Field Guide to Tree-related Microhabitats

Descriptions and size limits for their inventory in temperate and Mediterranean forests

WSL

This guidebook may be downloaded at the following link:
wsl.ch/fg-trems

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Further information:
Short videos on YouTube about tree-related microhabitats. You can see tree-related microhabitats and learn from an expert by watching our short videos with subtitles in English, German, and French.

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Introduction

A tree-related microhabitat (abbreviated as TreM) is a morphological feature present on a tree, which is used by sometimes highly specialised species during at least one part of their life cycle. These features may serve as shelters, breeding spots, or crucial hibernation or feeding places for thousands of species. Trees bearing at least one TreM are called habitat trees (Fig. 1). Various biotic and abiotic events can create TreMs: for example, a falling tree can injure the tree bark, snow can break off a tree top, fire can create fire scars, and a woodpecker can excavate a breeding cavity in the trunk. For some TreMs, such as vertebrate nests and witches' brooms, the tree is merely a physical support. Only morphological features that are known to have a direct link with one or more associated species are classified as TreMs (Larrieu *et al.* 2018).

Each TreM provides very specific conditions to the inhabiting species, depending on its characteristics, such as size, shape, position in the tree, degree of decomposition of the surrounding wood, condition of the bearing tree (living or dead), exposure to sunlight, microclimate, and moisture content.

The diversity of TreMs in a forest stand directly influences the diversity of species because different TreMs provide optimal conditions for various species to thrive. However, TreMs are ephemeral, and when one deteriorates or ceases to exist, the species that are reliant on it must locate and colonise a new TreM. Thus, the more often a specific TreM occurs in a stand, the easier it becomes for the associated species to establish in a new TreM when the previous one is no longer viable. To reinforce biodiversity in a stand and thus improve its resilience, we need to know which TreMs are present, and to preserve and favour them through adapted management practices.

This field guide describes 52 TreMs: 47 according to Larrieu *et al.* (2018) and 5 additional ones identified in this work. These microhabitats can be categorised into 17 groups, with these groups falling within 7 overarching forms. The guide also indicates recommended minimum inventory sizes for each TreM in temperate and Mediterranean forests and gives information about the TreM's frequency of occurrence and its replacement rate in the stand.

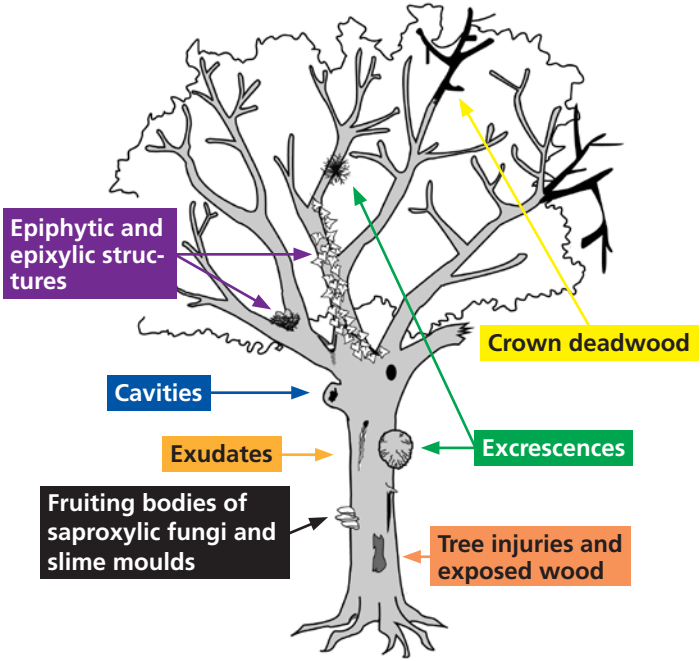


Fig. 1. A habitat tree bearing tree-related microhabitats essential to specialised species for shelter, breeding spots, hibernating or feeding, or even for their entire life cycle.

Legends and definitions

DM stands for "difficult to monitor" and signifies that this TreM type is difficult to monitor in a routine inventory, due to its small size, its location, or its sporadic incidence.

Natural forest: No forestry activity (e.g. harvesting, thinning, planting) for at least 100 years.

Managed forest: Ongoing or past forestry activities over the last 100 years.

Slow replacement rate in the stand: This type of tree-related microhabitat either takes a very long time to develop (for example, a rot-hole developing from an injury left by a broken-off branch) or is linked to rare, random events (lightning strikes, for example).

Rapid replacement rate in the stand: This type of tree-related microhabitat is generated by frequently occurring events (for example, bark injuries due to falling rocks in mountain forests), or it is immediately functional upon creation (woodpecker foraging excavations, for example).

Frequency: Frequency of occurrence of the microhabitat on either living or dead trees. Some microhabitats are more frequent on standing dead trees (for example, the fruiting bodies of saprophytic fungi). The frequency of occurrence indicated for managed forests pertains only to that type of forest and not to natural forests. The frequency values indicated are calculated from a European database and may differ at the local level.

Minimum size: Minimum size required for the tree-related microhabitat to be recorded in a survey. Certain size thresholds are related to the ecological requirements of the associated species. When these thresholds are unknown, the indicated values were defined by experts in order to reduce observer effect as much as possible ("experts' threshold").

Associated species: Species or species groups with a close relationship to the associated tree-related microhabitat, according to at least one reference in the scientific literature or based on the authors' own observations. The list below is not exhaustive and the species mentioned should be taken as examples.


Coleopterans


Dipterans


Hymenopterans


Ants


Butterflies


Aphids


True bugs


Spiders


Thysanoptera


Psocoptera


Siphonaptera


Myriapods


Springtails


Flagellates


Rotifers


Nematodes


Birds


Bats


Rodents


Carnivores


Amphibians


Reptiles


Gastropods


Mosses


Fungi


Lichens


Vascular plants


Ferns

Saproxylic species: a species that depends on senescent trees, decomposing wood or other saproxylic species for at least a part of its life cycle (from the Greek words “sapros” = rotten, and “xylon” = wood).

