“Our Vanishing Glaciers”

One Hundred Years of Glacier Retreat in Three Sisters Area, Oregon Cascade Range

GLACIERS OF THE PACIFIC NORTHWEST — bright white flowing masses of ice that mantle the region’s high mountain slopes — have attracted climbers, photographers, and scientists since their first recorded discovery here in the mid 1800s. They are beautiful, of course, covering and balancing the dark craggy volcanic peaks; but they also are scientifically significant. Glaciers shape landscapes — sometimes at continental scales, as during global ice ages. Glaciers are also extremely sensitive to climate, their size and deposits indicating past and ongoing changes in temperature and precipitation.

These geologic and climatologic aspects of glaciers had just been discovered and were hotly debated during the mid 1800s, meaning such conversations often occurred in conjunction with exploration of the Pacific Northwest. Since that time, explorers and scientists have continued to monitor shrinking glaciers in the Pacific Northwest with photography and measurements. Regional glacier shrinkage was perhaps most clearly first described in “Our vanishing glaciers,” a 1938 Mazamas Mountaineering Club publication describing glaciers in the Cascade Range of Oregon.¹ The Three Sisters region of the central Oregon Cascade Range, where glaciers are numerous and accessible and scenery has attracted photographers and outdoor recreation since the early 1900s, has been a central place for that monitoring. Photographs and measurements reproduced here show that glaciers continue to shrink and disappear.

Glaciers exist by the grace of climate. Only where snowfall is deep enough and the summer melting season short enough can persistent snowfields thicken and expand so that they transform into glacial ice masses that slowly flow down slopes. These conditions are restricted to the snowiest and highest mountainous areas of the conterminous United States — the Rockies, the Cascade Range, and the Olympic Mountains. U.S. Geological Survey (USGS) maps now show more than three hundred named glaciers in the conterminous United States.² Of those, thirty-six are in Oregon. Most are on the prominent stratovolcanoes of Mount Hood, Mount Jefferson, and the Three Sisters, but tiny glaciers cling to some minor Cascade Range peaks such as Mount Thielsen and Three Fingered Jack; Benson Glacier is the solitary vestige of glacier ice in the Wallowa Mountains.

Glaciers, born of climate, respond sensitively to climate change. That is especially true for the relatively small glaciers of the Pacific Northwest. The size of any particular glacier reflects the balance between snow accumulation during winter and snow and ice melt during summer. Increased snowfall or decreased summer temperatures nourish glacier growth, generally by causing the ice to thicken and flow farther down the valley. Likewise, either diminished winter snowfall accumulation or higher summer temperatures...
cause melting, starving a glacier and resulting in ice thinning and melt-back of its downslope terminus. If the balance consistently tips in one direction for several years, glaciers can visibly grow or shrink to a detectable extent. That multi-year response of alpine glaciers to small but persistent temperature and precipitation changes — the very types and magnitudes predicted by scientists who study ongoing climate change — has motivated their continued close monitoring. Glacier monitoring helps us understand not only current but also past climate change, because glacier behavior from times pre-dating temperature and precipitation records can be reconstructed from the deposits that glaciers leave behind.

The time of first glacier documentation in the western United States — in the 1870s — corresponded with the end of the Little Ice Age, a several-century period of cold and wet that resulted in glacier growth throughout the world. In Oregon, tree-ring dating indicates that Little Ice Age glaciers achieved their greatest length and thickness during the 1850s and 1860s. At that time, vigorous glacier streams scraped away at the friable volcanic edifices of the Cascade Range, rimming themselves with tall, sharp-crested moraines as their ice flows transported debris downward to the glaciers’ margins. At their greatest Little Ice Age extent, glaciers covered about 15 square kilometers (km²) in the Three Sisters area.

Glaciers have been vanishing globally for the approximately 150 years since the culmination of the Little Ice Age in the mid nineteenth century. This has been the case for the Three Sisters region, where Israel Cook Russell noted recent glacier recession as early as 1903. And modern studies in the Three Sisters area and elsewhere show that glacier shrinkage has continued since then, most clearly evident by comparing current conditions with historical maps, drawings, and photographs. Here we show some of this evidence for the Three Sisters area, comparing scenes of the early 1900s with views from the same spots captured in recent years. Some of those matched photographs span exactly one hundred years to the day. While the scenery remains stunning, the changes are dramatic. Vistas filled by glacial ice in 1903 and 1910 have transformed to barren rocky fields and slopes a century later.

