Stress-induced embolisms that interrupt water transport are a universal component of tree mortality

October 24 2017

Dead pine and fir trees in Sequoia National Park during a recent California drought. Credit: US Department of Energy

About half of carbon dioxide emissions are absorbed by trees and other plants. This carbon dioxide uptake is threatened by droughts, which are increasing in frequency. For the first time, scientists synthesized all known drought manipulation studies to determine how drought kills trees. They found that hydraulic failure is a universal component of tree death. Hydraulic failure is when a tree's water-transporting tissue is disrupted by embolisms. Carbon starvation also occurs, but it is not universal.

This research offers scientific modelers a direct path to better simulate how forests, grasslands, and other large areas can change. Also, the relative impact of hydraulic failure versus carbon starvation on drought-induced mortality has been a contentious debate. This study showed that hydraulic failure is ubiquitous, while carbon starvation is common. It is not an either/or choice between fracture and starvation; they can co-occur.

About half of carbon dioxide emissions are absorbed by plants, but this service is threatened by the increasing frequency of hot droughts. One of the largest uncertainties in land surface modeling is how vegetation will respond to greater exposure to life-threatening droughts. One of the most contentious theories in ecology today regards the mechanisms of responses. For example, how do plants regulate hydraulic failure and carbon starvation (if they even occur at all) during a drought? Hydraulic failure is where plants experience partial or complete interruption of the water-transporting xylem tissue function from stress-induced embolisms.

The interruption inhibits water transport, leading to desiccation. Carbon starvation is a phenomena where an imbalance between carbohydrate demand and supply leads to an inability to meet osmotic, metabolic and defensive carbon requirements. This study reviewed and synthesized the findings on all known drought studies that killed trees and found the occurrence of hydraulic failure was a universal characteristic proceeding

plant death, and co-occurring carbon starvation occurred in approximately 50 percent of the studies. The most advanced land-surface models today simulate mortality via carbon starvation but not via hydraulic failure. Therefore, current model development should incorporate hydraulic failure as a trigger to plant mortality to improve our understanding and predictions of eco-systems and vegetation.

More information: Henry D. Adams et al. A multi-species synthesis of physiological mechanisms in drought-induced tree mortality, *Nature Ecology & Evolution* (2017). DOI: 10.1038/s41559-017-0248-x

Provided by US Department of Energy