Gallery Guide

Losing a Legacy:

A photographic story of disappearing glaciers

Glacier

W.C. Alden photo, GNP Archives

Shepard

B. Reardon photo, USGS

Dan Fagre & Lisa McKeon, USGS

Climate Change in Mountain Ecosystems

USGS science for a changing world

BNSF Railway

Glacier National Park Fund

This gallery guide is provided to help you, the visitor, further interpret and appreciate this collection of photographs. We hope this guide will enhance your visit. Additional information is available at the web link located at the end of the guide.

The following collection of repeat photographs of glaciers has been assembled and re-photographed by USGS scientists. The exhibit blends climate change research with landscape photography from Glacier National Park. Funding and cooperation was provided by the Glacier National Park Fund and Burlington Northern Santa Fe Railway.

- *Photographs and panels were printed by Lee Kozlowski of Digital Planet, Kalispell, MT*
- *Photographs and panels were dry mounted by Jim Marjerrison of Glacier Frame Shop, Columbia Falls, MT*

1913, WC Alden, GNP

2005, G Pederson, USGS

Agassiz Glacier
1913 – 2005

Agassiz Glacier was one of the largest glaciers in the park prior to 1917. In fact, during the colder, snowier period before 1850 this glacier had advanced down the valley and into the existing forest, bulldozing down trees and creating a "trimline". During the drought between 1917 and 1941, this glacier retreated more quickly than others - more than 100 yards per year. This is partly due to the downward sloping bedrock underlying Agassiz Glacier and the relative thinness of the glacier ice, both of which contributed to faster melting and retreat. Agassiz Glacier now covers about 257 acres.

1914, EC Stebinger, GNP

2009 L McKeon, USGS

Blackfoot – Jackson Glacier
1914 - 2009

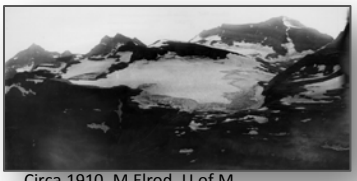
Blackfoot Glacier is one of the largest glaciers in the park. Impressive glacial features such as ice cliffs with blue color and large crevasses (i.e. cracks in the glacier ice up to 30 feet wide and 200 feet long) are still visible on this sizable glacier. Blackfoot and Jackson Glaciers were once joined as a single large glacier, but have since split in two as the ice retreated within distinct basins. A computer model that assessed glacier retreat rates under climate change conditions predicted that these two glaciers will melt by 2030. Recent data suggests that these glaciers are melting even faster than the model predicted and, at the present rate, will disappear before 2030. In the summer of 2007, a large part of Blackfoot Glacier collapsed and cascaded down the mountain as an ice avalanche.

1932, TJ Hileman, GNP

1988, J.DeSanto, U of M

Boulder Glacier, ice cave
1932 - 1988

This is one of the earliest photographs repeated from Glacier Park that shows the disappearance of glacier ice and helped to start the current Repeat Photography Project. The 1932 photograph shows a guide, wearing chaps, and three clients next to the ice cave. This was one of the popular routes during the hey day of horseback trips through the park and underscores the charisma that glaciers had for early park visitors. The 1988 photo not only shows a completely ice-free view 56 years later, but shows how vegetation has moved in to the area vacated by the glacier. Boulder Glacier is now about 14 acres and too small to be considered a viable glacier.



Circa 1910, M Elrod, U of M

2007, Fagre/Pederson, USGS

Boulder Glacier
circa 1910 - 2007

This view of Boulder Glacier was taken from a ridge above Hole-in-the-Wall that connects to a spur ridge from Chapman Peak. The 1910 photograph indicates that this area is just coming out of the grip of the "Little Ice Age," a 400-year period of below average temperatures and above average snowfall that increased the size of the glaciers. The glacier actually extended to the right and over Boulder Pass in 1910. A very different view is evident in 2007. If you hike over Boulder Pass today you pass beneath and between several sets of moraines that indicate where the glacier used to be.

1911, MR Campbell, USGS

2005, B Reardon, USGS

Chaney Glacier
1911 - 2005

The 1911 photograph shows glacier ice extending all the way down slope to the valley whereas Chaney Glacier is now confined to a small patch below the ridge in the 2005 photograph. Chaney is now about 87 acres in size. Note the small group of dark vegetation patches on the slope to the left of the glacier. These "krummholz" patches of subalpine fir have not changed much in 90 years and are likely hundreds of years old.

