# Global changes alter the timing of plant growth, scientists say

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Any gardener knows--different plant species mature at different times. Scientists studying plant communities in natural habitats call this phenomenon "complementarity." It allows many species to co-exist because it reduces overlap in the time period when species compete for limited resources. Now, in a study posted online the week of Sept. 4 in the *Proceedings of the National Academy of Sciences*, ecologists working at Stanford's Jasper Ridge Biological Preserve report evidence that climate change may alter this delicate balance.

"In the natural world, species have evolved to be finely attuned to the seasons--timing is everything," said lead author Elsa Cleland, who performed this research as part of her doctoral dissertation at Stanford and is now a postdoctoral fellow at the National Center for Ecological Analysis and Synthesis in Santa Barbara, Calif. "If climate change alters the timing of plant activity, then it could have a domino effect, impacting the feeding, breeding or migration patterns of the animals that rely on particular plant species."

Cleland's co-authors include Nona R. Chiariello, research coordinator of the Jasper Ridge Biological Preserve; Scott Loarie, who assisted with this research while a Stanford undergraduate; Christopher B. Field, director of the Carnegie Institution's Department of Global Ecology (located on the Stanford campus) and faculty director of Jasper Ridge Biological Preserve, and Harold A. Mooney, the Paul S. Achilles Professor of Environmental Biology at Stanford.

The findings are part of the ongoing Jasper Ridge Global Change Experiment, launched in 1998 and designed to demonstrate how a typical California grassland ecosystem may respond to future global environmental changes. Researchers from Stanford and the Carnegie Institution's Department of Global Ecology conducted the experiment in about two fenced-off acres of the 1,189-acre Jasper Ridge Biological Preserve. The experiment was designed to simulate environmental conditions within the range that climate experts predict may exist 100 years from now--a doubling of atmospheric carbon dioxide; a temperature rise of 2 degrees Fahrenheit; a 50 percent increase in precipitation; and increased nitrogen deposition--as a likely byproduct of fossil-fuel burning.

Scientists applied each of the four experimental treatments--elevated carbon dioxide, warming, increased precipitation and nitrogen deposition--to intact grassland plots both singly and in all possible combinations. The experiment included control plots that did not receive any treatments. Each of 16 possible scenarios was replicated eight times to allow the researchers to tease apart the separate influences of factors and test the statistical significance of their results. Data reported in this study were obtained from 1999 through 2003.

"Under today's conditions, grasses flower early in the growing season and wildflowers flower later, but when we increased the concentration of carbon dioxide to simulate future conditions, the two groups flowered at the same time," Cleland said.

## Early spring

In recent decades, scientists have observed accelerated springtime developmental activity in many plant and animal species and have assumed it was a response to global warming. In the experiment, researchers found that warming accelerated springtime flowering of all

species. But they were surprised to find differing responses to elevated carbon dioxide and nitrogen deposition: Wildflowers responded to these changes by flowering earlier, while the grasses flowered later. This caused the two groups to overlap in their seasonality, where under current conditions they flower at separate times.

Consequences could be significant, points out co-author Loarie: "If plant species overlap more in the future because their timing is altered by global changes, it could lead to decreases in local plant diversity and negatively impact animals that depend on those plants."

Satellite images in recent years have revealed that some regions of the globe are "greening" earlier in the spring--another signal that the Earth is responding to overall warming. The results of this study also showed that plant growth--as evidenced by peak "greenness"--occurred earlier in the growing season when the grassland was exposed to warming, simulating future conditions.

But plant growth was delayed by elevated carbon dioxide, consistent with the fact that grasses--which make up the majority of plants in this system--were flowering later. "Unless the growing season is extended, slower plant growth under elevated carbon dioxide could reduce the overall productivity of the ecosystem," said Cleland.

Said Mooney, a founder of the Jasper Ridge Global Change Experiment: "This research shows that warming is just one aspect of global change and highlights the surprising ways in which natural communities may respond to changing environmental conditions."

Source: Stanford University