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Vanishing Glaciers

A scientist observes the disappearing glaciers of the Cascades

Easton Glacier, Mount Baker, 2003. The line indicates the former glacier terminus in 1985. Nearly every glacier in the North Cascades is currently in retreat.

By Mauri Pelto

Much of the grandeur of Pacific Northwest mountain ranges stems from the extensive glacier cover. We often choose our hikes based on scenic geographic elements, such as waterfalls, glaciers and alpine lakes. We expect these features to remain the same, but today glaciers of the North Cascades are rapidly changing. Glaciers are more than just attractive vistas. They are also crucial to the late summer water supply of many rivers, and thus critical to the salmon that migrate up these waterways each year. Glaciers of the North Cascades provide 200 billion gallons of runoff each summer.

The White Chuck Glacier is just one of many glaciers in the Cascades that are vanishing. This glacier situated on Glacier Peak supplies flow to the headwaters of the White Chuck River, much of which is located in wilderness and is familiar to many hikers. Its white expanse has graced these headwaters for thousands of years. The White Chuck Glacier retreated slowly from its largest size in the Little Ice Age until 1930, when it began to retreat more rapdily. This retreat increased even more in the 1980s and culminated in the total disappearance of the north branch of the glacier in 2001. No more does this glacier dominate the headwaters, and its demise will continue to alter the hydrology of the White Chuck River headwaters. Why did this glacier disappear? Is this the fate of many Pacific Northwest glaciers?

A Brief History of North Cascade Glaciers

Glaciers form where snowfall accumulation exceeds melting. This excess snowfall thickens until downslope movement begins. If climate cools or snowfall increases dramatically, accumulation increases, which forces the glacier to expand and advance. When glacier melting exceeds accumulation due to warmer and/or drier conditions, the glacier loses mass and retreats. A glacier never really moves backward in its "retreat," rather, the lowest elevation, terminus area of the glacier receives the highest amount of melting, and is never replaced.

It's something like bad debt—if melting takes away more of the glacier than snow replaces in the "ice account," then the glacier will shrink as fast as a checkbook facing a high-interest credit card . If ablation (which scientists use to describe melting and evaporation of a glacier) equals or is greater than accumulation, the glacier is in disequilibrium and will eventually disappear.

A glacier must consistently have two-thirds of its surface covered by the previous winter's snowcover at the end of the summer melt season to endure. If a glacier is consistently nearly snow free it will not survive. Since glaciers record climate 24 hours a day, year in and year out, they have long been recognized as key climate indicators. Since 1984, the North Cascade Glacier Climate Project at Nichols College in Dudley, Massachusetts has been measuring the mass balance of ten glaciers annually. Mass balance for a glacier is much like for your bank account: expenditures (melting) must be balanced by income (snowfall) for the glacier to be in balance. Unfortunately, the cumulative balance of the glaciers has been a loss of 12 meters per year.

The Little Ice Age was a period of global cooling that led to glacier advances worldwide. Glaciers of the North Cascades advanced beyond previous terminal positions between the years 1650 and 1880. Terminal moraines—the huge heaps of rock debris at the terminus of a glacier—were established during this cold period. Retreat at the end of the Little Ice Age was modest prior to 1880. A progressive temperature rise from the 1880s to the 1940s led to ubiquitous rapid retreat of glaciers on Mount Rainier and in the North Cascade Range from 1890 to 1944. On Mount Baker, the average retreat of glaciers was 1,440 meters on glaciers that averaged 5 kilometers in length. Average retreat during this period of the 38 North Cascade glaciers was 1,215 meters.

Beginning in 1944, conditions became cooler and precipitation increased noticeably in the Pacific Northwest. Coleman Glacier on Mount Baker was the first glacier noted to be advancing by A.E. Harrison in 1948. In short order all of the major glaciers on Mount Baker and Glacier Peak were advancing. Advances of Mount Baker glaciers ranged an average of 480 meter, and these advances ended in 1978. Richard Hubley of the University of Washington began aerial photographic surveys of glaciers in Washington in 1950 to document these changes, and William Long alao observed the shift in behavior of Mount Baker glaciers. The aerial survey was continued from 1960-1979 by Austin Post of the U.S. Geologic Survey, whose pictures grace the Beckey climbing guidebooks. Challenger Glacier, Boston Glacier and Price Glacier became more crevassed as they accelerated and advanced. Most small North Cascade glaciers did not advance between 1948 and 1978, but most of the large, steep glaciers did.

On Mount Rainier a wave of ice was noted moving toward the terminus of Nisqually Glacier in the 1940s by Arthur Johnson. Subsequently, the Nisqually Glacier began advancing 10 years later. Thomas Nylen recently determined the history of these glaciers from photographs and found that the Nisqually Glacier advanced 700 to 800 meters by 1979. During the advance of this heavily debris-covered glacier visitors watched young vegetation being buried by the advancing terminus. The major Mount Rainier glaciers all advanced during this period, with Cowlitz Glacier advancing 500 meters and Puyallup Glacier 200 meters.

