Drought-affected trees die from hydraulic failure and carbon starvation

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Credit: Notneb82, Wikimedia Commons

The report finds that hydraulic failure, which is the inability of a plant to move water from roots to leaves to be almost universally present when trees died, while carbon starvation was a contributing factor roughly half of the time.

"Droughts are increasing in frequency and severity, and their impact on plants and humans, is becoming more intense," says research co-author, Dr Melanie Zeppel of Sydney University's Charles Perkins Centre.

"The discovery of how droughts cause death in trees, regardless of tree type, will let us make better regional-scale predictions of the effects of

droughts on forests."

The dramatic impacts of tree die-back on water and carbon cycles, as well as bush fire intensity and timing, have been observed in recent years in south-east Australia, Dr Zeppel noted.

As the number of hot droughts increases globally, scientists are looking to make more consistent predictions of what will happen to plants and vegetation in the future.

This matters for models used to predict climate change because plants take up a big portion of the carbon dioxide humans pump in the atmosphere.

Therefore, the effect of tree death and die-off, as observed globally in recent decades, could affect the rate at which climate changes.

"Current global vegetation models have a hard time producing consistent and accurate estimates of plant carbon dioxide-uptake, and their predictions vary widely based on the assumptions they use about how plants respond to climate," says Dr Zeppel.

"Trees and forests are particularly important because they take up and store a lot of this carbon dioxide, and also affect their environment in other ways."

"Understanding drought is critical to managing our nation's forests," says Lina Patino, section head of the National Science Foundation's Division of Earth Sciences, which funded the study.

"This research will help us more accurately predict how different plant species respond to different types of environmental stress such as drought, insect damage or disease."

The paper's lead author, Dr Henry Adams at Oklahoma State University explains that 99 percent of the water moving through a tree is used to keep stomata open, the pores that let in carbon dioxide, allowing it to carry out photosynthesis.

Trees respond to the stress of drought by closing those pores that let in carbon dioxide. At that point, they need to rely on their stored sugars and starches to stay alive, and could die from carbon starvation if they run out before the drought is over.

On the other hand, if the tree loses too much water too quickly, an air bubble (embolism) will form and the tree has hydraulic failure, it cannot transport water from the roots to the leaves, which becomes lethal as the whole tree dries out.

Adams and his colleagues saw that in many cases, both carbon starvation and hydraulic failure appeared to occur as trees died.

This makes sense, because the stored sugars and starches that could be reduced in carbon starvation are also important for preventing hydraulic failure. When converted to sugar, these can act as "osmoprotectants," increasing the tree's ability to hold on to its water.

"It's kind of like antifreeze in a car that keeps the engine from overheating," Adams says.

More information: Manuel Delgado-Baquerizo et al. Palaeoclimate explains a unique proportion of the global variation in soil bacterial communities, *Nature Ecology & Evolution* (2017). DOI: 10.1038/s41559-017-0259-7

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