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Stanford study shows U.S. grasslands affected more by atmospheric dryness than precipitation

According to 33 years of remote sensing data, productivity of U.S. grasslands is more sensitive to dryness of the atmosphere than precipitation, important information for understanding how ecosystems will respond to climate change.

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MARCH 6, 2017



Credit: Leonardo Mercon/Shutterstock

A new study showing dryness of the atmosphere affects U.S. grassland productivity more than rainfall could have important implications for predicting how plants will respond to warming climate conditions.

Published online March 6 in the journal *Nature Geoscience*, the study conducted by scientists at Stanford University and Columbia University looked at 33 years of climate and vegetation satellite data to determine how plants regulate water and carbon dioxide under dry conditions. The team concluded that U.S. grasslands are more than three times more sensitive to vapor pressure deficit (VPD), or atmospheric dryness, than they are to precipitation. The study's large-scale methods to understand plant behavior could be used to improve predictive models of how environments will respond to droughts, which are expected to intensify in the 21st century.

"Just looking at changes in precipitation isn't going to tell you the whole story," said lead author [Alexandra Konings](#), an assistant professor of Earth System Science in Stanford's [School of Earth, Energy & Environmental Sciences](#) (Stanford Earth). "U.S. grasslands are way more sensitive to vapor pressure deficit, which is important. Because VPD is so tightly linked to temperature, we can predict that it's going to keep going up in the future."

In the study, scientists analyzed the conditions under which grasslands open and close their stomata, microscopic openings on plant leaves that enable the transfer of water vapor, oxygen and CO2. When its stomata are open, a plant can take up CO2 from the atmosphere to make energy but risks losing water in dry conditions. The strategy different plants use – whether to risk drying out in order to keep taking up carbon, or to close up and stop growing – affects their productivity. A plant's behavior depends on the amount of water in the atmosphere as measured by VPD: higher VPD indicates greater potential for dry air to pull moisture out of the plant.

Variability in drought response

Using statistical analysis, the researchers separated out the effect of the plants' behavior from the impacts of regional conditions, such as differences in precipitation or temperature. Although many climate models treat all grasslands the same, the study revealed large variability in terms of how they respond to drought.

"More than the plant type, it is the plant physiology that will regulate their response to drought and heat wave," said study co-author [Pierre Gentine](#), an associate professor of Earth and Environmental Engineering at Columbia University.