1911, MR Campbell, USGS

2005, B Reardon, USGS

Chaney Glacier
1911 - 2005

This photograph pair clearly shows how the glacier has shrunk in area and also in thickness. In 1911, the glacier ice covered the band of cliffs and nearly reached the summit on the right.

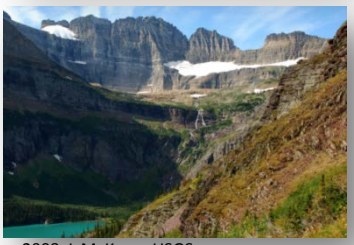
1914, Elrod , GNP

2010, R. Thornton, USGS

Clements Glacier
1914 - 2010

Clements Glacier was a viable glacier with crevasses in the early 1900s. Today, it is a small perennial snowfield with steep moraines that outline the glacier's previous size. Each summer, thousands of visitors hike past these impressively steep moraines along the trail from Logan Pass to Hidden Lake Overlook. The trail is visible along the left side of the 2010 photo.

1911, Stanton, USGS

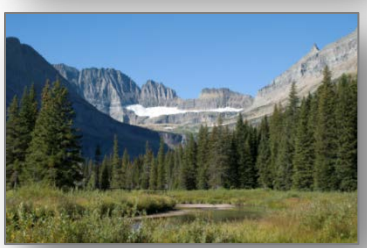


2008, L McKeon, USGS

Grinnell Glacier
1911 - 2008

The 1911 photo shows Grinnell Glacier poised at the top of the waterfalls and joined with what is now called the Salamander Glacier just before the ridgeline. George B. Grinnell described this wall of ice as being 1,000 feet high in 1887. As of 2008, that wall of ice had disappeared and Grinnell Glacier is not even visible in the contemporary photograph. Grinnell Glacier has retreated behind the buff-colored ridge just above the waterfalls. The Salamander Glacier is thinning in the middle so rapidly that it will probably be in two pieces within a few years. To the upper left is the small, rounded glacier, Gem Glacier, that until recently had not shown signs of retreat. It, too, is now becoming smaller.

1887, Lt Beacon, GNP



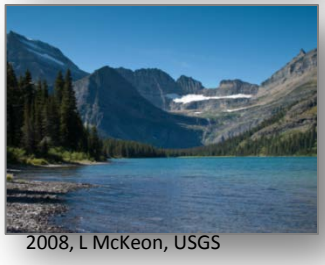
2008, L McKeon, USGS

Grinnell Glacier
1887 - 2008

The 1887 photo is by Lt. Beacon who accompanied George Bird Grinnell on his first exploration of the glacier. Beacon is credited with the suggestion to name the glacier after Grinnell. The 1887 scene is snowy and cold despite the fact that the exploration took part during summer. Trees are slowly encroaching on this view and will likely obscure it in another decade.

1914, T Marble, GNP

1938, TJ Hileman, GNP



2008, L McKeon, USGS

Grinnell Glacier
1914 – 1938 - 2008

This series shows when Grinnell and Salamander separated as glacial ice continued to melt during a prolonged dry and hot period from 1917-1941. Many of the park's glaciers experienced sharp reductions in size and tree-ring studies indicate that this was one of the larger local droughts in over 400 years.

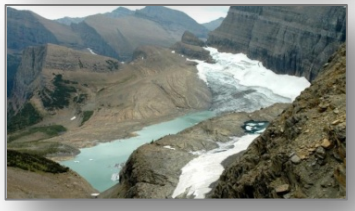
Circa 1911, F Kiser, GNP

2008, L McKeon, USGS

Grinnell Glacier
circa 1911 - 2008

Around the time Glacier National Park was established, the historic photo shows a group of women admiring Grinnell Glacier from the shore of Lake Josephine. Contemporary views from this spot differ greatly as Grinnell Glacier has receded, leaving only the Salamander visible from this perspective. This photograph indicates that glaciers were attractive to tourists a century ago and the photographers hired to promote this area often included glaciers in their scenes.

Circa 1940, Unknown, GNP

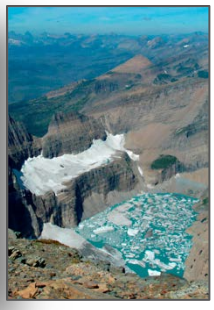


2006,K Holzer, USGS

Grinnell Glacier
circa 1940 - 2006

This overlook is accessed by a spur trail off the Highline Trail in the vicinity of Granite Park Chalet and shows the degree to which Grinnell Glacier has receded. It also offers a view of Salamander Glacier (right foreground) and the miniature meltwater lake that has formed as a result of accelerated melting.



