

**Supplementary material of the paper:****Key factors determining the presence of Tree-related Microhabitats: a synthesis of potential factors at site, stand and tree scales, and proposal for further research**

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**Table 1SM. Main features of the TreM datasets used in this study**

Dataset name (reference if published)	Country	Climate zone	Ecoregion	Elevation (m): mean (range)	Number of plots	Number of trees
BC_ALPES_Ref3	France	Alpine	Western European broadleaf forests	1324 (1200-1455)	3	1162
EFI	Belgium, Czech Republic, Denmark, France, Germany Hungary, Ireland, Luxembourg, Poland, Serbia, Slovakia, Slovenia; Spain, Sweden Switzerland	Alpine; Atlantic, Boreal, Continental; Mediterranean	Alps conifer and mixed forests; Baltic mixed forests; Carpathian montane coniferous forests; Dinaric Mountains mixed forests; Italian sclerophyllous and semi-deciduous forests; Northern Temperate Atlantic; Pyrenees conifer and mixed forests; Southern Temperate Atlantic; Western European broadleaf forests	488 (13-1818)	47	18886
IRSTEALP	France	Alpine	Alps conifer and mixed forests	1568 (1468-1715)	10	1377

Dataset name (reference if published)	Country	Climate zone	Ecoregion	Elevation (m): mean (range)	Number of plots	Number of trees
JM_IRAN	Iran	NA (outside Europe)	Hyrcanian Forest, Montane broadleaf forest	1334 (862-1802)	25	424
LL_CLIMTREE_BAVARIA	Germany	Alpine	Western European broadleaf forests	1084 (660-1352)	29	767
LL_CLIMTREE_PYRENEES	France	Alpine	Pyrenees conifer and mixed forests	1163 (705-1570)	56	1857
LL_HECHES	France	Alpine; Atlantic	Pyrenees conifer and mixed forests	1053 (883-1173)	40	1252
LL_LISIERE	France	Atlantic	Western European broadleaf forests	313 (185-358)	56	2023
LL_MARTELOSCOPES	France	Atlantic	Western European broadleaf forests	341 (203-464)	16	2630
LL_PLAINE	France	Atlantic	Western European broadleaf forests	387 (245-1863)	279	5492
LL_PNM_MELEZE	France		Alps conifer and mixed forests	2080 (1918-2177)	50	164
LL_ROMANIA	Romania		Carpathian montane coniferous forests	905 (757-1118)	20	892
LL_VFP	France	Alpine; Atlantic	Pyrenees conifer and mixed forests	1561 (603-2137)	62	1905
MS_PrimaryBeech	Albania; Bosnia; Bulgaria; Croatia; Romania; Slovakia; Ukraine	Alpine; Continental; Mediterranean	Carpathian montane coniferous forests; Dinaric Mountains mixed forests; Pannonian mixed forests; Rodope montane mixed forests	1192 (591-1667)	522	16607
MS_PrimaryBeech_2018_19_NewTypo	Albania; Bosnia; Bulgaria; Croatia; Romania; Slovakia; Ukraine	Alpine; Continental; Mediterranean	Carpathian montane coniferous forests; Dinaric Mountains mixed forests; Pannonian mixed forests; Rodope montane mixed forests	1324 (769-1713)	386	17698
TL_2007	Switzerland	Continental	Western European broadleaf forests	762 (460-1407)	88	1760

