Question 6

How does forest management affect biodiversity?

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Forests in Europe have a long history of human use. Management regimes have altered natural forest ecosystems over time at varying intensities and thus caused changes in forest biodiversity. Around 30% of European forests are dominated by single species, mostly conifers, while 70% of forests are mixed forests. The rate of monocultures has been declining slowly but steadily over the last 20 decades. Only small remnants of undisturbed forest thus remain intact in Europe. Those account for 2.2 % of the forest area, while around 94% of European forests are classified as semi-natural, and 4% are plantations.

Biodiversity in managed forests depends on the continuity of habitats, the variability of site conditions and tree species and forestry that mimics natural dynamics. Old growth and natural forests are particularly valuable for biodiversity (EEA, 2016), but also some intensively managed forests (e.g., coppice forests) can have high conservation value. The choice of tree species when planting or tending natural regeneration does not only directly influence tree diversity in a particular forest but also indirectly influences forest biodiversity, because of the numerous different host-tree associations of forest fauna and the varying growing conditions for plant species under different tree species. Among saproxylic species, fungi and beetle species, many are specialized on either coniferous or broadleaved trees, which seems to be a universal pattern (Stokland et al. 2012). The effect of tree species declines with the decomposition of deadwood, however. Still, many species are characterized by a narrower host-range. For example, first colonisers, such as bark beetles are specialized on a single tree species or a genus.

Particularly heated debates occur around the planting of non-native tree species. The introduction of tree species has a long history in Europe and today over 150 non-native tree species with a native origin outside of Europe are grown in European forests and make up 4% of the forest area (Brus et al., 2019). Motivations were, for example the need to restore forests, their often superior growth rates over native tree species, resistance against pests, drought and other climate change driven impacts (Pötzelsberger et al., 2020). Today, the need to adapt forest ecosystems to rapidly changing environmental conditions and the increasing demand for timber has renewed the interest in non-native tree species, but also the debate on how to balance benefits and risks (change nutrient and water cycling, competition, hybridisation, disruption of food-webs, encouraging pest outbreaks, invasiveness). Impacts however strongly depend on the tree species and the ecosystem (context dependency), and only few tree species have become invasive in Europe.

Another characteristic of managed forests is that they do not grow as old as unmanaged forests. Forests are generally harvested at the point of economic maturity as yield and market-based criteria are mainly considered. Consequently, forest phases of late development, degradation, or stand break down are either lacking or found only on a small scale. Due to their long habitat continuity, it is these development phases that hold a rich diversity of rare niches and species. Integrated forest management aims, amongst other things, to restore some old growth features in managed forests to provide habitat for old growth dependent species. In order to conserve and restore such species communities, forest management concepts have to ensure that structural elements found in late development phases, such as habitat trees, standing and lying deadwood and diverse stand structures, are re-established or re-introduced into managed forests (Kraus and Krumm, 2013). Thus, a main premise is that silviculture based on patterns and processes found in old-growth forests will contribute to maintaining a variety of non-timber forest functions, especially the provision of important habitats for biodiversity. However, particularly high species numbers and numbers of unique species are highest not only in late successional stages, but also in the early stages (Hilmers et al., 2018). There, primary production increases on the forest floor with more sunlight reaching the ground, resulting in and increased resource availability for phytophagous insects.

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Another important factor is the overall habitat heterogeneity, both at small as well as at landscape scale. While uneven-aged forest management maximizes within stand heterogeneity, it was found that applying this system at landscape scale can lead to an overall lower biodiversity in central European beech forests compared to an even-aged shelter wood system. The latter ensures a higher dissimilarity of environmental conditions and resources among forest stands (Schall et al., 2020).

Habitat trees, a typical old-growth element, are very large, very old, and dead or living microhabitat bearing trees. They are of prime importance for specialised forest flora and fauna. Cavity-bearing trees are among the most important habitat trees for forest wildlife. Old cavities with decayed residue host several of the most threatened forest beetles. Habitat trees are common in natural forests but often missing in managed forests (Larrieu and Cabanettes, 2012; Larrieu et al., 2018).

Deadwood plays a major role in forest ecosystems. Deadwood is not only habitat for saproxylic species; it also contributes to carbon sequestration, nutrient supply, natural regeneration, and protection against falling rocks. Depending on the forest type, deadwood quantities ranging from 20 m^3/ha to 50 m^3/ha have been identified as a threshold to maintain the majority of saproxylic species while very demanding species require more than 100 m^3/ha (Müller and Bütler, 2010). The average volume of deadwood in Europe‘s forests is 11.5 m^3/ha equal to 7.1 % of the average volume of the growing stock. Deadwood amounts and quality vary considerably between European countries and regions (Forest Europe, 2020).