1938, TJ Hileman, GNP | 1981, C Key, USGS | 1998, D Fagre, USGS | 2009, L Bengtson, USGS

Grinnell Glacier
1938 – 1981 – 1998 - 2009

This series offers a different perspective on Grinnell Glacier by highlighting the creation and growth of the meltwater lake in front of the glacier. It is also clear that the glacier has thinned with the ice surface elevation lowering hundreds of feet by 2009. The relative sensitivity of glaciers to climate change is illustrated by the dramatic recession of Grinnell Glacier while surrounding vegetation patterns remain stable.


1920, Unknown, NPS | 2008, C Miller, USGS

Grinnell Glacier
1920 - 2008

The 1920 photo shows National Park Service Director, Steven Mather, on Piatt Path near present day Grinnell Glacier Overlook. Darren Pfeifle strikes a similar pose in the 2008 repeat photograph.


1922, M Elrod, U of M | 2008, L McKeon, USGS

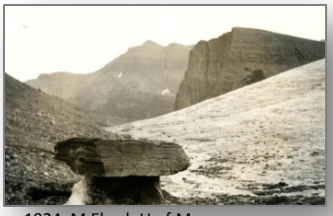
Grinnell Glacier
1922 - 2008

This striking pair of photographs gives a sense of the mass of ice that used to exist. On the right side of the 1922 photograph small human figures are visible walking on the glacier. The brighter patch in the background of the photograph is snow from the previous winter. Crevasses and striations of exposed glacier ice stretch along the foreground, now replaced by icebergs floating in the turquois water of Upper Grinnell Lake.

Unknown date, M Elrod, U of M

Grinnell Party on Grinnell Glacier
unknown date

This photo, taken from a similar perspective as the 1922/2008 pair above, shows a hiking party on the north end of Grinnell Glacier where today open water exists. On the far right is the party's guide, Hans Reiss (brother of artist W. Reiss) and next to him, George Bird Grinnell, for whom the glacier is named.



1924, M Elrod, U of M

2008, L McKeon, USGS

Grinnell Glacier
1924 - 2008

The rock in the foreground of the 1924 photograph is balanced on an ice pedestal that eventually melted and probably sent the rock sliding downslope. We searched for the rock, but it is likely at the bottom of the lake. In the 1924 photograph the edge of the glacier (coming in from the right) is covered with debris from rocks falling off the cliff, embedding in the ice, and being carried along with the creeping ice. The moraine (i.e. rock debris piled up by the glacier) is on the left. In the 2008 photograph, vegetation is now growing on the moraine, the glacier has retreated up into the basin, and icebergs are floating in Upper Grinnell Lake, formed by the receding glacier.

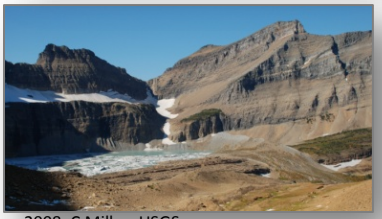
1926, M Elrod, U of M

2008, L McKeon, USGS

Grinnell Glacier
1926 - 2008

This large boulder was used by Morton Elrod and other scientists as a baseline to measure the retreat of Grinnell Glacier's terminus. It is now referred to as "Elrod's Rock," and the glacier's terminus is no longer visible from this point.

1920, WC Alden, USGS



2008, C Miller, USGS

Grinnell Glacier
1920 - 2008

This pair of photographs from Grinnell Glacier's southeast edge shows the dramatic change in the glacier's volume and area. Note the glacier's height along the headwall and how it occupies most of the basin in the historic photograph.

Circa 1930, TJ Hileman, GNP

2009, L McKeon, USGS

Hidden Lake
Circa 1930 - 2009

Vegetation change can be seen in this photo pair from the alpine region at the base of Bearhat Mountain. Notice the expansion of subalpine fir trees in the circled area, indicative of warming climatic conditions. Hidden Lake is in the foreground.

