Mountain mixed forest. ***Credit:*** *Karol Kalistý*

Natural cycle: the never-ending story of birth and death

In the natural world everything is constantly changing and evolving. Nothing is forever. To this end, large-scale, relatively quickly ongoing changes have a major impact. Referred to as disturbances, they happen in various parts of the globe and take diverse forms as they act on natural communities (ecosystems). In Šumava, disturbances in forest ecosystems like fires are not seen at any greater level; rather, winds and insect outbreaks are the main factors. In the case of winds, fallen and broken trees are pretty common to see when windstorms cause the tree to uproot or break. Often, however, winds function as triggers for another type of disturbance – outbreak of bark beetles. In this country, this most frequently involves the **spruce bark beetle** *(Ips typographus)* – a creature that can cause disturbances within far greater areas than the ones that had been affected by destructive winds.

Winds and bark beetles have been present repeatedly in Šumava in different intensities and frequencies since the distant past and form very important factors for the native forest to evolve. Any such disruption leaves behind a legacy – dead wood is one such outcome, essential for many plant and animal species, as well as the future of the forest ecosystem itself.

Terms to remember:
Disturbance - Events causing a temporary change of the natural conditions and a considerable modification within the ecosystem
Ecosystem - A system of living and non-living components of the natural world that are connected to each other (exchange of substances, energy and information)

A "veteran" European beech.
Credit: *Jan Mokrý*

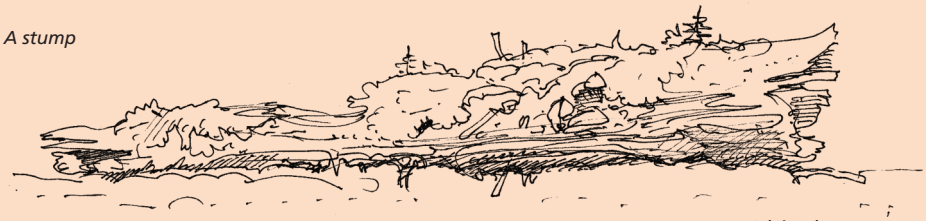
Dead wood – what does it really mean?

Standing snags, lying logs, windfalls, branches broken off, parts of disintegrated wood, stumps and stubs – all of this is dead wood. Dead wood, however, can also be found on living trees. The veterans – as the old trees reaching the end of their lifespan are sometimes called – create a lot of space for a wide variety of life, whether it involves all kinds of cavities, cracks, withered branches, and the like.

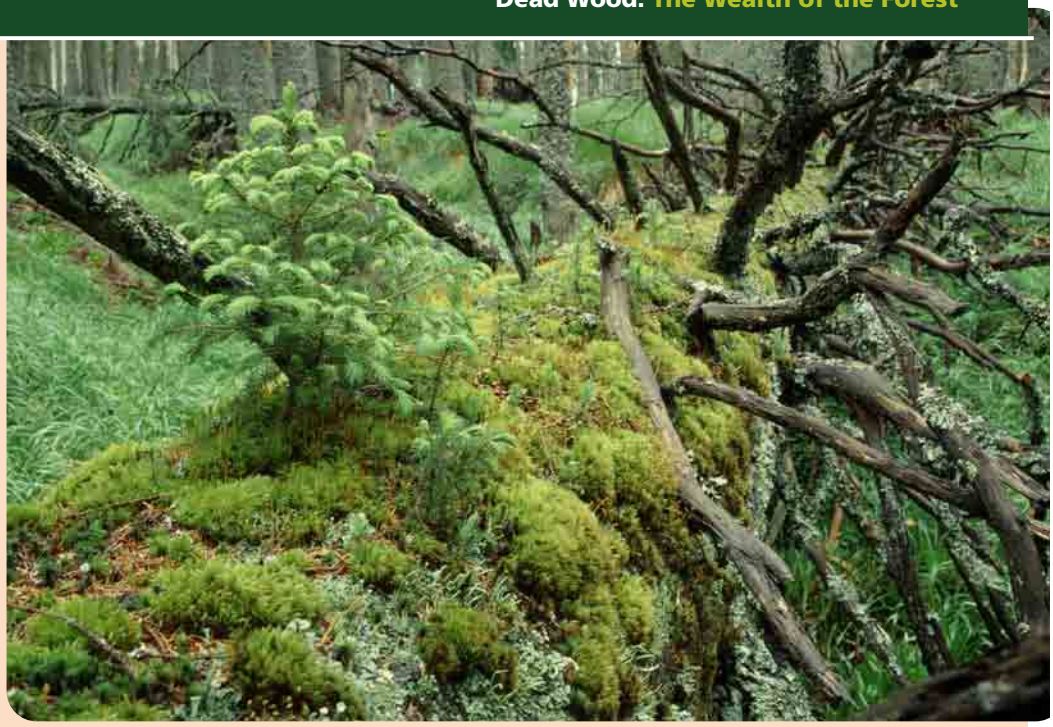
Dead wood plays a very important role not only on land, but also in water. In rivers, lakes or ponds, dead wood provides the necessary habitat for a host of species of fish and aquatic invertebrates.

Decaying wood is an essential part of forest ecosystems and is important for preserving species diversity of our nature. It forms a unique place to live, a shelter, and even a source of food for many species of plants, animals and fungi. Dead wood is a setting to encounter not only birds, bats and other mammals – well-known species that are easy to watch in the woods – but also plenty of organisms living undercover: insects, fungi and lichens. **Dead wood is full of life!** Eager to hear more? Then feel free to read more and discover this unknown yet rich world.

A stump



A lying log



A fallen spruce trunk, full of life. ***Credit:*** *Hans Kiener*

How important is dead wood?

Dead wood is one of the fundamental and essential components of natural forest ecosystems. Despite its importance, it used to be removed from the forests due to commercial management, which still continues. Today, we can see decaying logs in forests when visiting a protected area – one where human management is not so intense. In the past, leaving wood in stands was perceived as serious misconduct. Due to insufficient knowledge, dead wood was perceived as one of the causes of the spread of diseases of trees, proliferation of pest insects and spreading of forest fires. Results of the latest studies are changing the current view on the matter, refuting the myth that dead wood and old trees mean a forest that is unhealthy. Indeed, most such cases involve the contrary – a wood full of life and one with high diversity of natural sites for many species of organisms. Forests that we find old trees and dead wood in are healthier and – essentially – are better able to cope with climate change, diseases, pests and other hazards. Dead wood plays an invaluable role in the nutrient cycle and in the development of the natural recovery of forests; it influences the functions and the structure of watercourses, the morphology of slopes, the diversity of the habitat and – in particular – is a positive factor for biodiversity of thousands of species of organisms, whether bacteria, algae, fungi, mosses, liverworts, lichens and ferns or mites, insects, birds or other animals.

Terms to remember:
Biodiversity - A diversity of species; encompasses the diversity of life in all its forms.

