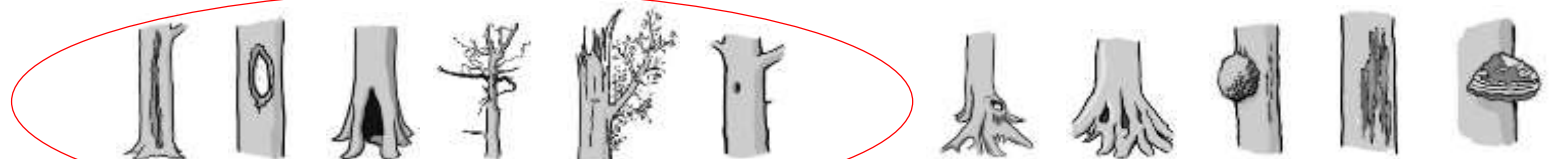
> 100 y: old-growth forest



**55 sites, 408 plots (0.05-1ha),  
20346 living and standing dead trees**

## 11 TreM-subgroups

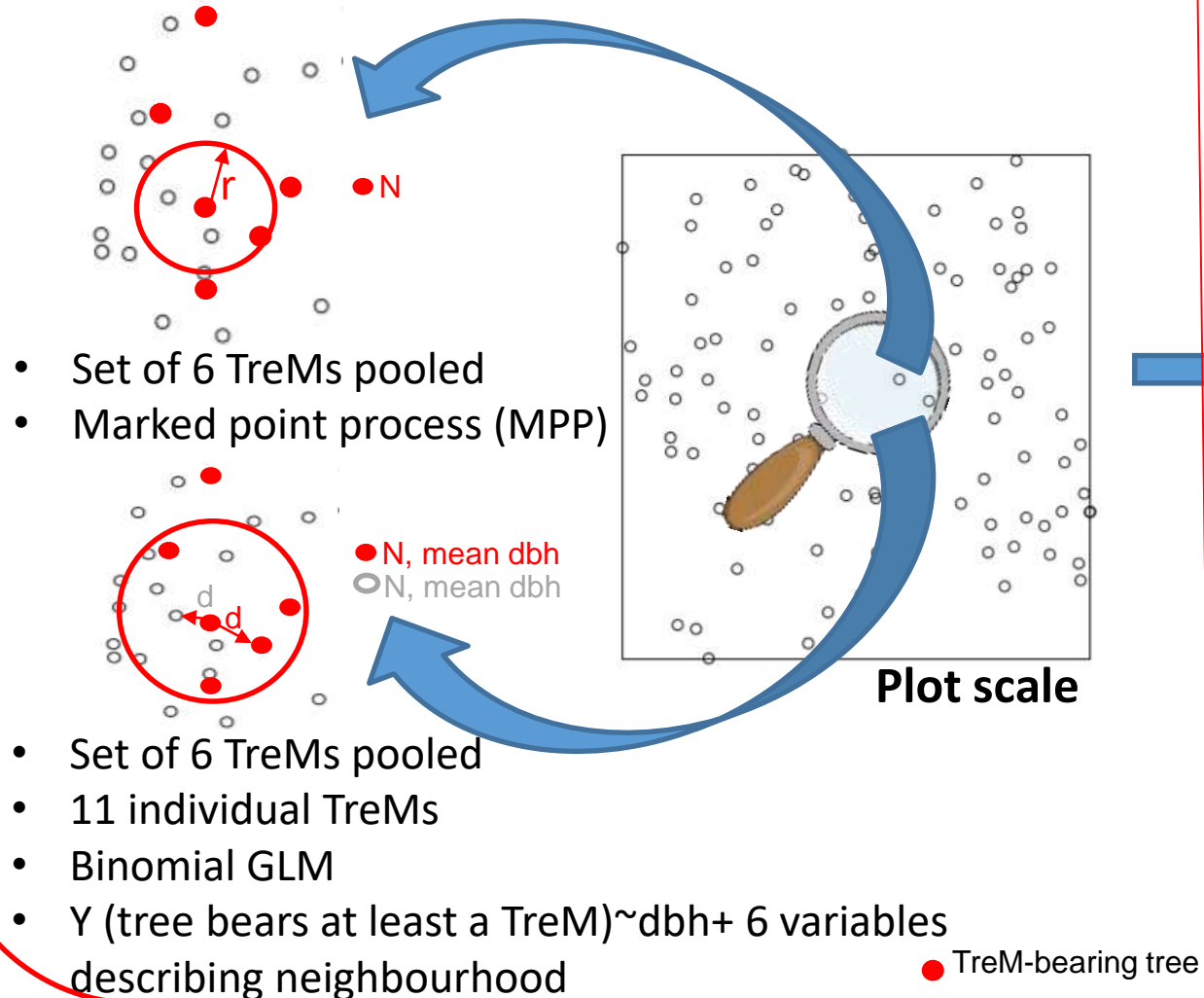
selected from Larrieu et al. EI 2018



Set of 6 TreMs common to all databases

# A multi-scale exploratory analysis

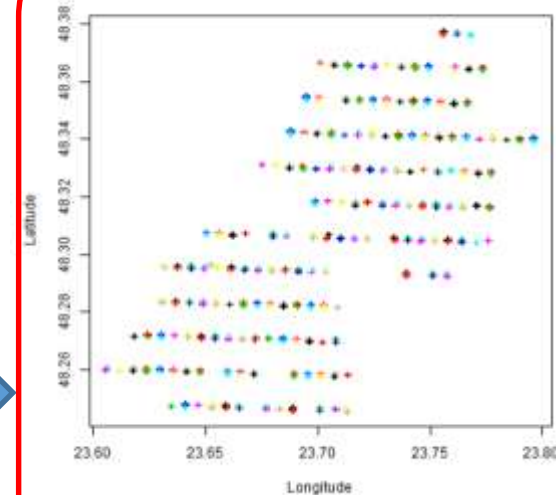