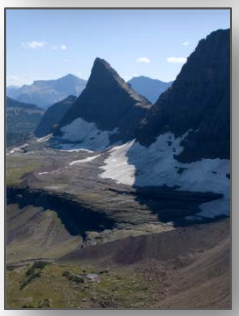
1911, M Elrod, U of M

2009, L McKeon, USGS

Jackson Glacier
1911- 2009

At the time this historic image was taken in 1911, Blackfoot Glacier encompassed the current Jackson Glacier. By 1939, Blackfoot Glacier's recession had resulted in two distinct glaciers, Jackson and Blackfoot. This photo pair shows glacial recession and successive vegetation establishment along Jackson Glacier's terminus.

1914, EC stebinger, GNP

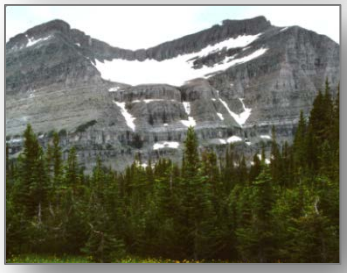


2009, L McKeon, USGS

Logan and Red Eagle Glaciers
1914- 2009

Although the 2009 photo location does not exactly match the historic photo point, a comparison of the relative glacial coverage can still be made. Logan Glacier is in the foreground, and Red Eagle Glacier sits beneath the pyramid shaped peak that bears its same name in the background. It appears that these two glaciers were joined at the time the historic photograph was taken, but have since recessed into their own basins.

Circa 1930, G Ruhle, GNP



1998, L McKeon, USGS

Piegan Glacier
circa 1930 - 1998

In the photograph pairs of Piegan Glacier there are two changes. The broad crowns of the whitebark pine (center of 1930 photograph) are missing in the modern photograph because they were killed by blister rust, an exotic pathogen. However, the subalpine fir trees have grown vigorously and encroached on the subalpine meadow, a valuable habitat for wildlife. This example illustrates that repeat photography is a potent tool for documenting other types of changes to mountain ecosystems over time. Piegan Glacier has recently become smaller and is now about 61 acres.

1913 WC Alden, GNP

2005, B Reardon, USGS

Shepard Glacier
1913 - 2005

This photograph pair illustrates one of the more dramatic cases of disappearing glaciers. In the 1913 photograph, thick ice is evident along the bottom lobe of the glacier and extensive crevasses are present on the upper section, indicating the glacier is flowing and has significant mass. By 2005, however, the contemporary photograph shows no ice on the bottom shelf, a small meltwater pond (center) and virtually no ice (two debris covered patches left of center). Shepard Glacier, at its current rate of retreat, is assumed to be below 25 acres and is not a viable glacier anymore.

1913, WC Alden, GNP

2008, L McKeon, USGS

Sperry Glacier
1913 - 2008

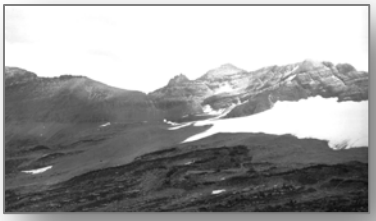
In 1913, Sperry Glacier's mass spanned across the entire basin and the glacier's terminus was recorded to be over 150 ft. tall. Contemporary images show how the glacier has receded and separated into fragments.

Circa 1930, M Elrod, U of M

2008, L McKeon, USGS

Sperry Glacier
circa 1920 - 2008

Repeating Elrod's photograph from the same photo point was impossible since the historic photograph was shot from the elevated perspective of the glacier's surface. The terminus of the glacier has retreated beyond the field of view, but these images give a sense of the glacier's extent and mass early in the 20th century.

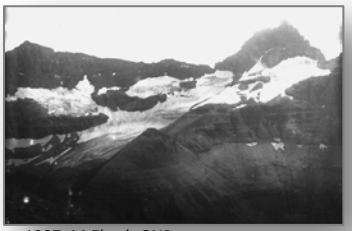


1913, WC Alden, GNP

2007, L McKeon, USGS

Sperry Glacier
1913 - 2007

This view of the northeast portion of Sperry Glacier shows evidence of the glacier's recession as well as the advancement of conifer species and other vegetation on the glacial moraines. Although melting glaciers are the most visible and direct indication of climate change in the mountains, the entire mountain ecosystem is responding. Using repeat photography and tree-ring studies, we have documented that trees are growing faster, becoming taller and filling in the spaces with adjacent trees. Young tree seedlings have established and are surviving in areas where deep snowpacks and harsh weather conditions had previously excluded them. These changes are representative of high-elevation forest changes occurring elsewhere in the park.



