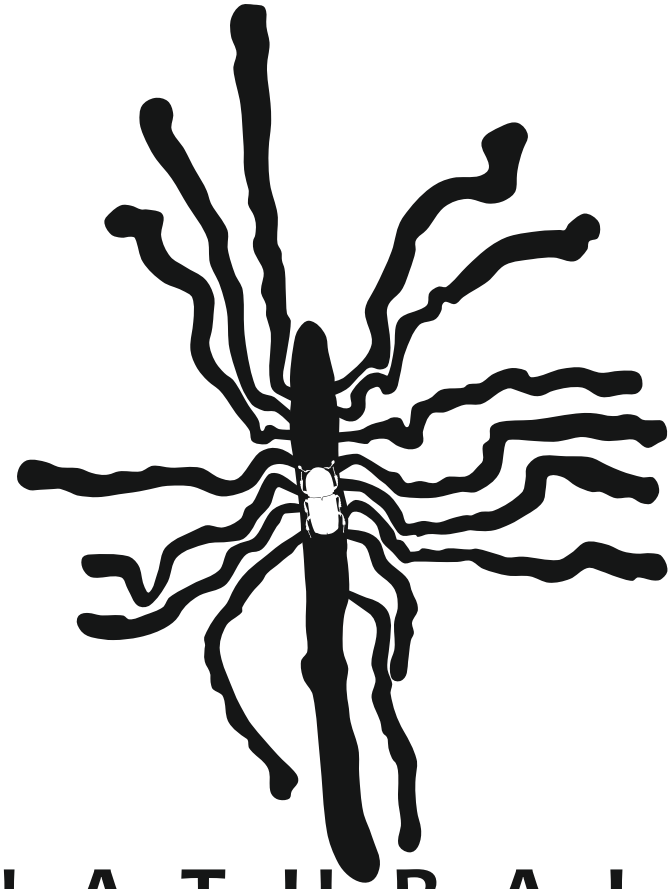


NATURAL DISTURBANCE CONFERENCE 2013

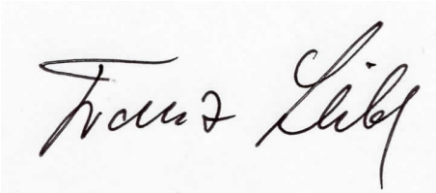
Field trips 30 April and 02 May 2013

Nationalpark
Bayerischer Wald

Words of welcome

No strictly protected area in Central Europe other than the Bavarian Forest National Park is characterized by large scale natural disturbance due to wind throw and bark beetle without subsequent management intervention. What constitutes an appropriate land-management response to a natural disturbance event is a controversial question. In particular, allowing beetles to kill trees in protected areas without any management intervention has intensified public debate over the costs and benefits of a "benign neglect" approach to management, and more generally, about the role of strict protected areas in national biodiversity strategies in Europe. The international disturbance conference in the Bavarian Forest National Park therefore aims to discuss and exchange experiences in order to broaden our view on the varied aspects relating to natural disturbance regimes. We are offering four field trips with different topics as a basis for the discussion. Here we focus on "water and element fluxes after the bark beetle outbreak", "large scale forest succession after bark beetle", "park management" and biodiversity in the forest ecosystems of the national park".

We are looking forward to fruitful discussions but also to sharing wonderful impressions with you in the field.



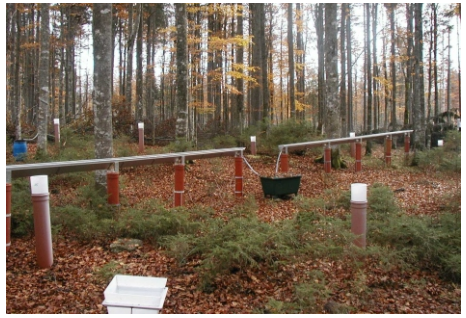
Dr Franz Leibl

Contents

Forest die-back affected plankton recovery from acidic stress

Long-term data on the chemical composition of the water in the Rachelsee were examined in the wake of changes that have occurred in acidic depositions in central Europe since the 1980s. Although there was a gradual recovery in the chemical composition of the Rachelsee, its biological recovery was delayed. In 1999, when both regular plankton sampling and the bark beetle outbreak in its catchment area began, the Rachelsee remained the most severely acidified lake in the Bohemian Forest. At that point, the lake's recovery went abruptly into reverse as a result of the natural forest die-back in its catchment area, which in turn resulted in an elevated terrestrial export of nitrate and ionic aluminium that lasted for about five years. This re-acidification episode provided a unique background for the case study, which has shown prompt plankton recovery in the lake after the rapid decline in nitrate leaching as a result of the natural reforestation of its catchment area. There was a sudden change in both the chemical composition of the lake's water and in the structure of plankton biomass, including decreased bacterial filaments, as well as increased phytoplankton biomass and abundance of rotifers. The shift from dominance of heterotrophic to autotrophic organisms suggested in all likelihood their substantial release from severe phosphorus stress. While three original open-water species of Crustacea are still absent, some littoral species, such as the acidotolerant rotifer Microcodon clavus, have occupied the empty niche. Such a rapid change in plankton structure in a lake recovering from acidity had not been previously documented.

