Two types of tundra affect carbon balance

Over the millennia, the Arctic's icy grip has bound significant amounts of the Earth's carbon in tundra as frozen peat. Researchers have worried that global warming could increase the release of these stores, emitting carbon dioxide that would worsen the greenhouse effect.

However, not all tundra in the high Arctic was created equal, says a report in the July 30 NATURE. Scientists from seven universities find that the two kinds of tundra in Alaska's North Slope differ markedly in soil chemistry, vegetation, and capacity to absorb carbon dioxide.

Previous studies may have overestimated tundra's capacity to store carbon because they did not distinguish between the two types, the authors say. Although they and other scientists are still debating whether tundra today secures more carbon than it emits, the authors predict that global warming could increase, rather than decrease, carbon storage by shifting the balance between the two varieties of tundra. Such an effect would tend to reduce carbon emissions as temperature increases.

The report shows that "vegetation type makes a big difference," says Christopher B. Field, an ecosystem ecologist at the Carnegie Institution in Stanford, Calif. The implications of these findings are global, he adds, because the two types of tundra are common across the Arctic regions of Alaska, Canada, and Russia and together cover about 7 million square kilometers.

"We're seeing that the tundra is probably more complex than we had originally thought," adds one of the authors, Donald A. Walker of the University of Colorado at Boulder.

The researchers studied differences in tundra by examining an unusually sharp boundary running east-west through the northern foothills of the Brooks Range, about 50 miles from Alaska's northern coast. South of the boundary lies acidic soil covered by mosses and shrubs. To the north is non-acidic soil supporting grasses. Arctic areas outside Alaska show a more gradual transition between the two types of tundra.

In the summers of 1995 and 1996, the researchers took daily measurements of carbon dioxide uptake and emissions at two pairs of sites, one on each side of the boundary. Because the sites on opposite sides were separated by only a few kilometers, they experienced equivalent temperatures.

Nevertheless, the results indicate that over a summer, plants on the acidic tundra soak up more than twice as much carbon dioxide per square meter as those on the non-acidic side do. Moreover, the acidic tundra contains twice as much carbon in a cubic meter of soil as the non-acidic tundra does.

Walker and his colleagues found that the thinner vegetative cover on the non-acidic tundra allows more sunlight to fall on its surface. The non-acidic soil thus thaws deeper during spring, to an average depth of 57 centimeters versus 37 cm in acidic tundra.

This thaw allows oxygen to seep further into the non-acidic soil and to decompose more organic matter, releasing carbon dioxide as a byproduct.

The authors say they cannot precisely explain the sharpness of the boundary they studied, but they speculate that foothills to the south play a role. They may create a windier climate in the plains to the north of the boundary, Walker suggests. A more extreme cycle of freezing and thawing there could give the northern soil an extra-big stir, raising minerals toward the surface and neutralizing acidity. This could sharpen the pH boundary.

If global warming heats up the Arctic, so that the non-acidic soil freezes less deeply, the location of the boundary would shift northward, the authors suggest. The spreading of acidic soils might lessen the emission of carbon dioxide, they say.

The shift in vegetation could also disrupt arctic wildlife, such as caribou, that prefer non-acidic tundra in which the stirring effect causes calcium to rise to the surface, Walker adds. The plants of that area may also be easier for the animals to digest. *—J. Brainard*

Local temperatures dance to global beat

The Arizona desert is a far cry from the European forests. In terms of temperature variability, however, a remarkable uniformity among those and other climate zones around the globe has emerged from a new analysis.

The nature of the similarity is subtle. Weather watchers know that a sunny day is likely to be followed by another sunny day and a rainy day by more of the same. Looking farther ahead, the correlation tends to hold, but less reliably. It is the rate at which this correlation diminishes that has proved to be nearly identical—for temperature, at least—at each of 14 randomly chosen, far-flung weather stations.

The uniformity, described in the July 20 PHYSICAL REVIEW LETTERS, was detected by a team of physicists and meteorologists led by Eva Koscielny-Bunde of the University of Giessen in Germany and Bar-Ilan University in Ramat Gan, Israel. While not claiming to know the reason for it, they venture that "rather fundamental mechanisms" are at work since the agreement holds despite variations not only in geography but also in the length of time covered by a temperature record.

From Tucson, Arizona, for instance, the researchers found that temperature correlation decayed in the same manner in 97 years of daily temperature data as it did in 218 years of data for Prague in the Czech Republic.

"We have found a global weather law," asserts coauthor Armin Bunde, also of the University of Giessen. Climate researchers could use the new law, he says, to test global-climate computer models, deeming flawed those that generate contrary temperature patterns.

The universal rate at which temperatures forget the past turned out to be quite leisurely. For weather stations scattered across Europe, the United States, Canada, and Australia, the group calculated how the daily maximum temperature varied from the average maximum temperature for that date over the recorded period. For each set of data, they then tested for similarities in that variation over increasing intervals ranging from days to centuries. They found a correlation that kicked in everywhere after about a week and then persisted for at least a decade, and possibly much longer, they say.

They also found that a mathematical description of the rate of decline belongs to a family of exponent-containing equations—called power laws—that have been linked in the last ten years to other natural phenomena and to urban growth patterns (SN: 1/6/96, p. 8). Power laws have cropped up across a spectrum that includes patterns of earthquake strengths, heartbeat rhythms, and bird foraging (SN: 8/17/96, p. 104).

Discerning the mathematics underlying such complex phenomena may lead to better predictions, says Boston University's H. Eugene Stanley, who specializes in ferreting out such patterns.

The new-found law, however, is unlikely to improve weather prediction, says Klaus Hasselmann, a director of the Max Planck Institute of Meteorology in Hamburg, Germany. While the law's universality is a first, meteorologists were already aware of power laws in temperature variability.

On the other hand, he agrees with speculation by the Bunde group that the oceans probably cause the correlation's long persistence. That stabilizing role poses a conundrum, however.

"Looking at different parts of the globe—those areas of the trade winds, or of the monsoon, for instance—you would think they would be influenced by the ocean in different ways," he says. "It's surprising they all show the same behavior as a function of time." *—P. Weiss*

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