Dataset name (reference if published)	Country	Climate zone	Ecoregion	Elevation (m): mean (range)	Number of plots	Number of trees
TL_2008	Switzerland	Alpine; Continental	Alps conifer and mixed forests; Western European broadleaf forests	771 (336-1592)	192	4800
TL_2020	Switzerland	Alpine; Continental	Alps conifer and mixed forests; Western European broadleaf forests	730 (427-1209)	176	7060
TL_JURA2017	Switzerland	Continental	Western European broadleaf forests	547 (436-682)	48	570
TL_PRATTIGAU	Switzerland	Alpine	Alps conifer and mixed forests	1211 (698-1535)	15	344
TL_TOXYWA	Switzerland	Continental	Western European broadleaf forests	662 (462-866)	70	1244
UH_HAP	Ukraine	Alpine	Carpathian montane coniferous forests	778 (735-835)	36	2488
UH_SP	Ukraine	Alpine	Carpathian montane coniferous forests	857 (478-1276)	314	7285
YP_GNB	France	Alpine; Atlantic; Continental; Mediterranean	Alps conifer and mixed forests; Northeastern Spain & Southern France Mediterranean; Southern Temperate Atlantic; Western European broadleaf forests	597 (59-1653)	232	7529

Table 2SM. Typology of Tree-related microhabitats (TreMs) for temperate and Mediterranean forests (Larrieu et al. 2018)

Forms	Groups	Group definition	TreM types
Cavities s.l.	Woodpecker breeding cavities		Small woodpecker breeding cavity

	Cavity excavated by a woodpecker for nesting	Medium-sized woodpecker breeding cavity
		Large woodpecker breeding cavity
		Woodpecker "flute" (breeding cavity string)
Rot holes	Cavity containing tree-hole mould (a mixture of decomposing wood, animal excretions and remains)	Trunk base rot hole Trunk rot hole Semi-open trunk rot hole Chimney trunk base rot hole Chimney trunk rot hole
		Hollow branch
Insect galleries	Holes and galleries excavated by saproxylic insect larvae	Insect galleries and bore holes
Concavities	Hole or hollow in the wood, either wet or dry, or a sheltered spot with no mould and which was not	Dendrotelm (phytotelmata, water-filled hole) Woodpecker foraging excavation

		excavated by insect activity	Trunk bark-lined concavity Buttress-root concavity
Tree injuries and exposed wood	Exposed sapwood only	Bark loss exposing the sapwood only	Bark loss Fire scar Bark shelter Bark pocket
	Exposed sapwood and heartwood	Breakage or splitting exposing both sapwood and heartwood	Stem breakage Limb breakage (heartwood exposed) Crack Lightning scar Fork split at the intersection
Crown deadwood	Crown deadwood	Deadwood located in the crown of the tree	Dead branches Dead top Remaining broken limb
Excrescences	Twig tangles	Excrescence forming a dense packet of small twigs	Witch broom Epicormic shoots

Burrs and cankers	Ball-shaped excrescences of more or less dense woody material	Burr Canker	
Fruiting bodies of saprophytic fungi and slime moulds	Perennial fungal fruiting bodies	The fruiting bodies of saprophytic fungi that develop over several years	Perennial polypore
	Ephemeral fungal fruiting bodies and slime moulds	The fruiting bodies of saprophytic fungi that develop over only one year, or slime mould plasmodia	Annual polypore Pulpy agaric Large pyrenomycete Myxomycetes
Epiphytic and epixylic structures	Epiphytic and parasitic crypto- and phanerogams	Vascular plants, mosses and lichens that use the tree as a physical support	Bryophytes Foliose and fruticose lichens Ivy and lianas Ferns Mistletoe
Nests	Vertebrate or invertebrate nests (excluding woodpecker breeding)	Vertebrate nest Invertebrate nest	

		cavities) placed in the tree or in a cavity	
Microsoils		Small amount of newly-created soil originating from the decomposition of organic matter from twigs, leaves, bark or mosses	Bark microsoil Crown microsoil
Exudates	Exudates	Fresh sap runs or resinosis	Sap run Heavy resinosis

