

Why the Białowieża Forest needs dead spruces?

Climate changes also affect European forests. Some species of trees, like Norway spruce *Picea abies*, are sensitive to high temperatures and water deficiency. After having been weakened by summer droughts they become vulnerable to more intensive colonization of tree-eating insects. Spruce trees which become infested by the European spruce bark beetle die and are replaced by deciduous tree species that are better adapted to current environmental conditions. This change in the tree species composition is a natural process and there is no danger for sustainability of the forest ecosystem. The forest is still alive, although the tree species composition is drastically changing. It also looks different from several years or decades ago. Very often we find it difficult to get used to the view of dead spruces trunks protruding from the thicket of young trees or a tangle of logs lying on the ground that make it more difficult to move around the forest. However, this does not mean it is an "inferior forest" or a "dead forest", rather it is the opposite and the forest is bursting with life!

If the forest is dominated by spruce stands, the "dieback" process of trees may become massive. This situation is now occurring in many places in Poland such as the western-most part of the Carpathians and also in some parts of the Białowieża Forest. We may be tempted to interfere in the same way as with commercial forests, which means to log dying spruce, put them in wood depots, sell them and to clear and plough the soil. Afterwards, grow seedlings in nurseries according to the Forest Service instructions, plant them and protect them with every possible method against herbivore browsing and take care of them to achieve a new tree stand in several decades.

But is this a good decision? The Białowieża Forest is the best preserved deciduous and mixed forest in Europe. Considering the exceptional character of the Białowieża Forest and the 500 year-old history of protection, shouldn't we let the current forest, that contains predominantly coniferous trees, convert gradually by natural processes to a forest with a predominance of oaks, hornbeams, limes and other deciduous trees? Isn't the desire of interference a result of financial incentives or a wrong belief that the forest will die without the help of a human?

Research in spruce-dominated forests proved that the dynamics and increase of the spruce bark beetle population is not much different in areas where the fight against it was conducted by taking every possible measure and in the areas where no measures were taken (Grodzki et al. 2006). Removing the trees that have been infested by spruce bark beetle or have died for different reasons is not an effective method against stopping the outbreak of the bark beetle population and dieback of the trees. Moreover, it may give the opposite effect: reduction of natural processes may increase the population and accelerate the disappearance of spruce forests because in the entire Białowieża Forest it is not possible to fell a sufficient percentage of infested trees (e.g. Fahse and Heurich 2011).

Currently, we have a huge knowledge concerning the positive role that dead wood plays in the forest, its impact on the forest microclimate, availability of water and promotion of biodiversity. Supply of woody detritus is vital for the energy flow between different levels of the trophic food chain. Detritus provides nourishment for a number of organisms. Logging and removing of dead trees impoverishes terrestrial and aquatic ecosystems and reduce biodiversity. It can also decrease the moisture content in the forests and increase the occurrence of frequent fires (Fleituch 2010). Dead wood is a characteristic feature of natural forests. Deprived of dead wood, forests lose their natural character and resemble commercial forests.

Below we present a list of the losses to nature that felling and removing dying trees from the forest will cause and a list of benefits of non-interference in this process.

By felling and removing dying trees we lose, inter alia:

