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Editorial: Current challenges in forest restoration and sustainable forest management

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Editorial on the Research Topic
Current challenges in forest restoration and sustainable forest management

In the face of an ongoing decline of biodiversity and the global loss of ecosystem services (IPBES, 2019), the protection and restoration of natural environments is nothing but a matter of human survival on our planet (Walder, 2018). To accommodate this urgent need, the United Nations have proclaimed the "Decade on Restoration" for the period 2021 to 2030 [United Nations Environment Agency (UNEA), 2019]. Forested ecosystems are a major land cover type on our planet (Pan et al., 2013), and provide manifold ecosystem services to billions of people (Brockerhoff et al., 2017). These are among others, the production of timber and non-timber forest products, local to global water and nutrient cycles, erosion protection, climate change mitigation, provision of human wellbeing and their importance as biodiversity reservoirs and cultural heritage (e.g., Çolak et al., 2018; Hua et al., 2022).

Nevertheless, forest cover continues to decline worldwide (Curtis et al., 2018; Estoque et al., 2022). Main drivers for this loss and ongoing fragmentation of remaining forests are land-use changes toward agriculture, unsustainable forest management, urbanization, mining, and wildfires (Curtis et al., 2018; Taubert et al., 2018; Zerbe, 2022, 2023), with climate change playing an overarching and negatively impacting role (Cook and Johnson, 1989; Kirilenko and Sedjo, 2007; Keenan, 2015). In some temperate regions, for example, increased periods of drought have led to increased fire frequency and intensity as well as sensitivity to pests, which already resulted in forest loss across large areas of Europe and the U.S. (Abatzoglou and Williams, 2016; Senf et al., 2020). In tropical and sub-tropical regions, local communities often directly depend on natural forest resources, and thus, forest degradation and loss can negatively impact their socio-economic development (e.g., Appiah et al., 2009; Curtis et al., 2018).

In order to combat forest loss, ongoing fragmentation and degradation, reforestation, ecosystem restoration as well as sustainable management are among the most important goals of our century (Chazdon and Brancalion, 2019). This requires, however, innovative concepts that encompass ecological, social, and economic aspects to simultaneously fulfill the Sustainable Development Goals (DSDG, 2020; Fischer et al., 2021). Accordingly, our Research Topic aims to outline concepts for sustainable forest management and forest restoration and to determine prevailing challenges.

In this Research Topic, we focus on temperate forests in Europe and deal with the potential invasiveness of Douglas fir (*Pseudotsuga menziesii*), the evaluation of a restoration approach in anthropogenic Norway spruce (*Picea abies*) stands toward mixed broad-leaved forests on the long term, the impacts of forest management on forest bird assemblages, and the effects of biochar and wood ash amendments on the soil-water-plant environment.

Axer et al. assessed the effects of admixed European beech (*Fagus sylvatica* L.) on the natural regeneration potential and humus condition of Norway spruce [*Picea abies* (L.) H. Karst.] afforestations in the German Ore Mountains. Positive effects on the organic layer of planted beech tree groups could be proven. However, due to an often high browsing pressure (e.g., by roe deer), fencing is recommended for forest conversion.

Regarding wildlife in forest ecosystem, birds are often considered as ideal indicator species to assess the ecological value and diversity of forests. Leitão et al. therefore evaluated the effect of different forest management scenarios for 15 different bird species in a Central European forest. Following their ecological niche models, species' responses to forest management vary and thus, reflect differences in their overall niches. Consequently, no single management practice could be outlined to benefit all species. However, the authors concluded that the conservation of a certain bird species (or species group), requires a fit-to-purpose management strategy considering the species' ecological requirements. For the conservation of a diverse forest bird community in turn, forest management needs to promote a diversity of habitat structure and enough habitat trees.

Moragues-Saitua et al. studied the short-term responses of wood ash and biochar application in two different mineral soil-water-plant systems in temperate forests. Although positive effects of these amendments could be found for the soil -water-plant system, further long-term field experiments are required to test the performance and potential toxicity of these by-products as soil enhancers. Main differences were so far attributed to soil characteristics, application rates, and nitrogen application.

Since Douglas fir [*Pseudostuga menziesii* (Mirb.) Franco], a non-native tree species introduced to Europe from North America, has a long-lasting history in Central European forestry, Lange et al. investigated its potential invasiveness, taking a mountain area in southwestern Germany as a case study. Although widespread in mixed and pure plantations in this area, this tree species cannot be considered invasive up to now and can be managed by appropriate silvicultural measures.

With this Research Topic, we could outline potential approaches for forest restoration and sustainable management in temperate regions. The results of these studies show on the one hand that there is no one-size-fits-all solution and that e.g., diverse and flexible forest-management approaches should be taken into account, that regional factors play an important role and that there is a need for further research. Besides scientific results or management concepts, all approaches and management plans require decision-making and the willingness of forest owners to adapt their forestry strategy or to invest in forest restoration. The increasing discussion about the future viability of native broad-leaved tree species in Europe leads to uncertainties among forest owners and practitioners and complicates the willingness to promote near-natural forests. Instead, non-native tree species are often presented as an alternative, especially in terms of a climate change adaptation strategy by simultaneously enhancing the timber production (e.g., Frischbier et al., 2019). Upcoming challenges in forest restoration and sustainable management will be balancing economic and ecological needs by accounting for ecosystem services and their related biodiversity. The discussion on the use of native or non-native tree species will therefore be one of the bigger challenges with forest owners becoming the decision-makers. Addressing their needs by incorporating biodiversity and sustainable restoration will be of outmost priority in the years to come.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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