Cryptic ground ice conditions in permafrost and northern agricultural expansion

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Permafrost Grown team members Melissa Ward Jones and Benjamin Gaglioti inspect thaw subsidence in a birch forest adjacent to a farm. An ice wedge trough is made visible through thaw subsidence and caused trees to lean is seen running along the center of the image.

Permafrost conditions are often heterogeneous and concealed beneath the surface, becoming evident only when thawing occurs. Melissa Ward Jones discusses these challenges and highlights a new publication that identifies ice wedges for the first time in the Yukon-Kuskokwim Delta region of Alaska

Permafrost conditions, including ground ice content, can be highly heterogeneous, but are hidden below the ground surface and are often only “revealed” when permafrost begins to thaw. Here, I discuss these potential challenges and highlight a new publication that found ice wedges in the Yukon-Kuskokwim Delta region of Alaska for the first time.

What is permafrost?

Permafrost is solely defined by temperature (below 0 °C for at least two consecutive years). Its composition can be a mixture of any type of earth material, for example, this could be bedrock, soil, organic matter, lots of ice, or no ice at all. The extent and composition of permafrost conditions, as well as the presence of permafrost itself in areas where it is discontinuous, are highly heterogeneous. However, what is common throughout is that it is hidden below the surface of the ground.

Figure 1: On right, Permafrost Grown team member Mikhail Kanevskiy analyzes a recent collect core collected from an ice wedge trough in Bethel, AK. On left, Mikhail holds a core section of wedge ice that will cause thaw subsidence if the permafrost it's in degrades.

Diverging responses of permafrost thaw

Permafrost that is ice-rich or ice-poor will look the same under stable (frozen) conditions. Where the types diverge in their response to thaw, ice-rich permafrost will cause ground surface collapse known as thaw subsidence, whereas the ground surface elevation of ice-poor permafrost will remain unchanged as it thaws (Ward Jones et al., 2022; Ward Jones, 2024).

This creates challenges for infrastructure and potential agricultural expansion in high-latitude regions, such as Alaska. For example, one farm in Fairbanks, AK, participating in the Permafrost Grown has two district areas within a single agricultural field: one side is ice-rich, where thaw subsidence occurs regularly, and repeated infilling and grading of these areas has occurred to manage permafrost thaw, while the other side has not experienced any measurable thaw subsidence.

While new construction and engineering projects are advised to continuously adapt and modify designs based on local ground and permafrost conditions at specific project sites (Connor et al., 2020), this can be challenging to implement for individual or family-owned farming operations, which are typical of Alaska. According to the 2022 Census of Agriculture, 39% of Alaskan farmers were new and beginning farmers, many of whom come from outside Alaska and may not have any knowledge of permafrost.

Some misconceptions on permafrost presence

General advice given to individuals and families seeking to buy new land, including to establish new farms, is to avoid permafrost. Common advice on how to identify land with permafrost is to avoid areas with black spruce trees and north-facing slopes, and instead target land with deciduous trees (such as birch and alder) and south-facing slopes. It can be challenging to find land with preferred aspects, and there are some misconceptions within this advice.

While black spruce is often associated with permafrost in Interior Alaska, land with deciduous trees does not guarantee that permafrost is absent. These trees are indicators of drainage conditions, and that there was likely some type of disturbance in the past, like a previous wildfire. From personal observations, the extent and scale of thaw subsidence that has occurred in spruce forest or mixed birch forest sites, for example, is identical.

New paper confirms ice wedges in Alaska's Yukon- Kuskokwim Delta Region

The hidden nature of permafrost conditions below the ground surface motivates the continuous research efforts of the permafrost research community to better understand and map permafrost. It has long been thought that ice wedges were absent from the Yukon-Kuskokwim (Y-K) Delta region of Alaska, with past studies conducted using this assumption.

Work published in the journal Permafrost and Periglacial Processes (Jones et al., 2025), led by Permafrost Grown co-investigator Benjamin Jones, found widespread ice wedge networks in the Bethel area. Ice wedges are the most common type of massive ground ice in the Arctic, forming from thermal contractions cracks in winter and subsequent water infiltration from spring snowmelt to create polygonal ground where wedge ice is found in troughs.

These findings have significant implications for permafrost knowledge in the region, as Jones acknowledges that these findings will rewrite the regional permafrost map. Mean permafrost temperatures in Bethel are near 0 °C, and air temperatures in Bethel have been warming over the last century. The study shows the resilience of permafrost with extensive ground ice being preserved within warming climate conditions, but also potential impacts to infrastructure, including potential future agriculture expansion, as these uncovered bodies of ice can drive thaw subsidence of over a meter.

The onset of permafrost thaw in discontinuous permafrost areas, like the Y-K Delta and Interior Alaska, is often driven by land clearing that removes the overlying protective insulation. Understanding these processes and developing permafrost-conscious agricultural practices, as is being done through the Permafrost Grown project, is critical to support sustainable agriculture activities in areas with permafrost-affected soils.

References

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