

Why dead spruce trees are needed in the Białowieska Forest?

The climate changes have impact on European forests. The tree species such as the spruce, sensitive to high temperatures and water deficit, weakened by summer draughts, become susceptible to more intensive colonisation by forest insects. The spruce trees overrun by the bark beetles die out, giving place to deciduous trees requiring a lot of light and better adapted to the present environmental conditions. The natural process of change of forest species composition is a long-term one, however the durability of forest ecosystem is not threatened during any of its stages. The forest continues to live, through the composition and percentage share of the comprising tree species changes radically. It also looks different than a few or a few dozen years before. Frequently this appearance does not correspond our habits - when the trunks of dead spruce are pointing upwards from the thicket of young trees or the maze of lying logs prevents navigation of the forest - but this does not mean that this is "a forest of worse quality" or "a dying forest".

If the forest is dominated by the spruce, the process of trees dying can take mass proportions. This situation is observed at present in many places all over Poland, e.g. in the Beskidy region or in some parts of the Białowieska Forest. Similar to ordinary timber forests we could easily give in to temptation to interfere - clearance of dying spruce, their removal to wood yards and sale followed by cleaning and plowing of the soil, planting of the seedlings grown in forest nursery according to the instructions and their protection with the support of any methods against herbivores and nurse to obtain after a few dozen years a structured, newly developed wood stand.

However is it a good decision? Considering the special character of the Białowieska Forest (it is the best preserved deciduous and mixed forest on European plains) and the continuing 500 year long history of its preservation should it be allowed that the current forest dominated by the coniferous trees would gradually transform as a result of natural processes into a forest dominated by oaks, linden, hornbeams and other deciduous trees? Does not the willingness to interfere result maybe from economical reasons or misconception that the forest would die without human help?

The studies on the processes of degradation of spruce forests indicated that the dynamics of bark beetle gradation does not differ much in the areas, where the fight with the bark beetle was carried out with the support of all available methods and in the areas, where such actions were not conducted (Grodzki et al. 2006). The removal of trees attacked by the bark beetle or dead for other reasons is not the effective method of stopping the bark beetle gradation and dieback of the spruce, but might even have opposite effect: through limitation of natural processes it may extend the gradation and accelerate the disappearance of the spruce trees, as in the Białowieska Forest conditions the effective clearance of sufficient percentage of attacked trees is not possible (e.g. Fahse and Heurich 2011).

At present we have a very extensive knowledge on the positive role of dead wood in the forest, its impact on forest microclimate, availability of water and increased biological diversity. Dead wood is the discriminant of natural forests. Without it they lose their natural character and do not differ from ordinary timber forests.

The list below presents the nature losses caused by the clearance and removal from the Forest:

dying spruce and benefits resulting from the lack of interference in this process.

Cutting and removing old spruce trees we lose inter alia:

