Frontiers in Forests and Global Change

TYPE Editorial
PUBLISHED 25 July 2023
DOI 10.3389/ffgc.2023.1256577

Check for updates

OPEN ACCESS

EDITED AND REVIEWED BY
Aaron Shiels,
Animal and Plant Health Inspection Service (USDA), United States

*CORRESPONDENCE
Renée M. Marchin
r.prokopavicius@westernsydney.edu.au
Zuoqiang Yuan
zqyuan@nwpu.edu.cn

RECEIVED 11 July 2023
ACCEPTED 13 July 2023
PUBLISHED 25 July 2023

CITATION
Marchin RM and Yuan Z (2023) Editorial: Natural tree seedling establishment and forest regeneration under climate change. *Front. For. Glob. Change* 6:1256577. doi: 10.3389/ffgc.2023.1256577

COPYRIGHT
© 2023 Marchin and Yuan. 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: Natural tree seedling establishment and forest regeneration under climate change

Renée M. Marchin[1]* and Zuoqiang Yuan[2]*

[1]Hawkesbury Institute for the Environment, Western Sydney University, Penrith, NSW, Australia, [2]School of Ecology and Environment, Northwestern Polytechnical University, Xi'an, China

KEYWORDS
seedling survival, forest distribution, drought, warming, elevated CO_2, remote sensing

Editorial on the Research Topic
Natural tree seedling establishment and forest regeneration under climate change

Forests provide valuable ecosystem services including carbon storage, water capture and supply, and local climate regulation (Miura et al., 2015) but are increasingly threatened by climatic changes and associated disturbances such as forest fires, drought, and storms. Large-scale mortality events have occurred in all forest biomes and are associated with hotter droughts (Hammond et al., 2022). The hotter, drier edge of species' ranges are becoming unsuitable in some landscapes, initiating conversion of forests to non-forested states (Davis et al., 2019).

Natural regeneration is required for long-term forest survival and relies on successful seedling establishment. Many variables influence forest regeneration, including soil temperature, soil fertility, and the existence of favorable microsites. Newly emerged seedlings are vulnerable before their root system develops, whereas established seedlings and mature trees have carbon and water stores and are more resilient to episodic climatic events. A better understanding of the processes influencing seedling survival is needed for predicting changes in forest extent.

This Research Topic of six articles explores the factors influencing seedling establishment and survival, from seedling to sapling to tree. The Research Topic outlines critical knowledge gaps and advances our understanding of how forest regeneration may change in the future. These studies span boreal forests in Canada and Sweden, conifer forests in the western USA, and temperate and subtropical forests in Asia.

In their review, Brodersen et al. outline a gap in forestry research—understanding the mechanisms by which climate, and other factors, inhibit seedling establishment at mountain forest boundaries. The upward elevational movement of timberlines depends on recruitment in favorable microsites facilitated by microtopography, existing vegetation, or inanimate objects (e.g., rocks, fallen logs). To enable cross-study comparisons, the authors proposed terminology to differentiate "emergent seedlings"—the initial 1–2 years of growth when cotyledons are present—from "established seedlings" that have developed their first set of leaves.

They advocated for further research aimed at long-term monitoring of first-year seedling abundance and mortality at both upper and lower forest boundaries, identification of the nature and frequency of favorable microsites, and a better understanding of seedling ecophysiology.

To help predict future forest distribution in fire-prone landscapes across the western USA, Rank et al. assessed soil surface temperature as a predictor of conifer seedling survival and forest regeneration potential. First, the authors extracted survival data from past laboratory experiments that exposed seedlings to elevated soil surface temperatures for varying durations. Next, they developed logistic models to predict survival of individual seedlings for different species, including species with very few observations. They found that the concept of a lethal temperature strongly depends on the duration of exposure, particularly from 45 to 60°C. Their findings suggest soil surface temperature is a promising climate metric for characterizing the environmental boundaries suitable for seedling survival.

Jia et al. tested if green-optimized solar-induced chlorophyll fluorescence (SIF) vegetation index can be used for real-time monitoring of gross primary productivity (GPP) in subtropical and temperate monsoon regions of southwest China. They used satellite observations from 2000 to 2015 to assess the potential for large-scale monitoring of drought and GPP. At a monthly scale, SIF was more strongly correlated with GPP than traditional vegetation indices such as the normalized difference vegetation index (NDVI). In forests with complex canopy structure, monthly NDVI was relatively stable and failed to fully capture the effects of a winter drought event. In hot, wet regions that lack seasonal water limitations, SIF was a useful real-time monitoring tool for predicting GPP and monitoring drought effects over large spatial scales.

