



OPEN ACCESS

EDITED AND REVIEWED BY
Lauren Bennett,
The University of Melbourne, Australia

*CORRESPONDENCE

Aziz Ebrahimi
✉ aebrahi@purdue.edu
Alireza Rahemi
✉ a.rahemi@moreheadstate.edu

RECEIVED 09 February 2026
REVISED 19 March 2026
ACCEPTED 20 March 2026
PUBLISHED 10 April 2026

CITATION

Ebrahimi A and Rahemi A (2026)
Editorial: Forest growth in a changing
climate: insights from predictive
modeling and adaptive strategies.
Front. For. Glob. Change 9:1807606.
doi: 10.3389/ffgc.2026.1807606

COPYRIGHT

© 2026 Ebrahimi and Rahemi. This is an
open-access article distributed under the
terms of the [Creative Commons
Attribution License \(CC BY\)](#). The use,
distribution or reproduction in other
forums is permitted, provided the
original author(s) and the copyright
owner(s) are credited and that the
original publication in this journal is
cited, in accordance with accepted
academic practice. No use, distribution
or reproduction is permitted which does
not comply with these terms.

Editorial: Forest growth in a changing climate: insights from predictive modeling and adaptive strategies

Aziz Ebrahimi^{1*} and Alireza Rahemi^{2*}

¹Hardwood Improvement and Regeneration Center (HTIRC), Purdue University, West Lafayette, IN, United States, ²Department of Agricultural Sciences, Morehead State University, Morehead, KY, United States

KEYWORDS

carbon balance, climate variability, dendrochronology, drought, machine learning, regeneration, remote sensing, resilience

Editorial on the Research Topic

[Forest growth in a changing climate: insights from predictive modeling and adaptive strategies](#)

Forests and woodlands, which are among the most productive ecosystems on land, cover 31.7% of terrestrial ecosystems and span almost as much area as the least productive ecosystems, such as deserts and tundra (Wright and Boorse, 2017). Unfortunately, forests worldwide face increasingly complex and varied growth responses as climate conditions continue to change. Human influence on the carbon cycle has been considerable and is driving global temperature rises. Changes in temperature patterns, precipitation, drought severity, and radiation interact with local site conditions, species traits, and stand development, affecting forest productivity, resilience, and long-term dynamics (Liang et al., 2016). Although observational studies have long documented climate-growth relationships, predicting future forest trajectories requires combining empirical data with predictive and mechanistic models. This Research Topic was organized to promote such integration by gathering studies that examine forest growth, resilience, regeneration, and ecosystem functions across different biomes, employing complementary analytical approaches.

The contributions to this Research Topic cover boreal, temperate, subtropical, and alpine forest systems and include a wide range of species and environmental gradients. Together, they show that forest growth responses to climate change are highly context-dependent and increasingly influenced by water balance, climatic extremes, and biotic interactions. Rather than providing uniform conclusions, the studies highlight how predictive modeling can be used to disentangle interacting drivers of growth and to guide adaptive forest management strategies tailored to specific ecological settings.

Climate controls on tree growth across regions and species

Several studies in this Research Topic identify the climatic and environmental variables that most strongly influence tree growth. By integrating dendrochronological data with predictive modeling, they demonstrate that growth responses arise from interactions among climatic and edaphic factors rather than from single drivers.

Across the Caucasus, sweet chestnut (*Castanea sativa*) growth was significantly influenced by stand age, minimum temperature of the coldest month, precipitation during the driest quarter, soil nitrogen, and soil pH (Metreveli et al.). Growth responses varied by developmental stage: younger stands (<50 years) showed higher growth rates under mild winters and moderate late-winter-to-early-spring precipitation, whereas older stands showed weaker responsiveness to these climatic conditions. This contrast indicates that climatic sensitivity is age-dependent, with early developmental stages benefiting more from favorable temperature and moisture regimes. Scenario projections further revealed regionally variable outcomes under future climate pathways, highlighting the importance of limiting extrapolation to conditions represented in the model training data.

Similarly, projections for sessile oak (*Quercus petraea*) and Turkey oak (*Q. cerris*) in southwestern Hungary showed that the statistical effect of winter water balance on basal area increment was stronger at drier than wetter sites (Móricz et al.). In addition, *Q. cerris* was more sensitive to summer water balance than *Q. petraea*, underscoring the importance of incorporating site-specific hydrological controls and species-level differences into predictive growth models.

