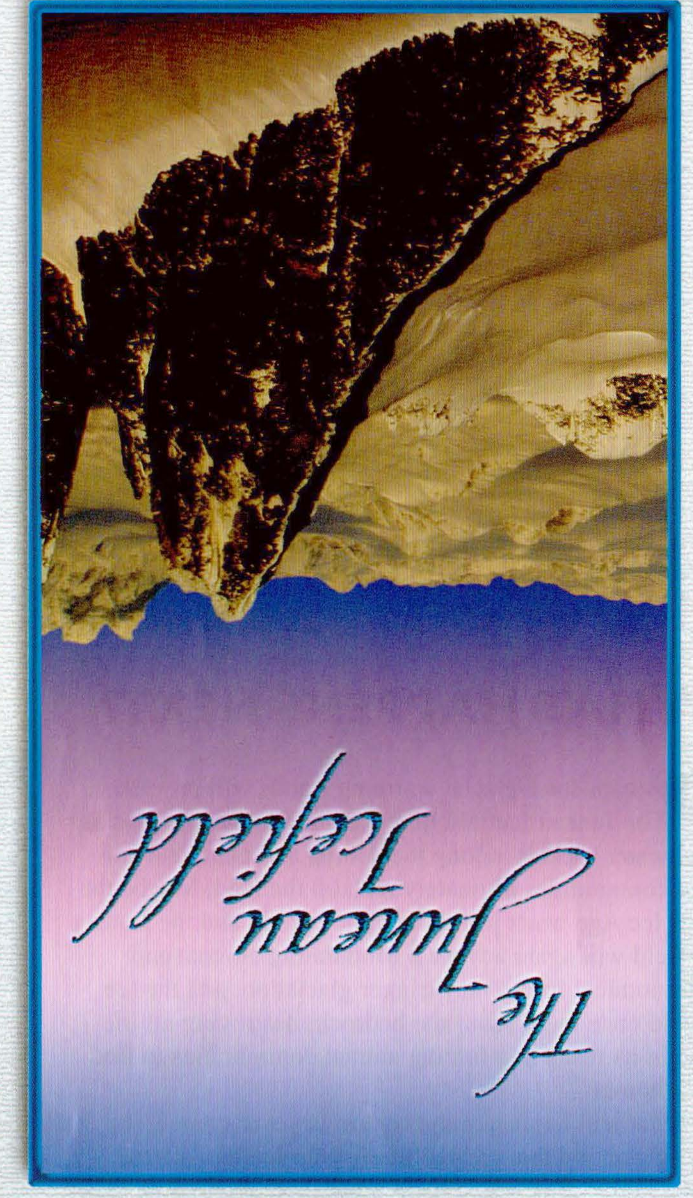
United States Department of Agriculture
Forest Service
America's Great Outdoors
Alaska
Revised 2006



The Juneau Icefield

Tongass
National Forest

This brochure is produced from the permit fees paid to the Tongass National Forest by the helicopter tour operators for the use of Juneau Icefield. The use of permit fee payments for this brochure follows the direction provided in the Federal Lands Recreation Enhancement Act of 2004 (PL 108-447).

