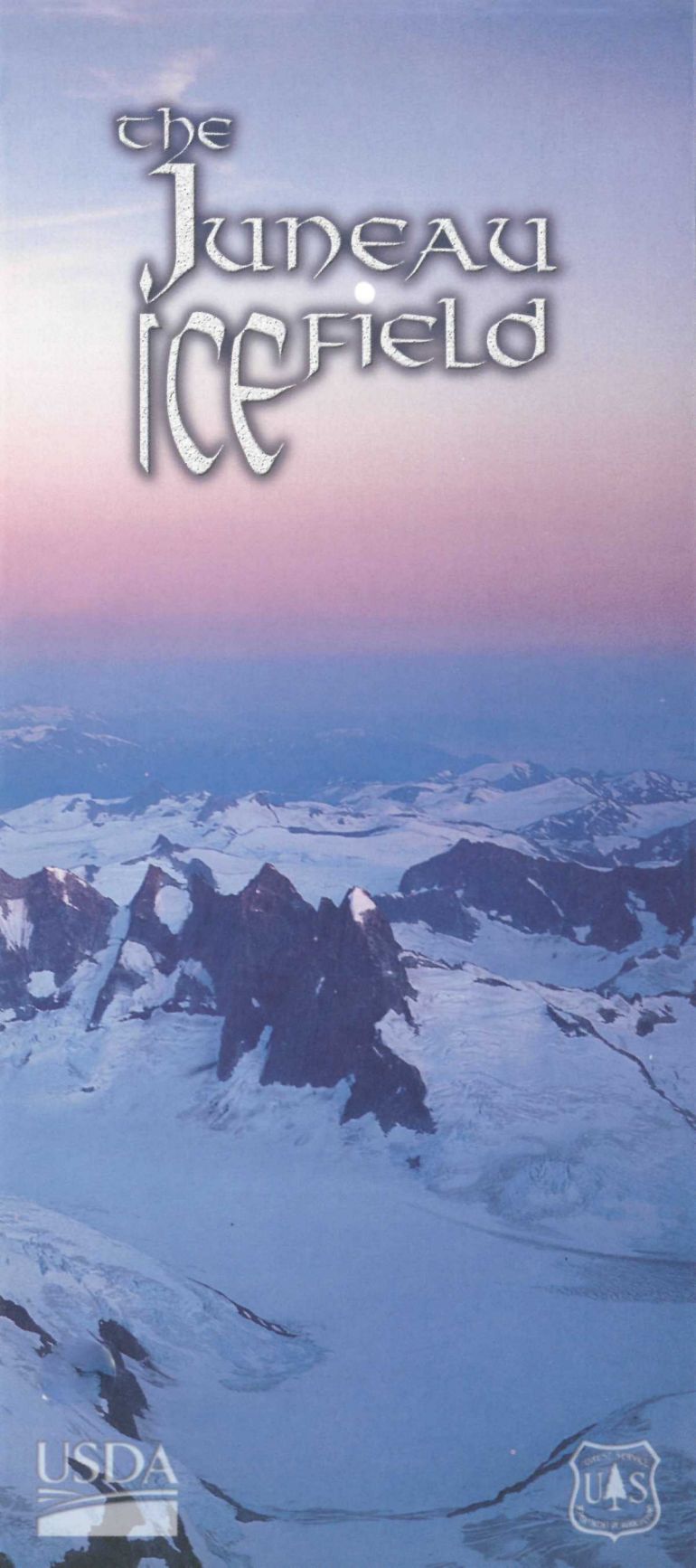
# The Juneau Icefield



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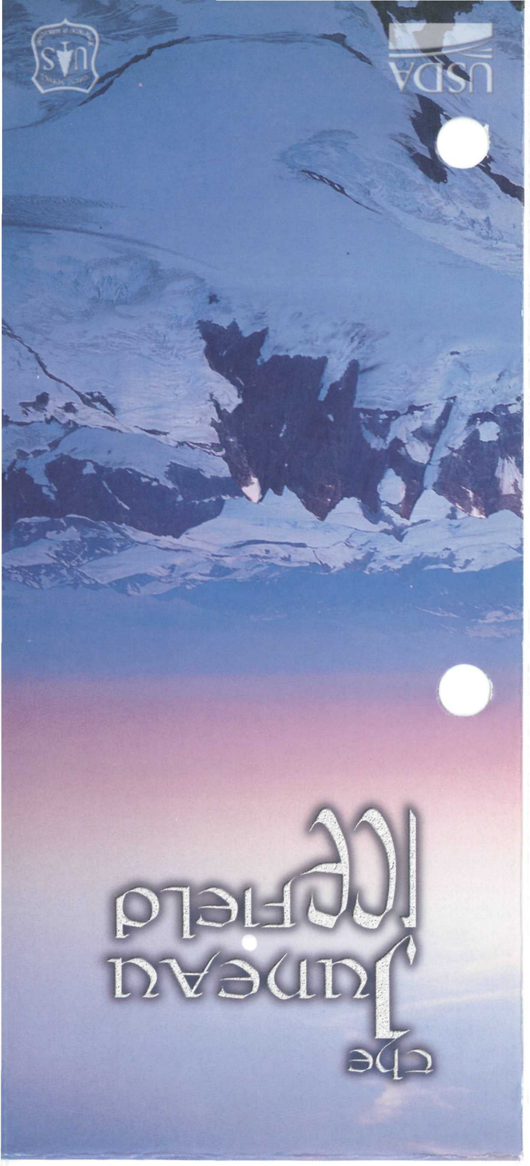


Recreation Fee Test Project

Your Fees at Work

## FEE DEMO

This brochure is produced from funds collected through the Recreation Fee Demonstration Project. Authorized by Congress, this national pilot program allows federal land management agencies to collect user fees which provide new enhancements and improve existing services.

Fees for this brochure are collected in partnership with helicopter tour operators for the Juneau Icefield, which is located in the Tongass National Forest. For more information or comments, please contact: Fee Demo Project Coordinator, USDA Forest Service, Juneau Ranger District, 8465 Old Dairy Road, Juneau, AK 99801
