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Editorial: Forests of high naturalness as references for management and conservation: Potential and pitfalls

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Editorial on the Research Topic
Forests of high naturalness as references for management and conservation: Potential and pitfalls

Forest ecosystems are critical to address the collapse of biodiversity and climate change crisis faced by our societies. The many habitats and ecosystem services they provide, such as carbon sequestration or water cycle regulation, need to be protected. In this context, forests of high naturalness have an exceptional importance because of the higher amount and quality of ecosystem services they provide compared to managed forests (Watson et al., 2018). "Naturalness" describes a gradient of human impact on nature, with naturalness increasing as human impact decreases (Winter, 2012). This concept is however rooted in the Western paradigm of "nature/culture" distinction (Ducarme et al., 2021). In this Research Topic, Clement et al. emphasize that high naturalness does not mean an absence of humans and interactions with their environment. The authors focus on the Amazonian Indigenous Peoples, who have been using and changing the Amazonian forest for millennia, a forest that is at the same time recognized for its high naturalness value (Potapov et al., 2008; Venter et al., 2016). Acknowledging that the loss of naturalness is mainly due to modern industrial activities, and not to human presence *per se*, is essential for considering the various issues explored in this Research Topic. For example, the Food and Agriculture Organization of the United Nations has recently recognized that a forest showing evidences of traditional indigenous activities can still be considered a primary forest (FAO, 2020).

Reducing or even halting the degradation of forests of high naturalness is a critical issue, as modern human activities continue to cause their loss around the world (Potapov et al., 2017), aggravating climate change and biodiversity loss crises. Tropical and boreal forests contain the largest remaining area of forests of high naturalness compared to other biomes, but are subject to a high level of threat. In this Research Topic, Grantham et al. show that about 20% of intact tropical forest landscapes are located in the areas of extractive concessions, implying significant short- and medium-term threats to these forests. Large-scale deforestation is a major issue that has affected tropical forests of high naturalness, causing major losses of habitat as well as carbon stored in these forests. The results of Grantham et al. highlight that the granting of extractive concessions will continue to maintain this degradation dynamic. The identification of "no go" areas and the application of effective mitigation strategies is therefore urgent to reduce the pressure of human activities on these forests.

The extension of forest management practices over increasingly large areas and the application of silvicultural treatments aimed at increasing the yield of wood products from forests have a major impact on the habitats and ecosystem services (Puettmann et al., 2009; Kuuluvainen and Gauthier, 2018). Boreal forests are an excellent example of these issues: their low productivity makes clearcutting the preferred silvicultural treatment, even in areas where stand-replacing disturbances such as wildfire are rare and old-growth forests are abundant (Östlund et al., 1997; Boucher et al., 2017; Martin et al., 2021). Extensive agglomeration of clearcutting in boreal areas has resulted in significant forest rejuvenation and fragmentation of old-growth forests (Haeussler and Kneeshaw, 2003). For this reason, alternatives to clearcutting closer to an old-growth dynamics are often presented as a trade-off between timber production and maintenance of the ecosystem services provided by forests of high naturalness (Puettmann et al., 2015). The study of Opoku-Nyame et al. demonstrates the beneficial impacts of partial cutting on bryophyte communities, supporting species associated with old-growth forests and vulnerable to clearcuts. These results confirm previous research demonstrating the ability of partial cuts to maintain habitats related to forests of high naturalness while allowing timber harvesting (Fenton et al., 2013; Franklin et al., 2019).

Developing management strategies that maintain forest attributes and then services provided by forests of high naturalness requires a detailed knowledge of their ecology (Bauhus et al., 2009; Kuuluvainen et al., 2021). In this Research Topic, the study of Pouta et al. improves our knowledge of the spatial structure of trees in old-growth forests of *Picea abies* mixed with *Betula pubescens* in Fennoscandia. The regeneration process of old-growth forests depends not only on competition for light, but also on the spatial distribution of trees at a small stand scale and the availability of microsites. These elements must therefore be considered to emulate old-growth dynamics through silviculture.

Evaluating the effects of forest management, for example on forest biodiversity, is however complex. Whether in natural or managed forests, knowledge of invertebrate, cryptogam, fungal or bacterial species is disproportionately less than that of vertebrates or vascular flora (Newbold, 2010; Feldman et al., 2020). These differences can be largely explained by the great difficulty of sampling and the high level of expertise required to inventory these under-represented species (Burrascano et al., 2021). Martin et al. propose a synthesis of the potential of tree-related microhabitats (Larrieu et al., 2018), as an indicator of forest attributes harboring a wide diversity of taxa, that can be integrated into routine surveys. Tree-related microhabitats are indeed used by many forest species, in particular those for which little is known, and are often more abundant and diverse in forests of high naturalness. However, it is still a recent concept, little known outside Europe and generally not well integrated in forest inventories. Martin et al. therefore stress the importance of disseminating the use of tree-related microhabitats on a wider scale to make it a common forest inventory tool, contributing to the monitoring of the maintenance of forests of high naturalness attributes in managed forests.

Author contributions

MM wrote a first draft of the manuscript. OV, PP, and YP reviewed and edited the manuscript. All authors approved the final version of the manuscript.

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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