Through-the-lens documentation of shrinking glaciers not only reveals clear evidence of ongoing climate change but also offers an opportunity to consider the climbers, geologists, and photographers behind the cameras. Geologic and glacier exploration and photography have rich histories in the Oregon Cascade Range. Those histories have strong links, through early western geological surveys, to nineteenth-century exploration and glacier science in North America as well as significant connections to new science in Europe. The Three Sisters region of the central Oregon Cascade Range has been a key part of that history.

GLACIERS AND THE WESTERN SURVEYS

Glaciers were a geological hot topic during the mid nineteenth century. Swiss geologist Louis Agassiz’s 1840 publication of his conclusion that vast Ice Age glaciers, not floods (biblical or otherwise), had shaped the landscape of Europe enthused the field of geology. Explorers and geologists were soon searching throughout the world for live glaciers as well as evidence of past glaciers. The extensive western surveys of the 1800s contributed to that effort. After a few missed opportunities, discovery of glaciers actively eroding Mount Shasta and evidence of ancient glacial carving in the Three Sisters helped demonstrate the impact of glaciers in North America. Western explorations therefore not only expanded the American frontier but also pushed at boundaries of geological understanding.

Scientific exploration of the Pacific Northwest started with the journaling and map making of the Meriwether Lewis and William Clark Expedition. Charged by Thomas Jefferson to observe “the soil & face of the country,” they duly noted the five Cascade volcanoes within their view. First observed on October 18, 1805, was Mount Hood’s “conical form covered with snow.” Lewis and Clark also described Mount Adams, Mount St. Helens, and Mount Rainier, and they named Mount Jefferson after their trip sponsor. While gazing upon the mountains “covered with snow,” they did not get close enough or were not interested in determining if actual glaciers — flowing masses of ice persisting through the years — made up the white caps of the tall volcanoes.

The first actual geologist on the scene was James Dwight Dana, who literally crashed ashore on July 18, 1841, when the U.S.S. Peacock wrecked on a bar at the mouth of the Columbia River. Dana, a Yale-trained, twenty-eight-year-old mineralogist and geologist, was a scientist on the United States Exploring Expedition commanded by Charles Wilkes. After spending some time along the Columbia River, first at “Peacockville” near Fort George (now Astoria) and then the Hudson’s Bay Company’s Fort Vancouver, Dana and thirty-eight others travelled overland to San Francisco during September and October 1841, following the interior valleys west of the Cascade Range. Observations from that journey and from the exploration in general fueled Dana’s subsequent long and illustrious career as a geology professor at Yale. Although he described “many a frosted peak” along the spine of the Cascade Range, he did not recognize that the white mantles were actual glaciers — and later even denied their existence in the Cascade Range.

Fourteen years later, in 1855, geologist and medical doctor John Strong Newberry criss-crossed the Oregon Cascade Range as the botanist, geologist, and surgeon for another U.S. government endeavor of western expansion: “Explorations for a Railroad Route, from the Sacramento Valley to the Columbia River.” While looking for a passable rail route through the
Cascade Range in the vicinity of the Three Sisters, Newberry described evidence of glacial action — becoming the first to publish the word glacier in conjunction with the Cascade Range. He was, however, describing grooves, scratches, and furrows left by massive, ancient glaciers of the last major Ice Age, which culminated about 20,000 years ago with vast ice sheets covering hundreds of square kilometers of the Cascade Range. He could see that glacial erosion "extended down at least 2,500 feet below the present line of perpetual snow" but did not recognize the snow as being much-diminished relics of the formerly large glaciers.

Both Dana and Newberry were in clear sight of Cascade Range glaciers at about the culmination of the Little Ice Age. While the Little Ice Age was substantially less extensive than the last major Ice Age, it was the time when alpine glaciers in Oregon and Washington grew to be as large as they had at any time in the past 10,000 years. Dana and Newberry had described the perpetually snowy summits but did not recognize that the white shrouds included actual flowing streams of ice like the glaciers of the Swiss Alps. Although they missed early-career opportunities to make a significant mark by identifying active glaciers in the American West, they each effectively steered North American geology, academically as well as politically, for much of the nineteenth century from their powerful academic posts at Yale and Columbia universities.

