Plants adapt to drought but limits are looming, study finds (Update)

January 22 2013

The University of Arizona?s Santa Rita Experimental Range is the oldest, longest-operating range-land research facility in the world. Using techniques like repeat photography, inclusion or exclusion of livestock and vegetation surveys since the 1950s, scientists study how ecosystems react to different influences such as climate change and grazing. Credit: Mitchel McClaran/University of Arizona

Scientists with the U.S. Department of Agriculture, or USDA, and their partners have determined that water demand by many plant communities can fluctuate in response to water availability, indicating a capacity for resilience even when changing climate patterns produce periodic droughts or floods.

But their research also suggests that a limit to this resilience ultimately could threaten the survival of these plant communities. Sensitive environments such as the arid grasslands in the Southwestern U.S. already are approaching this limit.

Results from this study were published in the journal *Nature* by a team of Agricultural Research Service, or ARS, scientists, including three scientists affiliated with the UA. ARS is USDA's chief scientific research agency.

The study was led by UA-affiliated ARS researchers Guillermo Ponce Campos and Susan Moran and an Australian team led by Alfredo Huete from the University of Technology, Sydney.

"We found that plants have a capacity for resilience even in the face of the severe drought over the past decade," said Ponce Campos, the study's lead author. Ponce Campos led the research as part of his doctoral work at the UA and now is a research associate working with Moran.

"From grasslands to forests, plants can tolerate low precipitation, but if drought conditions continue past a certain point, this resilience will fail," said Moran, who graduated from the UA and now is a researcher with the USDA ARS Southwest Watershed Research Center and an adjunct professor in the department of soil, water and environmental science in the UA College of Agriculture and Life Sciences.

Once that limit is reached, water-starved plants lose their ability to take advantage of increased precipitation, even if the drought makes way for wetter conditions, Moran explained.

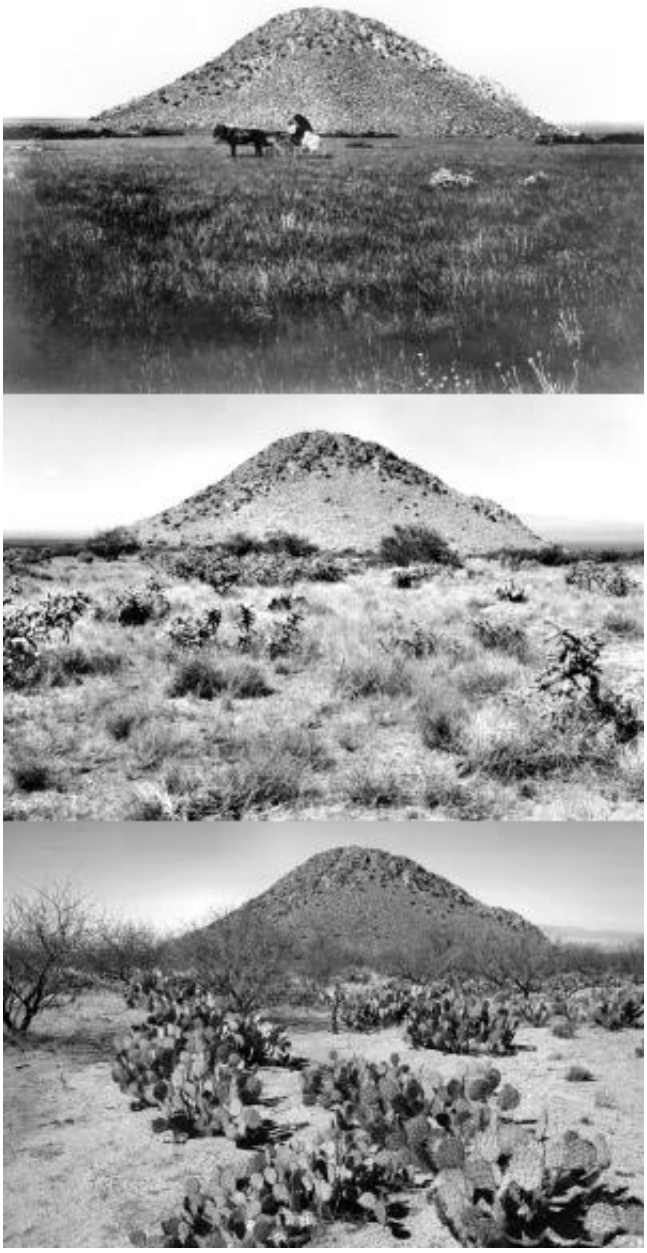
The researchers conducted their investigation using measurements made during 2000-09 at 29 sites in the United States, Puerto Rico and Australia. This provided data about precipitation patterns in the various