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## Legend

- international boundary
- latitude & longitude lines
- borough boundary
- main roads
- international airport

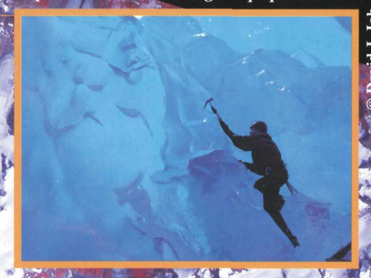
0 20 miles

0 20 kilometers

ALASKA — image location

This image is a Landsat satellite image acquired on June 27, 1992. The image is based on green, red and near infrared light reflected from the earth's surface. Healthy vegetation reflects strongly in the infrared band and is depicted in varyiing shades of red. The infrared band is also useful for delineating sediment plumes from glacier-fed streams and rivers.

*Ice climbing in the Juneau Icefield requires skill and the right equipment.*



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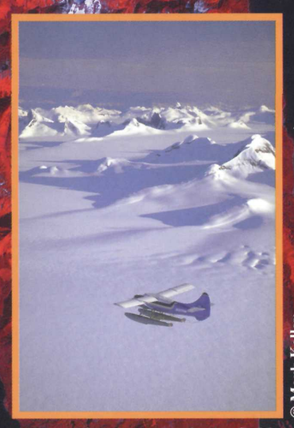
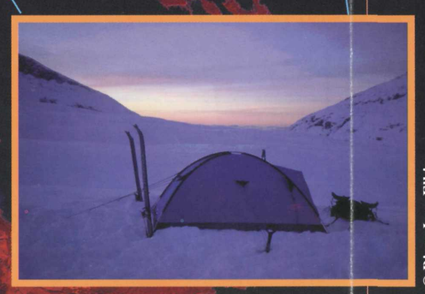


