Quantifying Variations in Soil C:N Relationships for the Permafrost Region

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Project Abstract: Recent worldwide efforts have improved estimates of soil organic carbon (SOC) stocks and their spatial and vertical distributions for the permafrost region. However, predicting the fate of these SOC stocks in response to changing climatic conditions and projecting their impact on carbon-climate feedbacks require better information on additional soil properties. For example, understanding the nitrogen (N) reserves currently held by permafrost-region soils, their relationships with SOC stocks, and their susceptibility to release under changing climatic conditions will be important for efforts to model future ecosystem and regional responses and feedbacks. Soil C:N ratio can be an indicator of decomposability as it can influence microbial decomposition processes—with related effects on N availability, nitrous oxide emissions, and vegetative responses to climatic and hydrologic changes. Yet, efforts to map the patterns of soil N stocks and C:N relationships for the permafrost region currently lag behind those for SOC stocks. The first study to estimate the distribution of soil N stocks across the northern circumpolar region (Palmtag et al., https://doi.org/10.5194/essd-2022-8, in review) used a thematic mapping approach based on land cover classes spatially available at 300-m resolution to upscale a newly available observational dataset. As an important soil forming factor, land cover affects the form and composition (including C:N) of recent organic inputs to soil and also generally reflects the integrated effects of climate and edaphic factors—making it a useful predictor for upscaling studies. In the permafrost region, however, unique cryo-pedogenic processes (such as cryoturbation) and the preservation of poorly degraded soil organic matter at depth suggests the need to investigate soil C:N relationships in the context of other soil forming factors at higher spatial resolutions. However, mapping and interpretation of soil property ratios (including C:N) is challenging, with no set standard, particularly for the heterogeneous profiles of permafrost-affected soils. The drawback to direct mapping of soil C:N is the assumption that similar environmental factors influence the spatial and vertical variability of both SOC and N, which might not be true. Another approach would be to map SOC and N stocks independently, to capture how different environmental factors affect each soil property, and then determine soil C:N distributions from the two digital soil mapping products. In this study, we compare these two approaches at high spatial resolution in Alaska to evaluate which can best capture and explain spatial and vertical variations in soil C:N relationships.