Generally, five wood decay stages are distinguished:

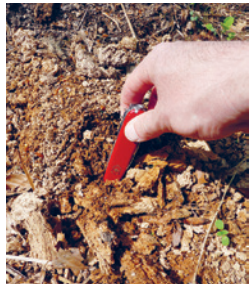
Stage 1: Current-year deadwood; the wood is very hard and shows little or no alteration. All of the bark is still well attached.

Stage 2: The wood is hard and only slightly altered; a knife blade will penetrate the wood with difficulty (<1 cm), even parallel to the grain. Virtually all the bark is intact, though it may no longer adhere very well.

Stage 3: The wood shows clear signs of decay and the surface has become soft or spongy; a knife will penetrate from one to several cms, parallel to the grain. The bark has partly or mostly fallen off (except for certain species, e.g. beech). The piece of deadwood has not lost any of its initial volume.

Stage 4: The wood has decayed considerably; a knife will penetrate to the hilt, at least in some places. There is no more (or very little) remaining bark. The piece of deadwood has lost some of its initial volume.

Stage 5: The wood has lost its structure and is easily scattered with the foot. Remnants contain saproxylic and soil-dwelling organisms (for example, earthworms). An in-depth inspection is necessary to identify the tree species.



Tree-related microhabitat forms

Cavities: holes or sheltered spots in the tree, dry or wet, with or without tree-hole mould, located on the trunk, in the crown or at the root collar.

- **Woodpecker breeding cavity:** cavity excavated by a woodpecker for nesting
- **Rot-hole:** cavity containing tree-hole mould (a mixture of decomposing wood, animal excretions and remains)
- **Insect galleries:** holes and galleries excavated by saproxylic insect larvae
- **Concavity:** hole or hollow in the wood, either wet or dry, or a sheltered spot with no mould and which was not excavated by insect activity

Injuries and exposed wood: sapwood or heartwood is exposed due to bark loss, splitting or breakage.

- **Exposed sapwood:** bark loss has exposed the sapwood only
- **Exposed sapwood and heartwood:** breakage or splitting has exposed both sapwood and heartwood

Crown deadwood: deadwood located in the crown of the tree.

Excrescences: Excrescences caused by a reaction of the tree to light or a bacterial, fungal or viral attack.

- **Twig tangle:** excrescence forming a dense packet of small twigs
- **Gall:** a deformity of a tree organ caused by a parasitic attack
- **Burr and canker:** ball-shaped excrescences of more or less dense woody material

Fungal fruiting bodies and slime moulds: the reproductive organs of saproxylic fungi or slime mould plasmodia, lasting at least several weeks.

- **Perennial fungal fruiting bodies:** the fruiting bodies of saproxylic fungi that develop over several years
- **Ephemeral fungal fruiting bodies and slime moulds:** the fruiting bodies of saproxylic fungi that develop over only one year, or slime mould plasmodia

Epiphytic and epixylic structures: structures or living organisms that use the tree mainly as a support.

- **Epiphytic and parasitic cryptogams and phanerogams:** vascular plants, mosses and lichens that use the tree as a physical support
- **Nests:** vertebrate or invertebrate nests (excluding woodpecker breeding cavities) placed in the tree or in a cavity
- **Microsoil:** a small amount of newly-created soil originating from the decomposition of organic matter from twigs, leaves, bark or mosses
- **Alluvial deposit:** a clay, silt, or other deposit on the tree trunk caused by flooding

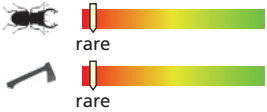
Exudates: sap run or resinosis.

1 Small woodpecker breeding cavity (ø < 4 cm)

Woodpecker breeding cavity with a round entrance < 4 cm in diameter. Lesser Spotted Woodpecker cavities are generally found in dead tree branches.

Minimum size: Cavity entrance ø < 4 cm

Frequency:



Replacement rate: fairly rapid

Associated species:

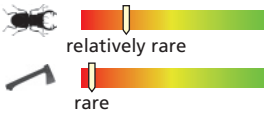
Did you know? In natural temperate forests, cavity density ranges from approximately 5 to 60 per hectare. In Central Europe, around 35% of forest birds nest in cavities.

2 Medium-sized woodpecker breeding cavity (ø = 4–7 cm)

Woodpecker breeding cavity with a round entrance 4–7 cm in diameter. The nesting cavities of medium-sized woodpeckers *(Dendrocopos major, D. medius, D. leucotos, Picus viridis, P. canus, Picoides tridactylus)* are usually excavated in decaying wood.

Minimum size: Cavity entrance ø 4–7 cm

Frequency:



Replacement rate: fairly rapid

Associated species:

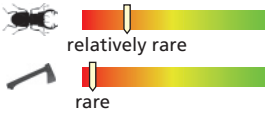
Did you know? Nesting cavities found on oak tree trunks are associated, in 95% of the cases, with the presence of wood-decay fungi like *Phellinus robustus.*

3 Large woodpecker breeding cavity (ø > 10 cm)

Woodpecker breeding cavity with an oval entrance > 10 cm in diameter. The Black Woodpecker generally excavates its cavities in the main tree trunk.

Minimum size: Cavity entrance ø > 10 cm

Frequency:



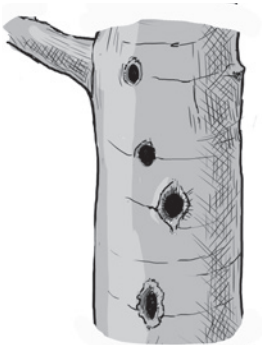
Replacement rate: fairly rapid

Associated species:

Did you know? The vertebrates that are secondary users of woodpecker cavities can transport large quantities of branches, grass and other materials into the cavity. Nitrogen input in the form of faeces, leftover food or carcasses becomes a source of energy for the many invertebrates that also live inside the cavities.

