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The diversity of plant species increases the resilience of ecosystems to climate change

Researchers from the CREAF and the UAB have participated in an international study that reveals how tree communities composed of various species are less sensitive to climate stress. They show that they maintain stable water and carbon fluxes in forest ecosystems in the face of droughts and high temperatures, such as those expected due to climate change.

Ecosystems such as forests provide our society with a range of services that are essential for the livelihood of many people. They are also essential to slow down climate change, via the sequestration of carbon dioxide and regulation of air temperature. Often these services are controlled by the capacity of ecosystems to regulate rates of fixation of carbon dioxide (photosynthesis) and transfer of water from the soil through plants to the atmosphere (transpiration).

How important is the species diversity that exists in the ecosystems to regulate these fluxes of photosynthesis and transpiration and their variation in space and time? The capacity to regulate fluxes depends on two variables, i.e., the maximum rates of these fluxes as well as the capacity to maintain them during stressful periods, which is quantified via their sensitivity to soil drought (reduced soil water content) and atmospheric drought (determined temperatures and reduced relative humidity of the air). Having a low sensitivity to atmospheric drought can maintain photosynthesis and transpiration during stressful

But can an increased diversity of tree species help regulate these fluxes and therefore the performance of the entire ecosystem?

It is well known that no tree species can excel at having both high maximum fluxes and maintaining them under stressful conditions. In other words, species that excel at maintaining high maximum rates of photosynthesis and transpiration often also have a high sensitivity to stresses, implying the existence of a trade-off. Species that maintain high flux rates are referred to as 'acquisitive', and those that have low stress sensitivity as 'conservative'. This can be understood based on the contrast between a 'factotum', who can do many jobs at an acceptable level, and an 'expert', who excels only in some tasks but fails in many others.

Although no tree species can be a jack-of-all-trades without also being a master-of-none, what happens when multiple species co-exist in a community? Does the same trade-off occur? In this paper, we examine this question at three different spatial scales, using data for the regulation of transpiration to low air relative humidity. We examined the response of individual tree species, communities of species, mixed in small plots, or larger communities at the spatial scale of several hectares, where the mixing of trees is also affected by changes in the environment where these species live (e.g., changes in soil features, competition levels, etc.).

We show that this trade-off is very strong at the scale of the individual species, but gradually disappears when we consider small plots, and it is largely absent at the spatial scale of larger communities. We also show that maximum rates of transpiration and sensitivity to atmospheric drought depend on both the mean characteristics (traits) of the species that compose the community, as well as the diversity of these traits (the difference in traits across species within the same community). The maximum rates of transpiration depended both on traits that are linked to maximum photosynthesis (mean specific leaf area) as well as traits linked to the capacity of the wood to resist drought stresses (the mean tension when 50% of the stem is unable to conduct water to the leaves). Equally, the sensitivity to atmospheric drought depended on variables related to the drought resistance of the trees. Communities composed of many species showed a lower sensitivity to atmospheric drought for the same level of maximum flux.

In short, the paper suggests that to understand the capacity of forests to maintain water and carbon fluxes in the context of global change, we need to consider how mixtures of multiple species interact to control the behavior of the entire community. It also suggests that more diverse communities show a lower trade-off between maximum fluxes and sensitivity to stress, i.e., that they can maintain more stable fluxes in the face of increased levels of stress, such as those expected because of climate change.

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