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TundraPEAT—Understanding Peat Expansion in Arctic Tundra in a Warming Climate

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This presentation will provide an overview of a new 5-year project, funded by US NSF's Macrosystem Biology program, to understand peat expansion in Arctic tundra. Amplified climate warming in the Arctic in recent decades has caused a multitude of changes in terrestrial ecosystems. Most of these changes have the potential for strong feedbacks on the global climate system, which has prompted considerable debate about C balance and the "greening" vs "browning" of high-latitude systems. However, the impacts of these changes on belowground processes and associated carbon (C) budget are still uncertain due to several complex interactions. Some Arctic tundra landscapes have shallow 'peat patches', which have organic layers too thin (<30 cm) to be classified as peatlands, but still represent a significant net C sink at decadal-centennial timescales. Also, these peat patches represent the initial stage of peatland formation in the pan-Arctic region, as peatland conditions may migrate northward in a warming climate. We recently found abundant peat patches dominated by Sphagnum (peat moss) on hillslopes dominated by tussock tundra communities on the North Slope of Alaska. However, we don't know how widespread these tundra peat patches are, why they are there, and what factors control their formation, distribution, and dynamics. We know that peatlands have been an important C sink over multi-millennial timescales. However, we don't know how they respond to recent and future environmental changes at decadal-centennial timescales, the most relevant timescales of rapid Arctic climate change and for climate change mitigation. Furthermore, we don't understand the possible cross-timescale interactions between plant production and peat decomposition processes.

In this project, we as a multidisciplinary team of researchers will combine (1) new data collection from multiple tundra sites along the northernmost peat-forming frontiers of the North American Arctic, together with (2) laboratory incubation experiments, (3) a synthesis of existing data from the tundra and boreal biomes, along with a group of international collaborators in Europe and Canada, and (4) ecosystem-scale process model simulations. Our overarching question is: Will the warming Arctic evolve into a peatland-rich landscape, as the boreal zone is now, or are there some essential conditions missing in a warming Arctic that will prevent this? To address this broad question, we will focus on two key elements: (i) peat patches, and (ii) the role of Sphagnum in the formation, persistence, and rapid rates of C sequestration of these potentially 'incipient' peatlands. We will use our observational, experimental, and modeling results, along with synthesis products from a coordinated international research network, to test several specific hypotheses on (1) the ages, C accumulation rates, and continental pattern of these rapidly forming and migrating peat patches; (2) the various responses of production and decomposition processes to temperature and moisture change; and (3) the role of Sphagnum in modifying microclimate and shifting balance between their productivity and decomposability. The results will help us understand environmental conditions and processes that control the formation and northward migrations of green peat frontier in a warming Arctic.