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Editorial: Vanishing old-growth forests: what are their roles and values for society under global change?

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Editorial on the Research Topic
Vanishing old-growth forests: what are their roles and values for society under global change?

Old-growth forests provide many precious ecological, economic, cultural, recreational and spiritual ecosystem services (Wirth et al., 2009). These ecosystem services are generally specific in comparison to younger or managed forests, explaining the high ecological and social value we place on their conservation, especially considering worldwide threats to them from human activities. These pressures are expected to increase in the coming decades in the face of global change (Wright and Muller-Landau, 2006; Kuuluvainen and Gauthier, 2018; Sabatini et al., 2018). Understanding how to protect and restore these old-growth forests in a changing world has therefore become a major forest management issue (Puettmann et al., 2015).

The success of policies and strategies to ensure the conservation of current old-growth forests and restoration of old-growth attributes in managed forests (e.g., through accelerating succession in managed secondary forests) depends on scientific knowledge of their ecology, as well as the integration of this information with indigenous knowledge and bio-cultural values. As they are highly complex ecosystems, our understanding of their dynamics and of the services they provide is still partial. Tree cavities, generally carved by woodpeckers, are for example a key habitat for a very wide variety of forest species and are generally found in greater numbers in old-growth forests. In this Research Topic, Cadieux et al. identified the network linking cavity-bearing trees, the number and diversity of cavity formation agents and cavity users increase as forest age in mixed boreal forests, reaching their maximum in the oldest stands. Interestingly, trembling aspen (*Populus tremuloides*) was the species almost exclusively chosen by woodpeckers to excavate cavities, independently of the succession stage. These results illustrate how the higher complexity of old-growth forests in comparison to the younger forests is an important factor explaining their high ecological value. From a carbon perspective, González et al. demonstrated that in Chilean *Fitzroya cupressoides* forests, the mass of aboveground carbon continues to significantly increase up to 1,600 years after the last stand-replacing disturbance. This study highlights the high value of old-growth forests to sequestrate atmospheric carbon on the long term, as well as the very important delay necessary to rebuild such stocks once these forests are degraded.

Successful management and protection of old-growth forests requires a proper identification of these forests and the recognition of the ecosystem services they provide. Two studies in this Research Topic address this issue and identify the risks of failing to do so. Lindenmayer and Bowd provide a review of research conducted over the past decades on old growth Mountain Ash (*Eucalyptus regnans*) forests in the state of Victoria, Australia. These forests have significant economic and social value, but they have been under great pressure since European colonization. The authors identify an increased risk of positive interaction between harvesting and fire, putting the last remaining old-growth Mountain Ash forests at high risk. A recent change in the governmental definition of old-growth forest, consisting of a 2-fold increase in age threshold but a 5-fold decrease in area threshold, reinforces these threats. Price et al. focus on the forests of the province of British-Columbia, Canada. Old-growth forests in this area present a wide variability in tree sizes, but those with the tallest and largest trees are more threatened by forest harvesting. Current provincial forest surveys do not accurately identify old-growth forests containing the largest trees. The authors therefore develop a method to correct this limit. The results reveal that old-growth forests containing large trees now represent <30% of the expected historical amount, posing a high risk for the perennity of these forests and the services they provide as well as the conservation of bio-cultural values for indigenous peoples.

Considering the global loss of old-growth forests, it is important that silvicultural practices become capable of maintaining or restoring old-growth attributes. Donoso et al. thus offer a perspective on silvicultural techniques to restore old-growth attributes in the temperate rainforests in Chile, which have been severely degraded by past management practices. Three silvicultural approaches have been tested: variable-density thinning in second-growth forest, irregular shelterwood in mature forests, and single-tree selection cutting in old-growth forests. The two first treatments improved old-growth attributes 7–10 years after treatment. In the old-growth forests, single-tree selection cutting however degraded some old-growth attributes. This research demonstrates the ability of certain silvicultural practices to restore old-growth attributes in degraded landscapes, but also the limitations and requirements to maintaining these attributes in forests that are already old-growth. At the same time, care should be taken with what can be considered old-growth attributes. Some old-growth forests show current characteristics that may be directly or indirectly influenced by human actions. Diaci et al. demonstrated that old-growth silver fir (*Abies alba*) forests in Slovenia have shifted to old-growth European beech (*Fagus sylvatica*) forests over the last 120 years. This transition from one stable state to another was caused by a combination of both anthropogenic disturbances (climate change, air pollution, overbrowsing) and natural disturbances (windthrows). These results demonstrate the importance of being cautious when studying old-growth forests, especially in landscapes that have been disturbed by humans for a long time. It is possible that what we observe only partially represents the natural dynamics of these forests. Since future forest characteristics are highly uncertain, it is even more important to have a good understanding of our past and present forests.

Overall, the diversity of topics covered by the articles in this Research Topic demonstrates both the richness and the complexity related to the knowledge, protection and management of old-growth forests. These articles also cover a wide range of forest types (temperate rainforest, temperate forest, boreal forest) and territories (South America, North America, Europe, Oceania), underscoring the global nature of the challenges related to old-growth forests. These papers published in this Research Topic thus make a rich contribution to the overall conservation of these forests, allowing the identification of common patterns or specificities specific to each territory or old-growth type.

Author contributions

MM wrote the first draft of the manuscript. PD, AA, and YB commented and edited it. All authors approved 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.

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