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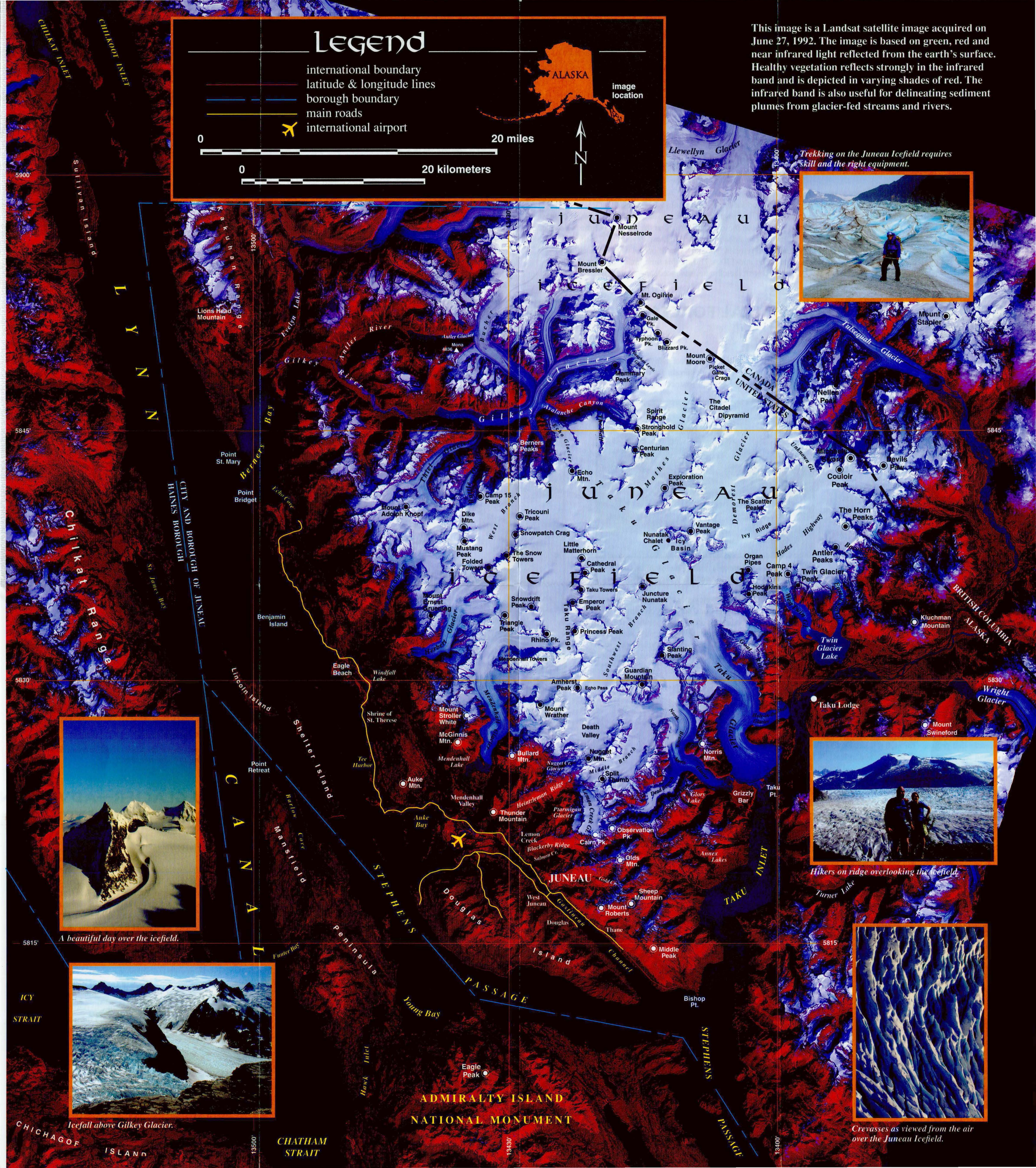
Publication No. R10–RG–172



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 varying shades of red. The infrared band is also useful for delineating sediment plumes from glacier-fed streams and rivers.

Trekking on the Juneau Icefield requires skill and the right equipment.

A beautiful day over the icefield.

Hikers on ridge overlooking the icefield.

Icefall above Gilkey Glacier.

Crevasses as viewed from the air over the Juneau Icefield.

THE JUNEAU ICEFIELD

The birthplace of glaciers.

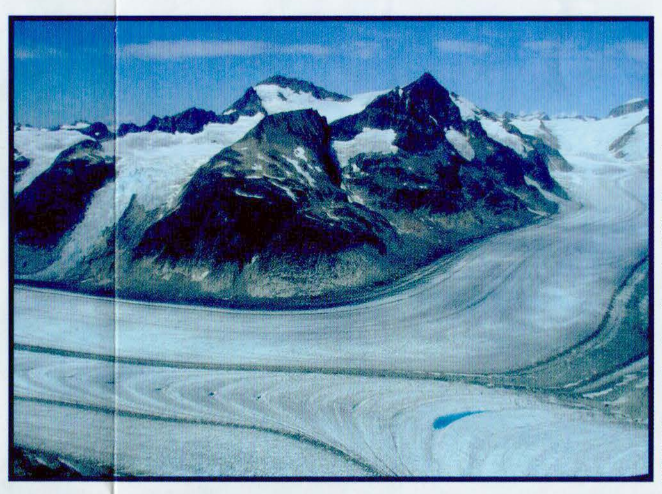
USDA Forest Service photo by Wayne Ward

Embark on 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 over 1,500 square miles of land, and stretches nearly 100 miles north to south and 45 miles east to west. Proceed up any 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 one and a half million years to the early Pleistocene when mammoths roamed the West and a cooling period locked moisture into ice. During this Great Ice Age several climate 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. Ten 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.[1]

