Studies showcase long-term effects of drought

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The drought experiment, set up in Austria's Stubai Valley. Credit: Eva Fessler

With the effects of climate change underway, drought is becoming an increasing problem in many parts of the world. Michael Bahn, researcher from the Department of Ecology at the University of Innsbruck, was

involved in several studies on the impact of drought on ecosystems. These studies, recently published in leading scientific journals, give insight into the complexity of processes underlying ecosystems responses to drought. They highlight the importance of biodiversity in enabling natural systems to resist drought.

The recent IPCC report makes a strong case that with ongoing climate change, extreme weather events will occur more frequently and dry periods will be increasingly intense. Professor Bahn and his colleagues recently published several studies addressing different aspects of the effects of drought on ecosystems.

Looking into the time machine

"To explore how ecosystems are affected by drought we have installed rainout shelters in grasslands and forests. The aim is to understand how an entire ecosystem with its numerous interactions reacts to drought," Bahn explains. "By warming grassland sections with heaters and adding CO_2 to their atmosphere we can mimic the effects of drought in a future world."

While warming increases both drought and heat stress, elevated CO_2 helps plant save water by reducing leaf water loss. Bahn's multifactor experiments suggest that under future climate conditions drought impacts will be more severe, but that recovery from drought will also be more rapid. "With this experimental approach we can predict future conditions today. It is like a time machine," says Bahn.

Such studies are invaluable for testing and improving ecosystem models. These enable scientists to anticipate changes in the environment of ecosystems and how these changes affect climate. This feedback is mediated primarily through greenhouse gases, which include CO_2 and nitrous oxide (N_2O). "Our studies show that drought greatly reduces the

uptake of CO_2 by ecosystems. At the same time, the rainfall following drought often leads to an increased emission of greenhouse gases. Such 'hot moments' are particularly critical for N_2O emissions, especially from fertilized soils," explains Bahn.

A synthesis study across many experimental and observational studies published earlier this year in *Nature Ecology & Evolution* revealed that productivity loss induced by drought can be up to 50% greater than that suggested by experiments. Consequently, models and larger-scale assessments should consider also long-term field observations and larger-scale analyses of satellite data. In another recent paper in the same journal the scientists suggest that as climate change progresses, the mechanisms operating in global drylands could play an increasing role in many of the currently more humid regions.

Resilience through diversity

The researchers have also started looking into how the projected future increases in drought frequency could affect ecosystems. "Our recent review article in *Global Change Biology* highlights that drought can have strong legacies on ecosystems, which can change the way ecosystems respond to subsequent droughts," says Bahn. For example, in a long-term drought experiment implemented by Bahn it was observed that recurrent drought altered the soil microbial community composition and, unexpectedly, made the soil less susceptible to drought.

The authors concluded in their paper in *Nature Communications* that recurrent drought alters the ecological memory of the soil. This could enhance the resilience of ecosystems in the face of future drought. In another paper recently published in *Science Advances*, the researchers showed that drought affects soil bacteria and fungi differently and that it favors soil pathogens. The scientists showed that this shift in soil communities can change the way in which biodiversity buffers the

effects of drought on ecosystem productivity.

Biodiversity increases ecosystem stability because diverse species have different ways of coping with environmental stresses. For example, Bahn and colleagues observed that in mountain grasslands fast growing plant-species tend to be more sensitive to drought, but also recover quickly; slow-growing plants are more resistant but recover more slowly. In the soil, it's the fungi that are more resistant, while bacteria can recover rapidly after drought. Upon rewetting bacteria release nitrogen, which benefits the fast-growing plants.

"Plant-soil interactions are important mechanisms underlying ecosystem responses to drought," explains Bahn. He also emphasizes the importance of supporting biodiversity when managing ecosystems: "To strengthen the resilience of ecosystems in the face of climate change we need to move away from favoring monocultures, such as the widespread spruce forests in Austria."

Climate neutrality is the most important measure

Bahn was recently involved in the scientific advisory board of the Austrian Climate Council. 100 citizens, selected to statistically represent the Austrian population, identified possible measures to achieve climate neutrality by 2040. Bahn noted that the citizens had a strong interest in actively and constructively addressing the issue of climate change and adaptation.

"Politicians should not underestimate the willingness of the citizens to support measures to mitigate the climate crisis," says Bahn. "While measures protecting and enhancing biodiversity are important steps towards increasing climate resilience, there is a pressing need to take rapid action to slow down climate change. This is the key driver of the recent and upcoming increases in the frequency and intensity of

droughts."

More information: György Kröel-Dulay et al, Field experiments underestimate aboveground biomass response to drought, *Nature Ecology & Evolution* (2022). DOI: 10.1038/s41559-022-01685-3

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