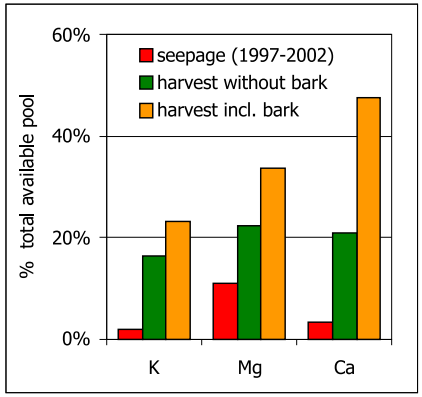
Deposition and immission effects in a mature beech stand



In response to the marked downward trend in acid deposition (-90 %), soil water chemistry has been recovering in a mature beech stand (growing stock of 400 m ha). Acid neutralizing capacity and pH have increased throughout the mineral soil, reducing concentrations of harmful aluminium ions. Nitrogen deposition did not show such a reduction (30%) and is currently equalling calcu-

lated critical loads (12 kg N $ha^{-1}a^{-1}$), assuming harvest. Since 1994, nitrate concentrations in seepage water have been very low (< 1 mg NO_3 L^{-1}).Therefore nitrogen losses are small in spite of large amounts of precipitation, indicating efficient sinks in this ecosystem. Tree growth, as well as the contents of nitrogen and base cations in the leaves, has been increasing in this beech stand. This has led to the conclusion, that recovery from acidification improved the physiological conditions for the roots and enabled additional uptake of both nitrogen and base cations and thus higher net primary production.

Bark beetle altered water and element cycling in a mature spruce forest



In 1996, the Schachtenau spruce stand, with its growing stock of 1000 m ha, died completely after bark beetle infestation. By1999, most of the dead standing trees had already fallen or broken down. The die-back caused dramatic changes in the stand structure, the micro-climatic conditions and the relations between producers and decomposers, inducing nutrient losses into the groundwater and affecting the ecosystem nutrient pools.
Two months after the bark beetle infestation, N concentrations began to increase in the organic layer percolate, but from 1997 to 2000 maximum nitrate concentrations up to 200 mg L-1 occurred in seepage water of the mineral soil. The excess production of nitric acid caused a marked increase in soil acidity and aluminium concentrations from soil exchange sites. Since 2002, pH-values and ion concentrations in seepage water have reached their previous levels. This six year period saw N losses via seepage of more than 500 kg ha-1, but also increased losses of nutritional base cations, which were two times (Ca) and three times (K, Mg) higher than it was before the die-back.

In comparison to the export rates resulting from a hypothetical harvest, these die-back induced nutrient losses appear rather small. Moreover, unless they are removed by harvesting, further nutrients will be released from the stand's slowly decomposing biomass.

Ecosystem disturbance and carbon balance development

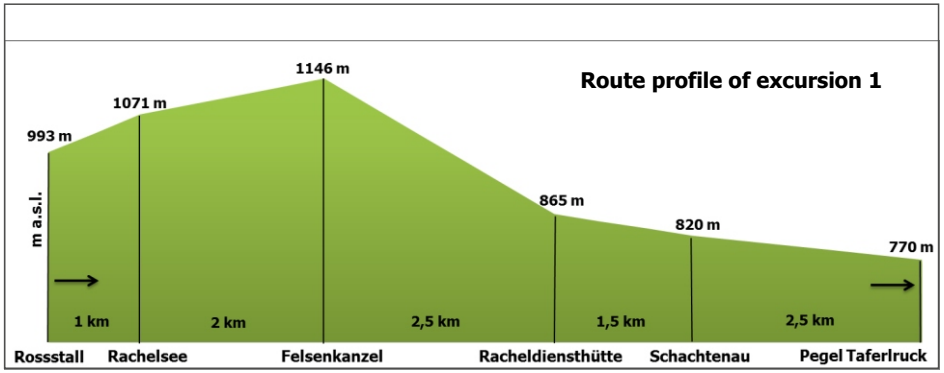
Forests in mid-latitudes are generally reported to serve as large carbon sinks. The potential of a forest to store carbon depends on its age, health, successional stage, and its history of disturbance. Stand-replacing disturbances do in all likelihood change the magnitude and sign of carbon fluxes. Additionally, damage to forests caused by disturbance is expected to increase in the future due to climate change. However, estimating carbon exchange in disturbed forest ecosystems is still challenging and investigations are scarce. In 2007, the severe winter-storm Kyrill led to large contiguous wind throw areas within the Bavarian Forest National Park. Some of these areas have not been cleared, providing an ideal opportunity for conducting long-term measurements of carbon exchange in a wind-throw disturbed upland spruce forest. From 2009 to 2012 we thus estimated the Net Ecosystem Exchange (NEE) of CO over a wind-throw area at the gentle hill "Lackenberg".

