



# Permafrost Landscapes



**Denali's landscapes underlain by permafrost can support areas of stunted spruce or treeless tundra.**

Permafrost is soil or rock that remains below 0°C for at least two consecutive years. North of the Alaska Range, landscapes are dominated by permafrost (both in Alaska and in Denali National Park and Preserve), but to the south, very little permafrost occurs. The active layer above permafrost experiences annual freezing in winter and thawing in summer. Permafrost is an important driver of Denali's ecosystems because thermal characteristics of the ground directly control or indirectly influence Denali's local hydrology, patterns of vegetation, and wildlife communities.

## **Characteristics of permafrost**

Depth to permafrost differs widely from place to place. Ice content varies from small ice crystals, lenses, and seams disseminated throughout the soil to massive ice features several meters thick. Some permafrost ground is "ice-rich", containing more than 50 percent frozen water in the soil, while other areas are "ice-poor", where the soil is colder than 0°C but contains little or no frozen water.

Spruce trees leaning in different directions (known as "drunken forest") can be a clue to frost heaving or melting of permafrost beneath. Another hallmark of permafrost landscapes is the abundance of summer bogs, ponds, and lakes even in areas of limited rainfall. Standing water collects above permafrost because the frozen layer restricts drainage and creates a perched water table.

## **Factors influencing location of permafrost**

Permafrost is a product of cold climates. Denali's northern latitude and the relatively cool mean annual air temperatures prevent well-insulated soils from thawing in summer. Other factors, such as soil type, vegetation cover, snow cover, fire history, and hydrology, also influence patterns of permafrost.

Soil grain size affects drainage and is important in the formation of permafrost. Fine clays and silts, which are extensive north of the Alaska Range, retain moisture more readily than coarse grains, making these soils ideal for permafrost formation. Permafrost is extensive on loamy-textured soils with silt and organic matter, and is only occasionally observed in gravelly soils.

Plants in the active layer provide an organic cover that insulates permafrost from warm summer temperatures. Snow insulates soils from the cold temperatures that would facilitate permafrost development. Areas of Denali dominated by permafrost tend to be areas where snowfall is limited or is blown away by the wind, so soils are exposed to deep winter cold. After wildland fires, permafrost ground warms and the active layer thickens until the plant cover grows back.

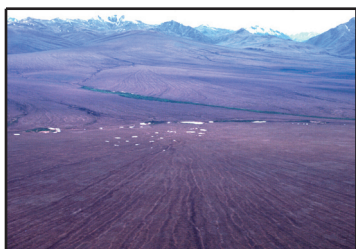
---

*This [climate change] is a big deal because you can't put the permafrost back once it's gone.*

—a climate scientist speaking about the Sub-arctic

---





Permafrost soils can be either “ice-rich” (see chunk of ice in top photo) or “ice-poor”.

Permafrost landscapes often include such features as gelifluction lobes (middle) and sheetwash rills (bottom).



Ice-wedge polygons form when water freezes after entering polygonal cracks in the surface of frozen ground. Thawing ice-wedge polygons produced this thermokarst in the permafrost-dominated Toklat Basin north of the Alaska Range.

### Extent of permafrost in Denali

Soil scientists have classified Denali’s soils (except the Alaska Range) based on the percentage of soils in a soil map unit that are underlain by permafrost. Permafrost can be continuous (i.e., permafrost exists in more than 80 percent of the soils), discontinuous (20 to 80 percent of the soils), and sporadic (5 to 20 percent). Nearly 45 percent of the park (more than one million hectares) has continuous (21%) or discontinuous (22%) permafrost. Approximately 14 percent of Denali’s landscape has sporadic permafrost and 10 percent has no permafrost. The Alaska Range and environs were not classified (32%).

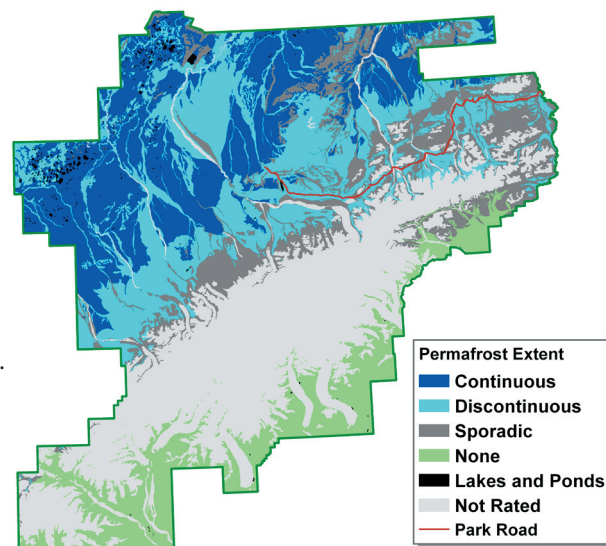
Soils supporting stunted spruce or spruce woodlands over permafrost are abundant in the northwestern part of Denali. Permafrost also dominates the Toklat River Basin in northeastern portion of the park.

### Beautiful features

In permafrost landscapes, cryoturbation (churning of soils by freezing and thawing) creates patterned geomorphic features such as frost heaves and earth hummocks, ice-wedge polygons, beaded streams (the beads along the stream are pools at the “corners” of polygons), cryoturbation steps, palsas (mounds of peat formed by ice lenses), non-sorted circles, non-sorted stripes, sheetwash rills (water drains off permafrost ground in small parallel channels), and gelifluction lobes (soil creeps downslope over permafrost).

### What is thermokarst?

When ice-rich permafrost thaws, the ice changes to a mud slurry that no longer supports the weight of soil and vegetation and the ground subsides up to several meters. Landslides can occur, and thermokarst terrain often develops (see photo below). Thermokarst features consist of channels, pits, troughs, potholes, ponds, and leaning trees. Thermokarst activity can drastically modify and remold the ground surface and change hydrologic systems, plant distribution and productivity, and landscape-scale interactions.



Denali’s landscapes of continuous and discontinuous permafrost occur primarily in the northwestern part of the park.

### A changing landscape

Formation of permafrost in Interior Alaska probably began during climatic cooling around 2.5 million years ago and has responded to the natural climate cycles (warming trends and ice ages). The last major period of extensive glacial coverage ended between 12,000 and 14,000 years ago. Climatic changes of the last century (warming since the late 1800s) and especially the last few decades (typically 1 to 2°C warmer since 1977), and predictions of warming by 2 to 5°C in this century are cause for concern. Increased mean annual air temperatures result in warming of permafrost.

Permafrost is considered fragile if it is within a few degrees of thawing. Denali contains some of the southernmost continuous permafrost in Alaska. Recent measurements in a permafrost bore hole near the park show that some of Denali’s permafrost may be within a degree of thawing. Permafrost soils are very susceptible to climate change, and significant landscape change is likely to occur with continued climate warming. Permafrost is one of the “vital signs” of ecosystem health selected for monitoring in Denali as part of the Central Alaska Network’s Inventory and Monitoring Program.

### For further information

Guy Adema  
 Center for Resources, Science, and Learning  
 Denali National Park and Preserve  
 P. O. Box 9, Denali Park, AK 99755  
[guy\\_adema@nps.gov](mailto:guy_adema@nps.gov)  
[www.nps.gov/dena](http://www.nps.gov/dena)