1907, M Elrod, GNP

2007, Fagre/Pederson, USGS

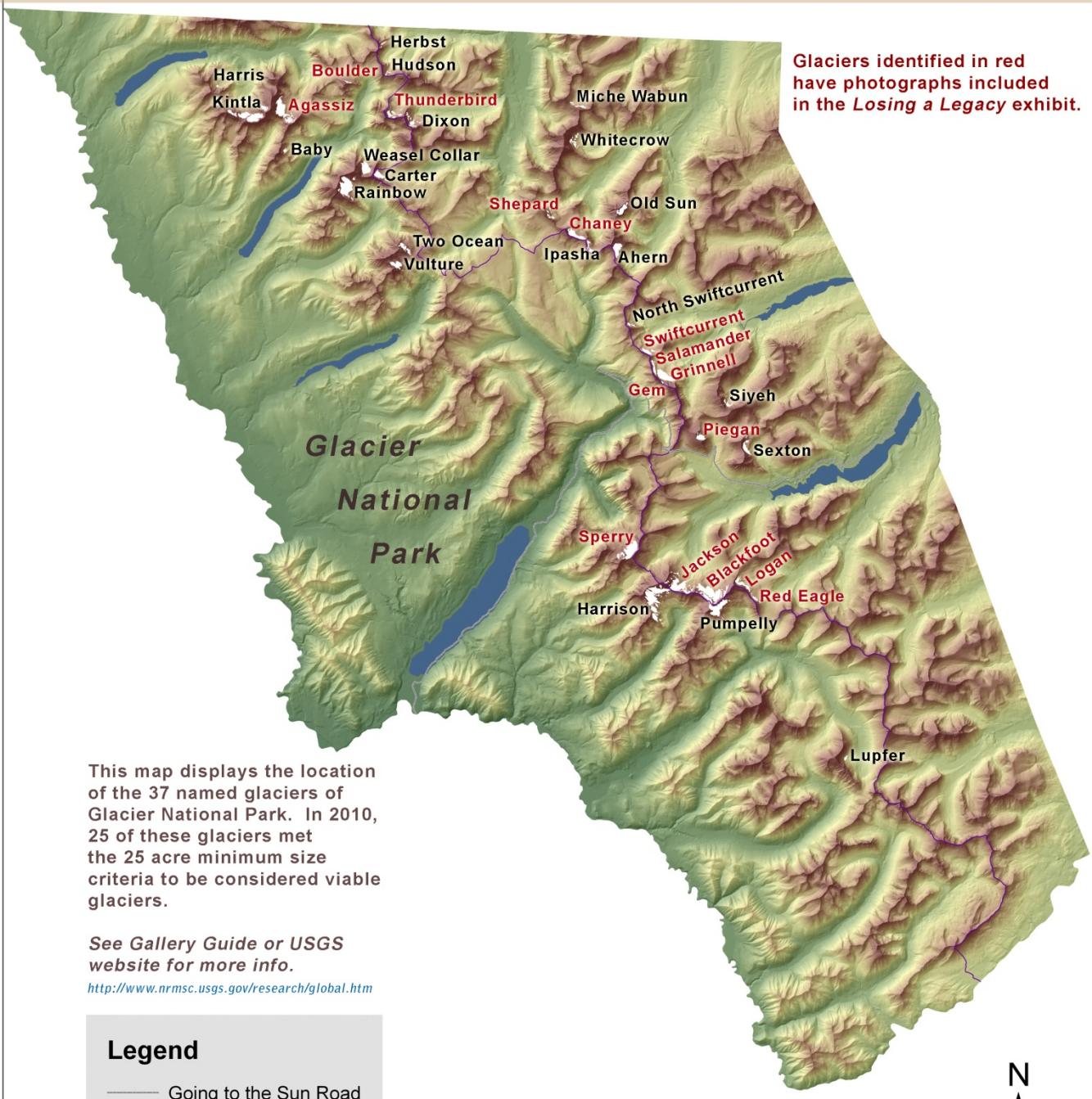
Thunderbird Glacier
1907 - 2007

This photo pair represents a century of glacier change. Thunderbird Glacier is now made up of numerous patches of ice and, when closely examined, this 2007 photo reveals a number of cliff bands that were covered by ice in 1907. Also, the corner of a tiny lake is just visible in the 2007 photograph. Acquiring the contemporary photograph involved some serious scrambling on cliffs and made us admire Morton Elrod, the original photographer, who carried much heavier and bulkier gear over the same terrain! Thunderbird Glacier is 59 acres but will probably disappear within a few years now that it is reduced to a collection of ice patches.