© Mark Kelley

*A beautiful day over the icefield.*



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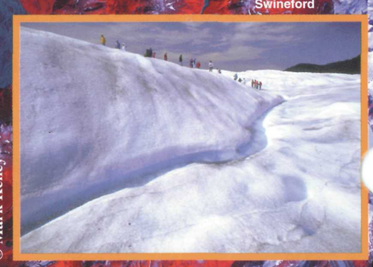
*Sunrise on Eagle Glacier.*



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*Visitors explore the icefield.*

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*A flightseeing helicopter glides over seracs in the Juneau Icefield.*

# The Juneau Icefield

Embark upon a trip back in time during a visit to the Juneau Icefield. Located in the Coast Mountain Range, North America's fifth largest icefield blankets more than 1,500 square miles of land stretching nearly 100 miles north to south and 45 miles east to west. Proceed up valley and observe the transformation. Watch the temperate rainforest diminish as the ice spreads like tentacles among the jagged mountain peaks. What ancient process fashioned this stark landscape? How will it be transformed in the centuries yet to come?

Step back two million years to the Pleistocene when mammoths roamed the West and a cooling trend locked moisture into ice. During this Great Ice Age several climatic fluctuations nourished glacial advance and retreat, and vast sheets of ice enshrouded nearly a third of the Earth's land mass and one half of Alaska. Twenty thousand years ago, as the climate warmed at the dawning of the Holocene, the ice released its hold on the land and retreated. In Alaska, ice remained at only the highest elevations. Continuing variations in climate prompted four smaller scale glacial advances and retreats. The most recent period of neo-glaciation to shape the Juneau Icefield began 3,000 years ago and ended in the mid–1700s. During this time, many glaciers in Alaska, including those which flow from the Juneau Icefield, fluctuated with the climate, advanced, and again retreated after reaching their glacial maximum in the mid–1700s.

© David J. Job

*The birthplace of glaciers.*

# Climatic and astronomical forces foster glaciation

Today ice covers only 5% of Alaska, though this region has actually hosted a glacier-favoring mixture of climate and topography for the last 12.5 million years. Weather and terrain are not the only factors that make glaciation possible. One widely accepted theory suggests that Pleistocene glacial and inter-glacial periods result from the Earth's orbital-rotational cycles. The fluctuation in the tilt of the Earth's spin axis and the shape of the Earth's orbit interact, varying the amount of seasonal sunshine which the Earth receives in certain areas. These changes in seasonal intensity may affect ocean currents, which ultimately influence the climate.

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*Glacial tributaries merge creating debris lines called medial moraines down the center of the glacier.*

In Southeast Alaska, maritime climate and coastal mountains work together to create favorable conditions for glaciation. The Juneau Icefield straddles the Coast Mountain Range on the United States-Canadian border, directly in the path of the Pacific Ocean's prevailing winds. Moist air rushes toward the mountains, rises, cools, and releases snow and rain. Annual snowfall on the Juneau Icefield exceeds 100 feet, and mild Southeast summers assure that snow accumulation exceeds snow melt at higher elevations. As the snow continues to accumulate, its own weight compacts snow layers from previous years into solid ice, causing changes in volume, density and crystal structure. Glacial ice absorbs all colors of the visible light spectrum except blue, which it transmits. Scientists estimate the icefield's snow and ice depth to be from 800 to over 4,500 feet deep.[1] As snow and ice continue to accumulate, gravity eventually pulls the ice mass into motion.

