2.6 Warming the Tundra: Health, Biodiversity, and Greenhouse Gas Implications

Summary

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Terrestrial ecosystems in the Arctic play important roles in the global climate system as heat sinks (through permafrost, snow, and ice) and as carbon stores. They provide living resources for communities throughout the North, and they are also stores of airborne pollutants; hence, they play important roles in human health and culture. Tundra and taiga ecosystems are expected to respond strongly to the predicted climate warming, although there will be regional differences. In the western North American Arctic, there have been noticeable changes in permafrost temperature and melting, in vegetation and in carbon fluxes. These changes will affect feedbacks between the ecosystems and the climate and human systems. Improved understanding of the role of high-latitude ecosystems in the climate system requires a concerted research effort focused on geographical variation in processes controlling land-atmosphere and land-water exchanges, species composition, and ecosystem structure. This project addresses some of the implications of these changes in terrestrial environments of the eastern Arctic with the major objectives to: (1) Assess the organic carbon content, potential exchange of greenhouse gases (CO2, CH4) relative to differences in moisture and nutrient dynamics along gradients at key sites. (2) Determine the effect of local and regional environmental gradients (e.g. temperature and moisture) on genetic and functional plant biodiversity. These comparative studies will provide correlations between climate, biodiversity and biomass production which will aid in forecasting future trends in vegetation, and provide baseline data for future changes. The results will be especially relevant for studies in Project 2.1. (3) Reconstruct historical climate variability at sites along the latitudinal gradient from dendrochronological analyses of long-lived woody plants. The instrumental climate record for the region is short and sparse. Using proxy climate date from tree-rings at treeline sites and stem growth in a long-lived arctic shrub (Cassiope tetragona) beyond treeline, we will provide a needed temporal perspective (150+ years) for the climate variability and changes in the region. Through the use of stable isotope analyses, these studies will be linked to similar studies in Project 2.2 to help extract proxy precipitation data, and allow an examination of variability in precipitation patterns. (4) Measure permafrost temperatures and active layer depths at key sites along the transect and reconstruct Late Holocene climate changes from the sequential analysis and dating of organic and mineral layers in appropriate sites of syngenetic permafrost in order to complement paleoclimate knowledge above the treeline (Allard, Pollard – see Project 2.4). Permafrost temperatures and maximum thaw depths provide information on regional temperature trends. (5) Determine the contaminant content of permafrost in watersheds of drinking water supplies and the extent to which these materials are mobilised by melting and leaching. (6) Determine the CO2, DOC, colour and bacterial content of permafrost in water supply catchments for assessing the potential release of greenhouse gases and to evaluate the transfer of microbiota and optically active materials to waterbodies. These projects are linked to the water quality research proposed in Project 2.2 and will lead to a better understanding of future water quality, and the role that terrestrial systems play in storage and release of contaminants and greenhouse gases.

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