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Please Do Not Disturb

Salvage logging's negative impact on biodiversity.

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This presentation will discuss how natural disturbances and sanitary logging affect biodiversity. By "sanitary logging" I mean the removal of trees from regions affected by disturbances, both for economic reasons and with the aim of pest management. The location of our research is the Bavarian Forest, situated in southeastern corner Germany, close to the border with the Czech Republic, and together with the Šumava National Park, it forms one of the largest continuous forested areas in Central Europe (the German portion encompasses 24,000 hectares, the Šumava National Park 16,000 hectares). These areas have been affected by the bark beetle, both recently and in the past. The effects include both small gaps in the forest cover as well as significant areas of deforestation.

Disturbance vs. biodiversity

Various types of disturbance, such as pest infestations, fires, windthrows, and avalanche damage, commonly occur in the forests of Europe. They can be of varying intensity and affect a surface area ranging from 1 ha up to 1000 ha. It should be borne in mind that the forests we observe today once were born as the result of disturbances and will presumably be destroyed by disturbances someday in the future, in a life cycle lasting centuries.

When a tree dies, fungi are among the first species that appear. In the case of beetle-killed spruce trees, one of the species most swiftly and abundantly colonizing the dead trunks is the fungus *Fomitopsis pinicola* (the red-belted bracket). It remains on the trunk for years, producing huge amounts of fruiting bodies, with which many other species are associated. These fungal bodies may be inhabited by many species, such as for instance we found 15 different species in family *Ciidae* (the minute tree-fungus beetles), many of which are on the Red List in Germany. Other organisms that live in the habitat created by *Fomitopsis*-colonized spruce trunks include the rare fungus *Antrodiella citrinella*, occurring at just a few sites in Germany. Research has shown that the quantity of deadwood is the main variable explaining the occurrence of such endangered fungi. So it was the disturbance, creating sustainable amounts of deadwood, that allowed this fungus to return to the Bavarian Forest, or more precisely to reemerge from very small relict populations.

In fact, *Antrodiella citrinella* is not an isolated case. We studied whole communities of species colonizing bark-beetle-affected forests, considering various groups such as birds, bats, insects, lichens, mosses, and fungi. The species richness for most of these species groups was higher in disturbed forests than in old tree stands, both for all species taken together and for the Red List species separately. The only group found to be a bit more common in old-growth forests was the wood-inhabiting fungi – perhaps not that surprisingly, as they require advance-stage deadwood which is not found in the early stages of forest succession, whereas the area we studied had experienced a bark beetle outbreak just six years earlier. In summary, bark-beetle affected forests provide a favorable habitat for many species, including many endangered ones.

Another important issue in the case of such disturbances it water quality. It was intensely debated in the Bavarian Forest and Šumava National Park as to whether a bark beetle outbreak could indirectly affect the quality of drinking water, by releasing significant quantities of nitrates from surface soils in outbreak-affected areas. When we looked at data

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from the past 50 years, since when the water composition began to be monitored in 1965, it turned out that even at the time of the largest outbreak, covering 60% of the catchment area of the river we studied, the highest nitrate level noted still never exceeded 50% of the WHO norms. It is clear, therefore, that even large outbreaks do not affect drinking water quality.

The finding that species depending directly on deadwood benefit from disturbances that create deadwood may seem obvious. However, we also looked at species that do not benefit from this directly: one is the barbastelle bat *Barbastella barbastellus*, which is mentioned in the habitat directive and is a protected endangered species in Germany. We found that it prefers to feed in the open areas that arise in outbreak-affected areas. Moreover, standing dead spruce were the preferred roosting sites for maternity colonies, with the bats most eagerly choosing standing dead trees surrounded by living ones.

The next step in our research involved looking at how communities of lichens and fungi respond to bark beetle deforestation. We found that the mechanisms that assemble species into communities are actually very resilient to such disturbances: although sun exposure and moisture change dramatically in outbreak-affected areas, the key factor for the organisms was the quantity of deadwood. In most cases, such disturbances have a positive impact on species diversity. For example, the threatened beetle *Tragosoma depsarium* has specific habitat requirements, living on spruce deadwood which cannot be in open terrain and has to have the right moisture. Such conditions were created by the infestation in the Bavarian Forest, where we recently observed a reappearance of the species.

