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Editorial: Forests under pressure: The need for interdisciplinary approaches to address forest vulnerability to tree mortality in response to drought

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Editorial on the Research Topic
Forests under pressure: The need for interdisciplinary approaches to address forest vulnerability to tree mortality in response to drought

Introduction

Extensive tree mortality and widespread forest dieback (i.e., high tree mortality rates at local to regional scales) linked to drought and temperature stress is an emergent concern in many forests that are sensitive to climate change. These dieback episodes highlight how the high vulnerability of forest ecosystems to climatic stressors can manifest as losses in tree vigor (e.g., leaf shedding, canopy and shoot dieback, growth decline, and ultimately tree death). Extended to a larger scale, dieback phenomena may lead to multiple joint effects on biosphere-atmosphere interactions and may play an important role in future water-carbon-cycle feedbacks through complex effects on forest biophysical properties and biogeochemical cycles. The assessment of forest vulnerability and forecasting changes in tree health in the context of climate change are complex issues, with various specific critical ecological, social, and economic thresholds across biomes and countries. Notwithstanding the variety of specific issues to solve, interdisciplinary research and networking are crucial to improve the monitoring of tree mortality and forest dieback. Therefore, this Research Topic of nine papers intends to improve our understanding of how forest ecosystems respond to global warming, especially to drought-induced climate change, covering different aspects, scales, methodologies, and approaches in the study of forest health.

Importance of hydraulic traits

Investigating the causes and mechanisms behind forest mortality is a research priority. The failure of the hydraulic system can be an important contributor to dieback phenomena and was reviewed by Anfodillo and Olson to explore possible links between vulnerability to drought-induced *hydraulic failure* and xylem water-transporting conduit diameter.

Although existing physiological experiments have failed to find a consistent diameter-vulnerability link, the authors maintain caution before rejecting this possibility, as the majority of the studies are from temperate regions. Additionally, there is an absence of experiments examining vulnerability in a wide range of conduit diameters under similar tensions in species adapted to frost-free and drought-prone habitats. Zhao et al. highlighted the importance of *hydraulic traits* in shaping community assembly patterns with different water availability conditions. They tested the difference between economic and hydraulic traits under different conditions of water availability in a large survey experiment of 167 species across two contrasting climatic regions (i.e., semi-arid and humid) in China. Their findings may have significant consequences for predicting plant species responses to drought-induced climate change. Using a dendroecological and process-based growth model approach, Valeriano et al. investigated two *Pinus pinaster* stands with contrasting growth rates and showing recent dieback in north-eastern Spain. They demonstrated that stand vulnerability to drought is contingent on site-specific conditions and highlighted the role of environmental conditions, such as access to soil water or *hydraulic traits,* and suggested their inclusion in process-based growth models to better forecast dieback.

Monitoring forest vulnerability using a remote sensing approach

Satellite-borne remote sensing is a suitable method for monitoring networks that enables the near real-time identification of forests that are subjected to dieback phenomena. Buras et al. created the European Forest Condition Monitor (EFCM), which is a remote-sensing based, freely available, interactive web information tool. Using six specific examples related to spring phenology, drought, late-frost, tree dieback, ice storm, and windthrow, the authors highlighted how the EFCM, by using the remotely sensed forest greenness data, may have the potential to aid in identifying hotspots of forest decline. Furthermore, they discussed the advantages and limitations when monitoring forest conditions at large scales to help guide potential users toward an appropriate interpretation. With freely available cloud computing infrastructures, such as the Google Earth Engine, access to satellite data and high-performance computing resources has become straightforward. Montzka et al. employed Sentinel-2 satellite data for monitoring tree crown transparency in spruce stands of the Northern Eifel region in Germany. They provided interesting insights that showed an increase in damaged trees from 2018 to 2020 in the region and identified sites where forest management may help by transforming spruce monocultures to mixed forests to improve biodiversity and resilience in future negative climate scenarios.

Assessing drought and other disturbance impacts on forests

Drought is considered one of the key drivers of forest dieback but other disturbances, in combination with drought, may also play a relevant role at large and small scales. San-Eufrasio et al. examined how 8-month *Quercus ilex* seedlings from three contrasting Andalusian populations responded to the combined stresses of *Phytoptora cinnamomi* (a widespread soil-borne pathogen causing root rot and cankering) and drought using morphological, physiological, and proteomics data. In all three populations, seedling damage (leaf chlorosis and necrosis) and mortality were greater under combined stresses; however, resilient individuals were also identified, at different percentages, in all the populations, linking variable proteins as putative markers for resilience in *Q. ilex*. Furthermore, Wang et al. applied an attribution approach to quantify the area and potential carbon loss/transfer in the continental US from four types of disturbances (anthropogenic, fire, drought-associated, and other) from 2000 to 2014. Anthropogenic disturbances were the most important drivers, contributing to 58.1%, whereas natural disturbances accounted for ∼41.9% of potential carbon loss/transfer. This result suggests that natural disturbances also played a crucial role in forest carbon turnover, and that these data can be used for evaluating the performances of predictive models of tree mortality under droughts. Shan et al. used extreme climate indices and tree-ring data to investigate the effects of climate events and anthropogenic activities on wild forests. Under the prolonged influence of inappropriate anthropogenic activities, extreme climate events caused the outbreak of pests and diseases resulting in the degeneration of wild forests. Zhang et al. focused on malondialdehyde, a substance produced by membrane lipids, that can be used as a drought indicator to evaluate the degree of plasma membrane damage and the ability of plants to tolerate drought stress. They applied the best malondialdehyde-predicting model to two exotic conifer tree species as plant material exposed to drought stress.

Altogether, these nine contributions to this Research Topic cover several aspects of forest vulnerability and mortality. This collection demonstrates advances in investigating and monitoring forest vulnerability and tree mortality from the local to regional scales. Some of these papers focused on a singular issue related to the mechanisms (i.e., hydraulic traits) involved in dieback phenomena, while other papers in this Research Topic highlighted the importance of remote sensing in detecting forest areas subjected to mortality phenomena. Each of the nine papers identified knowledge gaps and outlined future research directions. Overall, by reading these papers comes out the need to fill the gaps through integrated multi-scale (from cells to plant community), multi-temporal (from xylogenesis to long-term forecasting) and multi-method (from microscopy to satellite applications) approaches.

Author contributions

FR and AR drafted manuscript preparation. All authors reviewed the text and approved the final version of the manuscript.

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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.

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