Our investigations show that 2-5 years after the storm the ecosystem is still a net source of carbon in the order of 220 to 350 g C-2 m-1 yr. Remaining as well as new emerging vegetation, however, lead to an already strong Gross Ecosystem Production (GEP) in the order of 400 to 500 g C-2 m-1 yr. Ecosystem respiration was highly variable and ranged from about 660 to 760 g C-2 m-1 yr. Considering long-term simulations of the carbon balance we expect the ecosystem to switch from carbon source to carbon sink in about 10 years.

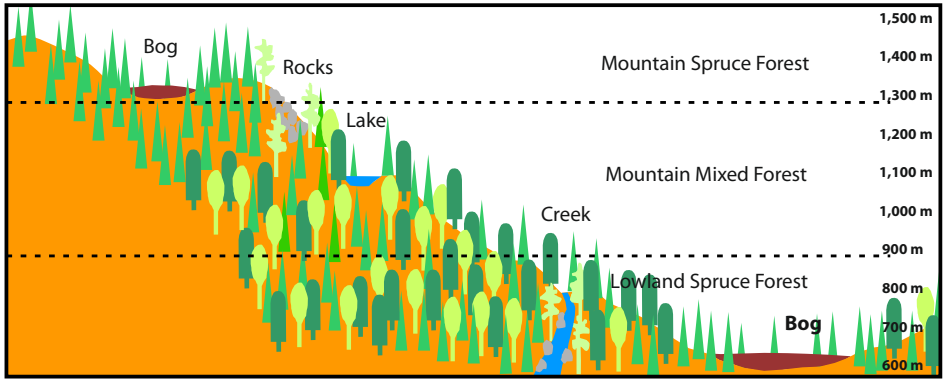
Disturbance and climate change related alterations in runoff dynamics and element cycling

Bark beetle affected catchments showed altered water cycles above an areal threshold of about 25%. The increase in annual runoff varies from 10% of precipitation in less affected catchments (60% bark beetle area) to 20% in catchments completely affected (80% bark beetle area). Increased low flow discharge in summer is clearly related to reduced evapotranspiration after die-back, but high flood dynamics are not altered. Even though precipitation amounts and maximum water storage in snow cover remained unchanged, the frequency of floods nearly doubled after wide-scale spruce die-back. This phenomenon cannot be traced back to bark beetle infestations as evapotranspiration is not important during the winter months. It is rather the result of the drastic and significant increase in the April air temperature of about 4 K during the last 40 years and to a less extent in the May temperature (2 K). This warming has brought the last day with snow cover significantly forward by three weeks and shifted the snow melt correspondingly.

The large nitrate leaching losses after excess mineralization among disturbed stands are not reflected in the chemical composition of groundwater and runoff water. Nitrate-poor seepage water from healthy stands and groundwater (mean residence time of 8 - 15 years) dilute nitrate rich inputs. At any time and at any spring or stream, nitrate concentrations have fallen far below the drinking water limits of the World Health Organization (WHO). When the acidification effects of forest die-back came to an end, macrozoobenthic communities and fish were able to benefit from increased concentrations of base cations and increased alkalinity.



Mountain Spruce Forests are a Special Habitat



Forest associations of the „Inner Bavarian Forest"