1. **A chance for more effective, quicker, natural and biologically diversified natural regeneration of the forest** (as demonstrated by examples from other European sites: Loch et al. 2001, Jonašova and Prah 2004, Jonášová 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. **The place of production and propagation of "biological weapon" against bark beetles.** Some of saproxylobiontic predatory beetles living in dead spruce trees are direct enemies of the European spruce bark beetle - they are attracted to spruce overtaken by the bark beetle by aggregation pheromone produced by female bark beetles at the time of conquering the tree. A high concentration of dying spruce trees taken over by the bark beetles becomes a place of intensive reproduction of predatory beetles as well as other predatory and parasitic insects, which expand from such reproduction sites to subsequent areas in search of their prey (Gutowski and Krzysztofiak 2005, Montano et al. 2016)
3. **Sites in the Forest, where the oaks are reproducing in natural manner on mass scale** (Bobic et al. 2011, Bobiec and Bobiec 2012, Bobiec 2013). The more numerous groups of dying spruce trees and the bigger surfaces of spruce wood stands attacked by the European spruce bark beetle, the more numerous, quickly growing natural oak regenerations. In other sites dominated by deciduous wood stands, the growth of the oak seedlings is impeded by the hornbeam regenerating on a mass scale.
4. **The living environment of many species of lichens and bryophytes.** The most numerous ecological groups of "forest relics" comprise epiphytic (mainly tree lichens and bryophytes) and epixylic (i.e. growing mainly on dead wood) lichens and bryophytes (Cieśliński et al. 1996). Spruce are very good substrate for the species dying out in Europe from genus *Bryoria* and *Usnea*. Nearly 90 species from the Białowieska Forest living on spruce trees were mentioned (Cieśliński 2003), including e.g. already recognised as regionally extinct in Poland *Usnea: Usnea longissima, U. cavernosa* and *U. uncinulata*.
5. **The only living environment of many species of saproxylic beetles, i.e. living on dead wood and dying trees and the subbark zone and touchwood found in such trees.** "The forest relics" include species belonging to formerly large group of saproxylic beetles, counting in the Central Europe over 1000 species, with beetles coexisting with dead trees being threatened the most by extinction. Some of them are found in Poland only in the Białowieska Forest. The larval development (sometimes a few years long) of these beetles take places in the spruce trees killed by the European spruce bark beetles and windfallen or broken, recently died back or already strongly rotted. Again their larvae feed on the decomposing phloem or wood, mycelia of fungi colonising dead trees or perform predatory life feeding on other small animals living in dead spruce trees (Gutowski and Buchholz 2000, Gutowski 2004, Gutowski et al. 2004). These insects include such rare specimens as: **wrinkled bark beetle *Rhysodes sulcatus*, Boros *schneideri*, *Pytho kolwensis* (these species live exclusively in spruce trees), flat bark beetle *Cucujus cinnaberinus*, *Cucujus haematodes*, *Lacon lepidopterus*.** By leaving dead spruce we also protect the places of few

year long larval development of such species as *Buprestis splendens* or *Peltis grossa*. *Buprestis splendens* for its development needs high dead spruce or pine trees exposed to a lot of sun, the best places are so called bark beetle nests left without any intervention of the foresters. *Peltis grossa* for its development needs thick standing coniferous trees (in the Forest these are usually the spruce trees already killed by the bark beetles), whose wood is already a subject of advanced rotting process.

6. The major breeding sites of rare woodpeckers, mainly three-toed woodpecker. The woodpeckers make new tree hollows every year and thus need a constant supply of thick dead trees. The three-toed woodpecker is four times more rare in the timber part of the Forest, where the bark beetle was being eradicated by removing the dead trees than in the strict reserve of Białowieski National Forest. This woodpecker avoids the tended parts of the forest and subjected to timber acquisition even when such works cover relatively small areas and small number of trees (Kajzer and Sobociński 2012). The studies demonstrate that 2/3 of tree hollows of this woodpecker are found in the Białowieska Forest in spruce trees, including 90% of them in dead spruce trees. The average breast height of the trees (i.e. the diameter measured at breast height), in which this woodpecker makes its hollows, is 37 cm (T. Wesołowski, unpublished data).
7. **The rich, diversified, available for many years feeding grounds for all species of the woodpecker, including the most rare species - the white-backed woodpecker and three-toed woodpecker.** The black, white-backed and three-toed woodpecker frequently feed on dead wood (Walankiewicz et al. 2002). The latter in 80% of cases feeds on dead spruce trees. These trees (both standing and fallen) are a good and diversified feeding ground for many years, as during the subsequent years of their decomposition are colonised by various groups of invertebrates. The abundance of food enables better breeding success of the woodpeckers and better survival rate of hatchlings (Kajzer and Sobociński 2012).
8. **The major breeding sites of pygmy owl – rare owl species,** which is dependent on the presence of hollows made by the woodpeckers. The pygmy owl occupies nearly exclusively the hollows made by the woodpeckers in the dying spruce trees (Mikusek 2009).
9. **The abundance of food for small predatory mammals (e.g. weasels and rare owls (e.g. Tengmalm's owl),** because the dying spruce trees intensively produce the seeds, which form the feed base for the rodents, i.e. the food for the predatory mammals and birds.

What are the benefits of the fallen and rotting trees?