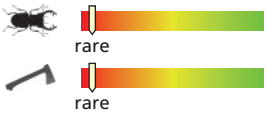
4 Woodpecker "Flute" (breeding cavity string)

At least three woodpecker nesting cavities aligned on the trunk with less than 2 m distance between two neighbouring cavities.



Minimum size: ≥ 3 cavities on one line; cavity entrance ø > 3 cm

Frequency:



Replacement rate: slow

Associated species:

Did you know? There are three groups of invertebrates associated with woodpecker breeding cavities:

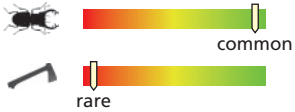
a) Parasites on vertebrates
b) Insects that feed on nesting materials and other residue
c) Predators and parasites of the first two groups.

5 Trunk-base rot-hole (closed top, ground contact)

The cavity contains decomposed organic material, or wood mould, with the quantity depending on the rot-hole development stage. The bottom of the cavity is in contact with the ground. Even so, the cavity entrance may be located relatively high up on the trunk. The cavity is protected from the external microclimate and rain (a roof is present).

Minimum size: Cavity entrance ø > 10 cm

Frequency:



Replacement rate: very slow

Associated species:

Did you know? Rot-hole development stages

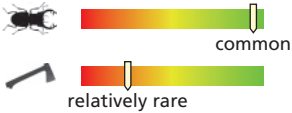
Drawing: Nicolas Gouix

6 Trunk rot-hole (closed top, no ground contact)

The cavity contains decomposed organic material, or wood mould, with the quantity depending on the rot-hole development stage. It is protected from the external microclimate and rain (a roof is present). The bottom of the cavity is not in contact with the ground.

Minimum size: Cavity entrance ø > 10 cm

Frequency:



Replacement rate: very slow

Associated species:

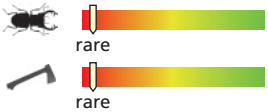
Did you know? As a cavity develops and becomes bigger, its structure becomes more complex and the diversity of its associated species increases. The mould inside has a high pH level, which favours specific rare species. Some rare bryophytes and lichens only grow on tree bark below a rot-hole, where pH is higher due to leakage from the cavity.

7 Semi-open trunk rot-hole

The cavity is not completely protected from the external microclimate and rain can enter. Note that the bottom of the cavity is not necessarily in contact with the ground, and that the entrance may be located relatively high up on the trunk.

Minimum size: Cavity entrance ø > 30 cm (experts' threshold)

Frequency:



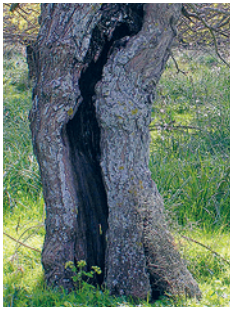
Replacement rate: very slow

Associated species:

Did you know? A very diverse fauna lives in the wood mould at the bottom of these cavities. In one kilogramme of cavity soil, researchers have found an average of 2500 individual arthropods, mostly springtails and Acarians. In very long-lived trees like oaks, these base rot-holes can persist for several hundred years.

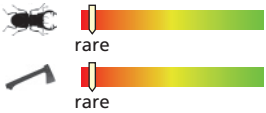
8 Chimney trunk-base rot-hole (ground contact)

The cavity is open at the top, often due to stem breakage. The cavity base reaches ground level, so the bottom of the cavity is in direct contact with the soil.



Minimum size: Cavity entrance ø > 30 cm (experts' threshold)

Frequency:



Replacement rate: very slow

Associated species:

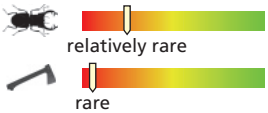
Did you know? Species associated with rot-holes, which are long-lasting tree-related microhabitats, generally have a more limited dispersal capacity than do species associated with ephemeral tree microhabitats.

9 Chimney trunk rot-hole (no ground contact)

The cavity is open at the top, often resulting from stem breakage. The cavity base does not reach ground level, so there is no direct contact with the soil.

Minimum size: Cavity entrance ø > 30 cm (experts' threshold)

Frequency:



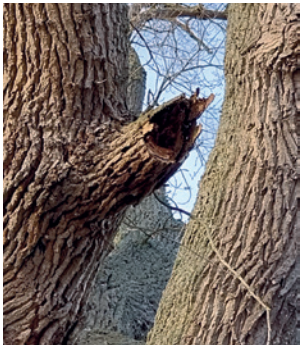
Replacement rate: very slow

Associated species:

Did you know? Both microclimatic (humidity and temperature) and physico-chemical conditions (at the interface between cavity mould and soil humus) are different in suspended cavities and trunk-base cavities. As a result, the organisms associated with the two types of cavities are not the same.

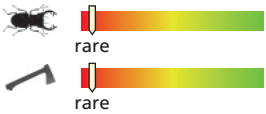
10 Hollow branch

A rot-hole located on a large broken limb, often forming a more or less horizontal, tube-shaped shelter.



Minimum size: Cavity entrance ø > 10 cm (experts' threshold)

Frequency:



Replacement rate: slow to rapid

Associated species:

Did you know? Certain insects can raid other species' food caches. This is known as kleptoparasitism. For example, carpenter bees store pollen and nectar for their larvae in microcavities, and this can attract other foragers.

11 Insect galleries and bore holes

Emergence holes left by wood-eating (xylophagous) insects indicate the presence of a cavity network in the wood. An insect gallery is a complex system of tunnels and chambers.

Minimum size: Bore hole ø > 2 cm or multiple smaller bore holes > 300 cm² (A5; experts' threshold)

Frequency:

relatively common

common

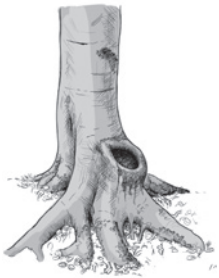
Replacement rate: fairly fast

Associated species:

Did you know? Xylophagous insects are sometimes considered to be forest pests. However, the vast majority of these species consume dead or altered wood and do not cause tree dieback.