We now know that alpine glaciers and rock glaciers, their dirtier cousins, are present in all the western mountain states except Arizona and New Mexico, but their existence remained enigmatic in the United States until 1870. Prominent geologists of the times, including Dana, Josiah Whitney of the California Geological Survey, and Louis Agassiz (the discoverer of the Ice Ages in Europe), declared the conterminous United States free of glaciers. That view changed when Clarence King, Dana's student at Yale, ascended the flanks of Mount Shasta on September 11, 1870, having diverted north while leading a geological survey paralleling the railroad route that followed the Fortieth Parallel (fig. 2). He was "thrilled to see a true moving glacier" in the form of three large ice masses flowing north from the summit.

King had already sent his assistant Arnold Hague to Oregon, where Hague witnessed glaciers on Mount Hood within days of King's discovery. Another assistant, Samuel Emmons, accompanied King's ascent of Mount Shasta on September 11, 1870.
Shasta and then went on to Mount Rainier, where he documented an even greater system of active glaciers.¹⁴

King’s thrill perhaps had to do with the dynamic and lifelike qualities of the creaking and groaning ice masses, but his excitement must also have been derived from the discovery itself. Explorers and geologists, motivated by Agassiz’s paradigm-shifting theory of the ice ages and the role of glaciers in shaping landscapes, were searching for evidence of glaciers, past and present, throughout the world. The glaciers of Mount Shasta were evidence that active glaciers persisted in the western United States, and Newberry’s 1855 evidence for ancient glacial carving in the Three Sisters demonstrated their past effects. In the decades following the 1870 observations of King and his assistants, recognition of the widespread distribution of active and ancient glaciers in the western United States continued, prominently summarized by geologist and geographer Israel Cook Russell (commonly and appropriately referred to by his initials, I.C.) in his 1885 publication of Existing Glaciers of the United States.”¹⁵

THE THREE SISTERS — “THE MOST INTERESTING FIELD”

In Russell’s Existing Glaciers, he reports that Joseph Silas Diller, an early USGS geologist, declared the “Three Sisters . . . as probably affording the most interesting field for glacial studies in the United States, with the exception of Alaska.”¹⁶ The Three Sisters area of the central Oregon Cascade Range includes three prominent stratovolcanoes, North, Middle, and South, plus several subsidiary cones and volcano remnants, including Broken Top and Mount Bachelor (see fig. 3). Among those peaks are seventeen named glaciers, although some names and locations have become confused and misplaced as the glaciers have shrunk during the past eighty-five years since most of the glaciers were mapped and named by Edwin T. Hodge in 1925.¹⁷ Diller was just beginning a forty-year career with the newly formed USGS in the summer of 1883 when he was assigned to systematically explore each of the tall volcanoes of the Cascade Range in northern California and Oregon. He might have momentarily lost interest in glacial studies when he first explored the Three Sisters that August with assistant Edward E. Hayden. Apparently while climbing North Sister, Hayden fell, injuring his head and knee. As Diller and his crew were assisting Hayden back to camp, Diller was “struck . . . insensible” by a falling rock.¹⁸ Nevertheless, Diller recovered sufficiently to inform Russell of his observations.¹⁹ Russell in turn named the two long glaciers extending east from the summit of Middle Sister after the scientists; Hayden and Diller glaciers now commemorate the episode.²⁰

FIGURE 3: This map of the Three Sisters area, central Oregon Cascade Range, shows key locations, photograph locations and directions, and the seventeen named glaciers of the area, plus the unofficial “East Bend Glacier” (on the east flank of Broken Top). The place and glacier names are as shown on U.S. Geological Survey maps.

Having recorded Diller’s impressions of the Three Sisters, Russell personally investigated the region in 1903. Like Diller, Russell had been one of the initial cadre of USGS geologists when the agency was consolidated in 1879 from the four western surveys, including Clarence King’s Geological Exploration of the Fortieth Parallel. Russell left the USGS in 1892 for a position...
at the University of Michigan but continued to produce USGS publications until his death in 1906. One of his last was on the water resources of central Oregon, published in 1905 but based on field work conducted in 1903. During the course of the 1903 field work, on August 16, Russell ascended the eastern flank of Middle Sister, following the tall moraine crest along the south edge of what he had named Hayden Glacier. His photographs, along with Rodney Glisan’s taken four weeks earlier, during July 19-20, are some of the earliest alpine photographs of the Three Sisters region. In part made to document the glaciers of the area, Russell’s photographs nicely show conditions on the east side of Middle and South Sisters. A panorama, captured from near a bedrock spur cleaving Diller and Hayden glaciers, shows particularly well the extent of Diller Glacier and several of the glaciers on the northeast flank of South Sister. Russell noted in 1903 “that [Hayden] glacier has recently been lowered by melting about 40 feet” below the sharp-edged moraine crests. That evidence of glacier thinning is minimal compared to what has come to pass. Photographs made ninety years later, and then another set on August 16, 2003 (100 years to the day after Russell’s photographs), show substantial loss of glacier ice and snow on Middle Sister, South Sister, and in the distance, Broken Top (see figs. 4 and 5).