# Gravity propels glacial flow

Terrain determines the flow and boundaries of an ***icefield***. Icefields form where numerous tongues of ice known as ***valley glaciers*** interconnect around peaks called ***nunataks*** which push through the ice. Devil's Paw, the icefield's highest peak, stands at 8,584 feet. Many small glaciers and at least 40 larger valley glaciers flow from the icefield. These glaciers form where annual snowfall exceeds annual snowmelt. Climate, geography and snowfall determine the advance or retreat of a glacier's face or ***terminus***. A glacier's ***accumulation zone***, located in higher elevations, accrues a wealth of snow and ice. The ***ablation zone***, located in lower elevations, loses ice through melting or ***downwasting***. A glacier's terminus advances when more snow and ice amass than melt, and it retreats when melt exceeds accumulation. When melt equals accumulation, the glacier's terminus remains stationary. Regardless of a glacier's advance or retreat, glacial ice persistently glides down valley. Although the Juneau Icefield is at least 3,000 years old, the ice remains young because its steady flow perpetually renews itself through snowfall at upper elevations. Glacial ice at the terminus of Mendenhall Glacier flows only 80 to 120 years on its twelve-mile trek to Mendenhall Lake.

Coerced by gravity, ice pursues the path of least resistance. Ice depth and bedrock angle influence the rate of glacial flow. Glaciers contain two zones of ice flow. The ***zone of plastic flow***, ice closest to the bedrock, experiences extreme pressure from the weight of the ice above and conforms to the anomalies in the bedrock. The ***zone of brittle flow***, the upper 150 feet of glacial ice, lacks this pressure and reacts inelastically to the bedrock features, forming elongated cracks called ***crevasses*** which fluctuate with the glacier's flow. Tubular chutes or ***moulins*** drain surface meltwater, and formidable spires of ice called ***seracs*** reach skyward. Ice plummets over particularly steep terrain creating ***ice falls***. One theory suggests that differences in seasonal flow rates over an icefall create the convex bands called ***ogives*** at the base of the falls, which undulate down glacier. The erosive power of glacial flow changes the landscape and scrapes even the most minute particle of topsoil from the mountains which channel its irrepressible flow.

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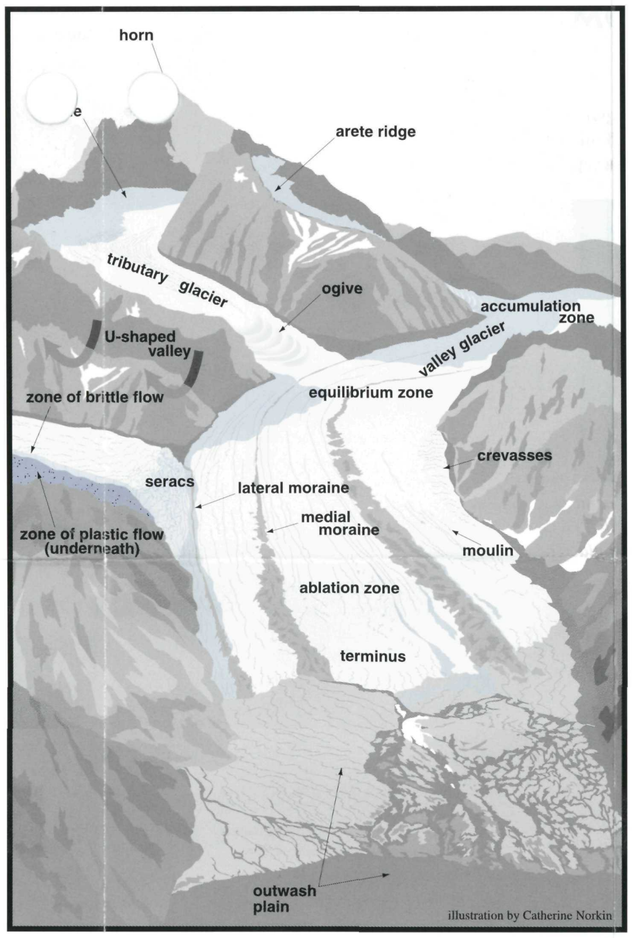
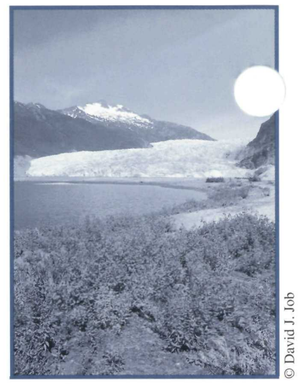
*Crevasses create an eerie pattern along a glacier's edge.*




