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Editorial: Structure and functioning of alpine treeline ecosystems

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Editorial on the Research Topic
Structure and functioning of alpine treeline ecosystems

Alpine treelines represent the uppermost limit of forest growth and serve as critical ecological boundaries between cold-tolerant, non-arboreal vegetation and forested communities (Negi et al., 2025). The intricate relationships between vegetation, soils, climate, snow, topography, and disturbance regimes shape treeline ecotones (Schwab et al., 2021; Wani and Pant, 2021; Schickhoff et al., 2023; Lu et al., 2025). These ecotones have drawn increasing attention in recent decades as sensitive indicators of environmental change (Körner and Change, 2018; Singh et al., 2021; Lu et al., 2021; Dandan et al., 2022; Chen et al., 2022; Xie et al., 2025), yet their responses over decadal to millennial timescales are complex and governed by poorly understood lags and feedbacks (Holtmeier and Broll, 2019). Our understanding of the patterns, processes, functioning, and ecosystem services of alpine treeline ecotones and their underlying drivers is still limited. This Research Topic aims to stimulate more and wider discussions about the manifold interactions in treeline ecosystems that influence the products and services on which people rely, the role of natural and human disturbances in affecting these sensitive ecosystems, and strategies to improve their functioning and management. We invited contributions focusing on treeline structure and functioning, degradation of treelines and its drivers, treeline biodiversity in response to global change, vulnerability of treeline ecosystems to climate change, ecosystem services provided by treeline ecosystems and challenges to the functioning of treeline ecosystems and restoration practices.

Among the contributions, Kumar and Pandey conducted a bibliometric analysis of more than a century of research on *Cedrus deodara*. Their study provides a comprehensive evaluation and visualization of research on *C. deodara* over the past 100 years. It also offers consolidated information and a research framework for scholars, policymakers, and the general public by identifying key research gaps and future directions. Bibliometric analysis studies have played a significant role in science and technology management and decision-making and such studies have received considerable attention, as they provide valuable information on scientific research and its progression in a specific field of study (Wani et al., 2023; Ridwan et al., 2023; Wani et al., 2024).

Paul et al. assess the population status and predict highly suitable areas of *Hippophae rhamnoides* subsp. *turkestanica* in the Trans-Himalayan region under changing climatic conditions. The predicted distribution maps of the species would help policymakers and decision-makers design appropriate management and sustainable utilization approaches in the near future. Khan et al. assessed the population dynamics of *Iris hookeriana*, along with its primary threats to survival in the subalpine and alpine zone of Hindu-Himalayan Mountains. The study emphasized the significant role of topographic and edaphic factors in shaping its distribution. Hoyos et al. evaluate how six different populations of *Polylepis quadrijuga* with distinct levels of anthropogenic disturbance affect foliar, stem, and root functional traits. The study showed that indicator species and plant associations vary with changing environmental conditions, providing valuable insights for sustainable biodiversity management in subalpine and alpine ecosystems of the Hindu-Himalayan Mountains. Thakar and Dave quantified the population status, distribution, impact of anthropogenic disturbances and ethnobotanical applications of *Dactylorhiza hatagirea* in the Paddar Valley of North-western Himalaya. The study provided essential insights for policy makers to develop conservation strategies for the species in this ecologically sensitive region. Angmo et al. provided the quantitative information on the population status and distribution pattern of the plant species frequently harvested from the wild in Western Ladakh, Indian Trans-Himalaya. The study recommended that there is an urgent need to initiate community led conservation action including closure of certain sites for extraction for few years, fixing the limits of harvest and self-regulated rotational harvest for other areas. All these studies underscore the importance of species-level ecological assessments in elucidating how treeline ecosystems respond to climate variability and anthropogenic pressures. Such research not only enhances our understanding of treeline biodiversity patterns but also supports conservation planning and restoration strategies.

Author contributions

ZW: Writing – original draft, Investigation, Validation, Visualization, Project administration, Conceptualization, Writing – review & editing. ZA: Investigation, Writing – review & editing, Conceptualization, Writing – original draft, Project administration, Validation, Visualization. JB: Project administration, Writing – review & editing, Writing – original draft, Data curation, Conceptualization, Investigation, Visualization.

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Conflict of interest

The author(s) declared that this work 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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The author(s) declared that generative AI was not used in the creation of this manuscript.

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