types of environments. Globally, the 2000-09 decade ranked as the 10 warmest years of the 130-year (1880-2009) record. The team compared these data with measurements taken from 1975 to 1998 at 14 sites in North America, Central America and South America.

To calculate ecosystem water use, the scientists used satellite observations to approximate above-ground net plant productivity at each site. Then they combined these approximations with field data of precipitation and estimates of plant water loss to generate indicators of plant water use efficiency.

The team observed that ecosystem water-use efficiency increased in the driest years and decreased in the wettest years. This suggests that plant water demand fluctuated in accordance with water availability and that there is a cross-community capacity for tolerating low precipitation and responding to high precipitation during periods of warm drought.

However, the team observed that the water-use efficiency data exhibited a trend of "diminishing returns." This suggests plant communities eventually will approach a water-use efficiency threshold that will disrupt plant water use and severely limit plant production when drought is prolonged.



Repeat photography is one of the tools range ecologists use to document how lands change: In 1902, photographer David Griffiths horse-drawn buggy was clearly visible in the open grassland, surrounded by scattered desert hackberry plants at the foot of Huérfano Butte, south of Tucson, Ariz. By 1941, an unknown photographer documented burro weed and cholla cactus popping up, along with velvet mesquite trees. In 2007, the grass cover had given way to velvet mesquite trees, and prickly pear have replaced cholla as the dominant cacti. Credit: Mitchel McClaran/University of Arizona

"Prolonged, warm drought makes a difference," Moran said. "To date, it appears there is resilience, but in the more sensitive biomes like grasslands, we are starting to see evidence of decreasing resilience. And as more and more ecosystems increase in aridity, more will reach this threshold."

The authors report that in some Australian grasslands, ecosystem resilience has decreased with the increasing aridity widely reported as a result of the prolonged warm drought over these biomes.

Moran cautioned that her team also saw the limit in some of the study areas in Utah, Arizona and New Mexico.

"We know what the resilience was in the 1980s and 1990s, and we compared it to the early 21st century," she said. "That's how we know it's decreasing. We certainly found resilience, but it is approaching the threshold."

Moran pointed out this study was only possible through the collaboration of researchers combining long-term observations at study sites across the globe to reach these conclusions, including the oldest, longest-operating range-land research facility in the world: the Santa Rita Experimental Range managed by the UA College of Agriculture and Life Sciences.

Established in 1902, the study area encompasses 52,000 acres, or about 80 square miles, on the western side of the Santa Rita Mountains south of Tucson.

"Here, scientists studying vegetation, animals and soils have documented changes in the environment as a function of land use and how weather and climate have influenced these patterns," said Mitchel McClaran, a

professor in the UA's School of Natural Resources and the Environment and the range's director for research, who co-authored the study.

"Making these long-term data available to researchers across the world today is what makes studies like this possible," McClaran said. "We perform experiments and explore best management practices so they can be adopted wildlife managers, ranchers and other natural resources managers throughout the Southwest."

Work like the present study can help resource managers develop agricultural production strategies that incorporate changes in water availability linked to changing precipitation patterns.

"In the United States, much of our agricultural productivity has depended on long-term precipitation regimes. But those patterns are changing and we need information for managing the effects of those shifts," said ARS Administrator Edward Knipling. "These findings can help managers respond to the challenges of global climate change with effective strategies for maintaining agricultural productivity."

Provided by University of Arizona