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Editorial: Impacts of global change on protective forests in mountain areas

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Editorial on the Research Topic
Impacts of global change on protective forests in mountain areas

Introduction

Forests in mountain areas play a vital role in protecting people and infrastructure against natural hazards (Teich et al., 2022a). Despite abundant evidence supporting the effectiveness of this Nature-based Solution (NbS) in mitigating hazards such as floods, landslides, and snow avalanches (Moos et al., 2018), the long-term and sustainable provision of this protective service faces challenges in the context of global change. Factors like changing forest dynamics as well as land-use and socio-economic shifts increase uncertainties about the long-term development of the protective functions and effects of forests. The complexities of the interactions between climate change and direct anthropogenic influences increase with rising temperatures and altering precipitation regimes, inducing shifts in tree species composition and influencing the vulnerability of protective forests to natural disturbances (Figure 1).

This collection of five papers within our Research Topic consolidates recent advances, providing a comprehensive understanding of the challenges and dynamics of mountain protective forests in the face of global change. Addressing diverse aspects of forest change at different scales, and using a range of methodologies and approaches, the papers address the need for understanding the changes of this crucial ecosystem service under global change as a basis for a sustainable and adaptive management of protective forests.

Global change impacts on mountain protective forests

Forests are facing increasing impacts of global change, including climate change, more frequent and severe natural disturbances, and shifts in land use. Their impacts

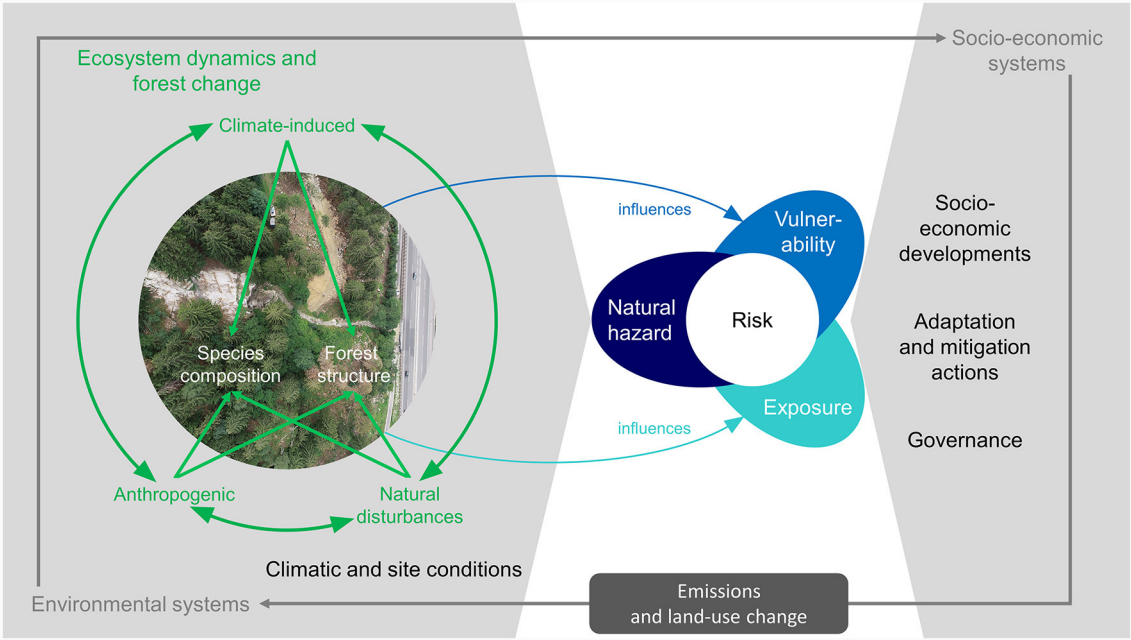

FIGURE 1
Impacts of global change on protective forests and natural hazard risk in mountain areas, resulting from interactions of natural hazards with exposure and vulnerability of human and natural systems. Adapted from Teich et al. (2022b).

on the protective effect of mountain forests worldwide were reviewed by Moos et al.. Their findings anticipate an increased protective effect at higher elevations but diminished efficacy at lower elevations, primarily attributed to increased drought. Key determinants included natural disturbances and forest management strategies, where salvage logging consistently reduced protective effects. The paper advocates for more cohesive modeling approaches, linking forest structure to hazard and risk, to deepen our understanding of how protective forests and the service they provide evolve in response to global change. The divergent impacts of climate warming on protective forests at different elevations were confirmed by a study in the Eastern Italian Alps, where Hillebrand et al. conducted a simulation experiment, utilizing a climate-sensitive forest succession model to examine the effects of climate change on protective forests. Lower-montane forests and stands in dry continental valleys experienced adverse changes due to drought-induced mortality, with more pronounced negative consequences under stronger climate change scenarios, while most subalpine forests benefited from elevated temperatures and extended vegetation periods. The study anticipates a decrease in avalanche protection but emphasizes that the capacity to maintain rockfall protection hinges on the severity of climate change and forests' vulnerability to its impacts.

Forest management strategies and their effect on the protective service

Forest management plays a multifaceted role in maintaining protective functions and other ecosystem services provided by mountain forests. Rackelmann et al. delved into the relationship between managing forests for health and flood risk reduction, elucidating synergies and trade-offs. While forest health and flood risk reduction objectives mostly align synergistically, trade-offs may occur in the proximity of watercourses, especially in places with a risk of clogging due to uprooted vegetation or large deadwood. The review underscores the necessity for balanced forest management, proposing a multi-goal management approach for vegetation along watercourses and strategies for comprehensive large wood management, accommodating various interests. As a guideline for the management of protective mountain forests in Switzerland, Scherrer et al. propose the use of naturalness of the tree species composition as a means to maintain protective effects. Through a comparison of National Forest Inventory data with potential Natural forest Site Types, they found that the tree species composition of 47% of protective mountain forests exhibit a "natural" or "close-to-natural" classification. Notably, Norway spruce and European larch are overrepresented, while silver fir and European beech are frequently absent. Species like oak and small-leaved lime are currently missing from more than 75% of the stands in which they are expected to be dominant under future conditions. The paper advocates for management interventions to gradually align tree species composition with environmental changes. National Forest Inventory data were also leveraged by May et al., who combined these data with a rockfall model to assess the long-term recovery of the protective effect of forests against rockfall after hypothetical stand-replacing disturbances. The study predicts a recovery timeframe spanning 50–200 years, depending on site conditions and rockfall disposition in Norway spruce, silver fir and European beech forests in Switzerland. This approach enables the

estimation of the long-term recovery of the protective effect for different tree species. Future investigations are recommended to explore the nuances of environmental and forest conditions, diverse disturbance intensities and legacies, facilitating the understanding of specific trajectories in the short- and long-term recovery of protective effects.

Summary and outlook

Collectively, the five papers comprising this Research Topic offer a broad exploration of the manifold challenges of ongoing global change and adaptations needed for sustaining protective functions and effects of forests in mountain areas. The collection presents advancements in understanding the impacts of global change on the protective service of mountain forests, spanning from local to regional scales. Some papers in this Research Topic employed modeling or data-based approaches, while others conducted literature reviews. Each of the five papers identified knowledge gaps and outlined future research directions. Together, these papers highlight the need to address these gaps through integrated multi-scale (local to regional studies), multi-temporal (short- to long-term monitoring and predictions), and multi-method (field observations to model applications) approaches.

Author contributions

AB: Writing—original draft, Writing—review & editing. CM: Writing—review & editing. AS: Writing—review & editing. MT: Writing—review & editing.

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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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