The case of the dying aspens

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Over the past 10 years, the death of forest trees due to drought and increased temperatures has been documented on all continents except Antarctica. This can in turn drive global warming by reducing the amount of carbon dioxide removed from the atmosphere by trees and by releasing carbon locked up in their wood. New research led by Carnegie researcher and Stanford University PhD student William Anderegg offers evidence for the physiological mechanism governing tree death in a drought. The work is published the week of December 12 by the *Proceedings of the National Academy of Sciences*.

Forests store about 45 percent of the carbon found on land. Their mortality can radically transform ecosystems, affect biodiversity, harm local economies, and pose fire risks, as well as increase to global warming.

Scientists had two competing theories for how forest trees die during a drought. One hypothesis proposed that the trees starved due to decreased photosynthetic activity. The other proposed that the system for transporting water within a tree was damaged beyond repair due to the stresses of the drought.

Without knowing which theory was correct, it was difficult for researchers to build models and make projections about the larger impact of drought-induced forest mortality.

The team focused their efforts on climate-induced die offs of trembling aspen trees in North America. They looked directly at both carbon

starvation and water-transportation stress on ongoing forest deaths.

Aside from Anderegg, the author team includes Carnegie's Chris Field and Joe Berry, along with William's brother Leander, and Duncan Smith and John Sperry of the University of Utah. Leander Anderegg was a Stanford undergraduate at the time the fieldwork was completed.

The aspen die-off, called Sudden Aspen Decline or SAD, began after severe droughts between 2000 and 2004 and affects about 17 percent of aspen forests in Colorado, as well as parts of the western United States and Canada. SAD continued through 2010, when the research was conducted.

"Large scale mortality events, such as we see with aspens, are the dynamite in ecosystem responses to climate change. We know that when they occur, they make a huge difference. But we are at the early stages of being able to predict occurrence," said Field, director of Carnegie's Department of Global Ecology and professor of biology and of environmental Earth systems science at Stanford.

The team found no evidence of significantly decreased carbon reserves in SAD-affected aspens. This undercuts the starvation theory, although it is possible that carbon starvation had occurred and already been rectified.

By contrast they did find notable losses of function in the tree's water-transportation systems, especially in the roots. SAD-affected trees showed about a 70 percent loss of water conductivity. Potted trees exposed to a summer's-worth of drought exhibited significant root mortality.

"Our study provides a snapshot of what future droughts could hold for the emblematic tree of the American West. Our results indicate an

impaired ability to transport water due to drought damage plays an important role in the recent die-off of aspens," William Anderegg said.

The team's work will provide guidance for scientists seeking to build models and projections of forest mortality as a result of climate change.

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