Integrating tree rings, remote sensing, and climate extremes

Advances in forest growth research increasingly rely on integrating multiple data streams to capture dynamics across different spatial and temporal scales. A study on *Larix sibirica* in the Altai Mountains combined tree-ring width indices, MODIS NDVI, and extreme climate indices to reconstruct long-term vegetation dynamics and project future growth trends (Che et al.). Significant correlations between radial growth and growing-season NDVI indicated a link between stem-level growth and canopy-scale productivity, while site-specific responses to extreme temperature and precipitation events highlighted the impact of climatic extremes on future trajectories. This multi-proxy approach demonstrates the importance of connecting dendrochronological records with remote sensing data to improve the detection of growth decline and enhance projections under increasingly variable climate conditions.

Extreme growth reduction events and forest resilience

Beyond gradual trends, extreme climatic events significantly influence forest vulnerability and resilience. A large-scale synthesis of tree-ring data from northern high-latitude regions measured historical extreme reductions in growth and separated resilience into resistance and recovery components (Tei). While the frequency of extreme growth-reduction events remained relatively consistent across regions, recovery capacity varied substantially. Lower resilience in some areas was primarily attributable to limited post-event recovery rather than to stronger initial growth suppression. These findings emphasize that recovery processes are a key determinant of long-term forest stability and suggest that management strategies aimed at enhancing post-disturbance recovery may substantially improve resilience under increasing climate extremes.

Mechanistic responses to climatic stressors

Several studies provide mechanistic insights into how climate stressors influence tree physiology and growth. An experimental study on *Shima superba* and *Phoebe bournei* seedlings demonstrated species-specific responses to intensified UV-B radiation, affecting photosynthesis, stomatal conductance, transpiration, and secondary metabolite production, suggesting differential vulnerability under altered radiation regimes (Parsons et al.).

At the northern limit of sugar maple (*Acer saccharum*) in Québec, a rainfall exclusion experiment showed that soil moisture under excluders declined to 56% of control plots, reducing basal area increment, particularly where understory beech (*Fagus grandifolia*) saplings proliferated (Parsons et al.). Rainfall exclusion increased foliar Mg insufficiency and altered soil nutrient supply patterns, including shifts in inorganic nitrogen, base cations, and acidity (Parsons et al.). These findings demonstrate that even modest drought can disrupt growth and nutrient dynamics through interacting abiotic and biotic mechanisms.

Ecosystem productivity and carbon balance

Forest growth responses correlate with ecosystem-level carbon dynamics. Using an optimized InTEC model, a study of subtropical forests in Zhejiang Province showed that the climate sensitivity of net ecosystem productivity varies with forest age (Zhang et al.). During early developmental stages, productivity is most strongly affected by precipitation, temperature, and solar radiation, while mature forests show a stronger negative response to temperature. These findings highlight the importance

of incorporating age-dependent processes into ecosystem models when assessing future carbon-sink potential.

Regeneration, population structure, and long-term dynamics

Long-term forest sustainability depends on successful regeneration and population structure. A synthesis of research on environmental controls of natural forest regeneration highlighted the roles of light availability, water resources, wind, soil properties, topography, and groundcover, while identifying key knowledge gaps in wind effects, coppicing regeneration, and predictive modeling (Liu). Complementing this review, an analysis of *Abies* forests in southeastern Tibet revealed clustered distributions of small trees, scarcity of medium- and large-diameter individuals, and variable spatial associations among species and developmental stages (Huang et al., 2024). These structural patterns provide insights into regeneration bottlenecks and coexistence mechanisms in climatically sensitive alpine forests.

Conservation strategies

Tropical dry forests (TDF) harbor rich flora and fauna that provide essential ecological services to surrounding human communities. Biodiversity assessment is critical for sustainable forest management, particularly in regions facing increasing environmental pressures (Shahzad et al.). Vegetation analyses across threatened forest sites in District Sialkot, Pakistan, documented 170 plant species distributed among herbs, trees, and shrubs, with herbs dominating. Principal coordinate analysis identified temperature, precipitation, soil pH, organic matter, Ca^{2+} , Mg^{2+} , Na^+ , Cl^- , and electrical conductivity as key environmental drivers shaping vegetation patterns (Shahzad et al.). Increasing temperature trends and declining rainfall indicate significant climatic influences on plant biodiversity. SWOT analysis further showed that population growth, housing development, road construction, farming practices, and excessive grazing are major anthropogenic pressures altering ecosystem structure and functioning. Future conservation strategies emphasize reducing unlawful resource consumption, restoring biodiversity within protected areas, and conserving rare species locally (Shahzad et al.).