Measures to increase biodiversity in managed forest landscapes can rely on integrative, segregative, or combined concepts. Their respective instruments have different spatial scales and impacts. At macroscale, segregative measures are for example the establishment of national parks and large strictly protected areas substituting primary forests. Close-to-nature forest management concepts can provide moderate habitat quality over an entire area if a set of basic standards are applied (Bollmann and Braunisch, 2013). The overall impact of close-to-nature forest management can be enhanced by additional segregative elements. Those are strict forest reserves, special biotopes or key structural attributes that are created through retention measures. In this way a network of actively and passively managed forest reserves is created which offers unique and rare niches for habitat specialists. It is however important to adapt the distribution of structural elements within the landscape to the dispersal capacities of species (Krumm et al., 2013; Krumm et al., 2020). Fast colonisers require a continuous supply of (often very short-lived) habitat over larger areas whereas slow colonisers are often dependent on the conservation and enlargement of relict habitat islands (Vandekerkhove et al., 2013).

For example, the White-backed and Threetoed Woodpeckers need several larger old-growth patches of at least 20–100 ha to form a successful breeding territory. Consequently, they are often restricted to conservation areas, with steppingstones in between the reserves (retention trees and key habitats) still being necessary to create a wide-scale regional functional network for a viable metapopulation of these species. Minimum viable metapopulations for fauna (to ensure population survival and avoid inbreeding) are estimated to constitute 4,000 to 5,000 individuals (Frankham, 1995). (For species with multi-year lifecycles, viable metapopulations may be smaller.) For some beetle species these minimum viable metapopulations may occur on a single tree, while other species need many more suitable trees within the dispersal range (for most species 1–2 km, sometimes only a few hundred meters). Consequently, a functional network of old-growth elements should consider these different life strategies. This requires the combination of larger and smaller set-asides, intertwined with a dense enough network of habitat trees, both dead and alive.

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Importantly, when integrating biodiversity measures in forest management, there is no one-size-fits-all solution as the impacts of management will differ with regard to geographic location, climatic conditions, native biodiversity, ecosystem properties, habitat, food web structures, selected tree species and many more environmental factors (Chaudhary et al., 2016). It is however important to understand the effects of management. Very often the impact of forest management depends on management intensity (Bauhus et al., 2017).

At the extreme end of the management intensity range is clear-cutting, which results in temporary deforestation of a previously forested area. Reduced Impact Logging is an example of a harvesting technique at the other end of the timber production management spectrum. Single tree selection is an example of reduced impact logging where the forest is never cleared in large patches (continuous cover forestry), and only single trees are removed, leading small canopy openings and a more uneven age structure and varying dimensions of trees. Patch fellings of different sizes, where groups of trees are removed, or clear-cut systems, where the forest stand is removed completely over larger areas (prohibited in some countries or with maximum areas defined in other countries, e.g., 2 hectares) have a different effect. Larger openings let more light reach the ground and therefore allow the growth of more light-demanding tree species in comparison to continuous cover forest systems. Herbal species will typically grow in higher abundance in larger canopy gaps, which herbivores will benefit from.

On the other hand, some more shade-loving species may not survive in full sunlight. All types of management change some properties of the forest and it is unrealistic to expect any type of forestry to have no impact on forest biodiversity. However, the same economic value of wood in different management systems may result in substantially different biodiversity impacts (Chaudhary et al., 2016).

Considerable shares of European forest areas are under a certain protection status. Nearly 24% of European forests are protected under the MCPFE classes 1 to 3. (Forest Europe, 2020). The Natura 2000 network covers around 18% of the EU's terrestrial area, with around 28000 sites. Forests make up almost 50% the area, whereas 40% of the Natura 2000 total area is farmland. Currently, 27% of the EU's forests are protected under Natura 2000 (EEA, 2020). The aim is not to abandon any economic activity, but to avoid activities that could seriously disturb species or damage habitats for which the site is designated and to take positive measures to maintain and restore habitats and species where needed. The assessment of habitats according to the EU Habitats Directive considers their natural range and areas they cover within that range, the specific structure and functions which are necessary for its long-term maintenance and the future prospects. While 31% of forest habitat assessments show a bad conservation status, forest habitats exhibit the highest proportion of improving trends among the assessments (13%) (EEA, 2020).

Birds are specifically protected in the EU through the Birds Directive. An indicator from the Forest Europe report on the State of Europe's Forests 2020 shows changes in breeding populations of bird species both common and characteristic for European forests. The index that is based on data from national breeding bird surveys in 28 countries shows that common forest birds have been relatively stable over the past 37 years. According to the latest State of Nature in the EU report (EEA, 2020), 32% of forest bird species show an improving and 40% a stable trend.

