Massive spruce beetle outbreak in Colorado tied to drought

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A new CU-Boulder study indicates the current spruce beetle epidemic in Colorado, including on Wolf Creek Pass shown here, is caused primarily by drought. Credit: University of Colorado

A new University of Colorado Boulder study indicates drought high in the northern Colorado mountains is the primary trigger of a massive spruce beetle outbreak that is tied to long-term changes in sea-surface

temperatures from the Northern Atlantic Ocean, a trend that is expected to continue for decades.

The new study is important because it shows that drought is a better predictor of spruce beetle outbreaks in northern Colorado than temperature alone, said lead study author Sarah Hart, a CU-Boulder doctoral student in geography. Drought conditions appear to decrease host tree defenses against spruce beetles, which attack the inner layers of bark, feeding and breeding in the phloem, a soft inner bark tissue, which impedes tree growth and eventually kills vast swaths of forest.

Spruce beetles, like their close relatives, mountain pine beetles, are attacking large areas of coniferous forests across the West. While the mountain pine beetle outbreak in the Southern Rocky Mountains is the best known and appears to be the worst in the historical record, the lesser known spruce beetle infestation has the potential to be equally or even more devastating in Colorado, said Hart, lead author on the new study.

"It was interesting that drought was a better predictor for spruce beetle outbreaks than temperature," said Hart of the geography department. "The study suggests that spruce beetle outbreaks occur when warm and dry conditions cause stress in the host trees."

A paper on the subject was published online in the journal *Ecology*. Co-authors include CU-Boulder geography Professor Thomas Veblen; former CU-Boulder graduate student Karen Eisenhart, now at Edinboro University of Pennsylvania; and former CU-Boulder students Daniel Jarvis and Dominik Kulakowski, now at Clark University in Worcester, Mass. The National Science Foundation and the National Geographic Society funded the study.

The new study also puts to rest false claims that fire suppression in the West is the trigger for spruce beetle outbreaks, said Veblen.

Spruce beetles range from Alaska to Arizona and live in forests of Engelmann spruce and subalpine fir trees in Colorado. The CU-Boulder study area included sites in the White River, Routt, Arapaho, Roosevelt and Grand Mesa national forests as well as in Rocky Mountain National Park.

The CU-Boulder team assembled a long-term record of spruce beetle outbreaks from the northern Front Range to the Grand Mesa in western Colorado using a combination of historical documents and tree ring data from 1650 to 2011. Broad-scale outbreaks were charted by the team from 1843-1860, 1882-1889, 1931-1957 and 2004 to 2010.

The researchers used a variety of statistical methods to tease out causes for variations in the dataset at 18 sites in Colorado. "The extent to which we could distinguish between the warming signals and the drought signals was surprising," said Veblen. "These are two things that easily can get mixed together in most tree ring analyses."

There are several lines of evidence that drought is the main driver of the spruce beetle outbreak. The new study showed when northwest Colorado was in a warm, wet climate period from 1976 to 1998, for example, both spruce beetle reproduction and tree defenses like "pitching" beetles out of tree interiors with resin were likely high. But during that period of warming, outbreak was minimal.

The strongest climate correlation to spruce beetle outbreaks was above average annual values for the Atlantic Multi-decadal Oscillation, or AMO, a long-term phenomenon that changes sea-surface temperatures in the North Atlantic. Believed to shift from cool to warm phases roughly every 60 years, positive AMO conditions are linked to warmer and drier conditions over much of North America, including the West.

Veblen said the AMO shifted from its cool to warm phase in the 1990s,

meaning the climate phenomenon could be contributing to drought conditions in the West into the middle of this century. A 2006 tree-ring study involving Veblen, his former student, Thomas Kitzberger and researchers from several other institutions concluded that the warm phase of AMO also was correlated to increased wildfires in the West.

In addition to AMO, the researchers looked at two other ocean-atmosphere oscillations—the El Nino Southern Oscillation and the Pacific Decadal Oscillation—as well as past temperatures, precipitation and aridity to better understand the spruce beetle outbreaks. The team found that another effective predictor of drought conditions was summer "vapor pressure deficit," a measurement of atmospheric dryness, said Veblen.

In the new study, the researchers were particularly interested in "radial growth" rates of tree rings from sub-canopy trees of various species in the study areas that thrived following outbreaks. One hallmark of spruce beetle outbreaks is that slow radial growth rates in such areas are followed by extremely rapid radial growth rates, an indication smaller trees flourish in the absence of the larger spruce trees because of decreased competition for water and increased opportunities for photosynthesis, said Hart.

The area of high-elevation forests affected by spruce beetles is growing in the West, Hart said. "In 2012, U.S. Forest Service surveys indicated that more area was under attack by spruce beetles than mountain pine beetles in the Southern Rocky Mountains, which includes southern Wyoming, Colorado and northern New Mexico," she said. "The drought conditions that promote spruce beetle outbreak are expected to continue."

One big concern about spruce beetle outbreaks is their effects on headwater streams that are important for water resources, said Veblen.

"In the short term, trees killed by spruce beetles will lead to less water use by trees and more water discharge into streams. But in the long term, the absence of the trees killed by beetles may lead to less persistence of snow and earlier runoff."

Veblen said it might seem counterintuitive to some that spruce-fir subalpine forests in Colorado are larger by area than lodgepole/ponderosa pine forests. "It is probably because spruce and subalpine forests are found in more remote areas not as visible to most people," he said. "But potentially, the current spruce beetle outbreak could affect a larger area than the mountain pine beetle outbreak."

The study had its beginnings in 1986, when Veblen and his students began compiling spruce and subalpine fir tree rings from various study sites in the Colorado mountains. Tree rings from individual trees—which carry information about weather, climate and even events like volcanic eruptions—can be matched up and read with rings from other trees, much like the pages of a book, from year to year and even from season to season.

Provided by University of Colorado at Boulder

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