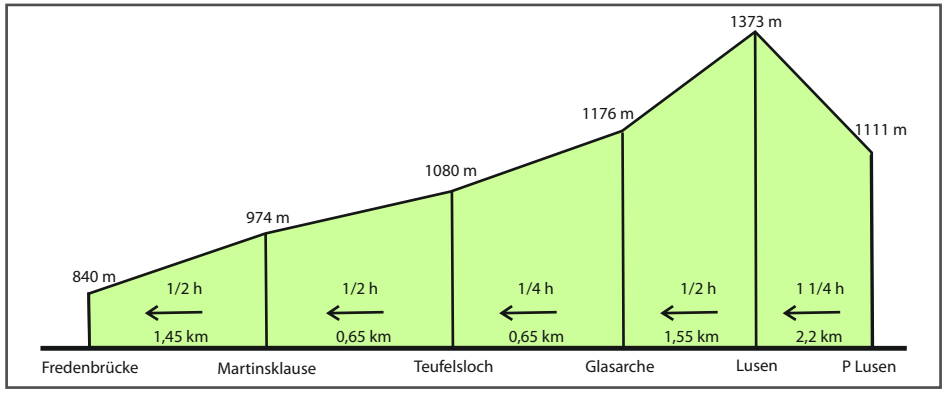
The largest natural spruce forests outside the Alps are situated in the Bavarian and Bohemian Forests. Along the ridge marking the border there are approximately 5,800 hectares of predominantly natural mountain spruce forest; there are more than 18,600 hectares on the Czech side. Their existence in this natural unit is a result of the prevailing climatic conditions. In altitudes of 1,150 metres above sea level, a distinctly raw climate prevails. An average of 1,800 mm of annual precipitation (up to 3,000 mm), a long period of snow cover, low average temperatures (3.0 - 4.5 C) all restrict the vegetation period, which is important for the growth of trees and allows only spruce (Picea abies) to grow. In addition to this main species, maple (Acer pseudoplatanus) enrich the appearance of the forest in places whilst the frost-resistant mountain ash (Sorbus aucuparia) has an important function as a frequent, quick-growing pioneer plant in locations where the old forest collapsed.

Mountain spruce forests, which are in many ways similar to northern coniferous forests, are habitats especially worthy of protection. Due to the adaptation to extreme climatic conditions, highly specialised species of plants and animals with sophisticated survival strategies exploit this habitat. The forest, partly much graduated, with its large crowns and smaller clearings here and there in the vicinity of upland moors, is the last refuge for the capercaillie (Tetrao urogallus). Picoides tridactylus is a species of woodpecker which is characteristic of the mountain spruce forest. Abandoned holes are taken into possession by Glaucidium passerinum and Aegolius funereus, two species of hoot owls. Some animals, such as roe deer (Capreolus capreolus) and red deer (Cervus elaphus) live in this part of the forest only in summer.

Wind throws and Bark Beetle Determine Natural Sucession

Wind throws with subsequent bark beetle infestations occurred from time to time in the past in the mountain spruce forests of the national park, usually at long intervals. This led to the regeneration of large areas of the forest. After wind throws spanning more than 1,000 hectares in 1868/70, many of the clearings were planted with seedlings of unsuitable lowland spruce species. These are less resistant to the pressure of heavy snowfalls than the "columnar" spruce of the mountain ridges with their pointed tops.

The bark beetle (Ips typographus) is a natural part of mountain forest habitats. Normally, the cool and wet climate means that more than one beetle generation cannot develop (it is up to three generations in lowlands). With annual precipitation of between 1,300 and 1,800 mm there is sufficient supply of water for the spruce at this altitude, to fight off successfully the penetrating beetle through the pressure of their resin. The causes of the present rapid dieback of the old mountain spruce forests, particularly in altitudes which are climatically unsuitable for bark beetle, are manifold.
In addition to the evident poor health due to the severity of industrial emissions over several decades, an extraordinary number of hot and dry years at the beginning of the 1990s were recorded. This "drought stress" weakened trees, mainly older spruce on the thin soils of the higher areas, and was favourable to the mass propagation of the bark beetle. Mountain spruce forests naturally are pure stanels..
In the national park, the average age is high, which makes the forest generally more susceptible to dieback over large areas. Additional possible causes include damage to the roots as a result of extreme storms in 1983, 1984 and 1990, as well as three years of seed shedding between 1988 and 1995. An analysis of a series of aerial photographs from 1988 revealed the progress of the die-off up to the present: 6,035 hectares of older spruce stands, equivalent to 50 % of the mountain spruce forests, were killed by the bark beetle and are now undergoing the remarkable process of natural regeneration.



Wildlife management of the Capercaillie (*Tetrao urogallus*)

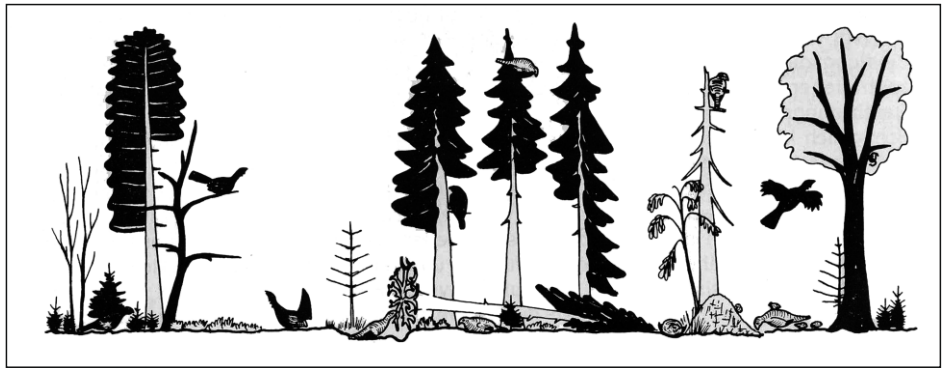


Illustration of an optimal forest habitat for Capercaillie (Scherzinger 1976).

