Long-term studies detect effects of disappearing snow and ice

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Ecosystems are changing worldwide as a result of shrinking sea ice, snow, and glaciers, especially in high-latitude regions where water is frozen for at least a month each year—the cryosphere. Scientists have already recorded how some larger animals, such as penguins and polar bears, are responding to loss of their habitat, but research is only now starting to uncover less-obvious effects of the shrinking cryosphere on organisms. An article in the April issue of *BioScience* describes some impacts that are being identified through studies that track the ecology of affected sites over decades.

The article, by Andrew G. Fountain of Portland State University and five coauthors, is one of six in a special section in the issue on the Long Term Ecological Research Network. The article describes how decreasing snowfall in many areas threatens burrowing animals and makes plant roots more susceptible to injury, because snow acts as an insulator. And because microbes such as diatoms that live under sea ice are a principal source of food for krill, disappearing sea ice has led to declines in their abundance—resulting in impacts on seabirds and mammals that feed on krill. Disappearing sea ice also seems, unexpectedly, to be decreasing the sea's uptake of carbon dioxide from the atmosphere.

On land, snowpack changes can alter an area's suitability for particular plant species, and melting permafrost affects the amount of carbon dioxide that plants and microbes take out of the atmosphere—though in ways that change over time. Shrinking glaciers add pollutants and increased quantities of nutrients to freshwater bodies, and melting river

ice pushes more detritus downstream. Disappearing ice on land and the resulting sea-level rise will have far-reaching social, economic, and geopolitical impacts, Fountain and his coauthors note. Many of these changes are now becoming evident in the ski industry, in infrastructure and coastal planning, and in tourism. Significant effects on water supplies, and consequently on agriculture, can be predicted.

Fountain and his colleagues argue that place-based, long-term, interdisciplinary research efforts such as those supported by the Long Term Ecological Research Network will be essential if researchers are to gain an adequate understanding of the complex, cascading ecosystem responses to the changing cryosphere. Other articles in the special section on the Long Term Ecological Research Network detail further notable scientific and societal contributions of this network, which had its origins in 1980 and now includes 26 sites. The achievements include contributions to the Millennium Ecosystem Assessment, to ecological manipulation experiments, to bringing decisionmakers and researchers together, and to mechanistic understanding of long-term ecological changes.

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