Pacific Northwest trees struggle for water while standing in it

July 25 2011

The Wind River Canopy Crane was used to study the response of conifer trees to different types of water stress, including summer drought and freeze-thaw cycles in winter. (Photo courtesy of Oregon State University)

Contrary to expectations, researchers have discovered that the conifers of the Pacific Northwest, some of the tallest trees in the world, face their greatest water stress during the region's eternally wet winters, not the dog days of August when weeks can pass without rain.

Due to freeze-thaw cycles in winter, water flow is disrupted when air bubbles form in the conductive xylem of the trees. Because of that, some of these tall conifers are seriously stressed for water when they are practically standing in a lake of it, scientists from Oregon State

University and the U.S. Forest Service concluded in a recent study.

It's not "drought stress" in a traditional sense, the researchers said, but the end result is similar. Trees such as Douglas-fir actually do better dealing with water issues during summer when they simply close down their stomata, conserve water and reduce their photosynthesis and growth rate.

"Everyone thinks that summer is the most stressful season for these trees, but in terms of water, winter can be even more stressful," said Katherine McCulloh, a research assistant professor in the OSU Department of Forest Ecosystems and Society.

"We've seen trees in standing water, at a site that gets more than two meters of rain a year, yet the xylem in the small branches at the tops of these trees can't transport as much water as during the summer," McCulloh said.

The ease with which water moves through wood is measured as the "hydraulic conductivity," and researchers generally had believed this conductivity would be the lowest during a conventional drought in the middle of summer. They found that wasn't the case.

"We thought if there was a serious decline in conductivity it would have been from drought," said Rick Meinzer, a researcher with the Pacific Northwest Research Station of the USDA Forest Service, as well as OSU. "It was known that air bubbles could form as increased tension is needed in the xylem to pull water higher and higher. But it turns out that freezing and thawing caused the most problems for water transport."

Studies such as this are important, the scientists said, to better understand how forests might respond to a warmer or drier climate of the future. And although this might imply that these conifers could be more resistant to drought than had been anticipated, the researchers said it's not that simple.

"If the climate warms, we might actually get more of these winter cycles of freezing and thawing," McCulloh said. "There's a lot of variability in the effects of climate we still don't understand.

"One of the most amazing things these trees can do is recover from these declines in conductivity by replacing the air bubbles with water," she said. "We don't understand how they do that at the significant tensions that exist at those heights. We're talking about negative pressures or tensions roughly three times the magnitude of what you put in your car tires."

When the field research on this study was done in 2009, the area actually experienced a historic heat wave during August when temperatures in the Willamette Valley hit 108 degrees. During such extreme heat, trees experienced some loss of hydraulic conductivity but largely recovered even before rains came in September. By contrast, greater loss of hydraulic conductivity was observed in the middle of winter.

The study was done at the Wind River Canopy Crane Research Facility, and published in the *American Journal of Botany*. The research was supported by the National Science Foundation.

"The commonly held view is that the summer months of the Pacific Northwest are extremely stressful to plants," the researchers wrote in their conclusion.

"Yet, our results indicated that the winter months are more stressful in terms of hydraulic function, and suggest that perhaps an inability to recover from increase in native embolism rates over the winter may cause greater branch dieback in old-growth trees than shifts in summer climate."

More information: An Annual Pattern of Native Embolism in Upper Branches of Four Tall Conifer Species - ir.library.oregonstate.edu/xmlui/handle/1957/22031

Provided by Oregon State University