A mountain forest left to spontaneous development. ***Credit:*** *Hans Kiener*

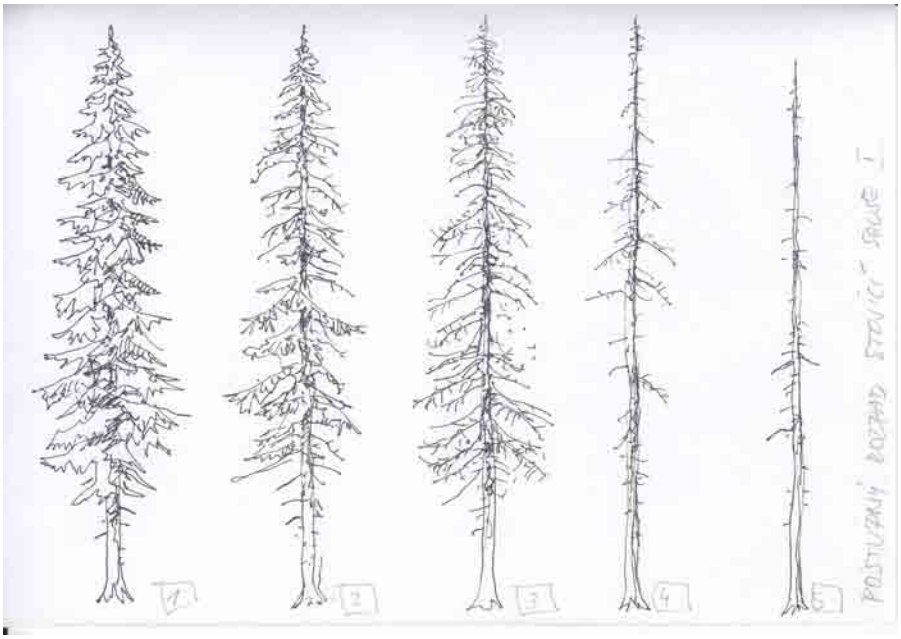
Dead wood in national parks

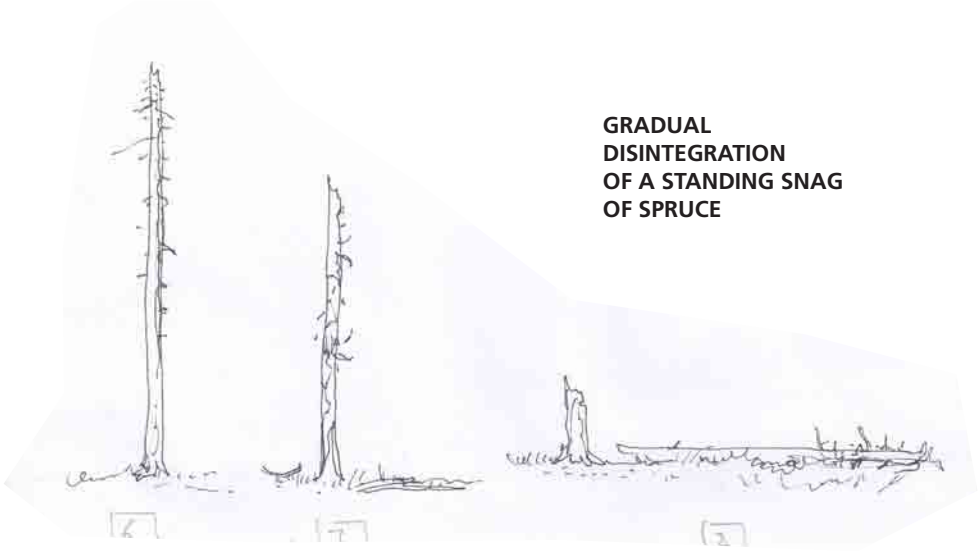
When a decision was made in Bavaria (1970) and in Bohemia (twenty years later) to set up a national park, the local natural systems were granted a unique chance to show what they can do within a relatively large territory. With about 900 km^2, Šumava National Park along with the Bavarian Forest National Park forms the largest complex of protected areas in Central Europe. The territory primarily serves the natural world and observation of natural processes. 'Let Nature Be Nature' is the basic idea behind national parks. After disturbances caused by winds and insects, this approach enabled dead wood to be retained within some part of the territory of the national parks; it is now slowly beginning to fulfil important functions in places where it had been seen only sporadically.

It is just the retained dead wood and its quantity which is currently one of the main differences between the natural forests and commercial forests. While in commercial forests we find a few or – at best – tens of cubic metres of dead wood per hectare, forests left to natural processes are capable of producing hundreds of cubic metres. There is no surplus or waste in forests of the latter type – everything that has grown up turns back into part of the forest as part of the natural cycle of matter and energy.

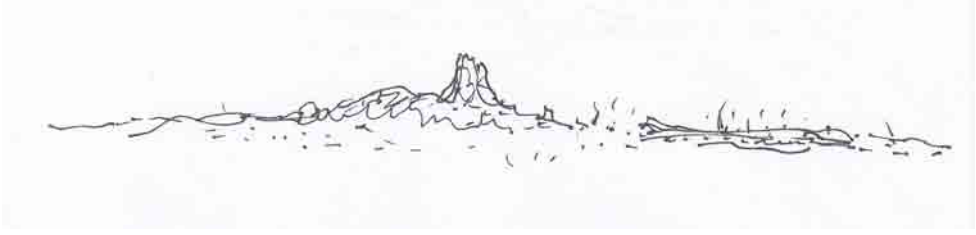
National parks are places where one can encounter these fundamentals of Mother Nature – new generations of forest as they emerge and disappear. **Let us take you for a walk through this secret world of the repeating cycle of birth and death.**

A commercial forest (spruce monoculture). ***Credit:*** *Jiří Kadoch*





GRADUAL DISINTEGRATION OF A STANDING SNAG OF SPRUCE



Wood-decaying fungi on a stump.
Credit: *Rainer Simonis*

How long does it take for wood to decompose?

Dead wood begins playing its role in the ecosystem in stages; still not disintegrated, hard wood serves the needs of just a very few organisms. The others must wait. For some of them, it is a matter of a few years, while others have to wait for decades before the tree becomes rotten and starts releasing important minerals into the soil. Fungi are very important in the process of decomposition; they "prepare" dead wood for future ecological processes and for other organisms. As the decomposition continues the quantity and the diversity of the species present or utilising decaying wood increase. The highest abundance of species is found in medium-decomposed logs. As the wood becomes more and more occupied, the resources and the volume of the wood drop down – species begin to compete and, as a result, their abundance slightly decreases in the most decayed trunks.
In addition to the wood qualities, such as the volume, the species, the hardness or the density, site and climatic conditions are the factors determining how quickly the wood decays; then, naturally, there are organisms found on wood and making a living from decaying it. A huge quantity of species is involved in the process; the role of wood-decaying fungi as well as insects is the biggest. For example, a beech tree may, if the conditions are good in a mixed forest, decompose relatively quickly – within just decades, there may be no sign of the original colossus. In spite of this, the remnants of a fallen log of spruce (Picea abies) may be evident even more than a hundred years later in a mountain spruce forest.

A windfall spruce at an advanced stage of decomposition. ***Credit:*** *Michal Valenta*

Terms to remember:
Wood-decaying/lignicolous fungi - Organisms permanently dwelling in dead wood

A debarked log. ***Credit:*** *Jan Rejzek*

The time to disintegrate also largely depends on whether the tree remains standing or lies on wet soil. Examples include a situation after infestation of the spruce by spruce bark beetles where there is no immediate log-ground contact. If that is the case, the snag may stay standing up to several tens of metres for as many as ten years. The tree gradually sheds needles during the first year or even smaller branches over the next few years. Bark may stay for a long time on the log or it is beaten off over time by massive strikes of various woodpeckers when larvae of various types of insects are developing under the bark. How many years after death each snag withstands without breaking particularly results from the action of decaying fungi that grow through the wood with their filaments to disintegrate the material. There are also more cases where no direct contact with the ground occurs – e.g. trunks falling on stones or layered over each other.

The speed of the disintegration may also be reduced if the trunk is debarked mechanically. Debarking is carried out in order to avoid the spread of bark beetles – which in our case involves spruce bark beetles in intervention areas of national parks. Here, wood matter dries up faster, thus worsening the conditions for wood-decaying organisms to cause decomposition. At first glance, such trunks retain their state a long time, extending the time needed to disintegrate and avoiding the growth of vegetation, including small seedlings.

The latest scientific studies have proposed a method involving slots cut (grooving) into the trunk. While this method prevents the spruce bark beetle from spreading, like debarking does, the notable influence on the characteristic xylobiont fauna is avoided here.

A grooved log.
Credit: *Archive of Bavarian Forest NP*

Terms to remember:
Xylobiont fauna - Organisms found on the surface and the inside of the wood, whether dead or living

Young spruce trees growing near snags where snow is melting earlier.
Credit: *Jiří Kadoch*

Standing snags – what they are good for

Certain types of tree withering may involve a rather large group of snags (sometimes entire dead stands) left standing within a large area. Whether it is a group of snags in a mountain spruce forest or a solitary snag in a mixed forest, the role standing snags play is a little different, but still essential:

- Partially shading the soil, reducing the loss of moisture through evaporation;
- Encouraging the natural recovery of the forest through providing shade to small seedlings while reducing the growth of highly expansive, light-demanding species of herbs and grasses – competitors of tiny trees;
- Providing the live trees around with shadow, so reducing thermal shock to which the trees are exposed within clear-cut areas;
- Acting as wind barriers – absorbing the gusts of wind, thus reducing the risk of uprooting for surrounding standing live trees;
- Absorbing solar rays and warming up faster than any other part of the forest with their darker surface; snow melts faster and winter ends sooner around them – the early melting makes it easier for seeds of trees blown by the wind along the snow cover to get hold at the foot of the tree so they can start to germinate sooner;
- Facilitating the recovery of mountain ashes in mountain spruce forests; seeds of this tree species are spread in faeces of seed-eating birds that like to sit in the dead trees;
- Remaining to serve, for some time, as "combs for moistness" in spring and autumn fogs, or as "frost traps"; their shadows also reduce the loss of water through evaporation;
- Boosting the species diversity; standing snags serve as hollow trees, providing a host of animals with cavities to dwell in.

Male and female of common redstarts nesting in a hollow of a snag. ***Credit:*** *Rainer Simonis*

A broken snag of spruce with red-belt conk.
Credit: *Tomáš Kalistý*

A decaying log of spruce with young spruce trees overgrown with mosses, lichens and fungi.
***Credit:** Jitka Zenáhlíková*

Dead wood full of life

The most notable functions of dead wood include the effect it has in terms of boosting biodiversity. There are a large number of organisms bound to it: 30 to 50% of all creatures living in the forest, according to studies. The main groups include fungi, bryophytes and lichens, beetles and birds. Lesser presence is seen for amphibians, molluscs, dipteran insects and other insect species. Of the above, numerous types are directly dependent on dead wood because it provides them with shelter, food or advantages over other sites. Accordingly, these species become the food or are used by other species that do not live specifically on the rotting wood so are bound to it only indirectly.

Dead wood can play a role even in the ecology of large mammals when for example it serves as bridges to overcome water courses and elevated places to rest or watch prey. Another essential part dead wood plays in supporting biodiversity is the way it helps aquatic ecosystems of streams and lakes of any kind.

Removing old and dead trees from a forest also removes the habitats of rare species, particularly those from groups like insects, fungi and lichens. In Central European forests, dead trees can host around 2,000 species of wood-decaying fungi and over 1,300 species of insects. For these insects, two thirds are endangered species. The shortage or absence of dead wood in a forest can mean a complete disappearance of certain organisms from the area.