Coastal forest growth responses to sea level rise and climate variability

Understanding how coastal forests respond to climate change and sea level rise is crucial for predicting ecosystem changes in low-lying areas. A study examining coastal forests along the Delaware and Barnegat Bays used dendrochronology

to evaluate how tree growth reacts to climatic variability and rising tidal flooding (Haaf and Dymond). By analyzing tree-ring widths of *Pinus taeda*, *Pinus rigida*, and *Ilex opaca* across environmental gradients, the authors employed gradient-boosted linear regression to assess the relationships between radial growth and factors like temperature, precipitation, and tidal water levels. Results showed that climate change and increased flood frequency can produce complex, non-linear effects on tree growth, with responses varying among species and locations. These findings highlight that local environmental conditions and species-specific tolerances strongly influence coastal forest resilience, emphasizing the importance of site-specific management strategies as sea levels rise and flooding becomes more frequent.

Modeling habitat suitability of alpine *Rhododendron* under climate change

Predicting how species distributions may shift under climate change is essential for conservation planning and the sustainable use of plant resources. Using ecological niche modeling, Dong et al. applied the Maximum Entropy (MaxEnt) model to forecast the potential habitat suitability of *Rhododendron delavayi*, a popular ornamental and medicinal alpine species native to Southwest China. By combining species occurrence records with environmental variables, the study identified key climatic and ecological factors influencing the species' distribution and projected how suitable habitats might change under different climate scenarios. The results provide insights into environmental constraints affecting the species' range and highlight regions with high habitat suitability for future conservation and cultivation efforts. These findings offer an important scientific basis for the introduction, domestication, and management of alpine *Rhododendron* species in the face of changing climate conditions.

Predicting pathogen distribution under climate change

Understanding how forest pathogens might change their geographic ranges under climate change is vital for proactive disease management and forest protection. Using ecological niche modeling, Li et al. applied an optimized Maximum Entropy (MaxEnt) model to forecast the potential distribution of *Cytospora chrysosperma*, the cause of cytospora canker, across Xinjiang, China. Based on occurrence records and various environmental factors, the study identified key climatic drivers influencing pathogen spread, including precipitation seasonality and potential evapotranspiration patterns. Model projections showed that large areas of Xinjiang currently offer suitable habitat for the pathogen and that its distribution center could shift under future climate conditions. These results underscore the growing importance of climate-aware

disease risk assessments and provide a scientific foundation for monitoring, prevention, and management efforts to reduce the impacts of cytospora canker on regional forest and fruit industries.

Conclusions and future directions

Together, the studies in this Research Topic enhance understanding of forest growth in a changing climate by combining empirical observations with predictive and mechanistic modeling across various forest systems. A consistent message is that growth responses are highly context-dependent and increasingly influenced by water balance, climatic extremes, and recovery processes. Future research will benefit from deeper integration of physiological mechanisms, multi-proxy datasets, and demographic processes into growth models. Such comprehensive approaches are vital for improving forecasts of forest dynamics and guiding adaptive management strategies amid ongoing environmental change.

Author contributions

AE: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AR: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

References

Huang, D., Ren, Y., Yang, S., Zhao, Y. and Zhao, G. (2024). Population structure and dynamic characteristics of three endemic Chinese *Abies* species in southeastern Tibet, China. *Front. Ecol. Evol.* 12:1487984. doi: 10.3389/fevo.2024.1487984

Liang, J., Crowther, T. W., Picard, N., Wiser, S., Zhou, M., Alberti, G., et al. (2016). Positive biodiversity-productivity relationship

Acknowledgments

We thank Wook Jin Choi for serving as a co-editor of this Research Topic of the article published in *Frontiers on Forests and Global Change-Forest Growth*.

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.

Generative AI statement

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

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

predominant in global forests. *Science* 354:aaf8957. doi: 10.1126/science.aaf8957

Wright, R. T., and Boorse, D. F. (2017). *Environmental Science, Toward a Sustainable Future*, 13E. Indianapolis, IN: Pearson Publication, 676.