frontiers | Frontiers in Forests and Global Change

TYPE Editorial
PUBLISHED 27 February 2024
DOI 10.3389/ffgc.2024.1379302

OPEN ACCESS

EDITED AND REVIEWED BY
Ana Cristina Gonçalves,
University of Evora, Portugal

*CORRESPONDENCE
Suzanne W. Simard
✉ suzanne.simard@ubc.ca

RECEIVED 30 January 2024
ACCEPTED 14 February 2024
PUBLISHED 27 February 2024

CITATION
Simard SW, Pickles BJ and Ryan ST (2024) Editorial: Retaining ecosystem legacies in forest management: effects on forest structures and functions.
Front. For. Glob. Change 7:1379302.
doi: 10.3389/ffgc.2024.1379302

Editorial: Retaining ecosystem legacies in forest management: effects on forest structures and functions

Suzanne W. Simard[1]*, Brian J. Pickles[2] and Sm'hayetsk T. Ryan[1]

[1]Faculty of Forestry, Department of Forest and Conservation Sciences, University of British Columbia, Vancouver, BC, Canada, [2]School of Biological Sciences, Ecology and Evolutionary Biology, University of Reading, Reading, United Kingdom

KEYWORDS

forest, soil, carbon, nitrogen, legacy, climate change, salmon, forest management

Editorial on the Research Topic
Retaining ecosystem legacies in forest management: effects on forest structures and functions

Introduction

Nature-based solutions have become a central focus of global climate policy for addressing the substantial terrestrial carbon and biodiversity deficits resulting from land-use change (IPCC, 2019). No longer is simply focusing on reducing greenhouse gas emissions from fossil fuels and cement production sufficient for avoiding catastrophic climate change; developing nature-based solutions to restore and protect existing carbon stocks, and enhance sequestration capacity, are also imperative (Austin et al., 2020). In addition to filling these historical deficits, enhancement of ecological resilience will be necessary to diminish accelerating greenhouse gas emissions resulting from severe climate-driven wildfires, insect outbreaks and forest diebacks (Sommerfeld et al., 2018). Forests in particular, along with other land and ocean ecosystems, are essential global carbon sinks, and protecting and enhancing their ability to sequester, store and safeguard carbon will be crucial strategies (Moomaw et al., 2020). Loss of forests to logging and other disturbances must be curbed, and degraded forest lands reforested, restored or pro-forested, and their health and resilience protected or enhanced (Tian et al., 2023). This Research Topic is particularly focused on the ecological legacies that underpin healthy forest structures and functions, and provides clues for nature-based solutions that protect them from forest management, wildfire and climate-associated losses.

Forests are complex systems composed of interconnected structures and functions across wide spatial and temporal scales, all nested within variable and shifting climatic patterns (Filotas et al., 2014). Forests experience continual managed and natural disturbances, and ongoing recovery and succession. Ecosystem legacies, or remnants that persist after disturbances, include "memory imprints" such as residual trees, dead wood, soils, seeds, above and below-ground biota, and biogeochemical cycles (Perry et al., 2008). Ecosystem legacies, or memory, are essential in the ability of the forest to recover and re-organize after disturbance, or to resist or adapt to climatic stress. In other words, ecological memory plays an important role in the direction of post-disturbance recovery of biotic communities, and hence in forest resistance and resilience to climate-driven disturbances. Understanding ecosystem legacies, therefore, is important in designing forest management regimes that foster resilience against global change.

This Research Topic gathered novel research findings on the role of ecosystem legacies in forest structure and function, and how these legacies are important in facilitating forest recovery from disturbance, as well as resistance, resilience, and adaptation to climatic stress. The Research Topic includes eight papers that emphasize: (i) carbon and nutrient legacies across climatic and salmon gradients in primary forests, (ii) wildfire, clearcutting, tree planting, and vegetation management effects on carbon and nutrient pools, and (iii) clearcutting, soil degradation, and tree planting effects on soil fungal communities essential to forest health.

Carbon and nutrient legacies in primary forests

Carbon and nutrient legacies were strongly influenced by regional climate aridity and salmon returns in the primary forests of British Columbia, suggesting that shifts in these ecosystem drivers with global change could affect forest productivity and carbon stocks. In their paper examining interior Douglas-fir forests across a regional climate gradient, Roach et al. found that total ecosystem carbon increased from 222 Mg ha^{-1} in an arid interior climate to 565 Mg ha^{-1} in a humid coastal climate, with about half in aboveground pools (trees and plants) and half belowground (coarse woody debris, forest floor, and mineral soil to 55 cm). Tree species richness was positively correlated with total carbon stocks, suggesting niche complementarity may enhance carbon sequestration. In the rainforests of the central coast of British Columbia, Larocque and Simard showed that increasing salmon density across 23 streams was associated with increased soil fertility, particularly as indicated by soil nitrate and ammonium. Soil fertility, and therefore forest productivity, was also correlated with greater tree and shrub diversity. Both of these studies show that increasing climatic aridity and declining salmon runs may be associated with loss of carbon and nutrient stocks from these Pacific forests.