## Statistical analysis

Example of command in R to call brm (package brms) for complete model: Rot Holes

```
modtot0= brm(pres~dbh*time+dbh*status+time*status-1+(1+status +dbh|siteplot) +(1+ status+ dbh|species), data=tot0,family=bernoulli(), prior = c(set_prior("normal(0,2)",class="b"), set_prior("exponential(1)",class="sd"), set_prior("lkj(6)",class="cor")),control=list(adapt_delta=0.9), chains=4, iter=3000, warmup=1000, cores=4)
```

command to get the variance information

```
TZ=predict(modtot0); 1-mean((TZ[,1]-tot0$pres)^2)/var(tot0$pres)
```

summary of the complete fit

Family: bernoulli

Links: mu = logit

Formula: pres ~ dbh \* time + dbh \* status + time \* status - 1 + (1 + status + dbh | siteplot) + (1 + status + dbh | species)

Data: tot0 (Number of observations: 104377)

Draws: 4 chains, each with iter = 3000; warmup = 1000; thin = 1;

total post-warmup draws = 8000

Group-Level Effects:

~species (Number of levels: 24)

	Estimate	Est.Error	l-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
sd(Intercept)	0.91	0.17	0.65	1.31	1.00	2681	3723
sd(status5)	0.87	0.24	0.49	1.43	1.00	3631	4764
sd(dbh)	0.70	0.16	0.44	1.08	1.00	3534	4703
cor(Intercept,status5)	-0.36	0.20	-0.71	0.06	1.00	6662	6522
(Intercept,dbh)	0.22	0.18	-0.16	0.56	1.00	3562	4752
cor(status5,dbh)	-0.07	0.22	-0.48	0.37	1.00	2775	4049

~siteplot (Number of levels: 2466)

	Estimate	Est.Error	l-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
sd(Intercept)	1.75	0.05	1.66	1.84	1.00	2284	3910
sd(status5)	1.85	0.11	1.65	2.08	1.00	2790	4957

sd(dbh)	0.43	0.03	0.38	0.48	1.00	2639	4940
cor(Intercept,status5)	-0.56	0.05	-0.65	-0.45	1.00	2857	4535
(Intercept,dbh)	-0.33	0.05	-0.43	-0.22	1.00	4790	5614
cor(status5,dbh)	0.23	0.08	0.07	0.39	1.00	1427	2640

Population-Level Effects:

	Estimate	Est.Error	l-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
dbh	0.65	0.18	0.31	1.01	1.00	3197	4692
time1	-3.36	0.22	-3.78	-2.91	1.00	1467	2536
time2	-4.66	0.25	-5.13	-4.15	1.00	1650	2421
time3	-4.76	0.25	-5.23	-4.26	1.00	1615	2532
time4	-4.01	0.24	-4.47	-3.52	1.00	1514	2705
status5	-0.30	0.31	-0.94	0.28	1.00	3779	5666
dbh:time2	0.48	0.08	0.32	0.64	1.00	7485	6265
dbh:time3	0.59	0.08	0.44	0.74	1.00	6164	5633
dbh:time4	0.83	0.07	0.70	0.96	1.00	8192	6851
dbh:status5	0.02	0.06	-0.10	0.14	1.00	5500	5977
time2:status5	0.28	0.28	-0.27	0.80	1.00	5721	5712
time3:status5	-0.17	0.34	-0.84	0.48	1.00	5982	6279
time4:status5	-0.09	0.27	-0.63	0.45	1.00	5782	6169

Draws were sampled using sampling (NUTS = No-U-Turn Sample ).

For each parameter, Bulk\_ESS and Tail\_ESS are effective sample size measures, and Rhat is the potential scale reduction factor on split chains (at convergence, Rhat = 1).

Example of command for model excluding variable: dbh

```
modtot0= brm(pres~time*status-1 +(1+status |siteplot)+(1+ status + dbh|species), data=tot0,family=bernoulli(), prior = c(set_prior("normal(0,2)",class="b"), set_prior("exponential(1)",class="sd"), set_prior("lkj(6)",class="cor")),control=list(adapt_delta=0.9), chains=4, iter=3000, warmup=1000, cores=4)
```