Not all glaciers advanced during this period. Glaciers exhibited three different histories during the twentieth century. Some glaciers 1.) Retreated from 1890 to 1950 then had a period of advance from 1950-1976, followed by rapid retreat since 1976. Other glaciers experienced 2.) Rapid retreat from 1890 to approximately 1950, slow retreat or equilibrium from 1950-1976 and rapid retreat since 1976. Still others showed signs of 3.) Continuous retreat from 1890 to the present, becoming more rapid after 1976.

This difference is due solely to how quickly a given glacier can respond to response time. Glaciers that are moving quickly respond more rapidly to climate change, and have mostly completed their adjustment to the end of the Little Ice Age climate change. As a result, these glaciers were able to advance. Glaciers that are slow to respond continued to retreat. Intermediate glaciers either stopped retreating significantly or advanced slightly.

Today, regardless of glacier type, rapid retreat is underway—indicating disequilibrium with current climate. Except for some of the glaciers that have retreated continuously, the glaciers are responding to climate warming since 1976, not still adjusting to the post-Little Ice Age climate.

The faster a glacier moves, the faster its response to climate. The factors that cause rapid movement are high slopes, high levels of snow accumulation, thick

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Left: Foss Glacier on the northeast face of Mount Hinman, 1988.
Above: The Foss Glacier in 2005, with the 1985-era terminus drawn in. The Foss has lost about half its area in the past century.

glacier ice, and a narrow terminus zone. Glaciers that are slow to respond to climate change will have several of the following characteristics: shallower slopes, thin ice, a broad terminus and low levels of snow accumulation. The lowest slope glacier on Mount Baker is Easton Glacier. It also was the last to begin advancing after 1944—in 1953—and the last to begin retreating after 1977--in 1987. This is because the low slope means it moves slower and responds to climate a bit slower than other glaciers. Thus, adjacent glaciers can have a different short term history.

Recent Changes

Curt Ebbesmeyer from the University of Washington noted that in 1977 a change to a warmer climate occurred in the Pacific Northwest, coincident with the beginning of a sharp warming of the global climate. The most recent period of retreat began around 1979 and has been picking up speed ever since. On Mount Rainier between 1985 and 2000, the Nisqually Glacier thinned by over 70 feet in the region immediately west of Glacier Vista. Kautz Glacier has retreated over 800 meters since 1985. South Tahoma Glacier lost over 1,000 meters in this period. Meanwhile, the Carbon Glacier has barely retreated at all, covered in thick debris as it is. The Paradise Glacier Ice Caves, which in 1978 had over seven miles caves mapped by the National Speliological Society, no longer exist after the Paradise Glacier has nearly melted away. New caves may open near the headwall of the glacier, but the location of former subglacial ice caves is now bare ground.

By 1984, all the Mount Baker glaciers, which were advancing in 1975, were again retreating. Between 1979 and 1984, 35 of the 47 North Cascade glaciers that the North Cascade Glacier Climate Project observed annually had begun retreating. By 1992, all 47 glaciers termini observed by NCGCP were retreating. By 2005, five glaciers we currently observe have completely melted away. Lewis Glacier melted away in 1990, Milk Lake Glacier was gone by 1992, David Glacier was lost in 1993, Lyall Glacier disappeared in 1994, West Lynch Glacier vanished in 1995 and North White Chuck Glacier was gone in 2001. Many others are threatened: by 2006 Boulder Glacier had retreated 480 meters, Coleman Glacier 440 meters and Easton Glacier 290 meters.

We mapped all of the glaciers in and around Glacier Peak to document changes since C.E. Rusk's visit of a century before. The most notable change from the 1984 USGS map was the formation of eight new lakes, due to glacier retreat exposing new basins. Foss Glacier, Hinman Glacier and Ice Worm Glacier in the Mount Daniel and Mount Hinman area each lost more than half of their area by 2006. We have been systematically remapping 12 glaciers in the North Cascades. Nine of them are thinning as much in the accumulation zone as near the terminus. This is a sign that the glacier is in disequilibrium with current climate and will disappear.