The capercaillie is a species native to forest ecosystems in the boreal, alpine, and low mountain ranges of Europe. In addition to its broad spatial needs it requires a variety of structural elements for its survival. Moreover, it is also known for its sensitivity to disturbances. The latter point is well documented by numerous studies showing spatial avoidance of certain areas and elevated stress responses to, for example, disturbances caused by humans. This can have severe consequences for reproduction and in turn the survival of local populations.

Severe changes in habitat quality due to intensive reforestation and pollution in the Bohemian Forest caused a dramatic decline in the size of the local population, to just two dozen birds in the area of the Bavarian Forest National Park in the late 1980s. As a consequence, a breeding and release programme was established to sustain the population. However natural disturbance events, such as wind throws and bark beetle infestations, repeatedly transformed the forest habitats at altitudes above 1,100 metres. In addition, increased recreation activities have put great pressure on the remaining capercaillie habitats.
Researchers recently showed that the population of the Bohemian Forest is viable with approximately 570 birds and well-connected among sub-regions. As such the population is one of the two largest and coherent relict populations in Central European mid mountain ranges. Furthermore, and contrary to expert opinion, a habitat suitability model demonstrated that capercaillies dwell intensively in open habitats. This suggests that wind throws and bark beetle calamities in the Bohemian Forest provide a highly variable mosaic of structural elements that are usually formed by natural fire events in remote boreal areas. However, in the Bavarian Forest and Šumava National Park (Czech Republic) tourism reduces the availability of these habitats.

Long term monitoring reveals luxuriant natural succession

The Bavarian Forest National Park is the oldest national park in Germany. The overall management concept of the park is to protect unaltered natural processes. The outbreak of a spruce bark beetle (Ips typographus) infestation in 1993 affected in particular the subalpine range of the park with its high proportion of spruce trees. This paper describes a study on how forest regeneration was affected by the process of the large-scale die off of forest trees. For this purpose, surveys from a total of 572 samples from the years 1991, 1996, 1998, 2000, 2005 and 2011were available. Compared to 1991, when the regeneration density was 978 trees per hectare, it had increased to 4363 trees per hectare in 2011. The distribution of the regeneration has also changed. While in 1998, only 36.7% of the inventory plots were found to have a density of greater than 1000 plants per hectare, this value had increased to 75% by 2011. No regeneration was found in only 0.52% of the inventory plots. Regeneration consisted mostly of Norway spruce (89.1%) and mountain ash (7.4%). European beech (2.6%) and all other tree species (0.8%) were much less significant. In addition, the proportion of tree heights has clearly shifted to taller trees. This indicates a favourable development of the trees in the regeneration. The proportion of trees damaged by browsing ungulates was 1.6%. Browsing damage to mountain ash was relatively high at 33.6%. Other forms of damage were relatively insignificant. Based on the present situation, it is not necessary to start with artificial measures to support the natural regeneration of the forest. However, it will remain important to observe closely the development of the newly emerging forest in the future. This presents a great opportunity for the scientific documentation of this unique development and for the fulfilment of the political mandate.

Wind blow and bark beetle management at Lackenberg

Fresh windblow in high montane spruce forest.

In the northern part of the national park, primarily in the development zone, approximately 1000 ha were felled, varying from single trees to areas covering several hundred hectares, by the storm Kyrill on 18 January 2007. Here the major legal guidelines, state that all the felled trees should be removed to reduce the risk of infestation by the bark beetle Ips typographus. After a policy debate those responsible decided to exclude around 50,000 m^3 of the 200,000 m^3 from the overall salvage logging operation.

Salvage logging operations on the wind throw areas where completed in autumn 2007. Two cable ways were used, particularly on wet soils and steep slopes, as well as two harvesters for logging the felled trees. A small numbers of trees that were difficult to remove due to sensitive soil conditions were stripped of bark to prevent any subsequent colonization by bark beetles. From 2008 monitoring of animals, plants, fungi and lichens was conducted on 48 plots in logged and unlogged wind throw areas.

The pipit (Anthus spinoletta) has colonized the logged areas on wind throws and on bark beetle areas.

The monitoring of groundwater was also initiated. First results indicated unexpected results for fauna, with many microclimatic effects due to the logging and not solely the result of removing the trees. Nitrate in ground water followed similar patterns to catchment areas previously affected by bark beetles in the southern part of the park. New species, such as the pipit Anthus spinoletta, colonized the heavily logged areas. The grouse species Tetrao urogallus avoided the clear cut areas in winter as a result of the absence of the small structures it requires in a habitat.