Salvage logging vs. biodiversity

Sanitary logging leaves behind significant amounts of deadwood as residue, even after the logs themselves are taken away (about 70 m^3 per ha). To examine the effects of removing dead tree trunks from outbreak-affected areas, we studied the species-rich group of nocturnal moths (which encompasses around 400 species in our region). In areas where logs were removed, the numbers of deadwood-feeding and detritus-feeding species was significantly smaller than in outbreak-affected areas where sanitary logging was not carried out. Removal of wood from an outbreak-affected area also means removing the organisms living in it. Most affected by these actions are the saproxylic beetles, as we confirmed in our research. Their numbers and diversity were lower in sanitary logged areas than in natural areas. Moreover, in this latter case their numbers peaked two years after the windthrow, which is related to the fact that this is also when the bark beetle population reached its maximum – and, as we have said, many other species are contingent on the bark beetle, be it as predators, etc.

In the sanitary logged areas, the niche related to the availability of deadwood and canopy cover habitats was reduced. Surprisingly, in areas cleared of logs we found more species preferring moister conditions and fresher wood, although we would have expected more sun-dependent species. This can be explained in terms of the fact that areas that have seen sanitary cutting are richly populated by *Calamagrostis* grass, which alters the entire microclimate and moisture conditions. And so, this means that even if the right amount of deadwood is left behind after sanitary cutting, the habitat conditions will still shift and the composition of saproxylic beetle communities will not be natural. Our studies of fungi, in turn, showed that the removal of deadwood introduces an element of randomness to processes that structure the fungal communities. Processes occurring within the fungal assemblages are resistant to natural disturbances, but not to salvage logging.

Winners and losers

The mechanisms we have described for the Bavarian Forest and Šumava National Park are not unique to these forests. In a meta-analysis of several hundred research reports from various places in the world, however, we have identified various groups of species that have suffered or benefitted from salvage logging. Overall, deadwood removal reduces the numbers of groups of species that benefit directly from deadwood, meaning saproxylic beetles, fungi, springtails, and also fungi and lichens growing on the forest floor, which most likely suffer damage from forestry management work. However, sanitary cutting is beneficial to such groups as the carabids and epigeal spiders – groups that attain high numbers and species diversity in open areas. Sanitary logging also frequently causes a shift in the species composition of an assemblage, even if the general diversity does not change, with this effect being most evident in the case of groups associated with deadwood.

So in this case what can we do? As Prof. Angelstam has said, that depends on what we want to achieve and what our goals are. There may be various circumstances in favor of engaging in salvage logging. The most frequent motivations in the world are timber harvesting and pest control, although only in Europe is it applied for this purpose in protected areas. Young spruce logs attacked by the bark beetle are of low economic value, not

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being suitable for either furniture production or burning. Note that the forest industry accounts for quite a low share of the GDP of the developed countries. In Poland it is only 0.3% and even if we include derivative sectors such as furniture production, it does not exceed 2% – and so the economic benefit and quality of the wood harvested from salvage logging are low.

Pest control may be a justification for removing deadwood in the case of windthrows, but not really in the case of bark beetle infested areas. However, there are other options than just leaving the trees, if one wants to try to combine together different stakeholder perceptions. We developed one such strategy in our area, which combines pest control, intensive management, and the "no intervention" strategy.

In conventionally managed forests, disturbed areas are completely salvage logged in order to maximize economic returns. Nevertheless, even then the characteristic legacies of disturbance-affected stands – such as uprooted root palettes or clusters of regenerated and surviving spruces – may be preserved as microsites. But in many national parks we are observing something "in between": to protect nearby commercial forests from the bark beetle, something has to be done with the dead spruce, though their full removal is not necessary; it may suffice to just remove the cork. We have also tested a new solution involved "scratching" the cork with a chainsaw, which destroys the bark beetle habitat but leaves the dead spruce biomass in the ecosystem. We compared the number of bark beetles in the untreated, decorked, and "scratched" trunks, and found that the latter two methods brought it down significantly as compared to untreated trunks. Moreover, in "scratched" trees the number of species, including protected ones, was retained. From the standpoint of the forestry services it seems that the "scratching" method is much quicker than decorking, and it therefore seems favorable from both the economic and natural point of view. This is just one of the possible ways of reconciling pest management with the preservation of biodiversity.

In summary, I will stress once again that bark beetle outbreaks increase biodiversity, whereas sanitary cutting and deadwood clearing have a huge negative impact on biodiversity and biotic processes. As such, sanitary cutting should be excluded in protected areas, as it runs counter to the objectives of such areas. In justified cases, on the other hand, it might be justified in economically managed forests.

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This is a summary of a presentation given by Dr. Thorn at the international conference "Managing the Bark Beetle Outbreak in the Białowieża Primeval Forest," organized by the Polish Academy of Sciences on 4 December 2017 (preceded by a study visit to Białowieża).