Location of Glaciers

Glacier National Park, Montana, USA

USGS science for a changing world



Glaciers identified in red have photographs included in the *Losing a Legacy* exhibit.

This map displays the location of the 37 named glaciers of Glacier National Park. In 2010, 25 of these glaciers met the 25 acre minimum size criteria to be considered viable glaciers.

See Gallery Guide or USGS website for more info.

http://www.nrmsc.usgs.gov/research/global.htm

Legend

- Going to the Sun Road
- Continental Divide
- glacier (1998 margin)
- lake

Parkwide Named Glacier Comparison 1966 – 2005

Glacier area determined by aerial photo analysis in conjunction with Portland State University

Glaciers that no longer exceed 100,00m2 in area

Glacier Name	1966 Area (m^2)	2005 Area (m^2)	1966-2005 % change
Gem Glacier **	29,135	20,379	-30.1%
Baby Glacier	117,111	77,510	-33.8%
Boulder Glacier	230,913	55,159	-76.1%
Harris Glacier **	152,694	34,526	-77.4%
Herbst Glacier **	170,162	53,550	-68.5%
Hudson Glacier	101,288	34,197	-66.2%
Lupfer Glacier	138,523	67,369	-51.4%
*Miche Wabun Glacier ^^*	*296,139*	*131,298*	*-55.7%*
N. Swiftcurrent Glacier	116,651	79,117	-32.2%
Red Eagle Glacier **	206,576	97,149	-53.0%
*Shepard Glacier ^^*	*250,609*	*110,254*	*-56.0%*
Siyeh Glacier	215,420	56,698	-73.7%
TOTAL	**2,025,221**	**817,205**	**-59.70%**

** Area calculated due to poor quality 2005 aerial photo. Area calculated by applying the average rate of change for 1998-2005 (14.2%) to 1998 area derved from aerial phootos

^^ At current rates of retreat it is assumed that in 2010 this glacier no exceeds 100,000m2.

Glaciers that exceed 100,000m2 in area

Glacier Name	1966 Area (m^2)	2005 Area (m^2)	1966-2005 % change
Agassiz Glacier	1,589,174	1,039,077	-34.6%
Ahern Glacier	589,053	511,824	-13.1%
Blackfoot Glacier	2,334,983	1,787,640	-23.4%
Carter Glacier	273,834	202,696	-26.0%
Chaney Glacier	535,604	379,688	-29.1%
Dixon Glacier **	452,211	241,940	-46.5%
Grinnell Glacier	1,020,009	615,454	-39.7%
Harrison Glacier	2,073,099	1,888,919	-8.9%
Ipasha Glacier	321,745	212,030	-34.1%
Jackson Glacier **	1,541,217	1,012,444	-34.3%
Kintla Glacier	1,728,828	1,136,551	-34.3%
Logan Glacier	503,298	302,146	-40.0%
Old Sun Glacier	421,254	370,257	-12.1%
Piegan Glacier	280,107	250,728	-10.5%
Pumpelly Glacier	1,489,137	1,257,211	-15.6%
Rainbow Glacier	1,284,070	1,164,060	-9.3%
Salamander Glacier	225,621	172,916	-23.4%
Sexton Glacier	400,444	276,780	-30.9%
Sperry Glacier	1,339,244	874,229	-34.7%
Swiftcurrent Glacier	261,410	223,519	-14.5%
Thunderbird Glacier	358,284	238,331	-33.5%
Two Ocean Glacier	428,828	275,022	-35.9%
Vulture Glacier **	649,267	315,001	-51.5%
Weasel Collar Glacier	592,420	553,018	-6.7%
Whitecrow Glacier	373,439	196,228	-47.5%
TOTAL	**21,066,582**	**15,497,709**	**-26.40%**

** Area calculated due to poor quality 2005 aerial photo. Area calculated by applying the average rate of change for 1998-2005 (14.2%) to 1998 area derved from aerial phootos

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Visit our website to learn more about glacier research in Glacier National Park

http://nrmsc.usgs.gov/research/glacier_research.htm

Acknowledgements

The USGS would like to recognize the many people who have contributed to the Repeat Photography Project: Carl Key, Jerry DeSanto, Karen Holzer, Blase Reardon, Greg Pederson, Lindsey Bengtson, Chris Miller, Deirdre Shaw, Ann Fagre, Ali White, Kim Corette, Mark Fritch, Donna McRea , Suzanna Carrithers, Dan Kotter, Richard Menicke, Jean Tabbert, Joe Giersch, George McFarland, Rick Yates, Brian, Maggie and Eloise McKeon, and any others we may have inadvertently overlooked.