A DECAYING TREE TRUNK
- FIXES MOISTURE NEEDED FOR GROWTH OF SEEDLINGS, WOOD-DECAYING FUNGI AND OTHER PLANTS

AN ELEVATED SITE ON THE LOG
- MORE SUNLIGHT, SNOW MELTS FASTER, SEEDLINGS CAN EASILY GROW FREE OF COMPETING GRASSES

MOSSES ON THE LOG SURFACE
- PREVENT LOSS OF MOISTURE, FIX AIR NITROGEN

DEPRESSIONS ON THE LOG
- RETAIN WATER, MAKING IT EASIER FOR SEEDS TO ATTACH AND SEEDLINGS TO GROW UP

XYLOBIONT INSECTS
- BOUND TO DECAYING WOOD WHICH THEY USE BY VARIOUS MEANS (LAYING EGGS, DEVELOPMENT OF THE LARVAE, PROVISION OF FOOD, ETC.)

WOOD-DECAYING FUNGI
- AS THEY CAUSE THE WOOD TO DISINTEGRATE, NUTRIENTS ARE RELEASED INTO THE SOIL

RETENTION OF WATER
- AS THE LOG PREVENTS WATER FROM FLOWING DOWN THE SLOPE, IT SUPPORTS ITS INFILTRATION

CAVITIES IN WOOD
- SPACE FOR SMALL CREATURES TO HIDE

Green shield moss. ***Credit:*** *Radek Drahný*

Which plants and lichens thrive on dead wood?

The convenient moisture and low competition of other plant species make lying logs a suitable place for mosses to grow. While there are species found on dead wood that normally grow on soil or other substrates too, some species are directly and specifically bound to the matter and nothing else. Such special cases include a large quantity of liverworts. Of the more common species, it is **creeping fingerwort** (*Lepidozia reptans*) that forms small crosses. Among those less common is **Heller's notchwort** *(Anastrophyllum hellerianum)* with purple gemmae on the top of the tiny plant.

Frequent and better known species of mosses include **cypress-leaved plaitmoss** *(Hypnum cupressiforme)* forming uninterrupted carpets. Important species include endangered **green shield moss** *(Buxbaumia viridis)* – a species bound to decaying wood of larger volume, especially that of spruce. Spotting this moss is possible only at the stage when it develops large, asymmetric spore capsules – the remainder of this plant is very small.

Together with mosses, fallen logs are settled by lichens. This includes a lot of miniature species, some of which are not visible to the naked eye, while for other well-known species such identification is not an issue. Out of the most famous types, there are various species of dog lichens and cup lichens.

Examples include **felt lichen** *(Peltigera praetextata)* – under dry conditions, it has a grey, frondose thallus turning to brown in wet situations; this lichen can

Terms to remember:
Gemmae - Parts of bryophytes used for vegetative propagation
Spore capsule - In bryophytes, an apparatus generating spores for reproduction

extend over an area of up to several tens of square centimetres. Of cup lichens, we can commonly see **lipstick powderhorn** *(Cladonia macilenta)* that is often found on decaying wood. Its podetia are very narrow, with brightly red fruiting bodies at the end. Another red-fruited species – **finger cup lichen** *(Cladonia digitata)* – may form fairly large stands, its grainy podetia being broader cup-like structures. Lichens are frequent to see even on standing snags that are suitable for the growth of old man's beard lichens and horse-hair lichens – species responsive to polluted air; they can also be encountered on live trees.

Logs overgrown with bryophytes and lichens retain moisture better, are quicker to decompose and serve as shelters for many invertebrates. They also help small seedlings of woody species attach and grow up.

Creeping fingerwort. ***Credit:*** *Štěpán Koval*

Heller's notchwort. ***Credit:*** *Štěpán Koval*

Cypress-leaved plaitmoss. ***Credit:*** *Ondřej Pexa*

Felt lichen. ***Credit:*** *Ondřej Pexa*

Lipstick powderhorn. ***Credit:*** *Ondřej Pexa*

Finger cup lichen. ***Credit:*** *Ondřej Pexa*

A fallen beech hosts common wood sorrels.
Credit: *Thomas Michler*

More plants found on dead wood

Even though mosses are prevalent on decaying wood, other higher plants and herbs too contribute to its gradual overgrowing and decay. Usually, they are only found on logs decomposed to quite an extent and numbers are rather low. As decaying wood holds moisture and is usually located in the shade of grown-up trees, most of these plants are included in moisture- and shade-demanding species while being common to mountain forest. Species growing on dead wood are taking advantage of the fact that conditions for their competitors (e.g. grass) to grow are worse.

Stumps and logs host **common wood sorrels** *(Oxalis acetosella)* boasting white flowers. Definitely common to decaying logs and stumps is **stiff clubmoss** *(Lycopodium annotinum)* – a plant with creeping stems that utilises fallen wood as a prop to reach toward the sunlight. Rather more decomposed cracked wood, however, reveals even larger members common to forest undergrowth such as blueberries, some ferns or **hairy reedgrass** *(Calamagrostis villosa)*. For ferns, species like **broad buckler-fern** *(Dryopteris dilatata)* and **narrow buckler-fern** *(Dryopteris carthusiana)* can be found locally in addition to **western oakfern** *(Gymnocarpium dryopteris)*.

However, these occur only singly or in small groups because there are considerable limits for them to grow.

Terms to remember:
Thallus - The body of bryophytes, lichens and certain algae

Credit: *Maxmilian Seifert*

***1** Touchwood fungus / **2** Artist's conk / **3** Sulphur shelf / **4** Red-belt conk / **5** Coral tooth / **6** Pholiota*

What are wood-decaying fungi?

Also called lignicolous fungi, these organisms are among the first to colonise dead wood. The role they play in this regard is important and essential for the forest. Through degradation of the wood, these fungi enable other organisms to utilise nutrients, thereby contributing to the cycle of minerals and nutrients in nature. Very plainly speaking, wood consists of celluloses and lignin. While celluloses are feasible to decompose for many species of organisms, lignin is the other way since most living things lack the necessary enzymes, apart from certain fungi that – as the only organisms on Earth – are capable of degrading lignin. This is the precise reason for the extreme importance of these in the cycle of nutrients on our planet.
Wood-decaying fungi form an integral part of forest ecosystem biodiversity. There are plenty of fungal species bound to dead wood.

Terms to remember:
Macromycetes - Fungi very well visible with the naked eye and featuring a large fruiting body

In the Šumava Mountains, they number at least 400 identified by scientists out of a total of around 2,000 species of large fungi (i.e. macromycetes) found locally; some of them are very rare.

Found in both deciduous and coniferous woods, **red-belt conk** *(Fomitopsis pinicola)* is perhaps the most exciting member of lignicolous fungi that can be encountered in Šumava, along with **tinder fungus** *(Fomes fomentarius)* that is bound to broad-leaved trees only. The most beautiful fungal species include **coral tooth** *(Hericium coralloides)* – a fungus resembling sea corals. Typical rather rare species of mountain spruce forests include *Phellinus nigrolimitatus* growing on fallen decaying logs of spruces in native mountain forests – more specifically, mountain spruce forests and woods which combine spruce, beech and fir.

Red-belt conk. ***Credit:*** *Markéta Rudlová*

Touchwood fungus. ***Credit:*** *Pavel Hubený*

Coral tooth. ***Credit:*** *Maria Hußlein*

Phellinus nigrolimitatus. ***Credit:*** *Jan Holec*

Beetles bound to dead wood

The slower the trunk is dying or decaying, the higher the number of xylobiont species that attach themselves to it, and the greater the diameter of the log, the more demanding the species of insects colonising it.

Net-winged beetle *(Platycis minutus):* found in moist, decaying wood which is in close contact with soil. The larvae feed on micro-organisms found in the rotting wood.

False ladybird *(Endomychus coccineus)*: its occurrence is bound to decaying wood with wood-decaying fungi growing on the surface; its larvae feed on spores of the fungi.

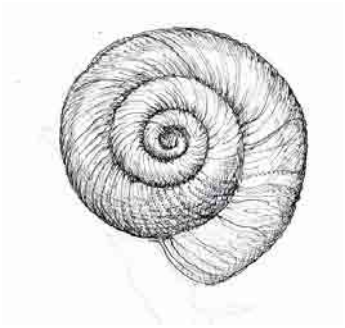
Pytho depressus: both the beetle and the larvae live under the bark of dead trees where they feed on other species of invertebrates. The species is rare and is found in the native mountain forests.

Two-banded long-horn beetle *(Rhagium bifasciatum):* a common long-horn beetle, its larvae develop in tree stumps and rotting wood of spruce. The beetle extends as far as mountain areas.

Stag beetle *(Sinodendron cylindricum)*: the species occurs in mouldering wood of broad-leaf tree species. Its development takes 2 to 3 years. Males differ from females in that they boast a distinct horn on the head.

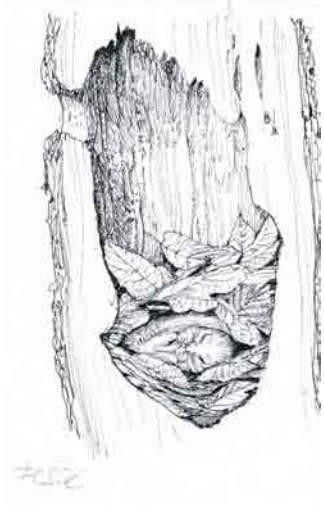
Longhorn beetle *(Tragosoma depsarium):* bound to old, coniferous, primeval forest stands where it finds sufficient suitable matter for its development, i.e. wood that is rotting. In this country, it is found in mountain spruce forests. As a highly endangered species, it enjoys legal protection.

