Climate change's effect on Rocky Mountain plant is driven by sex

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A female valerian plant stands sentry high in the Colorado Rocky Mountains.

Credit: Will Petry / UCI

For the valerian plant, higher elevations in the Colorado Rocky Mountains are becoming much more co-ed. And the primary reason appears to be climate change.

In a study appearing in *Science*, University of California, Irvine environmental biologists Kailen Mooney and Will Petry and colleagues report that an altering climate over the past four decades has significantly changed the growth patterns of male and female *Valeriana edulis* over elevation. Their work is the first to fully explain sex-specific species responses to climate change.

Valerian is dioecious, meaning individuals are either male or female. Unlike the majority of flowering plants, these cannot self-fertilize. Other well-known dioecious species include asparagus, ginko, papaya, holly, spinach, pistachio, willow and aspen.

In the Colorado Rockies, the sex ratio of valerian populations traditionally changed with climate from low elevation (50 percent male), where it's hot and dry, to high elevation (only 20 percent male), where it's cool and wet. At the highest elevations, the rarity of pollen-releasing males reduces the number of seeds produced by female plants.

Now all that's changing. Over the past 40 years, tests conducted through the Rocky Mountain Biological Laboratory in Crested Butte, Colo., have revealed the region to be warming and drying to such a degree that each valerian population across the elevation gradient is now experiencing a climate that was historically found at a much lower elevation.

Mooney and Petry said their study shows that as the drier, warmer

climate moves "up slope," so do the arid-adapted males, shifting the sex ratios. Because of this, populations in which males were formerly rare now experience less mate limitation, enabling females to successfully produce more seed.

"Nearly all animals and many plants have separate males and females, and they almost always differ in characteristics that affect how they interact with the environment," said Petry, who earned a Ph.D. in ecology & evolutionary biology at UCI this spring. "Understanding the responses of both sexes is important, because each sex must find mates of the opposite sex to reproduce, and no past work has connected ecological differences between males and females to their responses to climate change and the subsequent consequences for populations."

These elevation-based patterns of sex ratio change are due, at least in part, to a physiological difference in how males and females use water.

While the increase in males has led to flourishing valerian growth at higher altitudes, an excess of males at low elevations may ultimately result in population declines. In this way, the plants' sex-specific responses to climate change may cause the species to shift to higher elevations.

Furthermore, fluctuations in the relative abundance of valerian males and females may also have repercussions for species associated with this plant, as the two sexes support different communities of insects.

"Most past work documenting ecological responses to climate change has focused on range shifts of whole species," said Mooney, an associate professor of ecology & evolutionary biology. "In our study, we instead looked at a species characteristic - the population sex ratio. We're discovering that males and females respond to climate change differently and that the pace at which this species characteristic responds to climate

change is unprecedentedly fast - about 10 times the average rate that species ranges are moving in response to a changing climate."

More information: "Sex-specific responses to climate change in plants alter population sex ratio and performance," *Science*, DOI: 10.1126/science.aaf2588

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