Cable wires were used to remove wind blown trees on remote steep slopes, without damaging the soil.

Wilderness Camp Falkenstein

Children enjoying their time in the Wilderness Camp

The Wilderness Camp provides the opportunity to spend several days in simple themed huts within the national park. These themed huts, which are not equipped with electric current or running water, are compatible with the surrounding landscape, focusing on subjects like soil, water, forest or light, as well as allowing

people to stay in the huts to experience nature at close hand and reflect on these experiences. Groups of any age, primarily young people, can also stay in traditional huts and tents of indigenous peoples of national parks from other continents (Amazonia, Benin, Chile, Mongolia, Siberia, Venezuela, Vietnam). Although the educational work in the international part of the Wilderness Camp can be regarded as a modification of the themed hut concept, it has its own distinctive features. In contrast to the more general projects in the themed huts, the group work in the international huts remains within the scope of certain subjects, e.g. "global climate change" or "biodiversity". The participants work on these subjects in several teams. Repeatedly the whole group assembles, and the results of the teams are collected.

„Urwald" Mittelsteighütte

A valuable part of „Urwald" Mittelsteighütte

The Urwald "Mittelsteighütte" is an example of the previously widely distributed mountain fir beech virgin forests. The stand had been declared as protected as early as1760. From this time on logging was more or less forbidden. Glass factories were not allowed to use the valuable trees either. Tree composition in 1856 was described as 60% Silver fir, 10% Norway spruce and 30% European beech. In 1970 this had changed to 30% fir, 30% spruce and 40% beech. In 1914 the forest was declared as a "Schongebiet" or protected area in which only salvage logging was allowed. For instance in 1929 windblown trees were removed. Only after declaration as a nature protection area in 1939 were all kinds of tree removal stopped and also wood pasture. Compared with most other forests in Germany, the human impact was low in this forest stand. Many features of the forest, such as trees older than 400 years and large trunks in a state of decay for more than 40 years, are typical for beech-silver fir virgin forests.

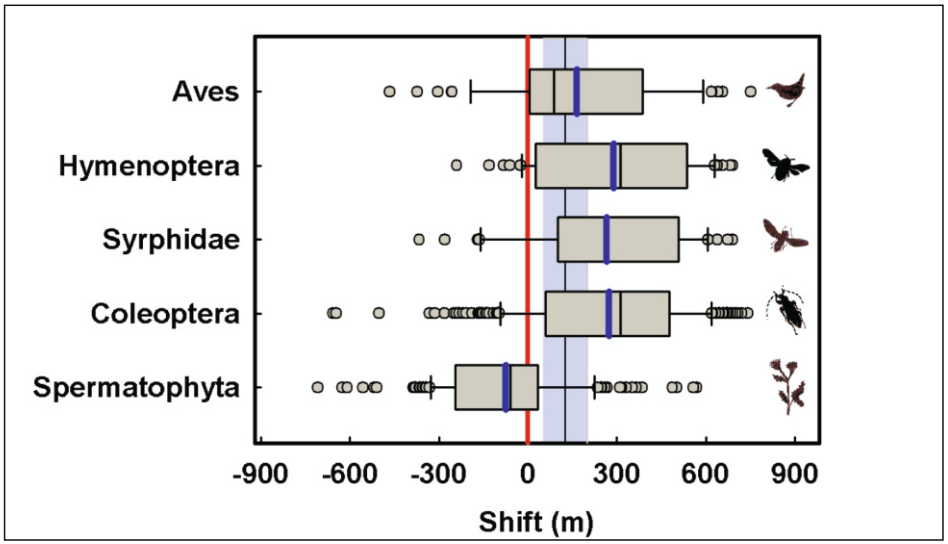
The high conservation value of the forest is also underpinned by the occurrence of some very rare species: The red-breasted flycatcher (Ficedula parva) is common. The stag beetle (Ceruchus chrsysomelinus), which is rare in Europe, develops in large fir trunks in late stages of decay. Its population here is one of the biggest in Germany. Extremely rare globally, the fungus Phellinus pouzarii, occurs regularly in the "Mittelsteighütte", but nowhere else in Germany.

The flycatcher Ficedula parva is a typical inhabitant of dense old beech-fir forest with overmatures trees.

The old protected area of an almost pristine forest today serves as source for many relict species, which have survived despite modern forestry over the last 100 years. They currently spread out to surrounding national park areas where former commercial forests are now re-wilding through natural disturbance.

