

Mountain Messengers

Scientists scale peaks and study plants to understand the impact of warming

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When a helicopter dropped Stephen Talbot into a remote corner of Alaska's Selawik National Wildlife Refuge late last June, he got straight to work. The U.S. Fish and Wildlife botanist was racing against time to inventory plant species on four peaks in the Hockley Hills. He had a month to complete his fieldwork. How long the plants have is anybody's guess.

As temperatures rise around the world, the fragile, cold-loving alpine plants clinging to peaks from the Alps to the Andes are increasingly at risk. These slow-growing perennials are perfectly adapted to their frigid, wind-blasted summits. Turn up the heat, and plants may slowly creep upslope to cooler elevations, if they exist. Ratchet it up too fast or too far, and the plants will go extinct.

Scientists such as Talbot are scaling peaks and studying plants worldwide to understand the impact of warming on mountain ecosystems. On mountaintops the average temperature, like that of the Arctic and Antarctic, is rising at twice the rate of the global average. That means that high altitude—and high latitude—regions are responding faster and sooner to climate change.

Harald Pauli, a botanist at the University of Vienna in Austria, began studying this phenomenon in the European Alps in the early 90s. Using historical data from as far back as 1835, Pauli and colleagues discovered that warming temperatures have chased plants to higher elevations at a rate of about a foot per year. This finding, along with the lack of detailed information on the distributions of species in alpine environments, led Pauli and others to launch the Global Observation Research Initiative in Alpine Environments (GLORIA) in 2001.

The beauty of GLORIA lies in its standardized, low-cost, low-tech process, says Dan Fagre, a U.S. Geological Survey ecologist who is based in Glacier National Park and established the first North American GLORIA study site there in 2003. By collecting specific data, revisiting peaks every five years and plugging the results into a central database, scientists around the world can now compare notes.

New sites are added every year, says Pauli, but the results take time. The seminal site, established by Pauli in 1994 on Mount Schrankogel in the Austrian Alps, is just now generating

data. In a paper published in *Global Change Biology* in January 2007, Pauli and colleagues documented an 11 percent increase in the past 10 years in the number of species present, called species richness. More plants are a good thing, right? Not necessarily, according to Pauli.

It turns out that the new species were alpine grassland plants that moved upslope. At the same time, all of the extreme nival species, those that live scattered among rocks and snow at the highest elevations, declined.

"It was a surprising signal that obviously the ongoing climate warming could be detrimental to very cold-adapted species," Pauli says. "[The increased species richness] is the beginning of a process, which will finally, we expect, result in the shrinkage of alpine life zones. As it progresses, species will no longer survive."

Why should the world care about the disappearance of a few wildflowers on remote mountaintops? In Europe, the alpine ecosystem covers only 3 percent of the landmass but is home to almost 20 percent of all native plant species. An enormous number of species would be affected.

"Loss is loss. Forever," Pauli says. "You could preserve the seeds in seed banks, but it's never the same. You cannot preserve entire ecosystems."

He also points out that the vegetation would not shift in an organized fashion dictated by contour lines; some species move upslope much faster than others. Furthermore, the transition from established species to new invaders could destabilize slopes, he says, leading to enhanced slope erosion and landslides.

For Brad Cardinale, an ecologist at the University of California, Santa Barbara, the loss of any species has potentially dire implications for life on the planet. In a paper published in *Proceedings of the National Academy of Science* (PNAS) in November, Cardinale and colleagues reviewed 44 studies conducted over two decades that simulated extinction to see how biodiversity affects ecosystem productivity.

Productivity is the term scientists use to describe the fundamental biological process by which plants grow and produce more plants. It may not sound sexy, Cardinale says, but the process is responsible for taking greenhouse gases, like carbon dioxide (CO₂), out of the atmosphere, and producing the oxygen, food, wood and biofuels that allow many of the species on the planet, including humans, to exist.

Cardinale, along with many in his field, have long argued that conservation efforts should be focused on the most productive species in an ecosystem, the less productive species could be ignored. He was shocked by a key finding of his analysis: species are not redundant.

In fact, species loss dramatically affects productivity. "As species go extinct from their natural habitat, we could lose 50 percent of the species, and that's probably an underestimate," he says. "I don't think that anyone expected it to be that large. That translates into 50 percent less productivity, 50 percent less oxygen, 50 percent less CO₂, 50 percent less food, wood and biofuel."

It isn't so much the loss of a particular species that matters, it is the loss of biodiversity, Cardinale says.

Recent climate change studies have shown that scientists have overestimated the ability of natural habitats to remove CO₂ from the atmosphere. Cardinale's analysis points to plant extinctions as a reason "As you cause extinctions, forests, grasslands and such become far worse at taking CO₂ out of the atmosphere," he says. "We potentially have this feedback: if climate change causes extinction, extinctions worsen climate change."

For Talbot, scrambling across rounded siltstone hills to establish the first GLORIA site in the North American Arctic, the sense of urgency is often hard to sustain. "A lot of it is boring monitoring work," he says. He'll have to wait three years before he returns to change batteries and download data from the 16 small thermometers he buried at the site.

The big creamy blossoms of mountain avens (*Dryas octopetala*) and delicate purple blooms of boreal carnations (*Dianthus repens*) might not be as exciting as many flashier and rarer species, but Talbot understands the value of even these humble plants to the global network. "We're a small part of the whole picture," he says. "One site alone doesn't mean much." But filling in the white spots on the GLORIA map will allow scientists to make sense of changes happening at multiple sites across the globe.

Biodiversity research is still a developing field, Cardinale says. What is clear is that mountain ecosystems may give a preview of what lies in store for the rest of the planet under warming temperatures. "It's scary enough to be seriously concerned about it," he says. "I don't think that we need to preserve every species in order to keep the planet productive. But at the same time, to lose 50 percent of all species, there are some pretty striking implications for humanity that we really haven't struggled with. And we need to begin struggling with them."