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Slight climate shifts can affect optimum water use in plant communities

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Dr. Georgianne Moore shows a graduate student how to install a sap flow sensor. Credit: Texas A&M AgriLife photo

A new discovery is providing scientists a better understanding of how rainfall is shared beneficially by the plant community and the human population, in addition to the effects of climate change.

"It's going to be a wet gets wetter, dry gets drier world," said Dr. Georgianne Moore, Texas A&M University department of ecosystem science and management associate professor, College Station.

"There could be big consequences, as it will affect forests, grasslands, savannas and deserts. Scientists can now use the model we have to help make predictions about the future of these plant communities."

Dr. Stephen Good, Oregon State University department of biological and ecological engineering professor, Corvallis, Oregon, was lead on the project. He and Moore were joined in their investigation by Dr. Diego Miralles, Ghent University Laboratory of Hydrology and Water Management, Ghent, Belgium.

Moore said she and Good both presented on posters at a conference in Ecuador on opposite sides of the room and found they had nearly identical results.

"On the spot, we decided to publish something together about those findings, and this paper is the product of that change encounter," she said.

Their paper, "A mesic maximum in biological water use demarcates biome sensitivity to aridity shifts," appeared on *Nature Ecology and Evolution*'s website, www.nature.com/natecolevol/, Nov. 13.

"We are looking at plant water use on a global scale across all climates," Moore said. "This paper will help understand the potential water use of a biome, or natural plant community, in an area given its regional climate."

Utilizing the model developed by Good, she said they can determine what fraction of rainfall is used by plants.

"If you were in an Amazon rainforest, it is a highly productive area and uses a large fraction of the rainfall to grow," Moore said. "In a desert, the fraction of the rainfall used by the plants is less because some of it will evaporate before it can be used.

"On the other end of the spectrum, if you go someplace even wetter, such as the cloud forests on the mountains of Hawaii, those systems use less of the rainfall beneficially because water is lost to streamflow or wet-leaf evaporation."

Moore said the team is characterizing the range between the two extremes of wet and dry.

"We have determined a mesic maximum, which is the middle of the curve between the two ends of the climate spectrum," she said.

"The fraction that occurs in a climate in that range is the balance where the plants can use slightly more moisture than what they usually get, which makes plants optimize the use of water for beneficial growth," she said. "You could call it the sweet spot."

Moore said she was in charge of collecting the data from field stations around the world. She selected data from natural observation studies to avoid places where productivity is greatly affected by management.

In addition to demonstrating the mesic maximum phenomenon using the naturally occurring data, they have modeled the outcomes using a novel mathematical approach. The model shows how rainfall is partitioned between plant water use, evaporation, runoff and interception.

"The projection very closely matches what was observed in field stations around the globe," she said. "We produced a map based on the model to show what parts of the world will fall off the curve and no longer use their rainfall as efficiently for beneficial growth."

Because these ecosystems don't get irrigated or have another option to get water, their production can be expected to decline, Moore said.

The scientists are striving to determine: What is water use likely to be, all else being equal? This new information can help scientists determine where optimal transpiration is in a given climate and how different management practices might change that, i.e., replacing older trees with younger trees or replacing grassland with cropland.

"For instance, those data could be used to figure out how much streamflow will be in the Mississippi River in the future," she said. "We need to know how much water is lost to figure out how much we will have for drinking water."

Also, Moore said, modelers will be interested in this information as they determine how much water is in the atmosphere, as that drives the climate.

"It's still a mystery to us who work in hydrology to determine where the water goes when it rains, and this study is a nice step forward to try to accomplish that," Moore said.

More information: Stephen P. Good et al. A mesic maximum in biological water use demarcates biome sensitivity to aridity shifts, *Nature Ecology & Evolution* (2017). DOI: 10.1038/s41559-017-0371-8

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