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Editorial: The potential impacts of climate change on the distribution of tree species

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Editorial on the Research Topic
The potential impacts of climate change on the distribution of tree species

We are presently standing on the brink of a climate crisis, with the ramifications of climate change on our planet's ecosystems becoming more evident by the day. One of these impacts is the potential redistribution of tree species. Trees are the backbone of terrestrial ecosystems, offering habitat, sustenance, and numerous essential ecosystem services. Therefore, understanding the potential effects of climate change on tree species distribution is key to mitigating its adverse outcomes on both the natural world and human societies.

Species distribution models (SDMs), also known as ecological niche models, are numerical models based on species presence data or species abundance data along with environmental variables as predictors. In these models, within a multidimensional mathematical space composed of environmental factors, the ecological niche requirements of species are modeled based on statistical information provided by sampling points (Guo et al., 2020). These requirements are then projected into a defined spatiotemporal space and expressed in probabilistic form to reflect the degree of species preference for the habitat. The model results typically represent the distribution of suitable habitats for species at a larger spatial scale. Currently, SDMs are one of the primary tools for studying the impact of climate change on species distribution and are widely applied (Anderson, 2013; Guo et al., 2023). Xie et al. employed two tools to fit SDMs, BIOCLIM and DOMAIN, to assess the potential geographical distribution of the invasive plant *Mimosa bimucronata* (DC.) Kuntze in China under current climatic conditions and various future climate change scenarios. He et al. suggests that the two subspecies of *Hippophae rhamnoides* respond differently to climate change, and therefore, conservation measures should be tailored to their respective ecological characteristics. La Montagna et al. concentrate on the distribution and niche characterization of the four endemic *Commiphora* species in Socotra and investigate the potential impacts of climate change on these species.

However, our current understanding and methodologies to study this vital topic are far from sufficient. The traditional data-driven approach has its limits (Carlson et al., 2020). Armed with the big data and rich ecological observations, like phenology, plant traits, tree rings, and physiological parameters such as root physiological parameters, chlorophyll content, light saturation point, it's high time we improved our modeling framework. For example, Chen et al. conducted research on the cellulose and lignin degradation of leaf litter from the two most dominant tree species along an elevational gradient, offering new insights into the relationship between species and the environment. Li et al. conducted lab experiments to investigate the interrelations among leaf functional traits in the desert poplar (*Populus euphratica*). This study explores the survival strategies of species under extreme environmental conditions and provides an example of the physiological explanation of species distribution. Lalor et al. conducted laboratory experiments to investigate the impact of drought on the survival rate of young trees, aiming to uncover the mechanisms through which future climate change poses a threat to tree distribution. This research holds significant importance for the understanding of the relationship between species distribution and environmental factors. Swanson et al. underscored the supportive role of downed woody debris in tree growth when facing the challenges of climate change, providing a crucial strategy for ecosystem restoration and forest management.

The integration of these ecological knowledge and data with current SDMs could potentially enhance their performance, increase their interpretability, and enhance their generalizability. This fusion of ecology and machine learning is a promising path forward for our modeling efforts. Zhao et al. have developed a novel model framework that utilizes observed data from Illingworth provenance trials and employs the universal response function (URF) approach to simulate and predict the fundamental climate niche of lodgepole pine. This provides insights for the construction of innovative knowledge-data-driven ecological niche models.

Furthermore, it is imperative that we seriously consider adopting cutting-edge methods and technologies from the field of artificial intelligence (AI), such as generative AI. Notably, Generative Adversarial Networks (GANs) have demonstrated the capacity to extract geographic attributes from web maps and satellite images linked to a specific location and transfer these attributes to another area. Additionally, causal analysis methodologies, extensively employed to enhance climate and weather prediction models, have displayed significant potential. Moreover, reinforcement learning holds promise in enhancing performance and efficiency in geospatial information processing (Li et al., 2023). By integrating these advanced AI technologies and methodologies, the potential for fresh insights and improved modeling capabilities can be unlocked. To effectively address the climate crisis and avert its worst consequences, we must refine our approach, utilize all available tools, and transcend conventional methodologies.

This Research Topic has identified potential approaches to enhance our understanding and prediction of tree distribution under future climate change. It includes examples that illustrate the impact of climate change on tree species. Additionally, other studies have analyzed the relationship between tree distribution and environmental factors through both laboratory and field experiments. These efforts have facilitated a more comprehensive apprehension of how climate change affects trees. Furthermore, one of the studies introduced an innovative species distribution modeling framework, adding a valuable tool to our arsenal for studying tree distribution dynamics. By addressing the remaining research gaps, we can further advance our knowledge of the potential consequences of climate change on the distribution of tree species.

Author contributions

YG: Writing – original draft. CL: Writing – review & editing. WG: Writing – review & editing. ZZ: Writing – review & editing. DY: Writing – review & editing.

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Conflict of interest

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