# Glacial episodes reshuffle flora and fauna

Each episode of glacial advance and retreat also shuffles the mix of flora and fauna. Fragile vegetation ventures into a seemingly barren wasteland. Carried by the wind, seeds and spores of pioneering plants cling tenaciously to life in the hostile environment. As lichen and moss clothe the exposed rock, the rebirth of the temperate rainforest begins, with alder, willow, cottonwood, spruce and hemlock systematically reclaiming the land they inhabited before the most recent glacial advance. Glacial debris, poor in nutrients, depends on flowering lupine, decomposing alder leaves, and alder root nodules to fix nitrogen into the developing soil. Overshadowed by cottonwood and spruce, decaying alder adds additional fertilizer to the forest floor, while hemlock ultimately rises to close the canopy, shading out most spruce and creating an old growth stand or ***climax forest***. Encompassing almost 350 years, this sequence of plant succession nurtures the development of the forest community and provides habitat for an increasing number of plant and animal species.

Barriers, created by the geography and the brief span of time since the Great Ice Age, inhibit the rapid re-establishment of animal communities in Southeast Alaska. River valleys provide primary routes into recently deglaciated areas. Several species venture rapidly into the developing landscape. Migrating songbirds, snowshoe hare and mice build homes in the young forest. During the summer months, mountain goats favor the rocky terrain which skirts the icefield and provides protection from less sure-footed predators. Salmon establish spawning areas in lakes and streams formed by retreating glaciers, while wolf wolverine occasionally journey onto the ice from the adjacent ridges and forest. Many other species including Sitka black-tailed deer, black bear, goshawk and weasel wait to take residence during the middle to later stages of plant succession.



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*Pioneering plants reclaim recently de-glaciated land near Mendenhall Glacier.*

© Bill Forrest

*Mountain goats favor the high ridges surrounding the icefield during the summer months.*

As the soil is replenished and the time since the last glacial advance continues to pass, additional species repopulate the land. Each episode of glacial advance and retreat renews the cyclic tug-of-war between ice and vegetation.

# Juneau Icefield Research Project—studying climatic change through clues in the ice

The American Geographic Society established the Juneau Icefield Research Project in the late 1940s to study glacial formation, botany, geology and many other related topics. Presently, the Foundation for Glacier and Environmental Research manages the project, continuing research while providing combined academic and field training for educators, university students and high school students. Evolving from Dr. Maynard Miller's search to find a prototype area to study Alaska's coastal glaciers and trends in climatic change, the foundation encourages young scientists to integrate academic learning with field experience.

Every summer students and scientists pursue research on the Juneau Icefield at several of the 15 permanent icefield camps, which are visible from flights over the icefield. Aided by skis and crampons, participants cross the icefield from Juneau to Atlin, British Columbia and conduct field investigations focusing on the effects of climatic change on the icefield. Many of the program's alumni have pursued careers related to continuing research in the natural sciences.