1. A chance for more efficient, faster, natural and diverse forest regeneration (as the examples of other places in Europe show: Loch et al. 2001, Jonašova and Prah 2004, Jonašová and Matijková 2007, Jonašova and Prah 2008, Müller et al. 2008, Müller et al. 2010, Čížkova et al. 2011, Lehnert et al. 2013, Beudert et al. 2015).
2. A place for the creation and spreading of "biological weapons" against bark beetles. Some of predatory insects living in dead spruce are natural enemies of bark beetles. They are attracted to spruces infested with bark beetles by a pheromone that is produced by male bark beetles at the moment of colonizing a tree. A big cluster of dying spruce that host bark beetles become a place of intensive proliferation of predacious and parasitic insects which then spread across larger areas to search for their prey. (Gutowski and Krzysztofiak 2005, Montano et al. 2016).
3. Places in the Białowieża Forest where oaks naturally regenerate (Bobic et al. 2011, Bobiec and Bobiec 2012, Bobiec 2013). The more spruces die and the larger the territory of stands infested by bark beetle is, the faster and more numerous is natural regeneration of oak. In other places dominated by deciduous stands the growth of oak seedling is hindered by the mass regeneration of more shade-tolerant tree species.
4. Habitat of many species of lichens and bryophytes. The biggest groups amongst the Białowieża Forest relicts are: epiphytic lichens and bryophytes (growing mainly on trees) and epixylic ones (growing mainly on decaying wood, Cieśliński et al. 1996). Spruce trees are very good hosts for species of genus *Bryoria* and *Usnea* being on the brink of extinction in Europe. In Białowieża Forest the presence of 90 species living on spruce were recorded, among them species locally extinct in Poland, like *Usnea longissima*, *U. cavernosa* and *U. uncinulata*.
5. The only natural habitat of many species of saproxylic beetles – connected with dying trees and dead wood and also inner bark and touchwood. Amongst the Białowieża Forest relicts there are species belonging to genus of saproxylic beetles which used to have more than 1,000 species in Central Europe. The most endangered are the ones connected to dead trees. Some of them are known in Poland only from the Białowieża Forest. The larvae phase of these beetles (sometimes lasting several years) takes place in spruces either killed by bark beetles or felled by wind, recently died or heavily decayed. Their larvae feed on decaying phloem or xylem, mycelium of the fungi that colonize dead trees or they have a predatory lifestyle and feed on other small animals that colonize dead spruces (Gutowski and Buchholz 2000, Gutowski 2004, Gutowski et al. 2004). Amongst these insects there are rarities like: *Rhysodes sulcatus*, *Boros schneideri*, *Pytho kolwensis* (this species colonize only spruce), *Cucujus cinnaberinus*, *Cucujus haematodes*, *Lacon lepidopterus*. Saving the dead trees we protect a place for the larval phase of *Buprestis splendens* or *Peltis grossa*.
6. The most important nesting site for rare woodpeckers, especially the Tree-toed woodpecker *Picoides tridactylus*. Woodpeckers excavate their nest holes every year and therefore they need a continuous supply of thick dead trees. The tree-toed woodpecker is four times rarer in the commercial part of the Białowieża Forest, where foresters fought against bark beetle by logging dead spruces than in the strict nature reserve of the Białowieża National Park. It avoids the parts of the forest where forestry management

occurs even if the management is with low intensity (Kajzer and Sobociński 2012). More than 60% of the nests of the tree-toed woodpecker in the Białowieża Forest are in spruces and 90% of them in dead spruces. The average diameter at breast height of the trees that this woodpecker excavate its nest holes is 37 cm (T. Wesołowski, unpublished data).

7. An abundant and diverse source of prey that is available for many years, for all species of woodpecker, including the rarest ones: White-backed woodpecker and tree-toed woodpecker. Black, white-backed and tree-toed woodpeckers often forage on dead wood (Walankiewicz et al. 2002). The latter, in 80% of cases, forage on dead spruces. These trees (standing or lying) harbour good and diverse prey base lasting for many years, because in the next phases of decomposition, they are colonized by different groups of invertebrates. The abundance of food influences the reproductive success of woodpeckers and the survival rate of their nestlings (Kajzer and Sobociński 2012).
8. The most important nesting site for the Eurasian pygmy owl. A rare species of owl which is dependent on the presence of woodpecker nest holes. The Eurasian pygmy owl occupies almost exclusively woodpecker nest holes in dying trees.
9. Abundance of food for small carnivores (e.g. weasel) and rare owls (e.g. Eurasian pygmy owl) because dying spruces produce seeds very intensively. Seeds are an important food source for rodents that constitute the prey for carnivores and raptors.

What are the advantages of dead and decaying trees?