Using an experimental approach, Marty et al. investigated the effects of soil warming and increased nitrogen deposition on soil organic N mineralization and tree growth in two eastern Canada boreal forests. In response to 9 years of soil warming (+2–4°C) and canopy N addition (+0.30–0.35 kg N ha^{-1} yr^{-1}), the soil was remarkably stable. Net soil N mineralization, soil chemistry and fertility, and soil organic matter quality were barely impacted, despite evidence that some of the added N reached the forest floor. Minor changes in seedling growth and foliar chemistry may have been driven by mycorrhizal fungi. The main effect of soil warming was to accelerate bud development and budburst, suggesting boreal seedlings may be more vulnerable to late spring frosts in the future.

In boreal forests in Sweden, Jessen et al. investigated the effects of warming, both directly and indirectly through changes in understory vegetation, on growth and survival of seedlings. They planted 6,400 seedlings and removed competing understory plants (feather moss and/or ericaceous shrubs), then installed passive open-top chambers to increase air temperature (+0.4°C) at sites with varying successional status. Seedling growth and survival was affected by understory vegetation and successional status, but not warming. Seedling survival increased with feather moss removal, with the greatest benefit in old, late-successional forests with thick moss layers. For birch seedlings, this effect was canceled by shrub removal, possibly because shrubs protected young seedlings from herbivores. For pine species, growth of seedlings was promoted by both shrub and moss removal, suggesting facilitation among understory functional groups is highly species-specific.

Ugawa et al. investigated the effects of elevated CO_2 and/or O_3 on the growth and composition of organic constituents of stems in planted two-year-old seedlings of Japanese oak. Elevated CO_2 (550 ppm) increased leaf and stem growth, plus structural stem components such as holocellulose, while decreasing the extractive content of stems by 21%. Extractive compounds such as tannins, flavonoids, and terpenoids are non-structural but have an antimicrobial function that inhibits biodegradation. Seedling growth and organic constituents were not sensitive to elevated O_3 (twice ambient), but O_3 reduced the influence of elevated CO_2. Their findings suggest elevated CO_2 and O_3 may lead to faster decomposition of Japanese oak and altered C cycling of temperate forests in East Asia.

This Research Topic identified potential approaches for monitoring forest productivity and better understanding and predicting forest distribution. Other studies highlighted that many interacting environmental factors, such as warming, nitrogen deposition, and changing atmospheric gas concentrations, affect seedling survival. Filling the remaining research gaps will help to better understand forest regeneration and safeguard forest ecosystems.

Author contributions

RM drafted the manuscript. RM and ZY reviewed the text and approved the final version for publication. All authors contributed to the article and approved the submitted version.

Funding

ZY was supported by the National Natural Science Foundation of China (32171581), the National Science Foundation of Liaoning Province of China (2021-MS-028), and the Fundamental Research Funds for the Central Universities. RM was the recipient of an Australian Research Council Discovery Early Career Researcher Award (project DE200100649).

Acknowledgments

We would like to thank the authors, reviewers, and Frontiers Editorial Office for contributing to this Research Topic.

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

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.

Author disclaimer

The views expressed herein are those of the authors and are not necessarily those of the Australian Government or the Australian Research Council.

References

Davis, K. T., Dobrowski, S. Z., Higuera, P. E., Holden, Z. A., Veblen, T. T., Rother, M. T., et al. (2019). Wildfires and climate change push low-elevation forests across a critical climate threshold for tree regeneration. *Proc. Natl. Acad. Sci. U. S. A.* 116, 6193–6198. doi: 10.1073/pnas.1815107116

Hammond, W. M., Williams, A. P., Abatzoglou, J. T., Adams, H. D., Klein, T., López, R., et al. (2022). Global field observations of tree die-off reveal hotter-drought fingerprint for Earth's forests. *Nat. Commun.* 13, 1761. doi: 10.1038/s41467-022-29289-2

Miura, S., Amacher, M., Hofer, T., San-Miguel-Ayanz, J., and Thackway, R. (2015). Protective functions and ecosystem services of global forests in the past quarter-century. *For. Ecol. Manag.* 352, 35–46. doi: 10.1016/j.foreco.2015.03.039