Piñon Pine: Studying the Effects of Climate Change on Drought Tolerance

Date: April 30, 2009

IN THE NAME OF SCIENCE, Henry Adams has killed a lot of trees. Adams, a PhD student at the University of Arizona, is studying the effect of climate change and drought on Piñon Pines. The Piñon Pine, a conifer with an extensive root system, grows at high elevations in the Southwest. Its root system makes the Piñon Pine remarkably drought tolerant, but in 2002-03, an extended drought in combination with a bark beetle outbreak killed 12,000 hectares of the trees. It was a 100 year drought, the driest period on record, and interestingly it coincided with temperatures 2 to 3˚C above recorded averages.

Research in Biosphere 2

Adams and his advisors wondered if increasing temperatures due to climate change might exacerbate the effects of drought and accelerate tree die-off. The University of Arizona has an unusual opportunity to test drought conditions and temperature change in its Biosphere 2 lab. Biosphere 2, a unique 3-acre enclosed "living laboratory" in the high Arizona desert, once hosted 8 people for two years of self-contained survival living. Now it hosts research projects, and Adams was able to use space inside to induce drought in two separate treatments of transplanted Piñon pines, one at ambient temperatures and one at temperatures 4˚C above ambient.

Sobering Outlook for the Piñon Pine

"Obviously, the warmer trees should die first," says Adams. "But we want to test whether temperature change, independent of other factors, accelerates mortality." If that acceleration in fact occurs, a shorter drought, the kind the Piñon Pine has historically been able to wait out, might cause a significant die-off.

Measuring Drought Response

Naturally, Adams and his colleagues did more than just watch how fast trees would die without water. They also studied the trees physiological response to drought, measuring gas exchange, water potential, and stomatal conductance. To measure stomatal conductance, they used the SC-1 porometer, making almost 9,000 separate measurements in sessions that lasted from sunup to sundown on one very long day once each week.

Stomatal Conductance in Conifers

There isn't much guidance in the porometer manual for people who want to use it on conifers, so Adams "played around with it a little bit" on non-drought stressed trees before he started his study. He found that the best way to get good readings was to cover the aperture with a single layer of needles. "Needles are this three-dimensional thing," he explains. "They have stomata on several sides, depending on the species. If you imagine that the fingers on your hand are needles sticking up from a branch, we just took those and pushed them together to make sure that there was just a one-needle thick covering over the aperture. If you spread your fingers, that's what it would be like if you didn't totally cover the aperture-then you underestimate the conductance. We also found that if we stuck several layers in there, we could drive the conductance number up.

Comparing at Leaf Level

Adams isn't concerned about absolute

conductance data. "We're making comparisons at the leaf level between treatments. We're not trying to estimate whole tree conductance or whole stand conductance. I can just compare leaf level in treatment X to the leaf level in treatment Y, and because it's the same species and the same needle shape, I have a lot of confidence in our data. We got pretty good numbers."

Sensitivity to Dry Conditions

Another part of the drought study involved a hydrologist who was interested in using weighing lysimeter data to parameterize some models used by hydrologists to model water loss during drought. "The lysimeters are a pain to run, but they're pretty sensitive," says Adams. "They can measure with a 0.1 kg precision, so that sounds like a good way to quantify water loss. It turns out that stomatal conductance from the porometer actually appears more sensitive than the weighing lysimeter data. Water loss from the scale hits zero pretty quickly, and we can't measure any loss after a couple of weeks, but we can still see water loss with our porometer data from the morning and the evening."

Expanding the Experiment

At the peak of the experiment, Adams had undergraduates and lab techs running up to three porometers at a time all day long, and although he's still buried in data from the first experiment, he's looking forward to accumulating even more data. "One limitation of our study is that the trees had pretty small root balls when they arrived. We've transplanted some trees [at different elevations at a site] in northern Arizona using a full sized tree mover to get as big a root to shoot ratio as possible in the transplant. We'll be using the porometers to try to understand the physiology of how these trees die and to predict their temperature sensitivity in the light of global climate change, using elevation change as a surrogate for temperature. We also have trees at the site that are not transplanted to serve as a control for the transplants."

Implications for the Future

Adams acknowledges that not everyone in the Southwest is worried about the Piñon Pine. "We work in a system that doesn't have a lot of economic value. A lot of the ranchers are happy to see the pines go. They just think there will be a lot more grass for the cattle, and firewood cutters are out there cutting up the dead trees and selling them." But if temperature alone makes trees more susceptible to drought, the implications go far beyond economics. Adams puts it succinctly, if somewhat mildly: "It's kind of scary."

Printed in USA

05-27-15