## Harvested and unharvested stands



## Plot-grouping scale

- Set of 6 TreMs pooled
- Binomial GLM
- $Y$  (tree bears at least a TreM)  $\sim$  dbh + site + site-plot + time since the last harvest

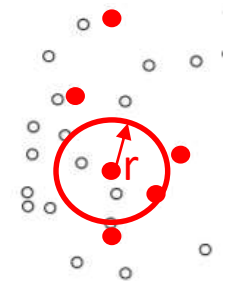
## Unharvested forest



## Forest scale (Uholka, OGF)

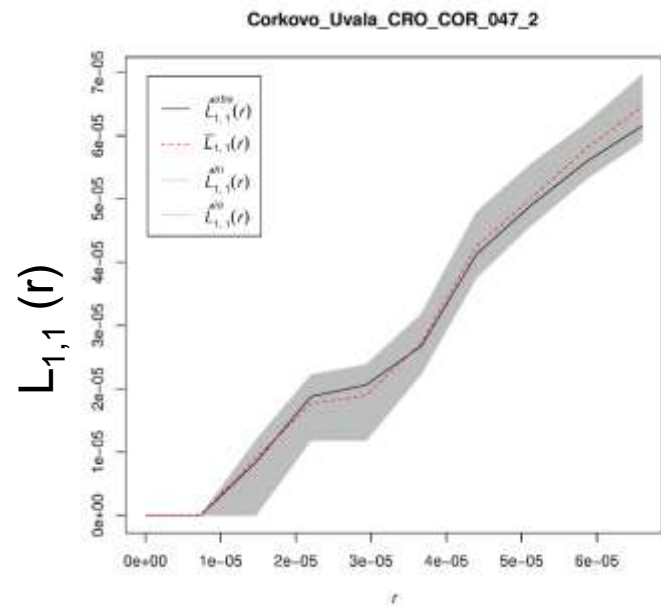
- 8 individual TreMs
- Binomial GLM/GLMM
- 266 x 500m<sup>2</sup>-plots