Terms to remember:
Spores - Used for asexual reproduction

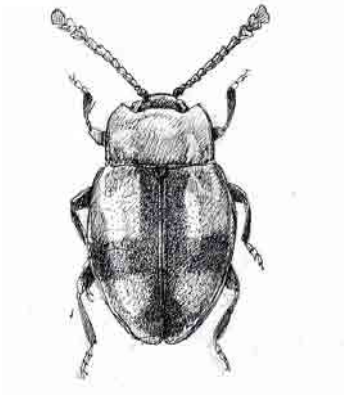


BROWN DISCUS SNAIL
(DISCUS RUDERATUS) A GASTROPOD, IT HAD BEEN PUSHED OUT TO HIGHER ZONES BY PRESSURE FROM MORE THERMOPHILIC SPECIES; IT IS FOUND UNDER LOOSE BARK OF BEECH OR SPRUCE LOGS.

LAND SNAIL
(CAUSA HOLOSERICEA) AN INCONSPICUOUS GASTROPOD BOUND TO DECAYING WOOD AND RUBBLE, E.G. IN THE TERRITORIES OF FORMER SETTLEMENTS

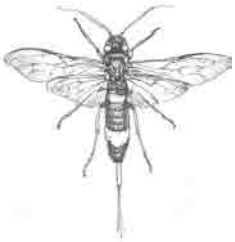


HAZEL DORMOUSE *(MUSCARDINUS AVELLANARIUS)* THE SMALLEST AS WELL AS THE MOST ABUNDANT SPECIES OF DORMICE LOCALLY, APPROXIMATELY THE SAME SIZE AS A HOUSE MOUSE. A NOCTURNAL SPECIES, IT BUILDS ITS NEST IN DENSE SHRUB VEGETATION OR EVEN IN THE HOLLOWS OF TREES AND TREE STUMPS. IT IS FOUND FROM THE LOWLANDS TO THE MOUNTAINS.



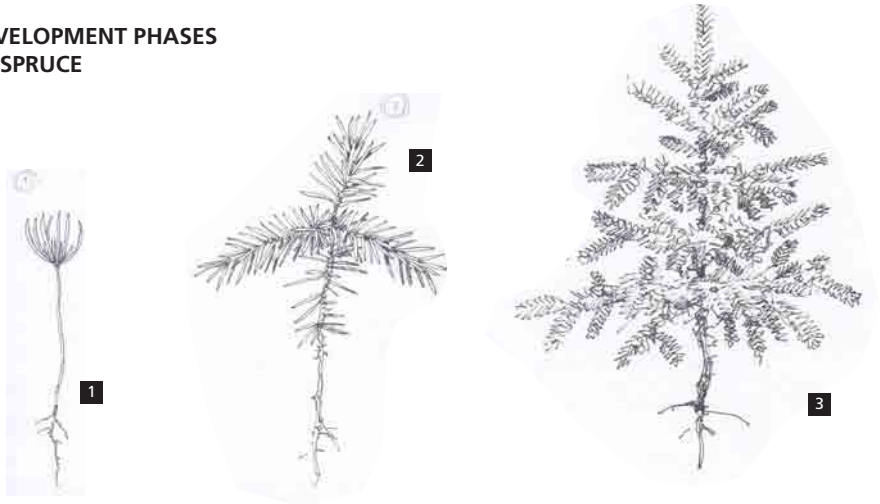
HANDSOME FUNGUS BEETLE
(MYCETINA CRUCIATA) A STRIKING BEETLE THANKS TO ITS COLOUR; IT IS FOUND ON ROTTING WOOD AS WELL AS IN WOOD-DECAYING FUNGI, SUCH AS TOUCHWOOD FUNGUS.

GIANT WOODWASP *(UROCERUS GIGAS)* A LARGE WASP-RESEMBLING INSECT; USING ITS STINGING OVIPOSITOR, IT LAYS ITS TUNNEL--BORING LARVAE IN THE WOOD WHILE INFECTING THE WOOD WITH FUNGAL SPORES; THE LARVAE DEVELOP IN THERE FOR THREE YEARS AND DEVOUR MYCELIUM OF THE FUNGI.

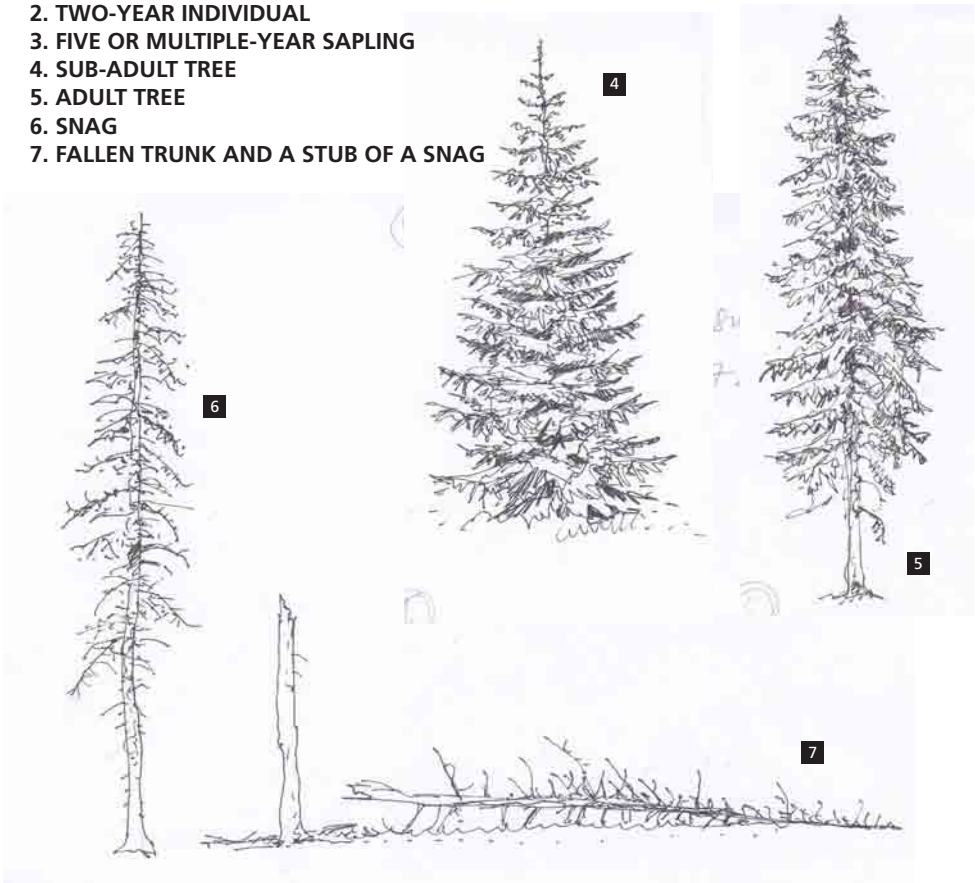


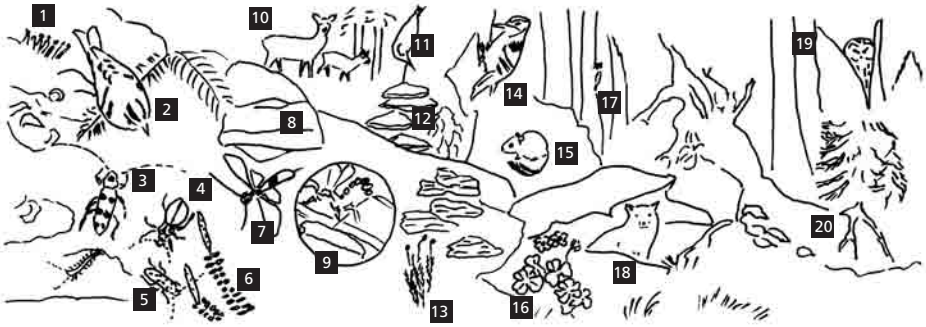
LONGHORN BEETLE
(OXYMIRUS CURSOR)
OCCURS IN CONIFEROUS AND MIXED FORESTS. THE LARVAE CAN BE FOUND INSIDE ROTTING ROOTS, STUMPS, AND FALLEN TRUNKS OF TREES. ADULTS APPEAR ON WOOD OR ON THE FLOWERS OF BUTTERBUR, FIELD SCABIOUS OR BLUE SOW THISTLE.

DEVELOPMENT PHASES OF SPRUCE



1. ONE-YEAR SEEDLING
2. TWO-YEAR INDIVIDUAL
3. FIVE OR MULTIPLE-YEAR SAPLING
4. SUB-ADULT TREE
5. ADULT TREE
6. SNAG
7. FALLEN TRUNK AND A STUB OF A SNAG





1 **LIPSTICK POWDERHORN** *(CLADONIA MACILENTA)*

2 **COMMON FIRECREST** *(REGULUS IGNICAPILLA)*

3 **ROSALIA LONGICORN** *(ROSALIA ALPINA)*

4 **GROUND BEETLE** *CARABUS AURONITENS*

5 **LONGHORN BEETLE** *SAPERDA SCALARIS*

6 **INTERRUPTED CLUB-MOSS** *(LYCOPODIUM ANNOTINUM)*

7 **GIANT WOODWASP** *(UROCERUS GIGAS)*

8 **TOUCHWOOD FUNGUS** *(FOMES FOMENTARIUS)*

9 **SABRE WASP** *(RHYSSA PERSUASORIA)*

10 **ROE DEER** *(CAPREOLUS CAPREOLUS)*, A FEMALE WITH A FAWN

11 **NUT HATCH** *(SITTA EUROPAEA)*

12 **RED-BELT CONK** *(FOMITOPSIS PINICOLA)*

13 **COMMON HAIRCAP** *(POLYTRICHUM COMMUNE)*

14 **MIDDLE SPOTTED WOODPECKER** *(LEIOPICUS MEDIUS)*

15 **HAZEL DORMOUSE** *(MUSCARDINUS AVELLANARIUS)*

16 **COMMON WOOD SORREL** *(OXALIS ACETOSELLA)*

17 **BLACK WOODPECKER** *(DRYOCOPUS MARTIUS)*

18 **RED FOX** *(VULPES VULPES)*

19 **URAL OWL** *(STRIX URALENSIS)*

20 **THE EARLY STAGE OF STILT ROOT**

The **Ural owl** *(Strix uralensis)* is a large owl species that nests in old-age beech/mixed forests; this generally occurs in the hollow sections of large, old, often already dead trees, but sometimes also within the points of breakage of thick trunks or even in former nests of birds of prey in tree tops.