While Russell nicely documented some of the prominent glaciers on the east side of the Three Sisters, he made no mention of Collier Glacier, the much larger glacier on the more moisture-laden west side. Collier Glacier probably covered two square kilometers in 1903 as it flowed northwestward from the saddle between Middle and North Sisters. Collier Glacier was likely about twice as large as any other glacier in the Three Sisters area, probably making it the largest glacier in Oregon.

The earliest known up-close photographs of Collier Glacier were made in August 1910. They are part of an exquisite set of alpine views taken by professional photographers, climbers, and a geologist who set up camp for ten days in a meadow west of Collier Glacier. The group camp was the annual outing of the Mazamas, a mountaineering organization still active today in promoting climbing and education from its southeast Portland headquarters. Club trips to alpine areas were annual events during the early twentieth century, and the 1910 outing was sandwiched between similar but smaller trips to the Three Sisters area in 1903 and 1916. The 1910 trip consisted of thirty-nine club climbers, aided by an unknown number of packers and cooks. On the trip were photographers Clarence L. Winter and George M. Weister, both of whom were established outdoor and mountain-photography specialists. Geologist Ira A. Williams of Iowa State College was also on the trip, and he apparently photographed several scenes. Other participants also had cameras. The weather was good, although it became smoky late in the trip, and climbing parties ascended all three of the major peaks. H.H.
Prouty accomplished the first known ascent of North Sister on that trip.30

Taken together, the photographs from that 1910 trip provide a broad inventory of the glaciers in the Three Sisters area. In particular, the views of Collier Glacier (see figs. 6 and 7) and the summits of Middle and South Sister (see figs. 8–10) show the extent of several of the largest glaciers, including Diller, Hayden, Prouty, Irving, and Carver. Colleagues and I repeated many of the 1910 Mazamas trip photographs from closely matched locations almost exactly 100 years later, during August 9–22, 2010. The matched shots document the profound recession of the area’s glaciers over the past century as well as other landscape changes.

The Mazamas returned in 1916. Because the terrain was snow covered and snow continued to fall while they were there, photographs of that trip are limited and show little of the glaciers. Photographs in 1914 by

Edmund F. Martin and in 1920 by Frederick W. Cleator, however, provide good documentation of Collier Glacier in the decade following the 1910 Mazamas trip. Martin was a studio photographer based in Eugene for several years from 1914 until at least 1921.31 On July 10, 1914, Martin, apparently to advertise the regional scenery, made the first known photograph from near the place shown on modern maps as “Glacier View,” which at the time had a stunning vista of Collier Glacier from near its terminus.32 That early-season photograph is snowy but shows the ice of Collier Glacier abutting its tall left lateral moraine (see figs. 12 and 13). By contrast, from Glacier View in 2011, one could barely see the glacier terminus, then a full kilometer away.

U.S. Forest Service recreation specialist Frederick W. Cleator was in the area in 1920 to survey and photograph his proposed route for the Skyline

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**Figure 6**: From the south shoulder of Little Brother, Clarence Winter of Kiser Photography photographed this view of Collier Glacier in August 1910. The peaks in the background are Middle Sister to the right and North Sister to the left. The two figures standing in the snowfield in the lower right of the image provide an indication of scale.

**Figure 7**: Jim E. O’Connor photographed the same view of Collier Glacier on August 9, 2010. There are also two people in the right foreground standing in the snowfield. A large part of the moraine in the foreground had slid away during the time between the photographs.
Trail, which eventually became the Cascade Crest Trail and then the Pacific Crest Trail. On September 8, he climbed to Glacier View and beyond, making a series of photographs of lower Collier Glacier. Those images show it thinner but still extended to the Little Ice Age moraines that encircle the terminus with tall rims of debris. In the summer of 2011, Cleator’s photograph was matched from just east of Glacier View on Collier Cone (see figs. 14 and 15). The vast field of crevassed ice viewed by Cleator has melted away, leaving a large debris-filled basin covered with a few lingering seasonal snow patches below the terminus of Collier Glacier.