CLIMATIC AND ASTRONOMICAL FORCES FOSTER GLACIATION

Today ice covers only 4% of Alaska, though this region has actually hosted a glacier-favoring mixture of climate and topography for the last 12 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 resulted from the Earth's orbital-rotational cycles. Oscillations in the tilt of the Earth's spin axis and the shape of the Earth's orbit interact, varying the amount of seasonal sunshine that the Earth receives in certain areas. These changes in seasonal intensity affect ocean currents that ultimately influence the climate.



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

USDA Forest Service photo by Mike Bartholow

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 flows toward the mountains, rises, cools, and releases snow and rain. Annual snowfall on the Juneau Icefield exceeds 100 feet, and mild Southeast summers cause winter snow accumulation to exceed summer snowmelt at higher elevations. Year after year, snow accumulates and compacts underlying show layers from previous years into solid ice, causing changes in volume, density and crystal structure. Glacial ice appears blue because it absorbs all colors of the visible light spectrum except blue, which it transmits. Glacial ice may also appear white because some ice is highly fractured with air pockets and indiscriminately scatters the visible light spectrum. Scientists estimate the icefield's snow and ice depth to be from 800 to over 4,500 feet deep.[2] 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*** that protrude through the ice. Devil's Paw, the icefield's highest peak, stands at 8,584 feet. Many small glaciers and at least 38 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 area***, located at higher elevations, accrues a wealth of snow and ice. The ***ablation area***, located at 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, a glacier achieves equilibrium and its terminus remains stationary. Regardless of a glacier's advance or visible 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 200-250 years on its 13-mile trek to Mendenhall Lake.[3]

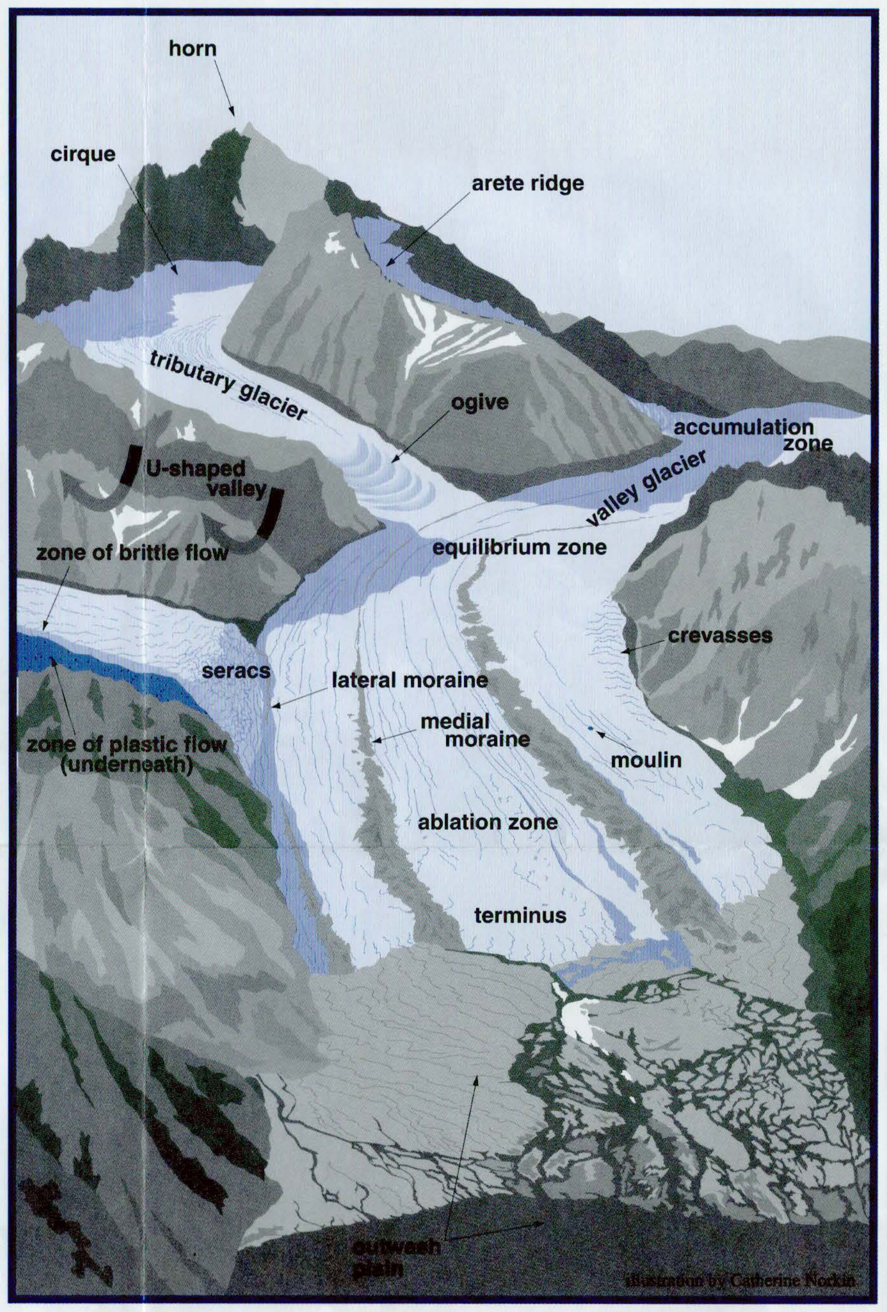
Coerced by gravity, ice pursues the path of least resistance. Ice depth and bedrock angle influence the rate of glacial flow. Glaciers contain two zones of ice flow. The ***zone of plastic flow***, ice closest to the bedrock, experiences extreme pressure from the weight of the ice above and conforms 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 much of the soil and rock from the valley walls that channel its irrepressible flow.