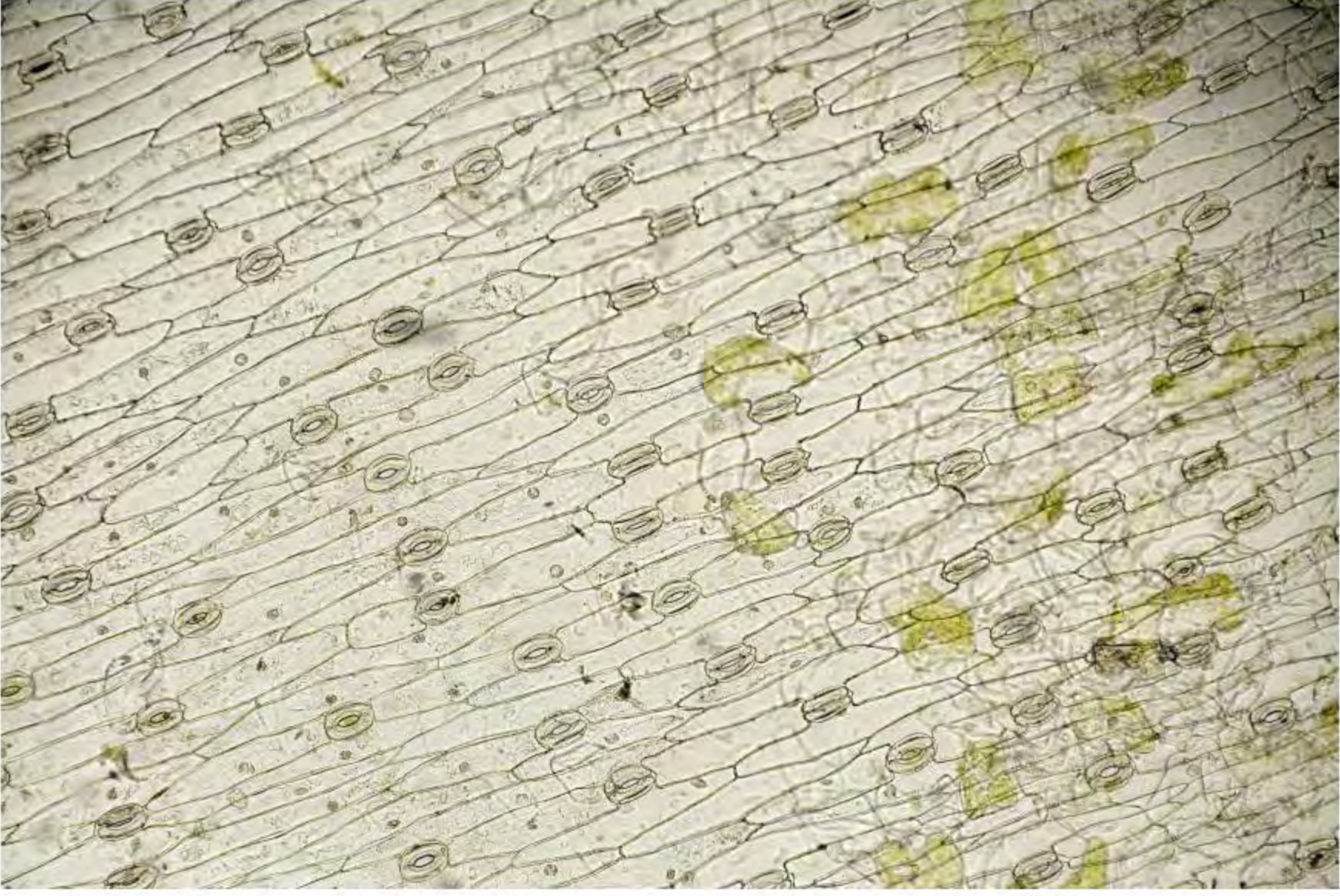
The researchers carried out their analysis using publicly available remote sensing satellite data from 1981 to 2013 displaying plant greenness, which is an indicator for plant productivity. They then combined that data with climate and observational precipitation datasets to divide American grasslands into different regions, depending on their behavior.

Understanding how plant stomata respond to changes in the atmosphere is especially important in U.S. grasslands, which are a predominant source of carbon uptake, or storage of carbon from the atmosphere. Grasslands host a variety of biodiversity and provide an important habitat for livestock in the meat and dairy industries, covering about 26 percent of the United States and nearly 20 percent of the planet's land surface; they are the largest land cover type on Earth.

"Carbon uptake is associated with growth and how that responds under climate is a large source of uncertainty in future climate change predictions," [Konings](#) said. "Under increasing temperatures, we're going to potentially see a lot less green grasslands – but this study shows that's going to be more true for some regions than others."

Behavioral differences

Analysis shows grasslands that respond to drought by keeping their stomata open (anisohydric behavior) are more sensitive to dryness of the atmosphere than those that close their stomata and stop growth to save water (isohydric behavior). Both behaviors are present in the U.S. The study shows plants that keep their stomata open are more damaged by drought in U.S. grasslands because it suppresses the plants' growth over the course of a growing season.



Researchers analyzed the conditions under which plants in U.S. grasslands open and close their stomata, tiny openings on plant leaves, as shown here through a microscope. Credit: D. Kucharski K. Kucharska/Shutterstock

"Grasslands are really interesting because they show such a huge diversity in that isohydricity behavior," said [Konings](#), who conducted initial research for the study while a postdoctoral researcher at Columbia before joining Stanford Earth. "They have really different strategies in how they respond to drought."

While previous methods for understanding drought response entailed on-the-ground measurements, the new metric enables researchers to measure these patterns across the globe. [Konings](#) said she hopes the method can be used to see if the study's findings about grasslands can be applied to other ecosystems or to better understand what causes some trees to die in response to warming conditions while others do not.

"I think there's a lot still to be done with this metric," [Konings](#) said.

A. P. Williams of the Lamont-Doherty Earth Observatory of Columbia University co-authored the study. The research was funded by Columbia University's Center for Climate, the Department of Energy, the National Science Foundation and Stanford University.

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