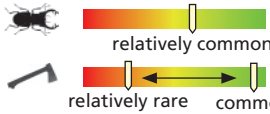
12 Dendrotelm

Cup-shaped hollows where rainwater can accumulate and then gradually evaporate. Healthy bark may have sealed the inside of the hollow, or the edges and bottom may be in a state of decay.



Minimum size: Opening ø > 15 cm

Frequency:



Replacement rate: slow

Associated species:

Did you know? There are only around 15 dendrotelm-dwelling insect species in Europe, but half of them are strictly associated with this specific microhabitat. Amphibians may sometimes use dendrotelms to moisten their skin. Decomposing leaves are the main energy source for dendrotelm-dwelling communities.

13 Large woodpecker foraging excavation

A hollow resulting from woodpecker foraging. The hollow is cone-shaped, in that the opening is larger than the cavity itself.

Minimum size: Depth > 10 cm; opening ø > 10 cm

Frequency:

relatively common

relatively common

Replacement rate: fairly rapid

Associated species:

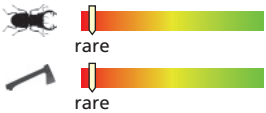
Did you know? When woodpecker foraging excavations are large enough, birds may use them to shelter their nests.

14 Bark-lined trunk concavity

A natural hollow in the tree trunk, with a hard bottom and bark on the inside walls.

Minimum size: Depth > 10 cm; opening ø > 10 cm

Frequency:



Replacement rate: slow

Associated species:

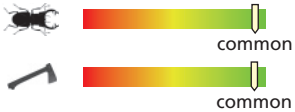
Did you know? Several species of undemanding cavity-nesting birds, for example the blackbird *(Turdus merula)*, use bark-lined trunk concavities as nesting sites.

15 Buttress-root concavity

A natural hollow with a hard bottom and bark on the inside walls formed between buttress roots or between a buttress and the ground. There is no presence of mould (classification is "Trunk-base rot-hole" if wood mould is present).

Minimum size: Opening > 10 cm; depth > 10 cm; "ceiling" angle < 45° (experts' threshold)

Frequency:



Replacement rate: slow

Associated species:

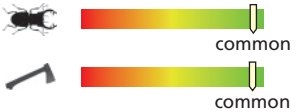
Did you know? Trees growing on steep slopes, rocky terrain, nurse logs, or stumps often have buttress-root concavities. Located at the base of the trunk and formed by the roots of the tree, these concavities are used as shelters by small and large mammals, birds, and amphibians. They can be used both as shelters from rain and as damp refuges during dry periods.

16 Bark loss

Bark is missing and the sapwood is exposed (bark loss due to tree felling, skidding operations, falling trees, rock fall, bark removal by mammals, etc.).

Minimum size: Surface > 300 cm² (A5; experts' threshold)

Frequency:



Replacement rate: rapid

Associated species:

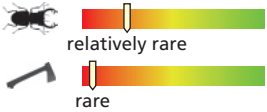
Did you know? Areas of exposed sapwood are easily colonised by fungi and insects. The tree can eventually heal a small injury. In this case, the exposed sapwood will only play a short-term ecological role. Larger injuries generally do not heal over. If the tree survives and stays in place, the injury will eventually become a rot-hole.

17 Fire scar

Fire scars located at the trunk base (often triangular in shape) or higher up along the stem (as cracks into the wood). Charred wood is often visible, and in conifers resin flows may occur on the exposed wood or surrounding bark.

Minimum size: Surface > 600 cm² (A4; experts' threshold)

Frequency:



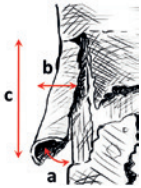
Replacement rate: very slow–rapid

Associated species:

Did you know? The so-called pyrophilous (fire-loving) species, mostly fungi and insects, require charred wood for development and have adaptations to locate it. For instance, pyrophilous insects can detect fire from tens of kilometers away.

18 Bark shelter

Loose hanging bark (peeled off from sapwood or from remaining bark) creates a shelter along the trunk (with an opening at the bottom).



a > 1 cm
b > 10 cm
c > 10 cm

Minimum size: Space between bark and sapwood > 1 cm; width > 10 cm; length > 10 cm (experts' threshold)

Frequency:


relatively common


relatively rare

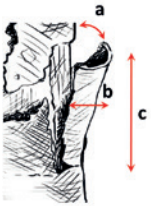
Replacement rate: slow

Associated species:

Did you know? Some bats, like the western barbastelle *(Barbastella barbastellus)*, take shelter under loose bark to rest during the day, or even to mate.

19 Bark pocket

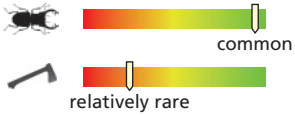
Slabs of bark detached from the trunk (peeled off from sapwood or from the remaining bark) that create pockets where wood mould and humus can accumulate (with an opening at the top).



a > 1 cm
b > 10 cm
c > 10 cm

Minimum size: Space between bark and sapwood > 1 cm; width > 10 cm; length > 10 cm (experts' threshold)

Frequency:



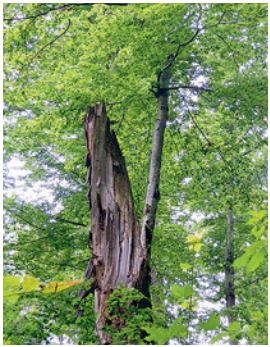
Replacement rate: slow

Associated species:

Did you know? Many arthropods, including arachnids, live in the organic matter that accumulates in the pockets formed by the detached bark. Bats, on the other hand, prefer to use bark shelters with an opening at the bottom so that they are protected from the rain.