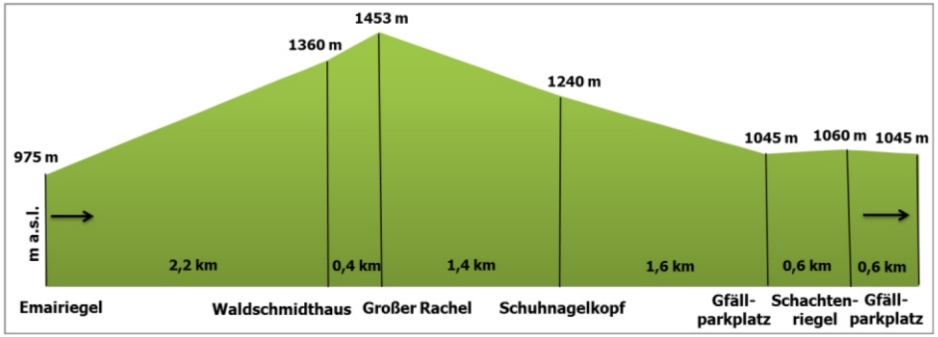
The Urwald-relict species Ceruchus chrysomelinus is abundant in the Mittelsteighütte and starts to recolonize surrounding area.

Biodiversity in the forest ecosystems and climate change

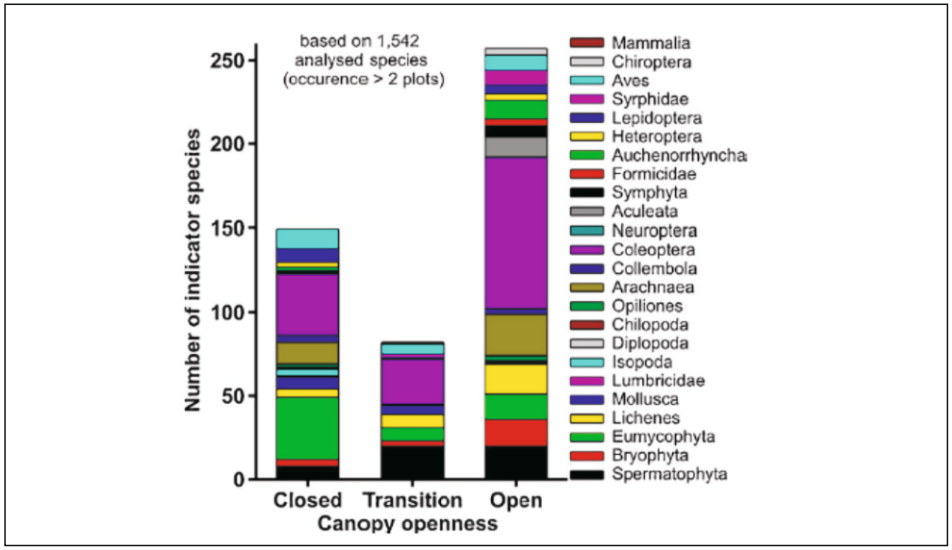


Mean annual temperatures have increased over the last decades in the national park as a result of global warming (0.01K*a-1, 1948-2002). The overall trend is mostly related to an increase since the 1980s. The mean sum of precipitation has changed very little. However, there is a trend towards a decrease in precipitation during the summer and an increase during the winter time. Climate models predict a further increase in temperature until the end of the century (c. 2K moderate scenario). A large increase in spring temperatures has led to a shift in the timing of budburst (approximately 20 days earlier than 1975).

A comparison of the upper range margin of species between 1904 and 2007 has revealed a clear shift for birds and insects but not for plants. There has also been no upward shift of European Beech in the park. Several studies aimed at quantifying



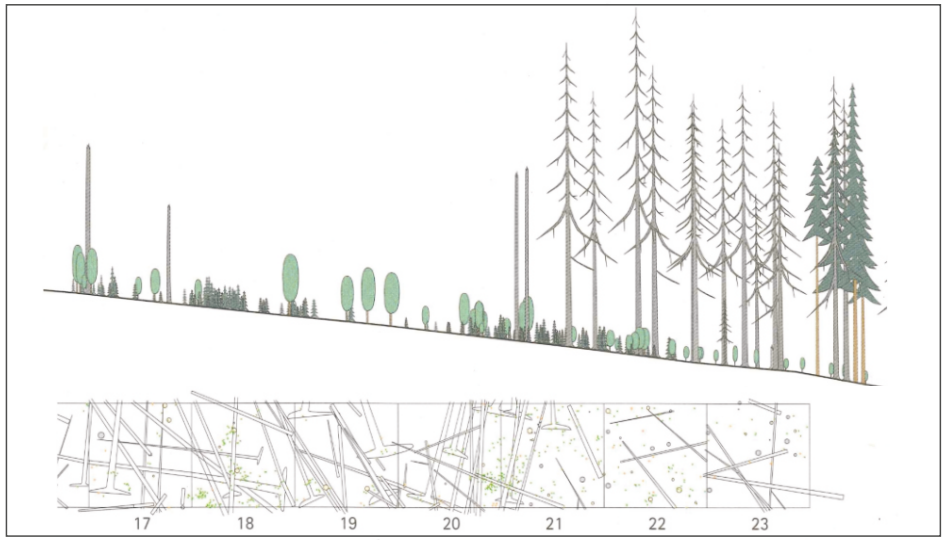
Biodiversity in the forest ecosystems due to protecting processes