The **three-toed woodpecker** *(Pycoides tridactylus)* occurs in mountain spruce forests where it nests in its self-made cavities found mostly in standing snags. The food – almost exclusively of animal origin – is mainly searched for along the bark of trees and, often, also in rotting wood.

The **pygmy owl** *(Glaucidium passerinum)* prefers rather small cavities that were formerly in use mainly by great spotted / three-toed woodpeckers.

The **Tengmalm's owl** *(Aegolius funereus)* is found mainly in mountain spruce and mixed stands, using former cavities of black/green woodpeckers as places of nesting and temporary shelters or just storing food.

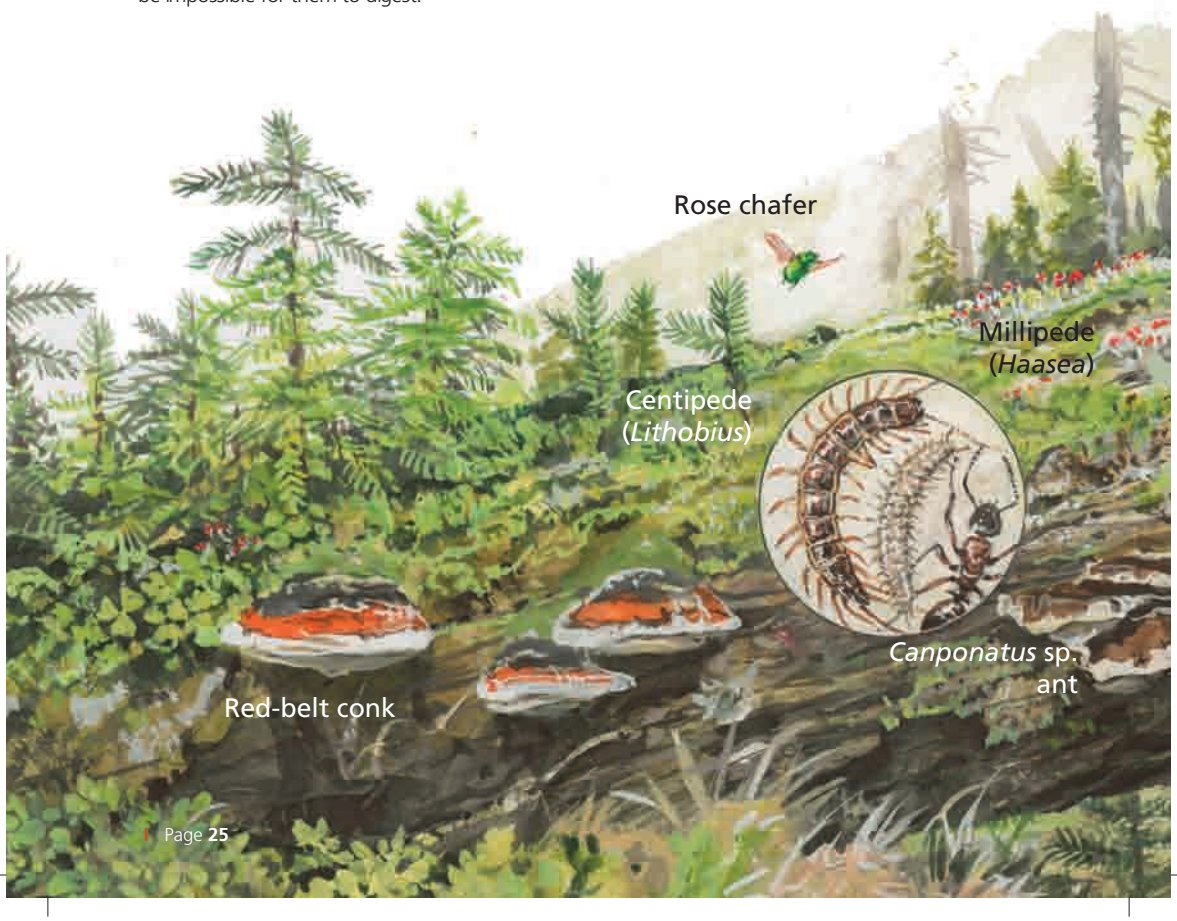
The **white-backed woodpecker** *(Dendrocopos leucotos)* is a rare dweller in mixed primeval forest stands, building the breeding cavity on its own in dead fragments of beech and foraging under their bark and in decaying wood.

The **red-breasted flycatcher** *(Ficedula parva)* is a rather rare species of perching bird, generally encountered (or rather heard) in broad-leaf forests, which in Šumava involves some beech woods. When nesting, it makes use of diverse cavities and crevices often found in hollow fragments of trees and in snags.

How gradual settlement of spruce (bark beetle) snags is underway

Decaying wood hosts a very rich kingdom of invertebrates. Most of these are specialist species – their development can take place nowhere else but in dead wood. It is precisely them that are, due to the lack of dead wood in standard forests, a very vulnerable group of animals. It primarily includes mites, insects and molluscs, but ants or centipedes and millipedes are involved as well. Most of them need decaying wood of larger dimensions for life – the greater the better. Where forests are managed by humans, with dead wood generally lacking or present only as too thin material (e.g. branches), such species have no chance to survive. For many species of insects that live on dead wood a co-existence with fungi is critical because without the help of fungal mycelia the wood mass would be impossible for them to digest.

It is precisely ill and weakened trees where settlement of dead wood by xylobiont fauna and fungi begins. Spruce bark beetles are the first to attack these trees; they make a system of corridors and chambers under the bark during its reproduction period. After the beetle flies out after eight weeks or so, the chambers and corridors become settled by other "tenants", such as larvae of flies. Faeces of insects and remnants of plants are a nutritious substrate for fungi; they are highly important because they transform cellulose and lignin into substances that are digestible for other organisms.




Red-belt conk
Handsome fungus beetle
Spruce bark beetle
Sulphur shelf
Two-banded longhorn beetle
Hairy rove beetle
Longhorn beetle
Wood louse
Discus snail
Phellinus nigrolimitatus

Wolf spider Acantholycosa lignaria. ***Credit:*** *Pavla Čížková*

In the next stage the tree becomes so weakened that more species – other bark beetles, longhorn beetles, elaterid beetles and rove beetles – can start to utilise it. This creates all kind of cracks and crevices in the tree that are colonised by carabid beetles, centipedes and wood lice. Nematodes, mites, springtails and snails find their space in wet, rotting wood under the loose bark.

Species that are only able to exist in dead wood arrive. As they feed on the wood or make corridors, they generate new areas for other organisms to exist: mites colonise corridors left by longhorn and elaterid beetles and mite larvae bore into the structures, followed by larvae of flies and long-horns. Moreover, all the hollow spaces are colonised by moths, bumble bees, wasps, parasitoid wasps, and spiders. There are quantities of prey insects as well.

The next stage is largely dominated by wood-decaying fungi that decompose lignin while holding moisture. This is the ideal time for large beetles, some of which are very rare, so strictly protected. As moisture increases and degradation is underway, the decaying wood becomes spongy and soft, suitable for the snail. Finally, the area becomes favourable even for earthworms and centipedes.

Spruce bark beetle

Young spruce trees growing in a row on decaying logs. ***Credit:*** *Rainer Simonis*

The "cradle" of the forest's young generation

Dead wood is an important substrate for the forest to regenerate. One cannot say how long it takes for a dead tree to turn into a substrate good for tree seedlings; yet the convenience for new plants to attach and grow up improves as the degree of decomposing increases. The same applies to the numbers of specimens growing on rotting wood. The most decayed logs, however, show reduced abundance of such plants due to them competing with each other as part of the same species and with other vegetation. However, the numbers are still not limited to the extent that is the case on the surface of soil.

The first seedlings may germinate on dead wood as early as the first years after death and the falling of the trunk. It may however take several decades before a fallen tree becomes a favourable home to young trees. During this time the wood begins to decay due to the action of various types of fungi, bacteria and other organisms that change its chemical and physical properties for the benefit of the young plants.

That small trees prefer growing on lying logs or in the vicinity of standing snags is very often evident in forests, manifest in mature trees growing in a single row as can be observed particularly in some forest reserves. They are trees that sprouted and grew up on the rotting trunk of their predecessor. The question may arise, however, as to what is the reason for new seedlings to prefer fallen logs?

Particularly in mountain spruce forest, with its unfavourable conditions for growth of trees – cold, snow, reduced rate of decomposition, accumulation of raw humus, and insufficiency of nutrients – dead wood forms an ideal, if not the sole, good place for the seed to germinate and for the seedling to grow.