USDA Forest Service photo by Sarah Iverson

*Researcher descends into crevasse to study ice layers.*

# Glacial flow carves the landscape

This landscape, unmodified by human demands, clearly illustrates the effects of Pleistocene and Holocene glaciation. Ice excavates the bedrock, forming bowl-shaped ***cirques***, pyramidal ***horns***, and series of jagged spires called ***arête ridges*** which separate glacial valleys. As glaciers carve ***U-shaped valleys***, rocks plucked from the bedrock and frozen in the ice etch ***grooves and striations*** in the bedrock. Rocks scoured from surrounding valley walls create dark debris lines or ***moraines*** along the edges and down the center of glaciers. Pulverized rock called ***rock flour***, ground by the glacier to a fine powder, escapes with glacial meltwater producing the murky color of glacially fed rivers and lakes. Glacial recession unmasks ***trimlines***, abrupt near-horizontal changes in vegetation or weathered bedrock that indicate a glacier's height at its glacial maximum. Meltwater transports glacially eroded material to the ***outwash plain***, an alluvial plain at the edge of retreating glaciers. Icebergs break away or calve from the faces of glaciers ending in lakes or in ocean tidewater.

# What happens next?

Perhaps inter-glacial warming trends will prevail. The Juneau Icefield may continue to melt as glacial meltwater trickles among the debris, and plant and animal communities ultimately reclaim the land. Maybe the next ice age waits just around the corner, and the Juneau Icefield will again advance. Modulating climate and astronomical forces may trigger glaciation, and the ice would once more scour the bedrock, destroying all life within its reach and forcing animal communities to find new homes.

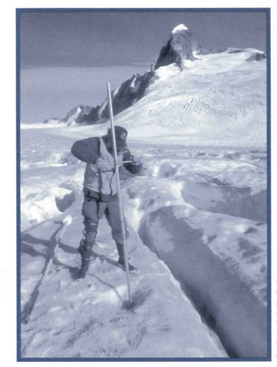
What will happen in the centuries yet to come? The neo-glaciation which created the Juneau Icefield started only 3,000 years ago, a mere blink in geologic time. Also youthful by geologic standards, the Holocene's climatic warming and glacial events began in Alaska just 10,000 to 15,000 years ago, and the history of the Great Ice Age stretches back almost two million years in time. Although clues from the past illuminate today's observations, the future of glaciation provides a perplexing question for scientific research. Regardless of advance or retreat, melt or accumulation, one factor on the Juneau Icefield will remain constant. Change will persevere.

# Taku Glacier—advancing while others retreat

Stretching to ocean tidewater, the Taku is the Juneau Icefield's largest glacier. The climatic changes which caused the advance and retreat of glaciers from the icefield also affected the Taku, which retreated in the mid-1700s with many of the icefield's other glaciers. However, the very nature of this ***tidewater*** glacier may cause separate advances and retreats unrelated to climatic change. Fed by its substantial accumulation area, the Taku began to advance again in the late 1800s pushing forward over four miles, while other glaciers on the Juneau Icefield continued to retreat.[2]

As a tidewater glacier advances, it pushes a mound of debris called a ***moraine shoal*** in front of its terminus, protecting it from deep tidal water. If climate or glacial dynamics force the glacier's terminus to retreat from its moraine shoal, the deeper water behind the shoal causes the glacier to calve, rapidly producing many icebergs and triggering its retreat. Once the glacier retreats to a stable position, calving slows, and the glacier advances, gradually rebuilding its moraine shoal.

Presently, the Taku's melt equals its accumulation, and its terminus remains stable, separated from tidewater by glacial debris. If its advance begins again, it may eventually block the Taku River as it has several times in the past. However, this transformation in the landscape may not come to pass for a century or more.



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*A researcher prepares motion stakes to measure ice velocity.*

© David J. Job

*Taku Glacier stretches into Taku Inlet.*


[1] Nolan, M., Motyka, R. J., Echelmeyer, K., and Trabant, D.C.: Ice-thickness measurements of the Taku Glacier, Alaska, U.S.A., and the relevance to its recent behavior. *J. Glaciology*, 41(139), 541-5

[2] Motyka, R. J. and Beget, J. E.: Taku Glacier, Southeast Alaska, U.S.A.: Late Holocene History of a Tidewater Glacier. *Arctic and Alpine Research*, 28(1), 42-51.