20 Stem breakage

The trunk has broken off and the heartwood has been exposed. The tree is still alive. The deadwood below the breakage is in contact with living wood where the sap still flows.



Minimum size: Stem ø > 20 cm at breakage (experts' threshold)

Frequency:

relatively common

relatively rare

Replacement rate: rapid

Associated species:

Did you know? When a new top grows from a broken stem, decomposition and growth occur at the same time in very close proximity within the tree. The juxtaposition of these two processes creates a vital tree-related microhabitat for a few highly specialised invertebrates (Diptera and Heteroptera).

21 Limb breakage

A large limb or a fork has broken off and the heartwood has been exposed. The damaged area is surrounded with living wood where the sap still flows.

Minimum size: Exposed surface > 300 cm² (A5; experts' threshold)

Frequency:

common

common

Replacement rate: rapid

Associated species:

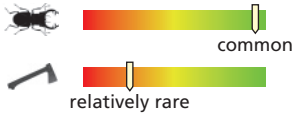
Did you know? Because the heartwood is dead, it has a very different chemical composition from that of the adjacent sapwood and the living wood, and this influences the roster of associated species.

22 Crack

Cracks through the bark and into the underlying wood. If the crack was caused by lightning, see "Lightning scar".

Minimum size: Length > 30 cm; width > 1 cm; depth > 10 cm

Frequency:



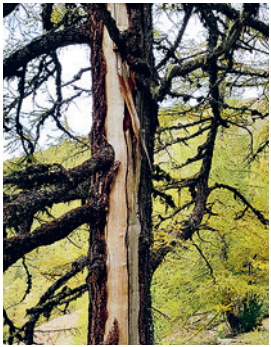
Replacement rate: slow

Associated species:

Did you know? Cracks shelter many types of animals: bats, treecreepers, flat bugs, tree spiders, mites, and other arthropods. Bats prefer cracks that are 1 to 5 cm wide, > 10 cm deep, and located more than 1 m above the ground. Arthropods can use shallower cracks. Cracks are more common in dead trees than in living trees.

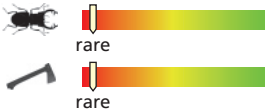
23 Lightning scar

A crack caused when a tree is struck by lightning; a lightning scar generally spirals along the trunk and the wood is splintered (multi-fissured crack).



Minimum size: Length > 30 cm; width > 1 cm; depth > 10 cm

Frequency:



Replacement rate: rare event

Associated species:

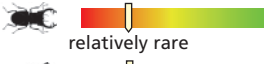
Did you know? The multiple fissures created by the splintered wood in a lightning scar often have such different characteristics that a wide variety of animals can co-exist in the same split trunk: spiders, bats, birds and gastropods.

24 Fork split at the intersection

Crack at the intersection of a tree fork. If one of the main branches of the fork has fallen off, the classification is "Limb breakage".

Minimum size: Length > 30 cm (experts' threshold)

Frequency:



Replacement rate: slow

Associated species: 

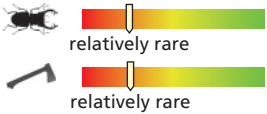
Did you know? Cracks formed by the separation of the two limbs at a fork offer shelter but little protection from precipitation. Furthermore, falling organic material (leaves, twigs, etc.) often accumulates in the opening created; this material decomposes and can create a "crown microsoil", where secondary tree roots can grow.

25 Trunk gnawed by beavers

A tree trunk with the deep feeding marks of a beaver, which are typically hourglass-shaped. In many cases broad teeth marks are visible on the hardwood.

Minimum size: surface > 300 cm^2 (A5; experts' threshold)

Frequency:



Replacement rate: fairly rapid

Associated species:

Did you know? Beaver activity can enhance the species richness of calicioid lichens and fungi. Their disturbances tend to create new relatively competitor-free living spaces for calicioids and other small organisms that grow on hard standing wood. In forests without beaver activity, lignicolous bryophytes and macrolichens rapidly colonise stumps and fallen logs and can effectively outcompete calicioids.

26 Dead branches

Dead branches in the crown, including branches lower on the stem.

Minimum size: Branch ø > 10 cm, or branch ø > 3 cm plus > 10 % of the crown is dead (experts' threshold)

Frequency:

common

common

Replacement rate: fairly slow

Associated species:

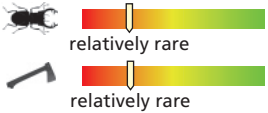
Did you know? Unlike deadwood lying on the forest floor, dead crown branches are subjected to frequent desiccation and widely varying temperatures. Certain invertebrates and fungi are specialists of dead tree branches. Other types of tree-related microhabitats (cavities, fungal sporophores…) sometimes complement dead branches in the crown, thus increasing the biodiversity of the associated species. This type of crown deadwood cannot simply be replaced by downed woody debris because the associated species assemblages are quite different.

27 Dead top

The top of the tree has died and the deadwood is generally exposed to the sun.

Minimum size: ø >10 cm at the base (experts' threshold)

Frequency:



Replacement rate: fairly slow

Associated species:

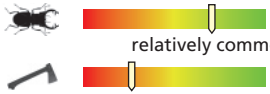
Did you know? Unlike dead branches inside the crown, dead tops are exposed directly to the sunlight. Their decomposition is carried out by more thermophilous species, which are able to withstand contrasted microclimatic conditions.

28 Remnants of a broken limb

A large limb has broken off. The remaining stub has shattered but the injury does not affect the trunk of the tree (if so, the classification is "Limb breakage").

Minimum size: Branch ø > 20 cm at the break, stub length > 50 cm (experts' threshold)

Frequency:



Replacement rate: fairly rapid

Associated species:

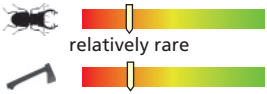
Did you know? The stub of a large broken limb hosts species that are different from those in an intact dead branch, even when the wood is the same diameter and at the same decay stage. The reason for this is that this complex tree microhabitat type features both cracks and a jagged break, with a large deadwood volume and surface area.