USDA Forest Service photo by Mike Driscoll

Crevasses and seracs form in the zone of brittle flow.

GLACIAL FLOW CARVES THE LANDSCAPE

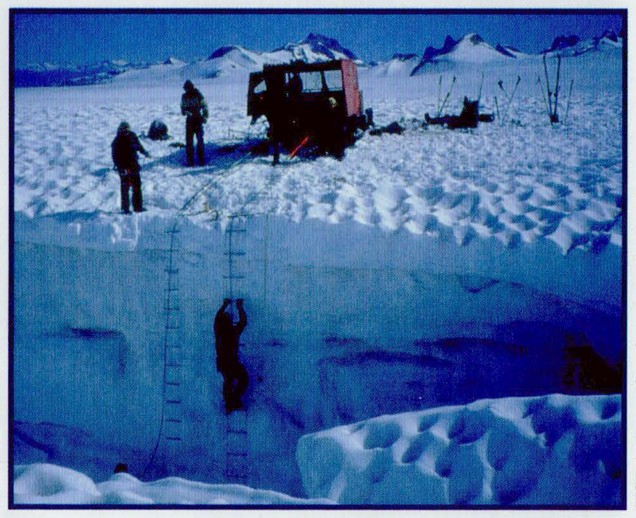
This landscape, unmodified by human demands, clearly illustrates the effects of Pleistocene and Holocene glaciation. Ice excavates the bedrock, forming bowl-shaped ***cirques***, pyramidal ***horns***, and a series of jagged spires called ***arête ridges*** that separate glacial valleys. As glaciers 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 called lateral or medial ***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***, slightly sloping changes in vegetation or weathered bedrock on the valley walls 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 the ocean.



JUNEAU ICEFIELD RESEARCH PROJECT—STUDYING CLIMATIC CHANGE THROUGH CLUES IN THE ICE

Dr. Maynard M. Miller established the Juneau Icefield Research Program (JIRP) in 1946 for a long-term study of the icefield's glacier system. In 1949, the Office of Naval Research added support to study northern latitude climate trends for military purposes, and additional support from the American Geographical Society encouraged JIRP to investigate the entire Icefield. Since then, JIRP has conducted extensive studies about the icefield's geology, geophysics, glaciology and ecology. The Foundation for Glacial and Environmental Research started managing the program in 1960 and established the Glaciological and Arctic Sciences Institute that encourages young scientists and educators to integrate academic learning and field training through first hand experience on the Juneau Icefield.

