Land cover change analysis reveals net permafrost aggradation over 45 years in the Baker Creek watershed, Northwest Territories

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Permafrost loss is a common thread across high latitudes in the past century, as warming leads to the thaw of perennially frozen ground. Discontinuous permafrost landscapes are particularly vulnerable to dramatic thaw, as permafrost loss can occur both vertically (through increased active layer thickness) and laterally (through decrease in areal extent). Examples of extensive lateral permafrost thaw in discontinuous permafrost landscapes have been described in lowland plains ecosystems, where forested permafrost plateaus collapse into treeless wetland features. Permafrost loss is then exacerbated by increased soil moisture, as drainage is often poor in these lowland areas. While also a discontinuous permafrost landscape, the Taiga Shield, with a network of lakes, wetland, soil-filled valleys, and forests all underlain by near-surface bedrock, may be a more stable terrain under warming climate than the lowland plains ecosystems. Additionally, “fill-and-spill” hydrology creates ephemeral water sources between low-lying parts of the shield landscape, leading to multi-year wetting or drying trends – this can contribute to varied trajectories for permafrost change in the Taiga Shield landscape. We investigated land cover changes and the implications for permafrost in the Baker Creek watershed, just north of Yellowknife in the Northwest Territories. We took measurements of soil organic layer (SOL) and frost table depth to characterize ground conditions of different land cover types. We acquired archival aerial photographs and recent satellite imagery in order to assess land cover change in the watershed between 1972 and 2017. We found strong associations between the ground-based measurements and land cover type which allowed us to use land cover class as a proxy for permafrost extent. While both aggradation and degradation of permafrost were observed locally within the watershed, we found a net increase in permafrost extent over this 45 year period. We found that a combination of local hydrology and climatic conditions that lead to colder, drier soils are likely driving the development of permafrost that we observed. This highlights the importance of considering landscape heterogeneity in the study of changing permafrost landscapes.