Although scientists and photographers such as I.C. Russell had shown with their photographs the recent thinning and recession of Three Sister glaciers by the early twentieth century, they were not engaged in systematic documentation. The first mapping and measuring of glaciers in the Three Sisters was done by University of Oregon professor Edwin T. Hodge and several students during the summer of 1924. For the most part, his names are those assigned to glaciers shown on modern maps — although some of those glaciers are now gone. Hodge was the first to quantify the glaciers’ size, measuring a total of 9.1 km² of glacial ice on the Three Sisters and Broken Top. Collier Glacier, with 1.8 km², was the largest, followed by Hayden Glacier covering 0.9 km². For comparison, Hodge at the time noted that Mount Hood’s Zig Zag Glacier, covering an upper southwest slope, was the largest glacier on the mountain with an area of 1.4 km².

Hodge’s mapping of the Three Sisters region in 1924 essentially completed the naming and mapping of almost all glaciers in Oregon, most of which by that time had thinned significantly but were still abutting the lower slopes of their Little Ice Age moraines. By the end of the warm and dry dust bowl years of the 1930s, however, retreat was in full swing. The glaciers were becoming noticeably smaller, prompting the Mazamas to begin systematic documentation. Aerial and on-the-ground surveys and inspections, primarily guided by Kenneth N. Phillips of the club’s Research Committee, led to the 1938 report titled “Our vanishing glaciers; observations by Mazamas research committee on glaciers of the Cascade Range in Oregon” as well as published aerial surveys of Mount Hood (1935), the volcanoes of southern Washington (1936), and the central Oregon glaciated areas of Mount Jefferson, Three Fingers Jack, and the Three Sisters (1937). The Mazamas commissioned another set of aerial surveys by Ackroyd Photography in...
Figure 10: From the summit of South Sister, this August 14, 1910, photograph taken by Ira Williams shows Middle Sister, North Sister, and Black Butte. This photograph was scanned from a version published in 1916 by Williams in “Some little-known scenic pleasure places in the Cascade Range in Oregon,” The Mineral Resources of Oregon, Oregon Bureau of Mines and Geology.

Figure 11: Charles Cannon captured a similar view of Middle Sister, North Sister, and Black Butte on August 14, 2010. Although the seasonal snow patches are of similar size, the glaciers, particularly Diller and Hayden, are much smaller.

Figure 12: E.F. Martin photographed this view of Collier Glacier from near Glacier View on July 14, 1914. In this photograph scanned from a postcard provided by Gerald W. Williams, Collier Glacier flows two kilometers northwest from the saddle between North Sister (left) and Middle Sister, whose summit pokes up in the center of the photograph.

Figure 13: To approximate the angle of the original view of Collier Glacier, a September 7, 2011, photograph has been placed on top of the 1914 view. Two figures in the foreground snowfield indicate the scale of the scene. Since 1914, Collier Glacier has vacated the large, morained rimmed basin in the foreground and has its present terminus far up the slope of Middle Sister.
1936. These efforts were probably the result of interested members curious about glacier changes, but Mazamas membership did and still does require summiting a glaciated peak — perhaps the specter of vanishing glaciers incited fears of vanishing membership.

As part of the monitoring efforts, the Mazamas also supported on-the-ground glacier inspections. The most systematic of those were by geoscientist Ruth Hopson Keen. Keen made her first trip to Glacier View in 1933 and then returned in 1934, photographing Collier Glacier for the first time in what became nearly annual trips for forty years until her last photograph from the spot in 1973. Having already begun independent documentation of changes to Collier Glacier with her photographs, Keen was asked in 1941 by François E. Matthes, an USGS geologist who chaired the American Geophysical Union's Committee on Glaciers, to continue to monitor glacier changes. It is not clear what exactly she reported to the committee, but she continued to monitor Collier Glacier, recording descriptions and publishing photographs in several issues of the Mazamas annual volume between 1960 and 1981.