1. Diversity of microhabitats (mosaics in the forest) increases because of the different phases of dying and decomposing wood, the area of uncovered soil, as well as speed and direction of the regeneration of the forest.
2. The organic matter of logs break down and become gradually incorporated in the forest soil as a result of slow decomposition.
3. Habitat for 230 species of macrofungi. They grow mainly on lying trunks with different phases of decomposition. Leaving dead spruces alone will give a long-term, suitable growing place for many species of Macromycetes connected with spruces, including extremely endangered ones and the ones known only from strictly protected areas of the Białowieża Forest.
4. The habitat of many epixylic lichens is growing. That includes rare species of *Calicium* and *Chaenotheca* genus, half of which are listed in "Red List of extinct and threatened lichens in Poland" (Cieśliński et al. 2006). On decaying spruce wood one can find the extraordinary and rare lichen that contains the gilled mushroom of basidiomycotas division *Lichenomphalia umbellifera*.
5. The number of many, but not very well-known in our country slime molds (*Mycetozoa* = *Myxomycetes*). Apart from the mountain areas, North-east of Poland is the area with highest abundance of these species. In the Białowieża Forest 107 species of Mycetozoa were discovered until 2015. Studies in 2013-2015 showed a much higher frequency of occurrence and variety of species of Mycetozoa in plots that contained dead wood than in plots without dead wood, both in the Białowieża NP and other parts of BF (Drozdowicz 2014).
6. Better conditions for germination of trees and many other vascular plants. Oak groves planted and cultivated in the Białowieża Forest by foresters will not replace the precious complex stage oak stands that were formed as a result of covering glades and abandoned

fields (Bobic 2013). Nowadays this sort of forest develops inside gaps that appeared after decay of spruce stands. Numerous logs of dead spruces lying on the ground facilitate the process of oak regeneration. As research done in the Białowieża National Park has shown, the vast majority of young oaks appeared in the vicinity of spruce logs. It may be connected with animals, mainly jays and rodents, choosing those places to hide acorns (Bobic et al. 2011, Smit et al. 2012) but also to the protective effects against herbivores of a tangle of fallen trees to larger oak saplings (Smit et al. 2012, van Ginkel et al. 2013).

7. Dead wood is a substratum colonized by almost 50 vascular plants (Chećko i in. 2015). Spruce seeds germinate perfectly and seedlings develop much faster on trunks of lying and decomposing "nursing" logs of spruce.
8. On the forest floor there are many reservoirs of water which is released and stored in lying spruce logs, as a result of decomposition of the wood by bacteria and fungi. Trees and other plants need this water for germination and growth.
9. Seedlings and young trees are much better protected against grazing and browsing because it is difficult for wild ungulates to get through a tangle of lying trunks and deer are afraid to feed in such a surrounding especially if there are wolves (Kuijper et al. 2013, 2015) and lynxes (Podgórski et al. 2008) close by. As a result, fallen trees create zones with lower ungulate browsing intensity and higher natural regeneration of trees (Kuijper et al. 2013, 2015).
10. Habitats of very rare species of beetles such as *Phryganophilus ruficollis* or *Ceruchus chrysomelinus*. Thick trunks that are lying, heavily decayed, and covered by moss, damp and shaded by the forest regenerating around, become a place of development for such rare beetles (Gutowski et al. 2004).
11. There are numerous damp hides that offer feeding grounds with an abundant supply of invertebrates and wintering places for many species of amphibians.
12. Dead wood has a positive impact on the number and structure of small mammal communities (Loeb 1999) and survival of small animals during very cold and very hot days.
13. It creates good conditions for hunting and resting for lynx. Lying logs give lynx a good cover which is essential for efficient hunting and hiding their prey and they provide them with security during daily rest (Podgórski et al. 2008).
14. Lying logs create a communication network on the ground which helps terrestrial animals in moving around and hunting. They are used by various animals such as dormice, weasels, stoats, martens, polecats, foxes, lynxes and wolves.

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