29 Witches' broom

A dense mass of intertwined twigs on a branch.

Minimum size: ø > 50 cm (experts' threshold)

Frequency:



Replacement rate: fairly rapid

Associated species:

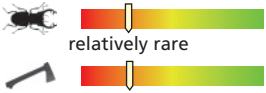
Did you know? The mass of intertwined twigs caused by witches' broom sometimes support the nests of small passerines like the short-toed treecreeper or the Eurasian wren, but birds of prey like the common buzzard may also build nests there.

30 Epicormic shoots

A dense mass of shoots on the trunk sprouting from dormant buds under the bark.

Minimum size: > 5 shoots (experts' threshold)

Frequency:



Replacement rate: fairly slow

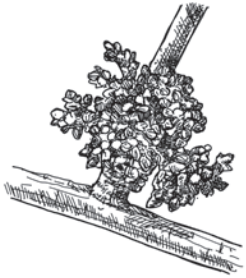
Associated species:

Did you know? The intertwined epicormic shoots sometimes support the nests of small birds like the song thrush and the blackbird.

31 Galls

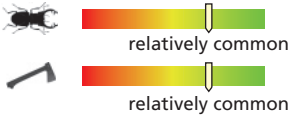
DM

Deformity of a tree organ (twig, leave, flower, bud) caused by a parasitic attack by bacteria, fungi, mites or insects. Galls are most frequently found on leaves (about 65%), but can also affect stems (20%), buds (10%), roots, flowers, or fruits (5%).



Minimum size: > 20 galls (experts' threshold)

Frequency:



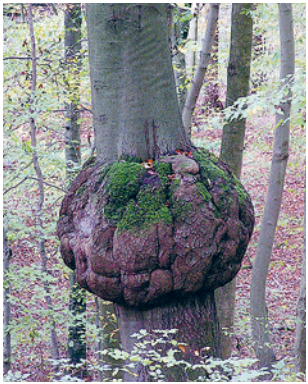
Replacement rate: rapid

Associated species:

Did you know? Galls stand out as extraordinary outcomes of biological evolution. These structures are created by plants exclusively to benefit another organism – the gall-inducer. In addition to the gall-inducer, the galls can be inhabited by fungi, natural enemies, and inquilines (commensal herbivores or omnivores). Many gall midges (Cecidomyiidae, Diptera) oviposit fungal spores together with the eggs which colonise the gall and serve as food for the developing larvae.

32 Burr

Proliferation of cells with rough bark but no rotten wood.



Minimum size: ø > 20 cm (experts' threshold)

Frequency:

relatively common

relatively common

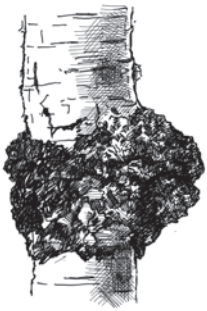
Replacement rate: slow

Associated species:

Did you know? When a tree is under stress (e.g. from injuries, fungi, bacteria, or viruses), it produces chemicals that tell the cells in its bark to grow in a different way. This results in the formation of burls. Unlike the wood found in cankers, burr wood has no rot and the bark appears intact. Certain *Synanthedon* larvae (Sesiidae family) mature in the cracked bark on burrs.

33 Canker

Canker with rotten wood and exposed sapwood, caused by *Melampsorella caryophyllacerum, Nectria* l.s., for example.



Minimum size: ø > 20 cm or covering a large part of the trunk (experts' threshold)

Frequency:

relatively rare

relatively common

Replacement rate: slow

Associated species:

Did you know? Some very rare fungi like *Inonotus obliquus* colonise cankers. The pH of the bark located under a canker is higher than on other parts of the trunk, thus favouring rare, threatened bryophytes. The rough surface of a canker also attracts foraging insect-eating birds.

34 Perennial polypore

Fruiting bodies of perennial bracket fungi with a woody texture and several layers of tubes (if more than one year old).

Minimum size: ø > 5 cm (experts' threshold)

Frequency:

common

relatively rare

Replacement rate: slow

Associated species:

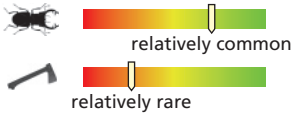
Did you know? Perennial fungal fruiting bodies are complex habitats, offering multiple food sources, each of which supports a unique guild of mycophagous insects. In Europe, the hoof fungus (Fomes fomentarius) hosts around 600 arthropod species. Woodpeckers sometimes excavate their cavities just below fungal fruiting bodies since the wood there is tender and the fruiting body shelters the entrance.

35 Annual polypore

Fruiting bodies of annual polypores remaining fresh for several weeks (which can still be observed until the following spring). European annual polypores have only one layer of tubes and are generally rather elastic and supple (with no woody parts).

Minimum size: ø > 5 cm or group of > 10 fruiting bodies (experts' threshold)

Frequency:



Replacement rate: slow

Associated species:

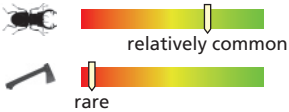
Did you know? Fungal fruiting bodies are a much richer energy source than wood. For example, the nitrogen content is 2 to 10 times higher in fruiting bodies than in sound wood. Associated invertebrates consume the spores, the tube layer, or the mycelium of the fruiting body. Fungal fruiting bodies host the smallest Coleopteron in the world (0.3–0.6 mm long).

36 Pulpy agaric

Large, thick, and pulpy or fleshy, gilled sporophores (Agaricales order), generally remaining for several weeks.

Minimum size: ø > 5 cm or group of > 10 fruiting bodies (experts' threshold)

Frequency:



Replacement rate: slow

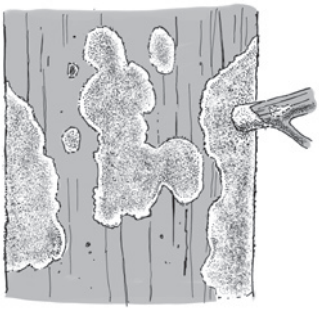
Associated species:

Did you know? The ephemeral fruiting bodies of pulpy agarics decompose too fast for most insect larvae to complete their development. That is why these fruiting bodies only host species with very short larval and pupal development periods, primarily Diptera but also a few beetle species.