Keen's record of retreating Collier Glacier is one aspect of her multidimensional life story. She forged new ground as a geologist and naturalist, not just in documenting glacier wastage but also in achieving new heights for women geoscientists. Born in 1906, she obtained B.A. (1931) and M.A. (1935) degrees in Geography from the University of Oregon while simultaneously working as a school teacher. She followed those degrees with a Ph.D. from Cornell University in 1946 with a dissertation titled "The study of a valley — The McKenzie River region of Oregon, with special reference to the educational significance of its natural history." While her dissertation is essentially a geologic study, she matriculated in the Education Department (hence the sub-title) because, as she told me in the early 1990s, "women weren't allowed to be geologists." Soon after graduation, in June 1947, she became the first woman hired as Ranger Naturalist at Crater Lake National Park. She later led conservation efforts aimed at protecting the Three Sisters region.

I first met Keen in 1993, while working on a USGS project assessing floods and landslides in the Three Sisters region. As I was completing that work, I gave an evening lecture for the Geological Society of the Oregon Country, a group of professional and amateur geologists first organized by...
Edwin T. Hodge in 1935. Keen had been president of the group in 1982. Our conversation after my presentation led to several meetings at her house to compare photographs of Collier Glacier. After several years, she agreed to let me borrow her negatives to make fresh prints — overcoming her reticence at possibly being scooped in publication. She died in 1998, before publishing the photographs shown here with a subsequent match of Collier Glacier from Glacier View (figs. 16–19). I am confident she would be pleased that the monitoring and reporting continues.

Glacier monitoring is now energized by rapid changes associated with global warming. Professor Andrew Fountain at Portland State University leads the “Glaciers of the American West” project, a compilation of historic photographs and observations of glacier extent, type, and distribution for all the western conterminous states. Like many glaciers in the western United States, Collier Glacier has been subjected to mass balance studies — precise annual measurements of accumulation and melting — first in the 1990s and again in more recent years by Oregon State University graduate students. New technologies are helping gather more precise data on glacier conditions. Recent high-resolution topographic maps made by laser altimetry, for example, can be compared to topographic reconstructions from historical aerial photographs to determine not just changes in the area covered by glaciers but actual ice-volume changes as well. Preliminary work of this type at Collier Glacier indicates as much as forty meters of ice thinning between 1955 and 2010. This ice loss attests to continued glacier diminishment, even where glacier area is not changing as dramatically as in the past, and shows that the warming of the past few decades continues to take its toll.

GLACIER EXPLORATION — PAST, PRESENT, AND THE FUTURE

Glacier exploration and monitoring of the western United States and the Three Sisters involved a disparate cast of explorers, climbers, and scientists. Yet, overarching themes and connections link many of the people as well as glacial science. The first explorers and observers of the “snowy summits” were sent west by the U.S. government to record the landscape but, more purposefully, to establish routes for transportation and commerce. J.D. Dana and J.S. Newberry were young geologists whose presence on the early expeditions to the Pacific Northwest shaped and nourished their careers. Both parlayed the experiences into influential posts at Yale and Columbia, where they molded the fledgling field of geology and were essential advocates for the U.S. Geological Survey, formed by the 1879 consolidation of four wide-ranging civilian and military geological surveys, including King’s survey of the Fortieth Parallel. The first exploration of the snowy peaks of the Pacific Northwest also coincided with an emerging understanding of the role of glaciers in creating landscapes. Russell in particular understood the climatic implications of glacier behavior, initiating documentation and monitoring that have continued for the 110 years since his photographs — some of the first — were taken of the glaciers in the Three Sisters.

This subsequent glacial monitoring enabled Ruth Hopson Keen to track Collier Glacier, which may have facilitated her Ph.D. at Cornell. Keen’s early glacier interest was likely sparked by her membership in mountaineering organizations including the Obsidians and Mazamas, as well as geological organizations such as Hodge’s Geological Society of the Oregon Country. The Mazamas — advocates for outdoor recreation, conservation, and research — have led or helped fund most glacier monitoring efforts in the Three Sisters since Russell’s early observations back in 1903. A presentation to the Geological Society of the Oregon Country led me to Keen, and from her, to the Mazamas. These connections, plus many willing backpacker and photographer comrades, made this account possible. My experience is that appreciation of these rich histories of people and places almost always improves the scenery.

The perhaps serendipitous conjunction of exploration, science, people, and photography in the Three Sisters area, moreover, provides firm understanding of the past and hints at the future. The 150 years since the culmination of the Little Ice Age has been a period dominated by glacier retreat. As far back as 1903, Russell noted “recent shrinkage of glaciers” in the Three Sisters. During the first several decades of that shrinkage, the glaciers still extended to the tall morainal rims, but thinned behind them. During the warm and dry 1930s and 1940s, glacier margins melted back rapidly, as shown by Collier Glacier’s quick retreat from Glacier View. After a few years of stabilization and even minor growth in the 1950s, the glaciers returned to a thinning and retreating mode. Now, several of the seventeen glaciers named by Hodge in the Three Sisters region are essentially gone or have retreated back into deeply shaded cirques and crevices. In 1990, we estimated 5.8 km² of glacier ice — about one third of the area that was ice-covered when Newberry passed by in 1855 — and it is surely even less now.