Forest management effects on carbon and nutrient pools

The forest gradient of Roach et al. was used by Robinson et al. to calibrate the Carbon Budget Model of the Canadian Forest Sector in order to simulate the effects of forest harvesting and climate change on total ecosystem carbon stocks 50 years post-harvest. Increasing harvesting intensity led to significant losses in total ecosystem carbon stocks, with clearcuts containing 36% less carbon than uncut forests after 50 years. Under the high emissions representative compensation pathway, RCP 8.5, total carbon stocks were projected to decline by only 7%, but caution was expressed that belowground carbon stocks and climate driven disturbance effects were not well-represented by the model. Carbon pools were also found to be strongly affected by management practices by Clason et al., who examined a chronosequence of 21 wildfires across central British Columbia. Site preparation that removed deadwood to make way for tree planting resulted in substantial total ecosystem carbon losses. Tree planting was projected to increase live carbon stocks by only 3% over a century, prompting the authors to recommend preserving carbon legacies by forgoing site preparation when replanting burned forests. Sanborn and Ott found that silviculture treatments aimed at reducing alder cover had little effect on the growth of lodgepole pine crop trees, and they recommended minimal treatment of the early seral plant community was needed to maintain forest productivity. Together, these three studies show that intensive forest management practices involving clearcutting, site preparation or vegetation management can have negative effects on carbon and nutrient pools, and that forest management practices should be carefully designed to protect these legacies for future forests.

Forest management effects on soil fungal communities

Soil fungal communities are essential legacies to forest ecosystem function and regeneration. The negative effects of clearcut logging on mycorrhizal and pathogenic fungal communities, as well as the regenerating plant communities in the HJ Andrews forests of Oregon, persisted four decades later. Spencer et al. suggested that tree planting could speed up the recovery, but also cautioned that planted trees can also introduce novel fungi that could negatively affect the recovery trajectory. At deforested and eroded ectomycorrhizal oak-dominated woodlands in Central Mexico, Bermúdez-Contreras et al. found that planting of arbuscular mycorrhizal juniper trees significantly changed the fungal communities associated with planted oak seedlings, but oaks did not similarly affect junipers. The junipers appeared to form, or at least closely associate with, ectomycorrhizas in the presence of oaks, potentially forming mycorrhizal networks with the native plants. The authors found juniper promising for reforesting severely degraded sites, but also cautioned that planting of non-native tree species can have negative effects on native ectomycorrhizal fungal communities in more intact woodlands. In the high elevations of the Columbia Mountains in interior British Columbia, Southam et al. found that the composition of the ectomycorrhizal fungal community was predictive of the health of whitebark pine trees and their resistance to a fungal pathogen, white pine blister rust. Planted whitebark pine seedlings and surrounding soils were diminished in ectomycorrhizas compared with naturally regenerated trees, and may be due to site effects that will compromise planted seedling survival. All three of these studies show that the legacy of the mycorrhizal fungal community from the pre-disturbance forest is important in the success of reforestation or restoration of disturbed areas, and retention of native trees, plants and soils can facilitate the re-assembly of healthy soil fungal communities.

Collectively, the findings from these eight studies highlight that protecting ecosystem legacies, or memory imprints, in forests, including migrating salmon, deadwood, trees, plants and mycorrhizal fungal communities, are important in carbon and nutrient accumulation and storage in ecosystems, as well as recovery and productivity of the forest. Carbon and nutrient stocks vary widely along natural gradients in climatic aridity and soil fertility, and this variation can provide insight into potential losses of these legacies as climatic or biotic (e.g., salmon lifecycle) conditions change. These stocks also provide insights into the importance of protecting forest legacies and memory for mitigating losses under anthropogenic climate change or altered disturbance regimes. Forest management practices focused on timber extraction and regrowth ought to be adjusted to protect carbon, nutrient and fungal legacies for the heath of future forests and soil productivity. Protection of salmon, legacy trees, natural regeneration, coarse woody debris and early successional plant communities are important techniques that can foster resilient forests for the future. By better understanding how these complex adaptive systems symbiotically function illustrates the critical need for forest management changes to value healthy forests as natural nature-based solutions.

Author contributions

SS: Conceptualization, Writing—original draft, Writing—review & editing. BP: Conceptualization, Writing—review & editing. TR: Conceptualization, Writing—review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. SS and BP were supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) STPGP 478832 - 15 and SS and TR were supported by the Donner Canadian Foundation E-47-19.

Acknowledgments

We would like to thank all authors and reviewers for their contributions to this Research Topic and the Editorial Office for their support in creating 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.

References

Austin, K. G., Baker, J. S., Sohngen, B. L., Wade, C. M., Daigneault, A., Ohrel, S. B., et al. (2020). The economic costs of planting, preserving, and managing the world's forests to mitigate climate change. *Nat. Commun.* 11:5946. doi: 10.1038/s41467-020-19578-z

Filotas, E., Parrott, L., Burton, P. J., Chazdon, R. L., Coates, K. D., Coll, L., et al. (2014). Viewing forests through the lens of complex systems science. *Ecosphere* 5:art1. doi: 10.1890/ES13-00182.1

IPCC (2019). *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems: Chapter 1: Framing and Context*. Geneva: IPCC.

Moomaw, W. R., Law, B. E., and Goetz, S. J. (2020). Focus on the role of forests and soils in meeting climate change mitigation goals: summary. *Environ. Res. Lett.* 15:e045009. doi: 10.1088/1748-9326/ab6b38

Perry, D. A., Oren, R., and Hart, S. C. (2008). *Forest Ecosystems, 2nd Edn*. Baltimore, MD: The Johns Hopkins University Press.

Sommerfeld, A., Senf, C., Buma, B., D'Amato, A. W., Després, T., Díaz-Hormazábal, I., et al. (2018). Patterns and drivers of recent disturbances across the temperate forest biome. *Nat. Commun.* 9:4355. doi: 10.1038/s41467-018-06788-9

Tian, D., Xiang, Y., Seabloom, E., Wang, J., Jia, X., Li, T., et al. (2023). Soil carbon sequestration benefits of active versus natural restoration vary with initial carbon content and soil layer. *Nat. Commun.* 4:83. doi: 10.1038/s43247-023-00737-1