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Tree diversity helps reduce heat peaks in forests

A forest with high tree-species diversity is better at buffering heat peaks in summer and cold peaks in winter than a forest with fewer tree species. This is the result of a study led by researchers from the German Centre for Integrative Biodiversity Research (iDiv), Leipzig University, and the Martin Luther University Halle-Wittenberg (MLU). The study was carried out in a large-scale planted forest experiment in China, and has been published in the journal Ecology Letters. It provides yet another argument for diversifying tree species in forests, especially under ongoing climate change.

Temperatures are increasing at many locations worldwide, largely due to increasing greenhouse gases. These climatic shifts include changes in temperature extremes: While cold peaks in winter are already decreasing in number (i.e., they are becoming warmer), heat peaks are increasing. Trees have long been known to buffer temperature extremes, reducing heat peaks within forests during hot summer and reducing cold peaks during wintertime. However, it was unknown whether the number of tree species, "tree species richness", could increase the potential of forests to buffer heat and cold peaks. "Former research has shown that the buffered temperatures below the tree canopy are important for forest biodiversity as they slow down the climate change-driven shift towards species that prefer warm temperatures," says co-first author Dr Florian Schnabel from the University of Freiburg, who oversaw this research while working at iDiv and Leipzig University and continued this work in Freiburg. "At the same time, the effect of tree diversity, a key facet of forest biodiversity, on forest temperature buffering remains largely unknown."

LARGEST PLANTED TREE DIVERSITY EXPERIMENT WORLDWIDE

To answer this question, the researchers took advantage of the largest planted tree diversity experiment worldwide, located in subtropical China. In the so-called BEF-China experiment, several hundred thousand trees were planted into plots consisting of 1, 2, 4, 8, 16, or 24 different tree species, respectively. Since the establishment of iDiv, the BEF-China project has been one of iDiv's key research platforms, resulting in a joint Sino-German international research training group that conducted the forest temperature measurements in this study over six years (2015-2020).

TREE SPECIES DIVERSITY BUFFERS TEMPERATURE PEAKS

The results showed that forests rich in tree species lowered temperatures below the canopy during heat peaks more than forests with fewer tree species. The effect was strongest during midday heat in summer. Cooling was up to 4.4°C stronger in experimental plots with 24 species compared to plots with just a single species.

Species-rich forests were also better at increasing temperatures during cold hours at nighttime and during winter. However, when looking at monthly averages, the researchers found no difference between species-poor and species-rich forests.

CANOPY DENSITY AND STRUCTURAL DIVERSITY EXPLAIN DIVERSITY EFFECT

The researchers also found a likely explanation for how species richness may affect temperature buffering. Experimental plots with many tree species showed both a higher canopy density (more leaf area per ground area) and a higher structural diversity (for instance, a higher variety of smaller and larger trees). These factors enhanced temperature buffering, probably by reducing the mixing of air masses.

“Temperature buffering effects are nice for humans seeking relief during a heat wave, but they also affect the ecosystem itself,” says co-first author Dr Rémy Beugnon from iDiv, Leipzig University, and the Centre d’Ecologie Fonctionnelle et Evolutive. “A buffered microclimate creates more favorable conditions for ecosystems and protects the services they offer. Under a buffered climate, forests are likely to grow and regenerate more effectively, while soils function better, supporting greater biodiversity, improving nutrient cycles, and increasing carbon storage.”

GOOD REASONS FOR PROMOTING SPECIES RICHNESS

The new study adds evidence to a list of arguments why increasing tree species richness may benefit people and nature. “Although typical tree monocultures as they are planted globally are important for providing timber, they do not only harbour less biodiversity than natural or diverse planted forests but provide fewer other services than wood production,” says senior author Prof Helge Bruelheide from iDiv and MLU. “Our study clearly showed that this temperature buffering effect of tree species richness has the potential to mitigate negative effects of global warming and climate extremes on the whole forest ecosystem.”

The authors conclude: “Overall, our findings thus highlight the benefits of diverse planted forests for large-scale forest restoration initiatives and urban forests that aim at reducing thermal stress in a warming world.”

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