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ABSTRACT TITLE: Biophysical drivers of CO2 and CH4 emissions from moist acidic tundra upon experimental warming

ABSTRACT: Arctic tundra ecosystems are experiencing structural and functional changes due to climate warming and associated changes in winter precipitation. Greater snow cover in the Arctic provides soil thermal insulation and induces vegetation changes that may affect the vulnerability of stored C. Higher mineralization of centurial C in forms of CO2 or CH4 emissions may cause positive feedback with the climate system. Specifically, vegetation shifts favoring ecosystem productivity and associated alterations in thermal and hydrological regimes with warming may trigger CO2 and CH4 emissions. Therefore, the CO2 and CH4 forms of C emission are relevant to climate models, but the biophysical mechanistic understanding of these warming-C cycling feedbacks is currently lacking for Arctic tundra. We measured O2, CO2 and CH4 soil gas concentrations and fluxes over a growing season adjacent to a snow fence (to mimic predicted increases in snow cover) located in moist acidic tundra at Toolik Lake, AK. To account for soil physical changes that may affect gas diffusivity we also measured the 222Rn flux. We found that this site may switch from being CH4 neutral to being a source of CH4 with warming. In contrast, CO2 efflux did not appear to be sensitive to increases in soil temperature, likely because of reduced gas diffusion coefficients under enhanced winter precipitation. Reduced diffusion of O2 into the soil may have prompted the large production of CH4, although ecosystem CH4 emission was limited by diffusion. The δ13C value of CH4 also indicates a progressive increase in the prevalence of methanogenesis by the CO2 reduction pathway relative to acetate fermentation with increased winter soil thermal insulation. Methanotrophy appeared to be limited by redox changes at shallow depths within the experimental treatment sites. Our findings indicate that biophysical factors affecting gas diffusion drive CO2 and CH4 dynamics in Arctic moist acidic tundra.