A regenerating stand. ***Credit:*** *Rainer Simonis*

Dead wood gives new seedlings a range of benefits. They are better exposed to the sun, warmth and light and receive balanced moisture conditions – so they grow up faster.

Seedlings growing on an elevated log or stub are safe from other competing plants such as ferns or grasses which would otherwise have defeated the small tree by shading it.

Dead wood retains water and nutrients that it progressively releases; in periods of drought, it serves as a water tank. It provides appropriate conditions for mycorrhiza fungi that support the growth of young trees. Dead wood ensures protection of young trees on steep slopes as well as shielding from flowing surface water, pathogens in the soil and from snow pressure. In some cases, fallen logs make access of hoofed game more difficult, preventing it from browsing the small trees.

One-year seedling of Norway spruce sprouting on a log. ***Credit*** *Dana Zývalová*

A log with regeneration of spruce.
Credit: *Vladislav Hošek*

Terms to remember:
Mycorrhiza - Symbiotic co-existence of fungi with the roots of higher plants

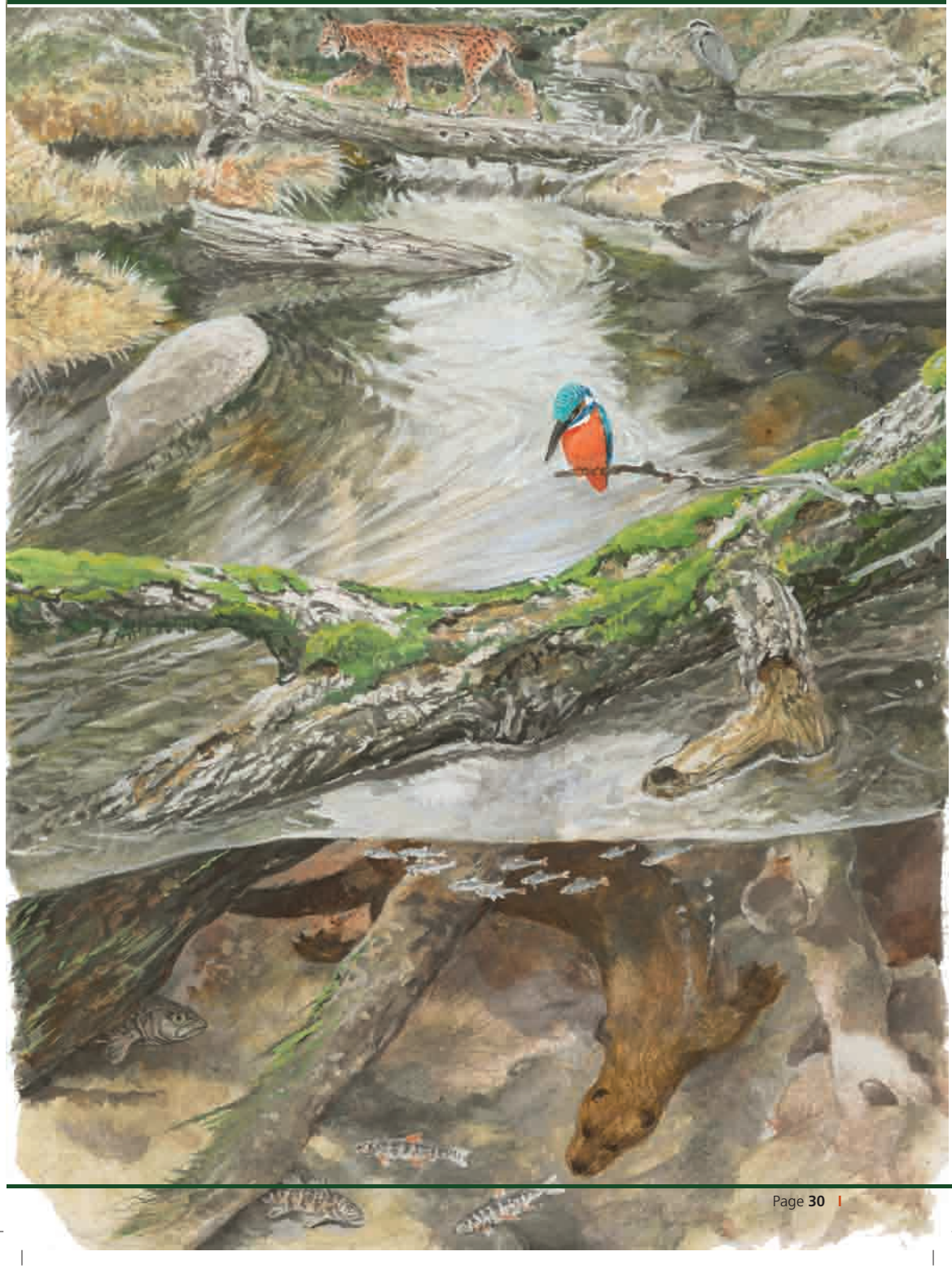
Fallen logs regulating the flow of water in the stream.
Foto: *Rainer Simonis*

Dead wood in aquatic habitats

Rivers and streams need dead wood – it is a natural component of them, as well as of the forest. Once a dead tree falls in the bed of the watercourse, the trunk begins to decompose by action of fungi and bacteria.

Since it may take several decades for a large log to disintegrate – the degradation of wood takes significantly more time compared with other organic materials such as leaves, needles, and small twigs – decaying wood in watercourses represents a long-term depot of nutrients. It is also a factor for the speed and rate of flow of the water: small streams have to bypass and meander around fallen trunks or windfalls. This extends not only the course, but also the time the water flows through the landscape, which in the case of impending floods may not be a negligible factor.

Decaying wood supports biodiversity of watercourses. It creates a number of new refuges for species like trout or bullhead, for example. It provides organisms with a shelter from enemies or strong stream of the water. As the process of wood disintegration continues, there are more and more algae and micro-organisms that serve as food for a number of other creatures. The organic layer on the surface of immersed wood significantly supports the self-cleaning capacity of watercourses.



FALLEN LOGS IN STREAMS AND RIVERS ARE ALSO AN IMPORTANT ELEMENT OF MIGRATION FOR A NUMBER OF ANIMALS AS THEY OVERCOME WATERCOURSES.

FALLEN TREES ARE OFTEN USED AS A PREFERRED PLACE FOR VARIOUS TYPES OF HERONS TO WATCH FOR TINY FISH. IN RARE CASES, THEY CAN EVEN DISPLAY SUCH A COLOURFUL GEM AS THE COMMON KINGFISHER.

AS THEY SLOW DOWN THE RAPID STREAM, LOGS IN THE RIVER CHANNEL REDUCE THE RATE AT WHICH THE WATER LEAVES THE LANDSCAPE.

INVERTEBRATES USE THE SURFACE OF LOGS IN WATER AS THEIR HABITAT.

THE EUROPEAN OTTER *(LUTRA LUTRA):* HUNTING SMALL FISH IN POOLS FORMED BY FALLEN LOGS.

FISH FRY OR SMALL FISH SPECIES – SUCH AS MINNOWS – USE BRANCHES AS A SHELTER FROM PREDATORS.

Does dead wood affect soil quality?

In Šumava, there are naturally acidic soils. This stems from the acid rock subsoil formed by gneiss and granite, in particular. The acidity even becomes increased through spruce litter-fall. The second half of the 20th century even saw the acidity increase through air pollution. Industrial plants emitted sulphur-based compounds into the atmosphere that entered the ground along with rain ("acid rains"). The action of acids wash out nutrients from the soil – as a result, the poor soils of Šumava are becoming even poorer as well as more acid. Decaying wood is a source of nutrients; the organic material derived from its disintegration also attracts toxic elements, which helps to improve the condition of the soil.

A fallen log - a future source of nutrients.
Credit: *Popp Hackner*

Decomposition of organic matter in the forest and the organisms involved

Decaying wood is a factor for biological and physical qualities of the soil:

- Positively influences the amount of organic matter in the soil;
- Provides a critical storehouse of nutrients in the forest ecosystem;
- Influences processes in soil as well as the quantity and composition of species of organisms involved in decomposition of organic matter & provides a habitat for symbiotic and nitrogen-binding bacteria;
- Influences the long-term cycle of carbon by being fixed in forest soil;
- Protects soil from hail or intense torrential rain; increases the stability of the soil surface and slows down runoff; protects from erosion on slopes;
- Alleviates extreme drying – retains moisture when in contact with soil;
- Minimises the temperature differences on the surface of the forest soil – in the springtime, the decaying wood warms up more quickly while freezing through later in autumn; it partially insulates the soil against cold.