37 Corticoid fungi (crust fungi)

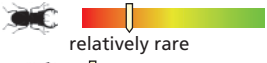
DM

A group of Basidiomycota fungi typically having sheet-like, smooth fruiting bodies that are mostly formed on the undersides of dead branches or dead tree trunks.



Minimum size: > 50 cm² (experts' threshold)

Frequency:



Replacement rate: rapid

Associated species:

Did you know? Several fungus gnat species (Mycetophilidae, Diptera) lay their eggs on corticoid fungi and their larvae feed on the fruiting bodies. Thrips species are among the smallest of the winged insects (1.5 to 3 mm). The thrips *Hoplothrips fungi* lives beneath encrustations of corticoid *Peniophora* fungus on dead oak branches.

38 Large pyrenomycetoid fungi

Usually black stromata, flat or hemispherical in shape, that resemble lumps of coal and contain many small perithecia.

Minimum size: Fruiting body ø > 3 cm or group covering > 100 cm^2 (experts' threshold)

Frequency:

Replacement rate: slow

Associated species:

Did you know? Pyrenomycetoid fungi are generally quite small (several mm in diameter) and cover patches of the trunk with hard dark bumps. One species, however, *Daldinia concentrica,* often found on the common ash, can reach several cm in diameter. The flat bug *Aradus bimaculatus* lives in the stromata of the pyrenomycete *Hypoxylon mammatum* (aspen canker).

39 Myxomycetes (slime moulds)

DM

Organisms that exist as slimy, gelatinous masses when fresh and are commonly found on decaying plant matter.

Minimum size: ø > 5 cm (experts' threshold)

Frequency:

Replacement rate: fairly rapid

Associated species:

Did you know? This slimy jelly-like mass is neither animal, plant nor fungus yet it can move up to several centimetres per hour when foraging for its food, which consists of bacteria, algae or fungi. Most of the species that consume slime moulds are strictly dependant on the relationship.

40 Bryophytes (mosses and liverworts)

Trunk covered in moss and liverworts (Hepaticophyta).

Minimum size: > 10 % of the trunk is covered (experts' threshold)

Frequency:

common

common

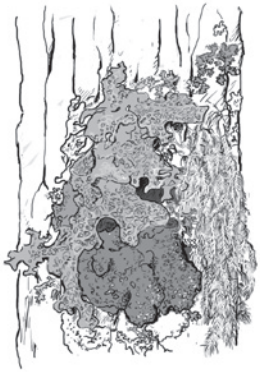
Replacement rate: fairly rapid

Associated species:

Did you know? The epiphytic species (mosses and lichens) carry out their own photosynthesis. They therefore only use the tree as a physical support and do not use the wood as a source of energy; they are not parasitic or damaging. Moss carpeting a tree may harbour other species. For example, the *Peltigera collina* lichen only grows on moss-covered trees.

41 Foliose and fruticose lichens

Foliose lichens (lobe-shaped) or fruticose lichens (bushy).



Minimum size: > 10 % of the trunk is covered, thickness > 1 cm (experts' threshold)

Frequency:

Replacement rate: slow

Associated species:

Did you know? Because of their small size and slow growth, lichens must find habitats poorly suited to plants to avoid being out-competed. Tree trunks, like stones and rocks, provide such habitats. Other organisms may use epiphytic lichens as a food source or as shelter or nest material. Certain fungi grow only on epiphytic lichens.

42 Ivy and lianas (woody vines)

Lianas and other climbing phanerogams such as ivy and clematis.

Minimum size: > 10 % of the trunk is covered (experts' threshold)

Frequency:

Replacement rate: fairly rapid

Associated species:

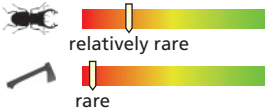
Did you know? Ivy flowers in the autumn and its fruit is available at the end of winter, during a time when plants offer little food. In addition, its leaves and twisted branches create small shady, moist niches where specialized epiphytic fungi grow.

43 Ferns

Ferns growing directly on the trunk or at the intersection of a branch (as an epiphyte).

Minimum size: > 5 fronds (experts' threshold)

Frequency:



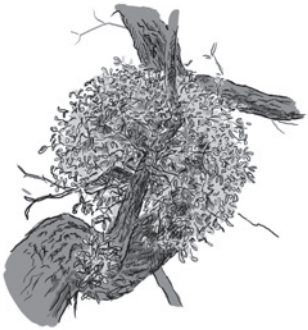
Replacement rate: slow

Associated species: 

Did you know? Ferns are rarely fed upon by insects. Nonetheless, in Western Europe, 22 species of sawflies (Hymenopterans) spend their entire life cycle on fern fronds.

44 Mistletoe

These hemiparasitic epiphytes generally grow in the tree crown. Examples include *Viscum* spp., *Arceuthobium* spp. and *Loranthus* spp.



Minimum size: ø > 20 cm for *Viscum* spp.and *Loranthus* spp.; > 10 clumps for *Arceuthobium* spp. (experts' threshold)

Frequency:

Replacement rate: fairly rapid

Associated species:

Did you know? In Europe, there are eight known insect species specific to the common mistletoe *Viscum album.* Its fruit is appreciated by certain birds in the winter, when food is scarce. Mistletoes also provide abundant pollen and nectar; in addition to many nectarivorous species, a broad range of insectivorous species have been recorded feeding from mistletoe flowers.

45 Vertebrate nest

Bird or rodent nest.

Minimum size: ø > 10 cm

Frequency:

relatively common

relatively common

Replacement rate: rapid

Associated species:

Did you know? Large bird nests provide nesting sites among their twigs for small birds as well as habitat for invertebrates like the Coleoptera in the Histeridae family (clown beetles).