Every summer students and scientists pursue research on the Juneau Icefield at several of the fifteen permanent field stations, some of which are visible from flights over the icefield. Aided by skis and using mountaineering skills, participants cross the icefield from Juneau to Atlin, British Columbia and conduct field investigations focusing on the effects of climate change on the icefield. Many of the program's alumni have pursued careers researching the natural sciences.



USDA Forest Service photo by Sarah Iverson

Researcher descends into crevasse to study ice layers.

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 summer, mountain goats favor the rocky terrain that 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 and 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. 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.

USDA Forest Service photo by David Beatley

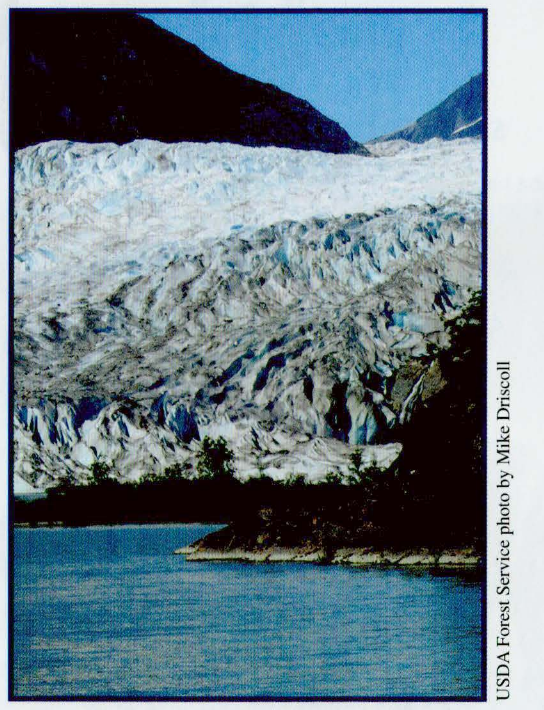
Mountain goats favor the high ridges surrounding the icefield during the summer months.

TAKU GLACIER—ADVANCING WHILE OTHERS RETREAT

Stretching to ocean tidewater, the Taku is the Juneau Icefield's largest glacier. The climate changes that 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 climate 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.[4]

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 again, gradually rebuilding its moraine shoal.

Today the Taku's melt almost equals its accumulation, and its terminus remains relatively 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.



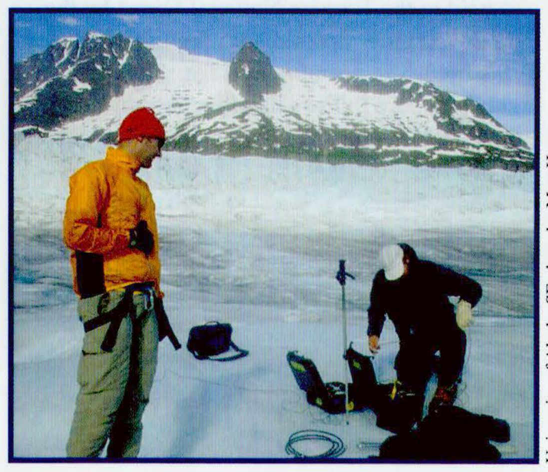
USDA Forest Service photo by Mike Driscoll

The rebirth of a temperate rainforest begins on deglaciated land near Mendenhall Glacier.

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 that 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 over one and a half 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.



University of Alaska SE photo by Matt Heavner

Researchers monitor glacial motion.

USDA Forest Service photo by Wayne Ward

Taku Glacier stretches into Taku Inlet.

1 Miller, M. M.: "Recent climatic variations, their causes and neogene perspectives" Late Cenozoic History of the Pacific Northwest. Ed. C. J. Smiley. American Association for the Advancement of Science. 1985.

2 Nolan, M., Motyka, R. J., Echelmeyer, K., and Trabant, D. C.: Ice-thickness measurements of the Taku Glacier, Alaska, U.S.A., and their relevance to its recent behavior. J. Glaciology, 41(139), 541-553.

3 Motyka, R.J., O'Neel, S., Connor, C., and Echelmeyer, K.: Mendenhall Glacier Studies 1999-2000.

4 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.