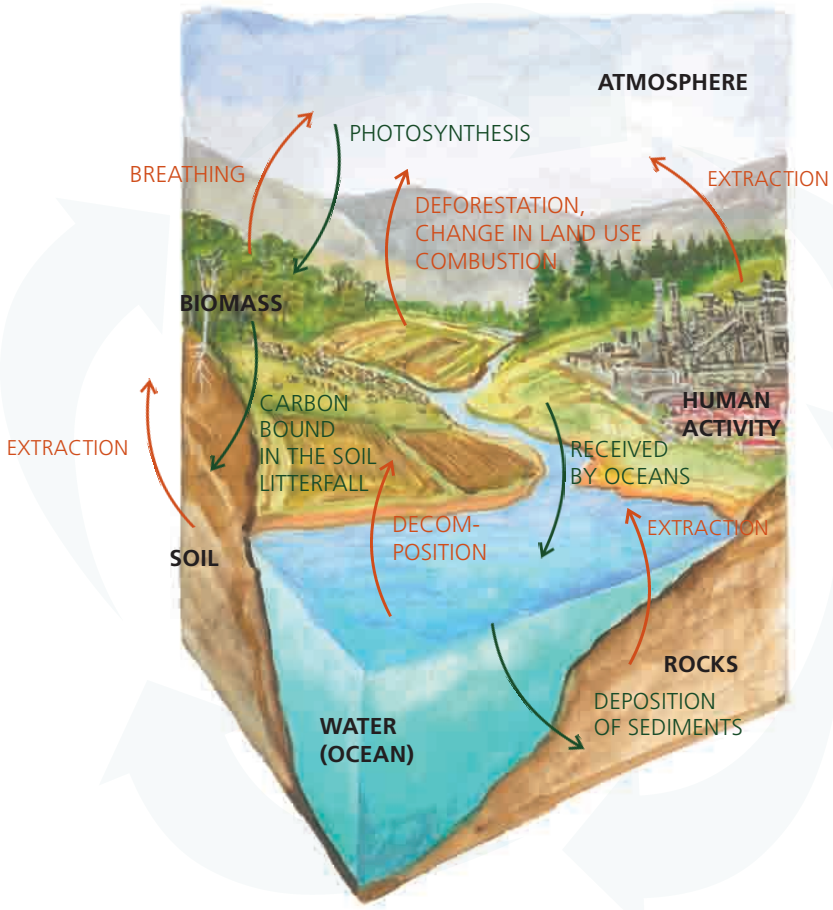
Terms to remember:
Symbiosis - Any close co-existence of two or more organisms

Carbon cycle

Carbon is a fundamental building block of all organisms. It is found on Earth in different forms:

- Inorganic (rocks & minerals)
- Organic (living matter
  - forests are the largest continental reservoir)
- Gaseous state (carbon dioxide, methane, carbon monoxide)

During the cycle there is transition of the carbon between these forms. In the past the amount of carbon was balanced in in the different forms. At present, the stock of carbon in the atmosphere is increasing due to the influence of humans which distorts the balance, causing climate change.



Spruce bark beetle. ***Credit:*** *Marek Drha*

Ecosystem Engineer

Spruce bark beetles have always been a natural part of spruce forests. While in managed forests they are considered to be the most dangerous pests throughout Europe because of the major economic damage they can cause, in the woods left to develop spontaneously the creature is seen as an "ecosystem engineer".
In standard situations, the bark beetles attack mainly rather old, weakened trees. Young trees do not provide favourable conditions for the beetle to develop with their thin layer of phloem. Recent studies refer to the beetle as a key species, one that forms a tool for the forest to regenerate in a natural manner, restores the natural character of the stand and has a positive influence on improving biodiversity in ecosystems. After windstorms, spruce bark beetles may propagate and cause old trees to wither, at a large scale, thus facilitating new generation of the forest.

Spruce bark beetles, of course, have their natural enemies such as the **three-toed woodpecker** (*Picoides tridactylus*), the **black woodpecker** (*Dryocopus martius*), and the **great spotted woodpecker** (*Dendrocopos major*), plus there are insects such as the **European red-bellied clerid** (*Thanasimus formicarius*) or parasitoid wasps. As the numbers of the spruce bark beetle rise, those of its natural enemies increase, too.

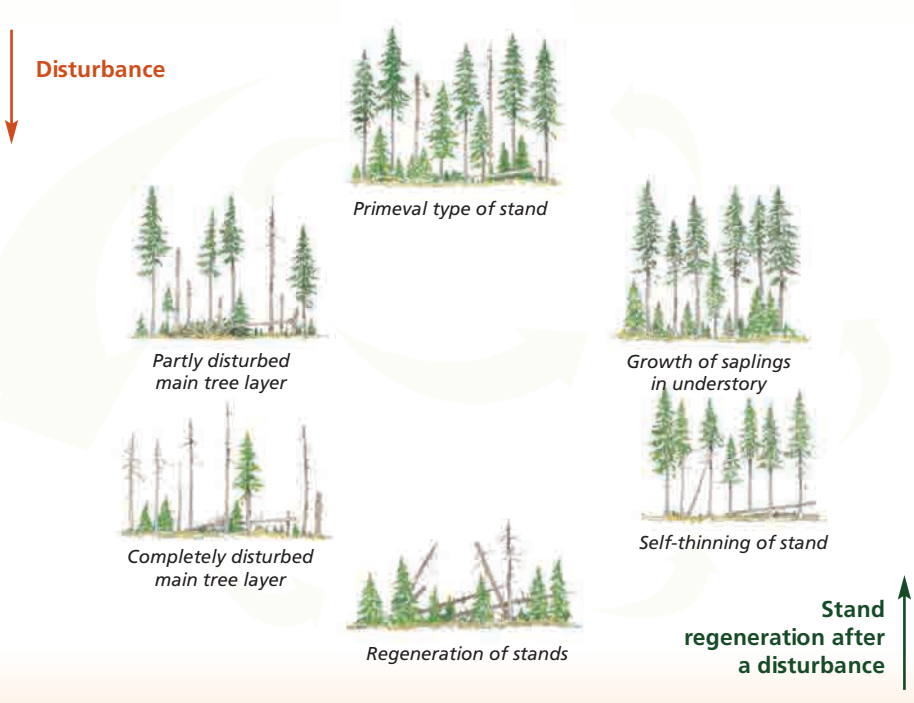
European red-bellied clerid. ***Credit:*** *Dana Zývalová*

The life of the forest

Unlike the mixed forests in lower elevations, large areas of mountain spruce forests are frequently renewed. Here, the death of old trees occurs due to strong winds or propagation of spruce bark beetles. The forest, however, is ready for such changes – they mean nothing dramatic. Old trees just vacate space and allow light supply for young spruce seedlings that have been waiting a long time for their opportunity underneath the old vegetation. Spruce is a tree species that attaches very well when shaded. This helps a large number of new trees waiting in the undergrowth to survive for this very situation.

When mountain spruce forest recovers from bark beetle escalation, **Norway spruce** *(Picea abies)* continues to be the major woody plant; pioneer species occur only to a very small extent. The reason is that when the forest had died off due to bark beetles, no spots with exposed soil develop which such species, e.g. **silver birch** *(Betula pendula)*, need for sprouting up. The few woody plants to accompany spruce include **European ash** *(Sorbus aucuparia)*. Exposed mineral soil is formed after a windstorm (windfalls). In this case, to a lesser extent, broad-leaf trees appear at disturbed sites along with spruce, such as **willow** *(Salix* sp.), **birch** (*Betula* sp.) and **common aspen** *(Populus tremula)*.

With the arrival of light due to the disintegration of the upper levels of trees, small trees start to grow. At favourable sites such as decaying wood, they shoot up faster than the surrounding vegetation that had also started emerging very quickly due to the open canopy. Gradually, the young trees take the place of the old, died off trees. This replaces the old generation of trees with a new one – disturbances are only a natural part of the cycle of life.



PHASE 1
Bark beetle bores into the spruce bark via a so-called entrance hole.

PHASE 2
The male bark beetle gnaws out a nuptial cell.

PHASE 3
The male bark beetle with two females in the nuptial cell.

PHASE 4
After copulation, females mine their egg-laying corridors along the axis of the trunk. On the edges of the corridors, the females make pits in the phloem to lay eggs; the process usually takes 10-12 days. During its life, a female lays an average of 60 eggs.

PHASE 5
Larvae hatch from the eggs to mine their larval tunnels perpendicular to the egg-laying corridor. This takes 7 to 50 days.

PHASE 6
At the end of each tunnel, the larva gnaws out a pupal chamber where it undergoes pupal development taking 8 days on average.

PHASE 7
After hatching, beetles execute maturation feeding through which they extend the area around the pupal chamber and gradually grow up.

PHASE 8
The adult beetle mines through to the surface of the bark via a so-called emergence hole. The time to grow to adulthood is 24 days; the total time for the beetle to develop is 6 to 10 weeks approximately.

Monitoring of the forest. ***Credit:*** *Veronika Janochová*

How we monitor the natural development of the forest

Numerous studies are underway in the territories of both of the national parks – they include the monitoring of forests in the areas left to spontaneous development, aiming to see how such forests look and how they act in such situations. There is a grid of research plots within which we strive to learn about the structure and the composition of the forest, and the properties of live trees, snags, decaying wood, regeneration and vegetation.

The research is still ongoing, but even now we know, for instance, that the number of young trees is an average of ten times bigger (in some cases, up to one hundred times) than the number of adult trees, seeing that the future of our forests is ensured. The results obtained from these data show the importance of the role dead wood plays in natural regeneration of forest. Wherever there are plants in large areas that prevent tree species from regenerating – whether by creating a continuous grass sod, or preventing solar rays from getting through with massive leaves – fallen dead wood is actually the only substrate where seedlings of woody plants have any chance to live. But dead wood is important not only at such extreme sites. Wherever found in a sufficient quantity and for a sufficiently long time, dead wood forms one of the most appropriate settings for woody plants to regenerate in a natural way in general, as shown by our own results as well as lessons learnt elsewhere.

A mountain spruce forest. ***Credit:*** *Tomáš Čamra*

Let's give forests a chance!