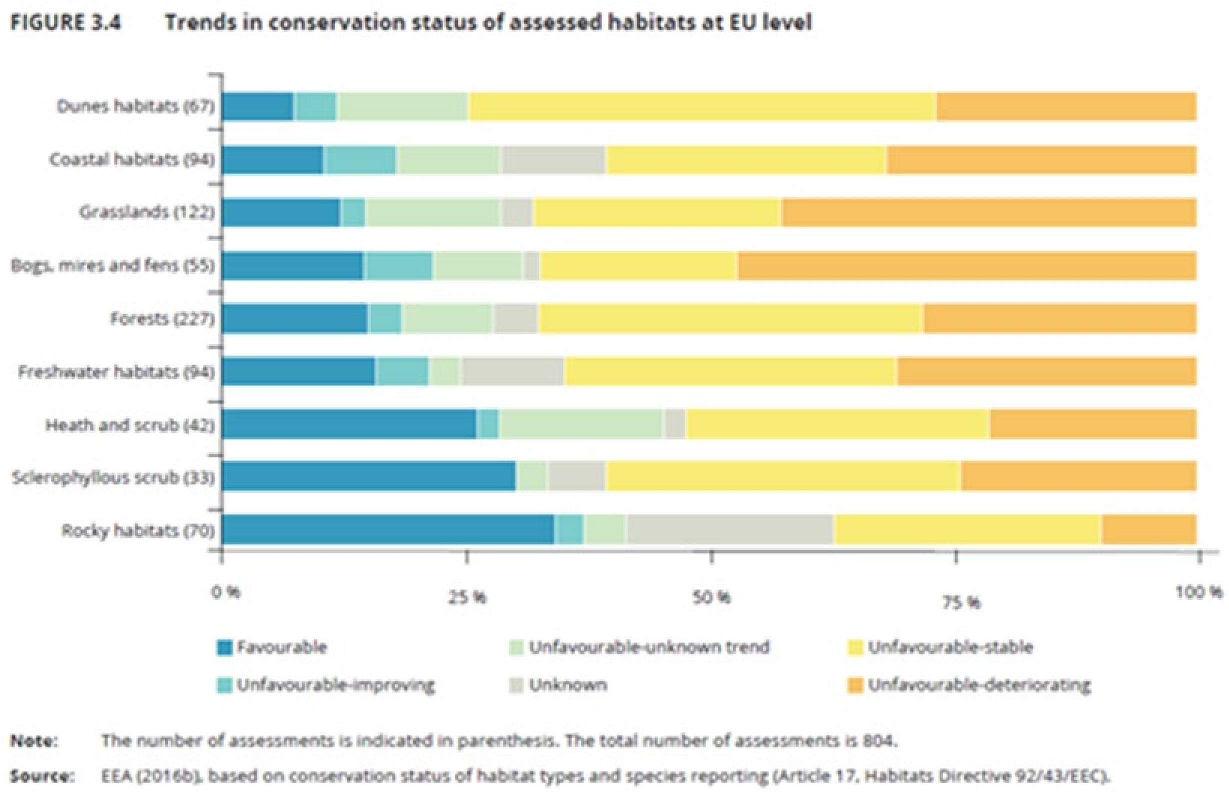

Figure 1: *Published in EEA, 2019. The European environment — state and outlook 2020. Knowledge for transition to a sustainable Europe.*

Conclusion

In recent decades there has been a change in public perception towards the functions of forests in Europe. This is being reflected in giving more attention to integrating biodiversity conservation with timber production and other functions in multi-purpose forestry. As a result, Europe's managed forests are continuing to become more diverse in species composition and structure while leaving room for typical old growth forest elements such as deadwood, habitat trees and small gaps providing increased habitat quality for many forest dwelling species.

However, managed forests will always differ from natural forest ecosystems even if silviculture greatly imitates natural processes. Combining integrated, multi-functional forestry with complementary segregative elements that are effective enough to preserve species richness in forests of high conservation value will serve many biodiversity conservation goals and enable forest managers to adapt the prevailing conservation concepts to their current environmental conditions, previous harvesting types, and future developments. This will not always be possible due to various reasons, for example the urgency to emphasise particular forest ecosystem services, forest owners' preferences or the lack of incentives.

There are many good and varying practice examples of integrated forest management in Europe that address the balance between forestry and biodiversity conservation. In order to develop the concept of integrated forest management further, one aim should be to strengthen the cooperation of forest enterprises to increase the connectivity of the biological infrastructure amongst them. Ideally, biodiversity measures should be taken at the landscape level, considering also interfaces to agriculture, water areas, and settlements.

Photo: Adobe Stock

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