46 Invertebrate nest

DM

Nest containing invertebrate larvae. Examples include pine processionary caterpillars, saproxylic ants and wild bees.

Minimum size: Presence (direct observation or associated insects; experts' threshold)

Frequency:

Replacement rate: fairly slow

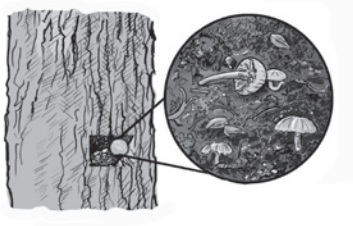
Associated species:

Did you know? More than 60 species of arthropods have been recorded in pine processionary caterpillar nests.

47 Bark microsoil

DM

Microsoil in fissures on the trunk bark formed from moss, lichen, or epiphytic algae residues and old, thick, and decaying bark.



Minimum size: Presence (direct observation or fungi; experts' threshold)

Frequency:

Replacement rate: slow

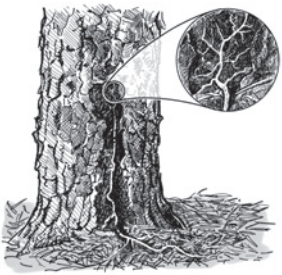
Associated species:

Did you know? Bark microsoils provide a habitat for a few highly specialised saprophytic fungi, which are sometimes dependant on a single host species.

48 Inter-bark microsoil

DM

Microsoil developed within the bark itself, borne by old trees of species that develop very thick bark as they grow old.



Minimum size: presence of humus on at least 300 cm² A5/P5 sheet of paper

Frequency:

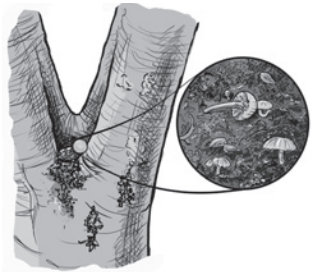
Replacement rate: slow

Associated species:

Did you know? This rare microhabitat is currently only known to occur on larch. An accumulation of organic matter (leaves, twigs) on the uphill side at the base of the trunk allows neighbouring trees (sometimes of a different species than the microsoil-bearing tree) to reach the microsoil and spread their roots.

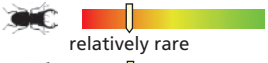
49 Crown microsoil

Crown microsoil forms from decaying leaves and woody debris fallen from the canopy or neighbouring trees, often hosting secondary roots from the tree. It is typically located between two joined trees, in flat areas of the crown, or in forks.



Minimum size: Presence (experts' threshold)

Frequency:



Replacement rate: slow

Associated species:

Did you know? Old trees sometimes harbour microsoil pockets in their canopy. Aerial roots sometimes sprout from the microhabitat-bearing tree and colonise the microsoil. The organic matter is thus recycled and reused directly by the tree or by other organisms. Though the phenomenon has long been recognised in tropical forests, it is still little known in temperate forests.

50 Clay or silt deposit

Base of the trunk or lower part of the stem covered by clay or silt deposits following flooding.

Minimum size: surface > 600 cm² (A4 sheet of paper; experts' threshold)

Frequency:

Replacement rate: rapid

Associated species: 

Did you know? Flood-mosses grow where flooding is intermittent but often deep. They are often confined to lower parts of the stem, boles, and roots of trees growing in the flood zone of lowland rivers and streams. Tree trunks with deposits of clay and silt are among their preferred substrates.

51 Sap run

Sap running along the trunk.

Minimum size: Length > 10 cm (experts' threshold)

Frequency:

relatively common

relatively rare

Replacement rate: fairly slow

Associated species:

Did you know? Sap runs are an attractive food source for numerous adult insects. In Japan, more than 100 species have been identified feeding on oak *(Quercus acutissima)* sap runs. Insect larvae living in sap runs do not consume the sap itself but rather the yeasts and bacteria that develop there.

52 Heavy resinosis

Flow of resin, either fresh or old casts.

Minimum size: Length > 10 cm (experts' threshold)

Frequency:


common


common

Replacement rate: fairly rapid

Associated species: 

Did you know? Resin is excreted by certain conifers to form a protective barrier rich in antimicrobial elements, which prevent pests and pathogens from penetrating the bark and entering the wood. The resulting antiseptic substratum is therefore quite inhospitable to living organisms. Even so, *Sorocybe resinae,* a microscopic ascomycete, lives exclusively in resin flows.

Bibliography

LARRIEU, L.; PAILLET, Y.; WINTER, S.; BÜTLER, R.; KRAUS, D.; KRUMM, F.; LACHAT, T.; MICHEL, A.K.; REGNERY, B.; VANDERKERKHOVE, K., 2018: Tree related microhabitats in temperate and Mediterranean European forests: a hierarchical typology for inventory standardization. Ecological Indicators, 84: 194–207.

Supplementary Material

Appendix 1: TreM-associated taxa
Appendix 2: Bibliography
Appendix 3: TreM pictures

Photo credits

Loïc Duchamp (p. 35), Pierre Henrioux (p. 14), Daniel Kraus (p. 38, 39), Thibault Lachat (p. 16, 62), Laurent Larrieu (p. 25, 33, 40, 58, 60), Thomas Reich (p. 9, 10), Rita Bütler (all the others)

Drawings: Lisa Apfelbacher, Céline Emberger, Daniel Kraus

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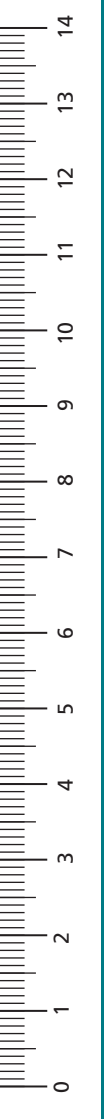

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