the effect of macroclimate versus local factors have shown no consistent pattern across different taxonomic groups. All these findings suggest that groups of species will undergo considerable re-organizations in times of climate change. Further studies have revealed characteristic (endemic) high mountain species as being very vulnerable to climate change. Here long term monitoring will bring more insight in the change of distribution patterns.

To quantify the effects on biodiversity of protecting natural processes, the national park set up a large biodiversity survey project in 2006. Altogether c. 25 taxonomic groups and numerous environmental variables were measured and recorded. Process protection with a subsequent change in forest stands over several thousand hectares due to wind throw and bark beetle, increased considerably the habitat variability. Species richness and the number of red list species increased in the area characterized by natural disturbance in comparison to areas that were still managed. This is true for several taxonomic groups, for example saproxylic insects or epiphytic lichens. The enrichment of dead wood due to bark beetle has enabled the recovery of rare species. One prominent example is the recovery of the rare polypore Antrodiella citrinella. This species survived in relicts of old growth forests and is today again distributed across the park's landscape. Cutpoint analysis revealed a critical threshold of c. 140m^3*ha-1 dead wood. An analysis based on 1,542 species across 24 taxonomic groups revealed the majority of species related to open canopies which underpins the importance of the early successional stage after bark beetle infestation on species diversity.

Wind throw and bark beetle outbreaks - triggers of radical changes in the Bavarian Forest national Park



A thunderstorm on 1 August 1983 uprooted countless trees, especially spruce forest stands on swampy and weak soil. Further storms in autumn 1984 extended the wind throw areas up to 173 ha and caused drastic changes.
According to the most important national park aims, the protection of natural or semi-natural ecosystems with their inherent dynamics (IUCN 1994), this event was accepted as natural and wind throw areas (85ha) in the core zone remained untouched.
In the subsequent years spruce forests were damaged by a bark beetle outbreak mostly adjacent to the wind throw areas; by 1991 210 ha of woodland had been killed. During the next two years the increase of damaged forests was insignificant, but since 1994 a new bark beetle outbreak of an unprecedented dimension has been observed. Beginning in 1988 we established six transects in wind throw areas in the main forest types of the park, half of them in the core zone without any management. The others had been cleared, but not afforested.

Detailed measurements have been conducted every 5 years. The objective is to document and compare forest development after disturbance in untouched and cleared areas. In addition to changes of species diversity, one can also study the influence of the versatile mosaic of different forest sites such as lying and standing dead trees, tree trunks and root plates.

Grave turnover in local avifauna due to extensive die back of old spruce stands in highland forests

Spruce stands in elevations above 1,100m, about 300 years old on average, were classified as autochthonous, near natural in structure and highly resistant against bark beetle infestations. Following the wind throw, which hit the mountain ridge in 1983, several "nests" of bark-beetle infestation became visible at the edges of the wind-born forest-aisle from 1987.

To study the reaction of bird fauna to this development, a monitoring project was started in a 70ha control area in January 1989, with a focus on woodpeckers.
In concern to fresh infestations of these insects, a very large increase in woodpeckers was observed (from 2 to 5 (6) species, and from 3 up to 28 individuals). However in 1996, following an exceptional seed mass in 1995, a great number of exhausted spruce trees were infested and killed by the beetles over huge areas –nearly at once!

These "catastrophic" changes in habitat conditions (with a total loss of canopy, covering the ground vegetation by a litter of dry needles, lichens and twigs; followed by infestation of dead trunks by fungi and a chaotic break down of dead wood) caused a striking loss of bird species, linked to tree crowns, but also in woodpeckers and small owl species too. On the other hand species linked to open and devastated tree stands could profit (for example Tree-Pipit, Redstart and different thrushes). Due to the growing dimension of clearings pioneer vegetation established itself (with mosses, berries, bushes and rejuvenation of trees). This stimulated an invasion of bird species, new for this forest type (such as warblers, Wren, Dunnock), and resulted in a "classic" species–turnover: within 12 years of observation 11 species were lost, and 22 arrived.

But still it was doubtful, if the locally endangered Capercaillie would outstay this process. In 2012 a three-year study, resulted in some very unexpected findings: Capercaillies hold out in their territories, lacking in food and cover, and fully exposed to predators! And an increase in the population was also registered, probably induced by higher reproduction on these highly diverse clearings.