Some aspects of the future are predictable but others less so. Rising temperatures in the twenty-first century will cause more glaciers to vanish. How many and how fast depends on the details of temperature and precipitation changes as well as the topography of source areas. Some glaciers will undoubtedly hang on in gouged-out shady recesses of the peaks. Knowing how sensitive glaciers are to climate change, scientists will continue to monitor glaciers in increasingly sophisticated ways.

But photographs often speak the story’s essence in fewer words. As long as humans have eyes, images will continue to forcefully convey the reality of our changing world. I suspect that if the flowing ice masses do not com-
Figure 16: Ruth Hopson Keen photographed this view of Collier Glacier from Glacier View on September 19, 1934, the first of nearly annual photographs taken until 1973. This photograph shows Collier Glacier still extending far down the valley from Middle Sister and flowing into a new lake forming in the moraine-rimmed basin. The limits of the Little Ice Age maximum glacier level are shown by the deposits emplaced against the flank of North Sister on the left side of the image.

Figure 17: Ten years after her first photograph of Collier Glacier, Ruth Hopson Keen's August 11, 1944 photograph shows the lake in the foreground, but the glacier terminus has retreated half a kilometer up the valley. Because Keen's photographs were made with different cameras and at different angles, Figures 16, 18, and 19 have been adjusted to match the field and perspective of this 1944 photograph.

Figure 18: This August 14, 1973, photograph from Glacier View is Ruth Hopson Keen's last image of Collier Glacier, made forty years after her first one in 1934. The lake has disappeared and the glacier terminus has retreated an additional 300 meters up the slope toward Middle Sister.

Figure 19: This August 11, 2010, photograph by Jasper Hardison was made during a snowier year than most, with many lingering snow patches in the foreground. The glacier terminus cannot be clearly identified, but close comparison of the 1973 and 2010 photographs shows more rocks emerging through the upper part of the glacier in 2010, indicating continued thinning over the last four decades.
pletely vanish, explorers, scientists, and climbers in the Three Sisters region — following footsteps of Dana, Newberry, Diller, Russell, Williams, Hodge, and Keen — continue to produce photographs portraying the size, beauty, and thrill of glaciers in the Cascade Range.

Dr. Ruth Hopson Keen in the 1969 Mazamas Annual. Keen first photographed Collier Glacier in 1931 and made nearly annual trips to document the area until 1973.

NOTES

In addition to the OHQ editors, this manuscript was improved by reviews and advice by Tim Crump, Karen Demsey, Andrew Foun-


2. Approximate number of glaciers determined from glacier listings on Portland State University Glaciers of the American West website: http://glaciers.research.pdx.


9. John S. Newberry, Geological Report, in Explorations for a Railroad Route, from the Sacramento Valley to the Columbia River, made by Lieutenant R.S. Williamson, Corps of Topographical Engineers, assisted by Lieutenant H.L. Abbott, Corps of Topographical Engineers, vol. 6, pt. 1, of Reports of Explorations and Surveys, to Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean, Made under the Direction of the Secretary of War, in 1855–1856. Senate, 35th Congress, ad Ses-


11. Thurman Wilkins, Clarence King, A Biography, Revised and Enlarged Edition (Albuquerque: University of New Mexico Press, 1988), 145.”Whitney, Dana, and Agassiz had even declared that no true glaciers remain inside the United States, exclusive of Alaska.”


15. L.C. Russell, Existing glaciers of the United States, USGS Annual Report 5 (Wash-

16. As stated in Russell, Existing glaciers of the United States, 341.

17. Many of these glaciers were first mapped and named by Edwin T. Hodge. See Hodge, Mount Multnomah: Ancient Ancestor of the Three Sisters (Eugene: University of Oregon, 1935). The seventeen named glaciers are those depicted on current USGS 7.5-minute quadrangle maps covering the Three Sisters and Broken Top. The glacier names on Broken Top have been slightly confused over the years. Crook Glacier as shown on USGS Broken Top 7.5-minute quadrangle map corresponds to “Crater Glacier” as described by Phillips (1938), and the unnamed glacier east of Broken Top’s summit was the “Crook Glacier” of Hodge and shown as such on earlier USGS topographic quadrangles, but has been more recently referred to as “East Bend Glacier” by O’Connor et al. Carver and Skinner glacers, both shown on current USGS 7.5-minute topographic quadrangles, for example, no longer correspond to coherent glaciers.