1. **The diversity of micro-habitats increases (forest mosaicity),** associated with the varying rate of die-back and decomposition of the wood, the area of uncovered soil, the speed and direction of forest regeneration.
2. **The organic matter accumulated in the logs is gradually released into forest soil** as a result of slow wood decomposition processes.
3. **The habitat is created for at least 230 species of large-fructification fungi.** They usually grow on fallen logs in varying degree of decomposition. leaving in place the dead spruce trees will create for years to come a convenient place for development of many species of spruce

related macro-fungi, including the terminally endangered species and known to date only in the strictly protected areas of the Białowieska Forest (Karasiński et al. 2010).

4. **The number of sites of existence of many epixylic lichens is growing**, including rare species from genus *Calicium* and *Chaenotheca*, with over half of them present on "red list of extinct and endangered lichens" (Cieśliński et al. 2006). One of five lichen species growing in Poland containing a basic fungus - *Lichenomphalia umbellifera*, can be also found on the rotting spruce wood.
5. **The number of habitats is growing, which are favourable for numerous slime molds poorly recognised in Poland (*Mycetozoa = Myxomycetes*)**, for which north-east Poland - apart from the mountains - is the place of the most numerous occurrence (Panek and Romański 2010).
6. **A lot better conditions are created for germination of the trees and many other vascular plants**. The oak plantations planted and cultivated in the Białowieska Forest by the foresters will not replace valuable Forest old-growth oak forests, which emerged as a result of a slow gradual overgrowing of the clearings and abandoned fields (Bobiec 2013). At present such oak forests grow as a result of spontaneous overgrowing of vast gaps created as a result of the breakdown of spruce wood stands. The numerous dead spruce logs laying on the ground perform especially positive role in the oak renewal process. The studies carried out in Białowieski National Park indicated that the majority of young oaks emerges in the direct vicinity of spruce logs. This may be related to selection of such sites by animals distributing and hiding the acorns, mainly jays and rodents (Bobiec et al. 2011, Smit et al. 2012, van Ginkel et al. 2013).
7. **The natural spruce renewal appears which takes place neatly exclusively on dead wood in the mixed deciduous forests of the Białowieska Forest**. Dead wood is a substrate colonised by nearly 50 species of vascular plants (Chećko et al. 2015). The spruce seeds germinate very well and the seedlings grow much quicker on the logs of decomposing spruce trees.
8. **Many natural water reservoirs emerge on the forest floor, which is stored in spruce logs during precipitation and is also released in the logs as a result of the wood decomposition process by bacteria and fungi**. This water is needed for germination and growth of trees and other plants (Gutowski et al. 2004).
9. **Seedlings and young trees are protected a lot better against chewing**, because it is more difficult for large animals to get through the maze of the logs and the deer are afraid to feed for a longer period of time in such surroundings, especially in place frequently visited by the wolves (Kuijper et al. 2013, Kuijper et al. 2015) and lynxes (Podgórski et al. 2008). As a result the fallen trees form the zones with increased natural trees regeneration (Kuijper et al. 2013)
10. **The numerous habitats are created of very rare beetle species such as *Phryganophilus ruficollis* or *Ceruchus chrysomelinus***. The fallen, strongly rotted big spruce trunks, overgrown by moss, moist and staying in shade by the regenerating surrounding forest become the place of development of such rare beetle species (Gutowski et al. 2004).

11. **The numerous hideouts, feeding grounds with abundance of invertebrates and the wintering sites for many species of amphibians are available.**
12. **The presence of dead wood has positive impact on the number and structure of groupings of small amphibians** (Loeb 1999) and the successful survival of both freezing and hot days by many small animals.
13. **The convenient conditions are created for the hunting and resting lynxes.** The laying logs provide the lynxes with a cover necessary for effective hunting and hiding of the prey and provide safety during the daily rest (Podgórski et al. 2008).
14. **The laying tree logs create a convenient communication network in the Forest, elevated above the ground and convenient for hunting and moving around, used by various animals,** e.g. doormice, weasels, stoats, common martens, polecats, foxes, lynxes and wolves.

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