# No consistent spatial pattern, neither in managed nor in old growth forests

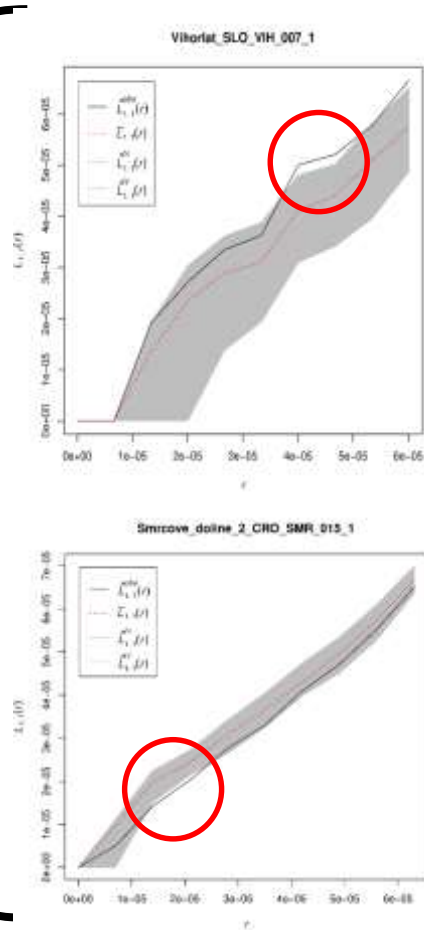


MPP without control of the spatial structure for dbh

## General case



and very rarely...



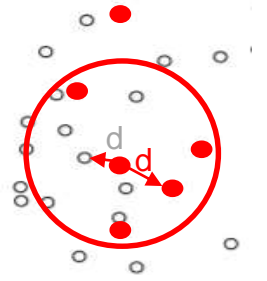
Aggregation of TreM-bearing trees

Repulsion

- random distribution of the TreM-bearing trees
- █ Confidence interval
- L1,1 (r) function: counts the nb of TreM-bearing trees in the r-radius disc



# Neighbourhood features have a significant effect on TreM bearing tree occurrence



GLM binomial

Y=tree bears a TreM or not

for **50 %** of the plots in Managed forest



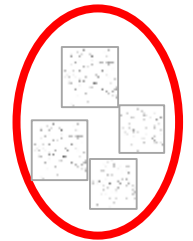
**+ 10% of variance explained** by neighbourhood  
(in addition to dbh)

for **25%** of the plots in Old-growth forest






**+ 18% of variance explained** by neighbourhood  
(in addition to dbh)

# The effect of dbh on TreM occurrence depends on both TreM and forest status

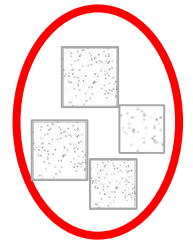


**GLM binomial**  
Y=tree bears a TreM or not

| TreM  | Old Growth Forests     | Dbh effect | Managed forest          |
|---|------------------------|------------|-------------------------|
|    | + for 97% of the plots | =          | + for 100% of the plots |
|    | + for 52% of the plots | + → +      | + for 88% of the plots  |
|  | - for 65% of the plots | - → +      | + for 94% of the plots  |

**% var. explained by plot:dbh >> % var. explained by dbh**

# Local conditions are the main driver of TreM occurrence



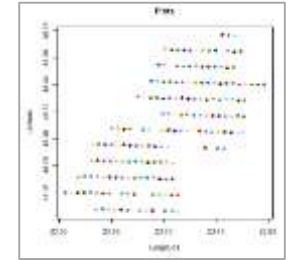
GLM binomial

Y=tree bears a TreM or not

- **dbh \*\*\*, but low explanatory power (3%)**
- Time since the last harvest (dbh\*time) \*\*\*, medium explanatory power (17%)
- Site (dbh\*site)\*\*\*, high explanatory power (36%)
- **Site-plot (dbh\*site-plot)\*\*\*, the highest explanatory power (42%)**