Death of a Glacier

The White Chuck Glacier on your topographic maps features a northern branch and a southern branch, each with a separate accumulation zone, joining shortly just above the terminus. At the

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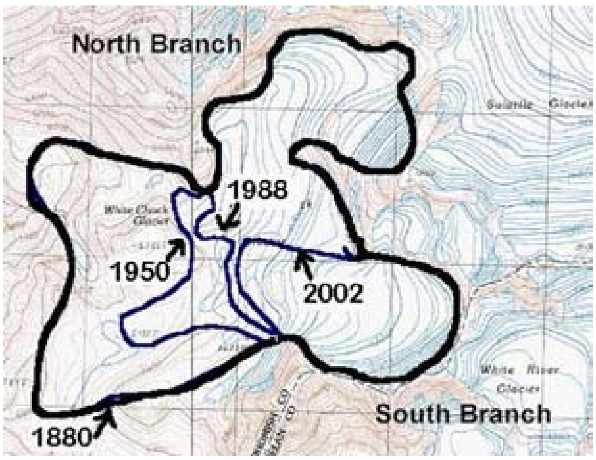

John Scurlock

Top left: White Chuck Glacier on Glacier Peak, 1960. Top: White Chuck Glacier, 1988. Above: The White Chuck Glacier in 2005. A new lake has formed where the lower glacier used to fill the basin.

peak of the Little Ice Age, White Chuck Glacier covered an area of 4.8 km^2 . Retreat from the advanced Little Ice Age positions was modest prior to 1880. Then the White Chuck Glacier retreated rapidly in the first half of the twentieth century. By 1950, the glacier's northern terminus had retreated 1,050 meters and the southern terminus 750 meters. More importantly, the glacier had thinned dramatically. The USGS topographic maps of Glacier Peak from 1958 show the still large White Chuck Glacier with an area of 3.1 km^2. In 1988, the southern terminus of the glacier ended in a new lake at 2,020 meters. The lake is not in evidence on the 1984 updated USGS topographic maps or in 1979 aerial photographs of the area. The terminus had retreated 510 meters since 1955. In 2002, the northern branch of the glacier was entirely gone. Instead of an ice-filled valley extending 1.6 kilometers from the lake to Glacier Gap at the former head of the glacier, there was only a boulder-filled basin. A new lake has developed at 2,000 meters. The walk to Glacier Gap now takes much longer. We had to pick our way through loose, bouldery terrain on a recent trip there.

The southern lobe of the glacier is still thinning slowly, and retreating. The total area of glacier ice left, including the stagnant section by the northern terminus is 0.9 km^2, less than 30 percent of the area just 30 years ago. At the current rate of thinning with the current ice thickness, this glacier will likely endure for the first half of this century. The south branch is not close to equilibrium and though its retreat is hastened by the recent warm weather, it still has not completed its adjustment to the post-Little Ice Age conditions.

The retreat of the White Chuck Glacier has led to the development of five new lakes, three in the last twenty years. The two smallest of these may fill in with sediment. The new, bare, bouldery surface can be slowly colonized by vegetation. Compared to many areas of glacial retreat where natural revegetation takes place fairly rapidly, here it is an achingly slow process, where even the portions of the basin exposed for fifty years have gained little colonizing vegetation. This may be because of the extremely limited growing season (the basin still has snowcover into July), and its relative isolation from seed sources. The White Chuck Glacier has simply not been happy with the 1.2° F warming the North Cascade region has experienced since the 19th century. Its reduced income in the form of reduced snow accumulation, and increased expenditures in the form of increased ablation have led to a negative balance in its glacier ice savings account.

Glacier biota, such as ice worms, springtails, algae, bacteria and other invertebrates and microbial organisms living on, in, and under these glaciers, have experienced a substantial change in population. This represents a substantial loss in biological processing and material that would otherwise be transferred downstream. The amount of runoff entering the White Chuck River will also decline substantially in the summer. For thousands of years, each square meter of glacier has contributed 800 gallons of runoff from July 1 to October 1. With the loss of glacier ice, this contribution should drop by 65-80 percent, based on observations at two other sites where glaciers have disappeared. The change since 1950 in glacier area has reduced summer glacier runoff in the North Cascades by 1.5 billion gallons annually. This represents a loss of between 20 and 25 cubic feet per second for the White Chuck River. The water will also be warmer and contain less sediment. The impact will be less water for fall salmon runs, and fewer stream invertebrates on which salmon feed in the Sauk and Skagit Rivers.

In 1971, the USGS released a report identifying 756 glaciers in the North Cascades. This was based on assessment of photographs from the early 1960's. Today, repeating this exercise, we have found 53 of these former glaciers are now gone. Most of these were small, unnamed and east of the crest, but we are beginning to see some larger and more renowned glaciers disappearing. Pay attention the next time you see glacier as you round the switchback and break from trees or arrive at the pass. Notice how it has changed since the last time you've seen it. And remember that view you see today. It will undoubtedly change before your next view. Unfortunately, these changes are not happening at a glacial pace.

Mauri S. Pelto is the director of the North Cascade Glacier Project at Nichols College in Dudley, Massachusetts. To learn more about the project, and to read detailed scientific studies of glacial retreat in the North Cascades, visit www.nichols.edu/departments/Glacier/. ♦

Left: Lower Curtis Glacier, Mount Shuksan, as seen from Lake Ann, 1908. Right: Lower Curtis Glacier from Lake Ann, 2003. Of the 756 North Cascade glaciers identified by the U.S. Geologic Survey in 1971, 56 have completely disappeared.