Vegetation creeps upslope
Change apparent in Scandinavia and Russia, but slow in coming at RMNP
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Ancient path: Dan Weiss pauses on a trail in Rocky Mountain National Park that was used by generations of Utes traveling to their hunting grounds. The geography grad student is looking for clues about the factors that control the current elevation of tree line in the Colorado Rockies.

ROCKY MOUNTAIN NATIONAL PARK — When the Utes walked Trail Ridge in the 1800s, they traversed a wide-open tundra landscape where the tree line was a bit lower and scrubbier than it is today.

Trail Ridge is named for the narrow footpath left behind by generations of Utes traveling between their summer and winter hunting grounds.

On a sunny late-summer morning, University of North Carolina researcher Dan Weiss hiked the path on a hunt of his own: He was looking for clues about the factors that control the current elevation of the tree line in the Colorado Rockies.

The answers should help Weiss and his colleagues — who are two years into a five-year project funded by the U.S. Geological Survey — better predict the changes likely to occur at the upper boundaries of Western forests if global warming progresses as computerized climate models predict.

"Even if the temperature improves for the trees, the climate up there is still incredibly harsh, so the changes will be extremely slow," Weiss said of the Rocky Mountain National Park tree line.

"The change will eventually happen, but it won't happen in our lifetime," the geography graduate student said.

About 20 miles to the south, another research team prepares to launch a long-term monitoring program on three isolated peaks along the Continental Divide outside the park.

The goal is to watch in the coming decades for brush and weeds creeping up from the forest into the alpine tundra as Colorado warms.

Both projects should provide insights about the future of the rare and biologically rich tundra community that cloaks the summits of the Colorado Rockies.

Those rolling, treeless expanses help draw about 3 million visitors annually to Rocky Mountain National Park and are a defining feature of the Colorado high country.

In the coming decades and centuries, tree lines in many forests around the world are expected to rise in response to global warming. In some places, such as Scandinavia and the Ural Mountains in Russia, dramatic changes already are apparent and are being blamed, in part, on human-caused climate warming.

In the Swedish Scandes, for example, the tree line has marched up- slope about 500 feet in the past century, according to Lief Kullman of Sweden's Umea University.

In addition, scattered saplings of mountain birch, spruce and pine have recently become established 1,650 to 2,310 feet above the current Scandes tree limit, "suggesting the potential for further encroachment into the alpine tundra," Kullman wrote in a recent article, "The Changing Face of the Alpine World."

Photos reveal changes

Subtler changes have been noted in places like Rocky Mountain National Park.

At a few wetter sites, tree line has crept uphill perhaps 30 to 50 feet over the past century, said University of Wyoming researcher William Baker.

In addition, conifer seedlings and saplings have moved into meadows just below tree line.

And some patches of stunted, scrawny, wind-battered krummholz at the tundra's edge have grown into upright, vigorous-looking trees.

The changes were revealed when Baker and his colleagues rephotographed tree-line vistas originally shot around 1900.

Krummholz is German for "twisted wood" or "crooked wood."

These wedge-shaped clumps of gnarled, shrubby, ground-hugging conifers define the tree line, marking the most punishing environmental conditions the dwarf trees can tolerate.

The growth changes documented by Baker's team are interpreted as responses to a warmer, wetter climate.

But wait. Don't blame gas-guzzling SUVs.

These vegetation changes are seen as a delayed response to a period of warming that began around 1850, at the close of a centuries-long, hemisphere-spanning cool period called the Little Ice Age.

Because of the short growing season, frigid temperatures, limited moisture, meager soils and near-constant winds, the tree-line conifers of the Colorado Rockies grow at a glacial pace and are slow to respond to climatic change.

"It's been 150 years since the end of the Little Ice Age and we're still seeing the response," Weiss said.

Weiss and his mentors are trying to tease apart the environmental factors that will determine how Western forests respond to global warming.

They've established study sites in four Western national parks: Glacier, Olympic, Sequoia and Kings Canyon, and Rocky Mountain.

After a roughly two-mile hike along Ute Trail, Weiss reached Site 12A at an elevation of 11,425 feet. A long finger of krummholz snaked up a slightly concave, boulder-strewn hillside from the forest below.

Weiss pulled out his field notebook and recorded the pertinent facts: east-southeast facing hillside with an 18-degree slope, spruce and fir krummholz 0.5 to 1.5 meters high. A GPS receiver provided coordinates and elevation.

The data Weiss collects on the ground will be used to validate information gleaned from satellite images and aerial photography.