**Same trend observed at the individually TreM level!**

# In addition to dbh, plot features matters for explaining the occurrence of most of the TreMs

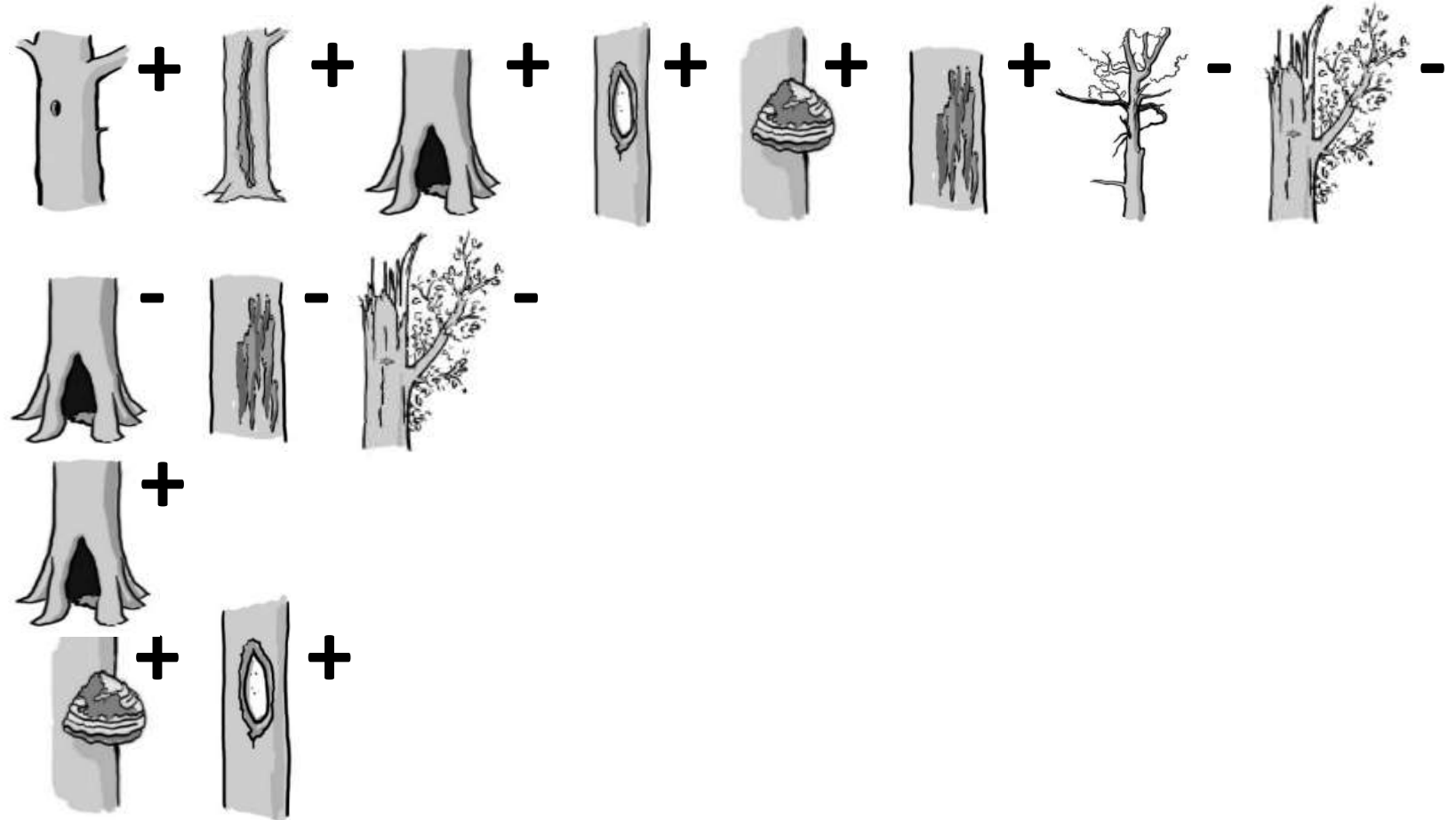


GLM & GLMM, binomial  
Y=tree bears a TreM or not

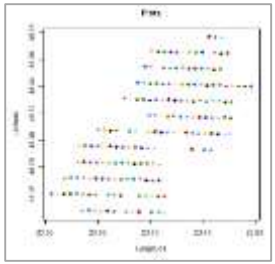
## Drivers

- DBH
- Plot features
  - canopy cover
  - slope
  - elevation

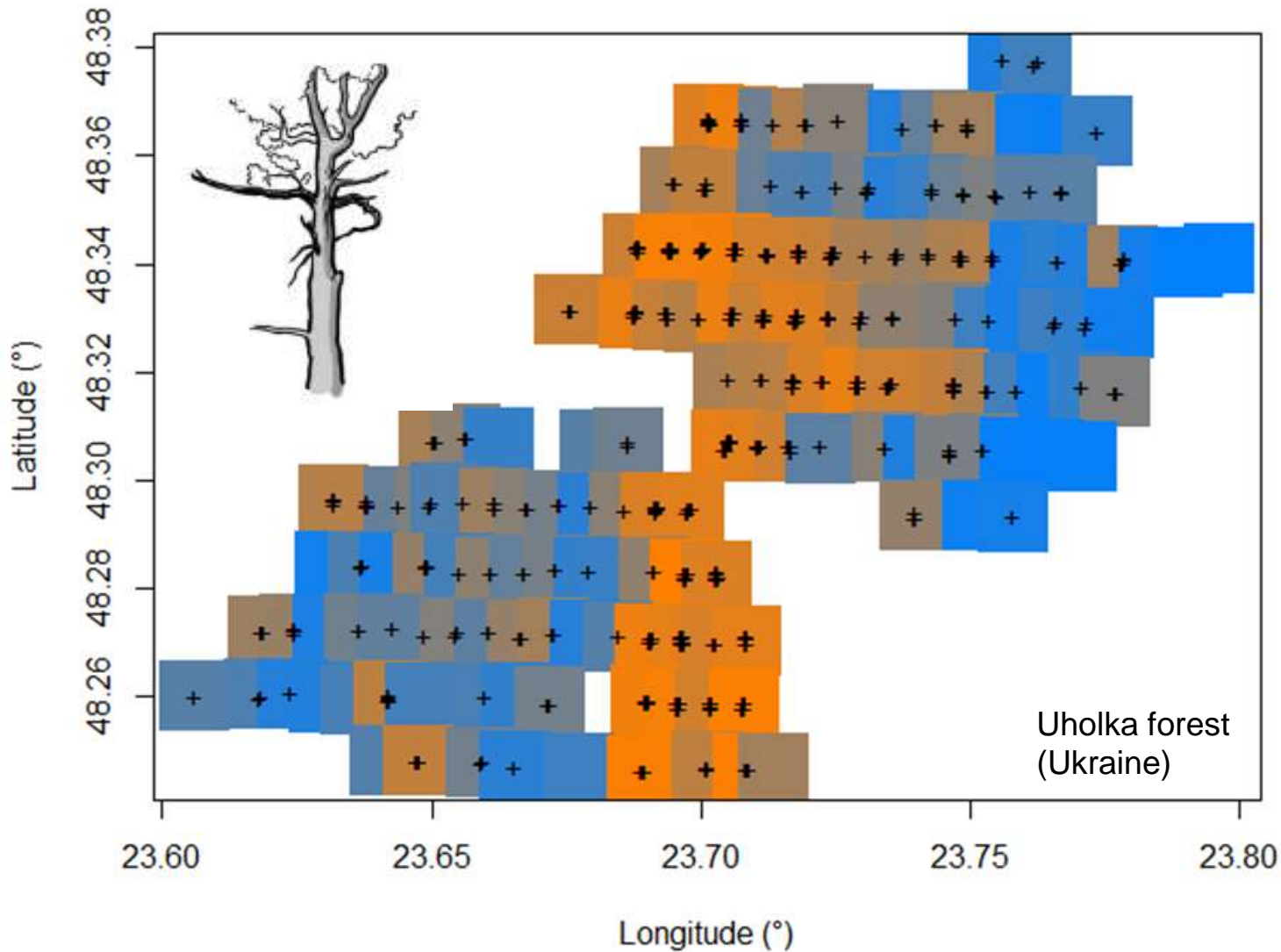
## TreMs



# Crown deadwood is mostly driven by a spatially-autocorrelated plot random effect



Bayesian CAR





# In a nutshell

- **Tree dbh spatial distribution is not a consistent surrogate within plot for TreM spatial distribution in old-growth forests**
- **Strong effect of local conditions on TreM spatial structuration**
- **Management influences the way TreM spatialization occurs (mainly by changing relationship between TreM and dbh)**

**Thanks for your attention**