Denali National Park and Preserve

Permafrost Landscapes

Permafrost is soil or rock that remains at or 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. Because thermal characteristics of the ground directly control or indirectly influence Denali's local hydrology, patterns of vegetation, and wildlife communities, permafrost is an important driver of Denali ecosystems.

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 00 C, but contains little or no frozen water.

Spruce trees leaning in different directions (known commonly 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 it restricts drainage and creates a perched water table.

Permafrost soils can be either "ice-rich" or "ice-poor".

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 influence patterns of permafrost also—soil type, vegetation cover, snow cover, fire history, and hydrology.

Soil grain size affects drainage and is important in the formation of permafrost. Fine clays and silts extensive north of the Alaska Range retain moisture more readily than coarse grains and make these soils ideal for permafrost formation. Permafrost is extensive on loamy- textured soils 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 windswept away, so soils are exposed to deep winter cold. After wildland fires, permafrost ground warms and the active layer thickens until re- growth of the plant cover.

Extent of Permafrost in Denali

Denali's 2+ million hectares have been classified based on the percentage of soils in a soil map unit that are underlain by permafrost. Permafrost can be continuous (permafrost exists in more than 80 percent of the soils), discontinuous (20 to 80 percent), and sporadic (5 to 20 percent). Nearly 45 percent of the park
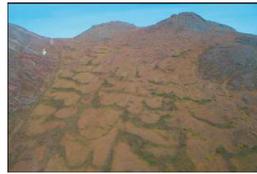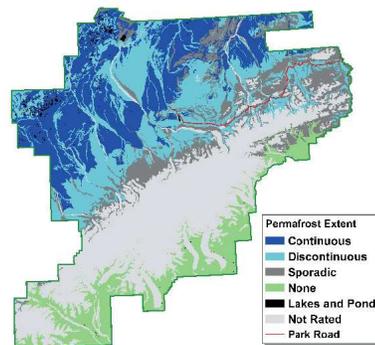

Permafrost feature: Gelifluction lobes

(more than a 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. The Toklat River basin in northeastern Denali National Park is also dominated by permafrost.

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),

Permafrost Extent
- Continuous
- Discontinuous
- Sporadic
- None
- Lakes and Ponds
- Not Rated
- Park Road

cryoturbation steps, palsas (mounds of peat formed by ice lenses), non- sorted circles, nonsorted stripes, sheetwash rills (water drains off permafrost ground in small parallel channels), and gelifluction lobes (soil creeps downslope over permafrost).

Denali's landscapes of continuous and discontinuous permafrost occur primarily in the northwest portion of the park.

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, left). Thermokarst features consist of channels, pits, troughs, potholes, ponds, lakes, 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.

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.

A Changing Landscape

Permafrost in Interior Alaska probably began during climatic cooling that began around 2.5 million years ago, and has varied in response to the natural climate cycles (warming trends and ice ages). The last major period of extensive glacial coverage ended about 12,000 to 14,000 years ago. Climatic changes of the last century (warming since late 1800's) and especially the last few decades (typically 1 to 20C warmer since 1977), and predictions of warming by 2 to 50C 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 show some of Denali's permafrost is 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 has been selected as one of the "vital signs" of ecosystem health to be monitored in Denali as part of the Central Alaska Network's inventory and monitoring program.