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A new study at the UA's Laboratory of Tree-Ring Research has confirmed the existence of a multi-decade drought period in the second century A.D. The findings give evidence that extended periods of aridity have occurred at intervals throughout our past.



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Almost 900 years ago, in the mid-12th century, the southwestern U.S. was in the middle of a multi-decade megadrought. It was the most recent extended period of severe drought known for this region. But it was not the first.

The second century A.D. saw an extended dry period of more than 100 years characterized by a multi-decade drought lasting nearly 50 years, says a new study from scientists at the University of Arizona.

UA geoscientists **Cody Routson**, **Connie Woodhouse** and **Jonathan Overpeck** conducted a study of the southern San Juan Mountains in south-central Colorado. The region serves as a primary watershed for the Rio Grande and San Juan rivers.

"These mountains are very important for both the San Juan River and the Rio Grande River," said Routson, a doctoral candidate in the environmental studies laboratory of the UA's department of geosciences and the primary author of the study, which is upcoming in **Geophysical Research Letters**.

The San Juan River is a tributary for the Colorado River, meaning any climate changes that affect the San Juan drainage also likely would affect the Colorado River and its watershed. Said Routson: "We wanted to develop as long a record as possible for that region."

Dendrochronology is a science of using annual growth rings of trees to understand climate in the past. Because trees typically add a normally clearly defined growth ring around their trunk each year, counting the rings backwards from a tree's bark allows scientists to determine not only the age of the tree, but which years were good for growth and which years were more difficult.

"If it's a wet year, they grow a wide ring, and if it's a dry year, they grow a narrow ring," said Routson. "If you average that pattern across trees in a region you can develop a chronology that shows what years were drier or wetter for that particular region."

Darker wood, referred to as latewood because it develops in the latter part of the year at the end of the growing season, forms a usually distinct boundary between one ring and the next. The latewood is darker because growth at the end of the growing season has slowed and the cell walls are more dense.

To develop their chronology, the researchers looked for indications of climate in the past in the growth rings of the oldest trees in the southern San Juan region. "We drove around and looked for old trees," said Routson.

Literally nothing is older than a bristlecone pine tree: The oldest and longest-living species on the planet, these pine trees normally are found clinging to bare rocky landscapes of alpine or near-alpine mountain slopes. The trees, the oldest of which are more than 4,000 years old, are capable of withstanding extreme drought conditions.

"We did a lot of hiking and found a couple of sites of bristlecone pines, and one in particular that we honed in on," said Routson.

To sample the trees without damaging them, dendrochronologists use a tool like a metal screw that bores a tiny hole in the trunk of the tree and allows them to extract a sample, called a core. "We take a piece of wood about the size and shape of a pencil from the tree," explained Routson.

"We also sampled dead wood that was lying about the land. We took our samples back to the lab where we used a visual, graphic technique to match where the annual growth patterns of the living trees overlap with the patterns in the dead wood. Once we have the pattern matched we measure the rings and average these values to generate a site chronology."

"In our chronology for the south San Juan mountains we created a record that extends back 2,200 years," said Routson. "It was pretty profound that we were able to get back that far."

The chronology extends many years earlier than the medieval period, during which two major drought events in that region already were known from previous chronologies.

"The medieval period extends roughly from 800 to 1300 A.D.," said Routson. "During that period there was a lot of evidence from previous studies for increased aridity, in particular two major droughts: one in the middle of the 12th century, and one at the end of the 13th century."

"Very few records are long enough to assess the global conditions associated with these two periods of Southwestern aridity," said Routson. "And the available records have uncertainties."

But the chronology from the San Juan bristlecone pines shows an even earlier drought:

"There was another period of increased aridity even earlier," said Routson. "This new record shows that in addition to known droughts from the medieval period, there is also evidence for an earlier megadrought during the second century A.D."

"What we can see from our record is that it was a period of basically 50 consecutive years of below-average growth," said Routson. "And that's within a much broader period that extends from around 124 A.D. to 210 A.D. – about a 100-year-long period of dry conditions."

"We're showing that there are multiple extreme drought events that happened during our past in this region," said Routson. "These megadroughts lasted for decades, which is much longer than our current drought. And the climatic events behind these previous dry periods are really similar to what we're experiencing today."

The prolonged drought in the 12th century and the event in the second century A.D. may both have been influenced by warmer-than-average Northern Hemisphere temperatures, Routson said: "The limited records indicate there may have been similar La Nina-like background conditions in the tropical Pacific Ocean, which are known to influence modern drought, during the two periods."

Although natural climate variation has led to extended dry periods in the southwestern U.S. in the past, there is reason to believe that human-driven climate change will increase the frequency of extreme droughts in the future, said Routson. In other words, we should expect similar multi-decade droughts in a future predicted to be even warmer than the past.

Routson's research is funded by fellowships from the **National Science Foundation**, the **Science Foundation Arizona** and the **Climate Assessment of the Southwest**. His advisors, Woodhouse of the **School of Geography and Development** and Overpeck of the **department of geosciences** and co-director of the UA's **Institute of the Environment**, are co-authors of the study.