"The aim is to assess where and why we might expect the tree line to respond to climate change," said University of Iowa ecologist George Malanson, one of the research team's leaders.

"And we're trying to look at it from the perspective of the environment that a little seedling is going to experience," he said. "The conditions for that initial establishment have to be nearly perfect for it to work in that environment."

Improved climate models

At Rocky Mountain National Park, critical factors that determine the tree line include not only temperature and the length of the growing season, but soil moisture, wind and snowfall, Malanson said.

Snow helps shelter exposed trees in the winter and provides moisture into the summer.

Nearly three years ago, a team of Colorado State University researchers completed a three-year, $800,000 study of the likely effects of long-term climate warming on the 415-square-mile national park.

More than 100 square miles of the park lie above tree line — a stark landscape of bare rock, ice and tundra.

The Colorado State researchers said warmer temperatures could allow spruce and fir trees to survive at higher elevations, eventually pushing the tundra off the park's highest peaks.

"Over the long term — over the next 50 or 100 years — our models would suggest that tundra is likely to be eliminated from the park," project leader Thomas Hobbs said at the time.

But that study used computerized climate models that projected significant annual precipitation increases for the West in coming decades, along with several degrees of warming.

The latest models, run on supercomputers at places like the National Center for Atmospheric Research in Boulder, tell a different story.

In a Sept. 30 >paper in the journal Geophysical Research Letters, NCAR senior scientist Gerald Meehl and his colleagues analyzed results from nine state-of-the-art climate models.

The models suggest that Colorado will see little or no change in its average annual precipitation total by 2100.

Seasonally, winter precipitation is expected to increase, but summers will be drier, according to the study. Due to warming, however, a higher percentage of the winter precipitation is expected to fall as rain, rather than snow.

By 2100, Colorado is expected to warm 3.6 to 7.2 degrees Fahrenheit, according to Meehl's latest study.

"If that warmth is not accompanied by more moisture, we don't expect the tree line to march up the hill," said the University of Wyoming's Baker.

"Across most of that tree-line area, it's a pretty severe place for them and they need more moisture to be able to regenerate and really grow, and particularly to move up into the alpine."

To track the tree line in coming decades, long-term monitoring plots have been established in Rocky Mountain National Park, said U.S. Geological Survey ecologist Tom Stohlgren.

Repeat photography also will be used to monitor the tree line periodically.

But again, any changes are likely to unfold slowly.

That means the tree line in the Colorado Rockies probably won't serve as a sensitive indicator of global warming responses, said William Bowman, director of the University of Colorado's Mountain Research Station.

Mountaintop sentinels

Tundra plants will likely provide a better red flag.

On Colorado's highest peaks, the alpine tundra community is a ground-hugging mix of some 350 species of grasses, sedge, wildflowers and other forbs, moss, lichen and low shrubs such as dwarf willow and birch.

To detect changes in tundra vegetation patterns in the coming decades, permanent monitoring plots will be established next summer atop three peaks within the city of Boulder watershed, along the Continental Divide.

The peaks — 13,276-foot Kiowa, 12,609-foot Albion and 13,150-foot Arikaree — were selected in part because the watershed is off-limits to the public, so summit-area vegetation is relatively undisturbed, said Bowman, who is heading the project.

"A severe problem is finding a summit of a mountain in Colorado that isn't trampled to death," Bowman said.

"Especially along the Front Range, almost every summit is climbed regularly," he said, "and you can have vegetation change resulting from that trampling."

Sixteen 1-square-meter plots will be established just below the summit of each peak — four in each of the four cardinal directions.

Temperatures and vegetation will be monitored periodically — hopefully, for decades to come.

The project is expected to cost $2,000 to $3,000 a year, with a portion of the funding provided by the National Science Foundation.

The three Colorado peaks will become part of an international network of long-term alpine monitoring sites called GLORIA, which stands for Global Observation Research Initiative in Alpine Environments.

Established in 2001, the program has grown to more than 30 sites around the world, from the poles to the tropics.

Along the tundra-forest boundary of the Front Range, early indications of a response to warming could include upward migration of shrubs — various willows and blueberry, for example — and non-native weeds such as dandelions, Bowman said.

The number of tundra species might increase initially, as the intruders move into previously inaccessible areas.

But as the decades pass, extinction of alpine plants is possible, accompanied by a decline in species diversity, Bowman said.

That decline, in turn, could affect wildlife that rely on tundra plants for sustenance.

"The plots could provide a strong indicator that global climate change is having an effect on vegetation," Bowman said.

"They might be an early warming indicator."