18. See L.R. McArthur, Oregon Geog-raphical Names 71th ed. (Portland: Oregon Historical Society Press, 2003). On the basis of the description of the incident described in the Oregonian (September 29, 1983, p. 3), Jeff Thomas of the Mazamas believes that the incident may have occurred on or near Glisan Pinnacle on North Sister as described in the Oregonian, September 29, 1888, p. 3.

19. Edward Everett Hayden, age twenty-five at the time, lost his left leg as a consequence of the fall but went on to a distinguished career as a meteorologist and hydrographer for the U.S. Navy, ultimately retiring in 1921 at the rank of Rear Admiral. He was also a founding member of the Na-

tional Geographical Society. His journal for the summer and fall of 1883 is archived in the Library of Congress.


21. Ibid: For a description of the consoli-
dation of the western geological surveys and the early history of the USGS see Mary C. Rabbit, The United States Geological Survey:


29. The Mazamas Research Library has prints made by 1910 trip participant Martha Goldapp in addition to several Clarence Winter photographs. The Oregon Historical Society also has several of the Winter photographs in its Kiser Photography collection (Kiser Photo Company photographs, Org. Lot 140, Oregon Historical Research Library), including several colorized versions in a Three Sisters album (Album 140–9). Riddell, "Three Sisters Outing," 12.

31. Martin made photographs in the Three Sisters area in July 1914, was featured in a 1918 article in The Photographic Journal of America (55): 156–58, and was making photographs in Eugene and the McKenzie River in 1921, http://www.oldoregonphotos.com/photographers/edmund-f-martin.html, (accessed October 2, 2011). According to voter registration records as described to me by descendant Sandy Shirley in January 20, 2011, email, Martin was living in San Diego County, California, in 1914 and then later in Humboldt County, California, on October 6, 1928.

32. This trip was formally recorded by a member of the group in the Mazamas' Middle Sister Summit register (1903–1929): "On top of Middle Sister Mountain at noon July 10, 1914. I have climbed up here alone this forenoon but did not expect to do when I left camp. Four of us are camped at the head of White Branch — or the foot of the Glacier to the west of the North Sister. Our party is composed of the following: M.J. Duryea, Sec. Eug. Com. Club; E.F. Martin, Photographer; Eugene; Luke S. Goodrich, Cashier; Nat. Bk. Eug.; Harry G. Hayes, professional guide and packer [from] Mackenzie Bridge. We are taking pictures to use in advertising this beautiful country. Luke L. Goodrich."


34. Hodge, Mount Multnomah: Ancient Ancestor of the Three Sisters. Many of the photographs in this volume are from E.W. Cleator. The accompanying topographic map is the first such map of the Three Sisters region and shows all seventeen named glaciers.

35. Phillips, "Our vanishing glaciers," Phillips, 1987–1995, was a civil engineer employed by the U.S. Geological Survey (1921–1962), serving as District Engineer of the Oregon Water Science Center office (where I now work) from 1948 until his retirement in 1962. He also served as president of the Geological Society of the Oregon Country in 1943–1944. I corresponded with him after a presentation for the society in the early 1990s, when he reported that he was still climbing Mount Tabor daily.


37. Russell Hopson Keen biographical information from the "Presidents Album" of the Geological Society of the Oregon Country.


40. I have also been aided and particularly supportive. Thomas provided access to photographs from the 1910 Mazamas outing, helped determine photograph locations, and searched the summit logs for records of E.F. Martin's 1914 trip.

41. Gerald W. Williams provided photographic materials. Jasper Hardison III and David Wiesprechst have been key participants in most of the photograph-matching campaigns. I have also been aided and accompanied by Chauncey Anderson, Charles Cannon, Kathy Cashman, Terrence Conlon, Janet Curran, Natalie Deligne, Andrew Fountain, Gordon Grant, Jon Major, Brennan O'Connor, Justin Olschlager, Joshua Roering, and Kristin Sweeney.

46. Russell, Preliminary report on the geology, 126.

O'Connor, “Our vanishing glaciers”