Special thanks to the exhibition sponsors

Glacier National Park Fund

Burlington Northern Santa Fe Railway

Hiking party near Sperry Glacier, circa 1930 Hileman collection, GNP Archives

Visit our website to learn more about the Repeat Photography Project

• downloadable version of this gallery guide

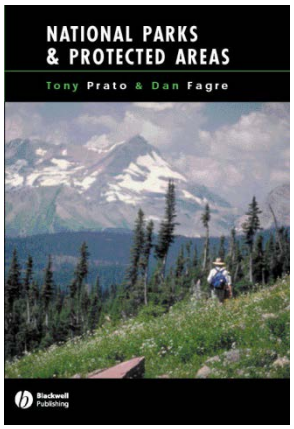
• downloadable versions of photographs from the exhibit

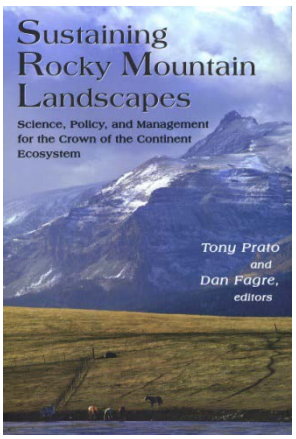
http://nrmsc.usgs.gov/repeatphoto/

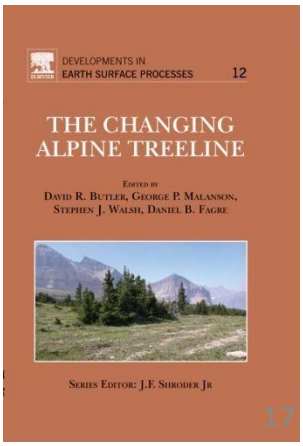
Dan Fagre

Dr. Dan Fagre is Research Ecologist for the Northern Rocky Mountain Science Center of the U.S. Geological Survey and Director of the Climate Change in Mountain Ecosystems Project. He is stationed at Glacier National Park, Montana and is a faculty affiliate at the University of Montana, Montana State University, University of Missouri-Columbia, University of Arizona and several other universities. He's worked for the past 18 years with many staff, partners and collaborators in the Northern Rockies to understand how global-scale environmental changes will affect our mountain ecosystems. His diverse research programs have addressed glaciers, avalanches, amphibians, alpine plants, paleoclimates, snow chemistry, and ecosystem dynamics. He has particularly enjoyed incorporating his life-long passion for photography into his research and feels that better use of photography is critical to effectively communicating scientific findings. This exhibit on repeat photography is a convergence of many of his interests.

Dan received his Ph.D. from the University of California, Davis, and has held positions in universities and several federal agencies. He helped establish the Western Mountain Initiative, a program to tie mountain science across different areas, and is active in several international science networks that address mountain issues. He served on the Montana Governor's Advisory Board for Climate Change, and recently was lead author for a commissioned report to the President and Congress through the U.S. Climate Change Science Program. He received the Director's Award for Natural Resource Research from the National Park Service and a National Special Service award from the USGS Director. He is an author on more than 120 publications and has co-published three books recently.







Lisa McKeon

Lisa McKeon has been employed as a Physical Scientist for the USGS Climate Change in Mountain Ecosystems (CCME) program since 1997. She has worked on the Repeat Photography Project since its inception and has perused hundreds of archival photographs, hiked many backcountry miles in search of the correct photo point, and managed the expanding collection of photographs. In response to the public demand for repeat photographs of the receding glaciers, Lisa created the current website which allows the public to download images for their own use. The diverse uses to which these photos have lent themselves have surprised her as much as the rate at which she has seen the glaciers retreat in Glacier National Park. Lisa and her husband, Brian, make their home in West Glacier where they enjoy recreating in Glacier National Park with their two young daughters.