

ANL Terrestrial Ecosystem Science SFA: Soil Organic Carbon Stocks and their Distributions across Ice-Wedge Polygons of Arctic Alaska

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Estimates of the quantities of organic carbon stored in permafrost-region soils have improved immensely within the last few decades. However, uncertainties in these estimates remain high and affect our ability to reliably predict the vulnerability of the region's vast carbon stocks to remobilization caused by permafrost thaw and other perturbations related to climatic changes. Two major sources of uncertainty are (1) the uneven distributions and limited numbers of observational data, due to constraints on accessibility for much of this remote region; and (2) the high spatial heterogeneity of cryoturbated soils found in patterned ground — where freeze/thaw, frost heaving, and other cryogenic processes cause soil deformation, breaking/mixing of soil horizons, and deep burial of relatively labile organic matter. Ice-wedge polygons are ubiquitous throughout Arctic coastal plains and drainage basins. These patterned ground features are large enough (~5-30 m across) that a better three-dimensional understanding of their carbon stocks might improve geospatial upscaling of observational data. We investigated the horizontal and vertical (up to 3 m deep) distributions of soil organic matter across three polygon types on the North Slope of Alaska: low-centered (LCP), flat-centered (FCP), and high-centered (HCP) polygons, with each type replicated three times. We found variations in the thickness and quality of surface organic horizons for different polygon types. Below the active layer, organic-rich cryoturbated horizons were located in the transition zone and fingered down into the upper permafrost. The HCPs exhibited more prominent deformation than LCPs and FCPs. The cross-sectional distribution and heterogeneity of organic carbon density differed among polygon types, which led to type variations in overall polygon carbon stocks as well (HCP > LCP > FCP). Our findings suggest that an approach based on accounting for polygon-scale features (wedge to rim to center) and/or landscape-scale (polygon type) variations, in tandem with remote sensing and geospatial tools, could help constrain the uncertainties associated with upscaling of carbon stocks for areas of patterned ground dominated by ice-wedge polygons.