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Editorial

Impacts of Climate Change on Tree Physiology and Responses of Forest Ecosystems

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1. Tree Adaptive Responses to Climatic Variability

In a changing climate, forest trees have to deal with a range of altered environmental conditions. Within this Special Issue, researchers aimed at revealing the responses of different forest species to various globally changing abiotic parameters, such as increasing atmospheric CO_2, elevated temperatures, and limited water availability.

In an experiment with open-top chambers, Kim et al. [1] studied the physiological and transcriptome responses of Poplar hybrids to elevated CO_2, being one of the main components of global change. They identified differentially expressed genes and alterations in chlorophylls, starch, and soluble sugars in response to increasing CO_2. The impact of elevated CO_2 was also assessed by Wang et al. [2], who reported photosynthetic declines in *Phoebe bournei* Hemsl., an endemic tree threatened by habitat loss in China. However, they concluded that this negative impact of increased CO_2 may be alleviated by the application of ammonium or nitrate fertilization. The effect of drier growth conditions on the tree radial profile of sap flow was assessed in a coastal Mediterranean Aleppo pine ecosystem [3]. A steeper decline in sap flux density with increasing sapwood depth was observed in drier periods. The limiting role of water availability in such xerothermic environments was further supported by the fact that sap flow responded positively to a favorable microclimate only when water availability exceeded a certain threshold. The effect of rising temperature was studied by Sambayo-Maldonado et al. [4] who assessed the thermal time and cardinal temperatures of *Cedrela odorata* in order to estimate changes in the germination of red cedar under different climate change scenarios. It was found that as the temperature increases in line with the predictions for 2050 and 2100, the germination of the soil seed bank will accelerate, which may have implications for the future distribution of this important forest species in tropical environments.

Common gardens and provenance trials are an experimental approach offering long-term information regarding the potential of different forest species and origins to adapt to future climate. In order to assess the suitability of different Mediterranean oak species for potential assisted migration schemes in central Europe, Bantis et al. [5], established a four common garden experiment and evaluated the early field performance of oak seedlings of different species and provenances. Based on survival rates, morphological, and physiological features, they concluded that *Quercus pubescens* may be a suitable candidate forest tree for poor and dry soils under the expected summer heat and drought conditions in Central Europe. In the same context, a provenance trials approach was used to evaluate nine European beech (*Fagus sylvatica* L.) provenances under contrasting climates [6]. An acclimation potential of provenances transferred to warmer and drier conditions was indicated by the development of smaller leaves with decreasing stomatal density and length of guard cells. However, the higher phenotypic plasticity in stomatal traits was also associated with increasing mortality under more arid conditions.

2. Responses to Changing Climate at the Ecosystem Level

Climate change is also expected to induce alternations in the distribution range of forest species, species' replacement and losses of forest land, with important economic and ecological consequences.

In this context, Zindros et al. [7] monitored the changes in tree line over a 40-year period in the core of Olympus Mt. National Park in Greece and reported a warming-related upward shift in the tree line. Apart from spatial shifts, temporal shifts in forest ecosystems ecophysiological and phenological responses are also related to climate change. Marquardt et al. [8], compared the sensitivity and temporal stability of climate–growth relationships in *Pinus arizonica*, and *P. ponderosa* var. *brachyptera* consisting of two needle-types, in Arizona, USA, in order to characterize their growth responses to changing climate. They concluded that the species responded to summer precipitation pre-1950 but are now responding to spring precipitation post-1950, representing a shift in allocation of tree resources from maximizing biomass in the summer to reproduction spring. In the same lines, Ogaya and Peñuelas [9] found that a small but continuous decrease in soil water availability for 21 years in a Mediterranean holm oak (*Quercus ilex* L.) forest resulted in the gradual replacement of holm oak by another evergreen shrub (*Phyllirea latifolia* L.), which is more tolerant to hot and dry conditions.

3. Conclusions

The above-mentioned and other forest trees' and ecosystem responses to rapidly changing climate are reviewed by Kijowska-Oberc et al. [10]. In their review, they brought together literature reports on a range of adaptive responses to both forest abiotic threats (such as drought and heat) and biotic threats (such as pathogens and insects) and they discuss the role of epigenetics, phenology, and phenotypic plasticity for tree adaptations to climate change.

The studies included in this Special Issue illustrate the clear effects of climate change on forest trees' function, evidenced by different responses on genes expression, biochemical, and physiological levels. However, it is also indicated that different forest species from a broad range of climate zones and ecosystem types are able to develop adaptive mechanisms to cope with the current climatic variability. On the ecosystem level this may lead to distribution shifts and changes in vegetation composition. Further research is needed to identify if measures, such as assisted migration or others, may facilitate the transition to climate change resilient forest ecosystems.

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