We got used to expecting forests to serve us mainly as a source of timber as a raw material needed for our lives, as well as places of leisure and partaking in various pleasurable activities.
Over the long years of exploiting woods, we formed a vision of an orderly, clean, well-arranged forest in which dead wood has no place, and if any is there, it is a "shortcoming", "mess" or "sign of poor management". Decaying wood is something for which we even lack skills to evaluate or monetise (except, perhaps, for artistic photographers or painters). This is one of the reasons why there is a minimum of it today – namely in commercial forests – even though for the existing and future forests dead wood is an irreplaceable source of nutrients, as it is for the current dwellers of the forest that escape our attention so often.

"No dead wood = dead forest". Sounds like nonsense? Perhaps at first. Died off trees do not mean a "dead forest" – rather, dead wood is the basis and a chance for a new forest to emerge, regenerate in a natural manner and exist as a community of countless species – not just trees. It may be that it will be a different kind of forest to the type we are used to, perhaps from our mushroom-picking walks into the "clean" forest just outside the town.
National parks, however, are places where forest should get a chance as a whole – including all the organisms that belong to it – a chance to show its strength and ways tested by Mother Nature and proven through the ages.

Let's give forests a chance!

Tips for trips to the Šumava and Bavarian Forest national parks

Dead wood is a phenomenon that we can find and see in any natural and near-nature forest because that is where it belongs, as do live trees, fungi, and countless species of animals. If you wish to watch natural processes in action, you can experience such forest territories by visiting the Šumava National Park and the Bavarian Forest National Park.

To Březník

Setting-off point: Modrava
User types: Hikers, Cyclists, Skiers, Wheelchair Users, Baby's Pram Users
Seasons: Spring, Summer, Autumn & Winter
Trail length: 15 km (circular trail)
Incline: 309 m
Time demanded: 4 h & 30 min
Level of difficulty: Moderate

Start from Modrava - for hikers to get right to Březník, they can follow the green marks via the mire of Cikánská slať. The way back to Modrava (blue marks) leads along the stream of Modravský potok; this path can be used by the remainder of users to get there and back. Březník offers one of the most beautiful views of the Šumava Mountains when looking at Mt. Lusen and the Lusen valley from the site (note that Mt. Lusen is already Bavaria). The Lusen valley offers very harsh living conditions; there are many rare species of plants and animals such as gentians, alpinebog swertia, capercaillie, etc. On the surrounding hills one can see what forest looks like nearly 20 years after a bark beetle attack. The lush green of spruce is beginning nearly outgrow the remnants of standing snags. The Březník lodge dominating the valley was also made famous by writer Karel Klostermann placing the plot of his novel "Ze světa lesních samot" (EN: From the world of forest hamlets) at the site. Today it hosts a visitor centre and an exhibit dedicated to the writer.

Around Mt. Lusen

Setting-off point: „Igelbus“ stop Waldhausreibe (in winter: Waldhäuser Aussicht Car Park)
User types: Hikers
Seasons: Spring, Summer, Autumn & Winter
Trail length: 4.7 km (winter: 6.3 km)
Incline: 664 m (winter: 764 m)
Time demanded: 2 h (winter: 3 h & 30 min)
Level of difficulty: High

Start at Igelbus Stop “Waldhausreibe” – then continue to the Glass Ark (Glasarche) – from here take the “summer road” (Sommerweg) to reach the top of Mt. Lusen (elevation: 1,373 m) – optional refreshments and bed & breakfast in the cottage of Lusenschutzhaus – then follow the “winter road” (Winterweg) to get back to the setting-off point. When around the mountain top, experience the fascinating process of forest regeneration as since the windbreak of 1984 and bark beetle attack in the 1990s – just use the marked circular trail called The Lynx (Luchs). With a little luck you may catch a glimpse of either of two members of fauna typical of mountain forests as they forage: the capercaillie and the ring ouzel.

Experience poetry and fascination with the forest on the “Trail of Souls”

Setting-off point: „Igelbus“ stop Seelensteig
User types: Hikers
Seasons: Spring, Summer & Autumn
Trail length: 1.3 km / **Incline:** 55 m
Time demanded: 1 h / **Level of difficulty:** Low

Start at Igelbus Stop “Seelensteig” (elevation: 900 m) – take a 1.3 km long path through a distinctive forest landscape, where the “forest for our children and our children's children” has had the chance to regenerate after the windbreak of summer 1983. Encourage the observer in you by taking the elevated boarded walkway with its stairs, footbridges and platforms, points to sit and take some rest, and information panels with short, contemplative texts, all offering a unique experience amidst a forest.

“Mountain Grazing Land and Fens” Adventure Trail

Setting-off point: „Igelbus“ stop Buchenau
User types: Hikers & Cyclists
Seasons: Spring, Summer & Autumn
Trail length: Hikers 2.8 km; Cyclists 14.4 km
Incline: Hikers 60 km; Cyclists 500 km
Time demanded: Hikers 1 h, Cyclists 1 h & 45 min
Level of difficulty: Moderate

The municipality of Buchenau is the starting point for this tour combining a cycling and hiking experience. While here, ride your bike as far as the cyclist car park near Hochschachten (“high-mountain pastures”); then follow the “wolf trail” - a circular, hiker-only route. Between Hochschachten and Kohlschachten (“coal pastures”), where there are no standard routes, there is a boarded walkway leading across the mystical bog of Latschenfilz. On sunny days, there are dragonflies hovering around you and – with a bit of luck – you can even encounter a rare carnivorous plant – the sundew! Turning and going down a small branch to the small peaty lake of Latschensee is also well worthwhile.

„Spirit of the Virgin Forest" Adventure Trail

Setting-off point: Nová Pec or Jelení Vrchy
User types: Hikers
Seasons: Spring, Summer & Autumn
Trail length: 15 km / Incline: 664 m
Time demanded: 6 h / **Level of difficulty:** High

Set off for the lake of Plešné jezero from the car park Nová Pec Láz (green marks, 6 km), or from Jelení Vrchy (blue & green marks, 6 km). The trail begins at the dam of this glacial lake. Once you have covered 1.5 km, you climb to the place called Stifterova vyhlídka (Stifter Viewing Platform), which offers stunning views over the glacial kettle of the lake as far as Lipno Dam and the forests surrounding it. Three-toed Woodpecker – a feathery dweller typical of primeval forests with lots of standing and fallen wood – is the mascot of this trail. Around the lake you can already see a new, considerably grown-up generation of forest composed of not only spruces, but also of rowans and firs. From the monument you can do a circuit via the highest mountain in the Czech part of Šumava - Mt. Plechý (1,378 m) and descend back to the lake dam following the yellow marks leading along the other side of the lake via the place called sea of stones or continue straight to Nová Pec following the green marks.

To the springs of the River Vltava

Setting-off point: Kvilda
User types: Hikers, Cyclists, Skiers, Wheelchair Users, Baby's Pram Users
Seasons: Spring, Summer, Autumn & Winter
Trail length: 16 km (circular trail)
Incline: 268 m / **Time demanded:** 4 h & 30 min
Level of difficulty: Moderate

You can cover the Kvilda - River Vltava Spring Site distance following the blue marks leading over a generally flat road. Heading back to Kvilda you can complete the circle by ascending to Bučina via the foot of Mt. Stráž; then go to Kvilda on the paved road. (In summertime, there is a Green Bus riding from Bučina to Kvilda to take you back.) In January 2007, the devastating Hurricane Kyrill swept across Šumava causing outbreak of spruce bark beetles and dieback of mature forest stands. This occurred along this route and elsewhere. On the way you can observe amounts of dead wood such as standing snags, stubs, and fallen logs; you can also see the process of natural regeneration, verdant with a new generation of the forest.

"Windbreaks in the Mountain Spruce Forest" Adventure Trail

Setting-off point: Prášily
User types: Hikers
Seasons: Spring, Summer & Autumn
Trail length: 17 km (circular trail)
Incline: 536 m / **Time demanded:** 6 h
Level of difficulty: High

Start from Prášily (or Slunečná Car Park) and follow the red marks to reach Mt. Poledník passing by the lake of Prášilské jezero. Take the green-marked path and then follow the red marks to get back. Please note that the Poledník - Frantův most route is open only from 15 July to 15 November. The 37 metre-high lookout tower offers a panoramic view nearly throughout the Šumava Mountains. The adventure trail starts near the mountain top. As the wooden walkway squeezes through spruce trees uprooted by a windstorm along a rugged terrain as far as an elevated platform, it offers a very close look at the power of natural elements and advancing natural regeneration of the forest. Note: Staying one night on the top of Poledník is legally possible at a designated site.

Across the primeval forest fragment "Mittelsteighütte" near Zwieslerwaldhaus

Setting-off point: „Igelbus" stop Zwieslerwaldhaus
User types: Hikers, Skiers
Seasons: Spring, Summer, Autumn & Winter
Trail length: 3.1 km
Incline: 50 m
Time demanded: 1 h
Level of difficulty: Low

Start in the car park, at the Igelbus Stop "Zwieslerwaldhaus". In this 38-hectare fragment of virgin forest, marked hiking trails offer the opportunity to admire the local superb forest landscape. Going through this wonderful forest located directly in the surroundings of the village is a truly unique experience with the 500 years old, up to 52 metres high firs and spruces with awesome broad trunks. With its 50 species of local birds the forest area boasts the highest number of bird species in the national park. Amongst them, species of special rarity can be found such as the red-breasted flycatcher, the white-backed woodpecker and the Ural owl.

Credit: *Jan Mokrý*

Caution! Falling trees!

On the territory of national parks, where emerging and fading away is governed by the laws of nature, there is an increased risk of branches and trees falling spontaneously. Please be warned that you enter the forest at your own risk.