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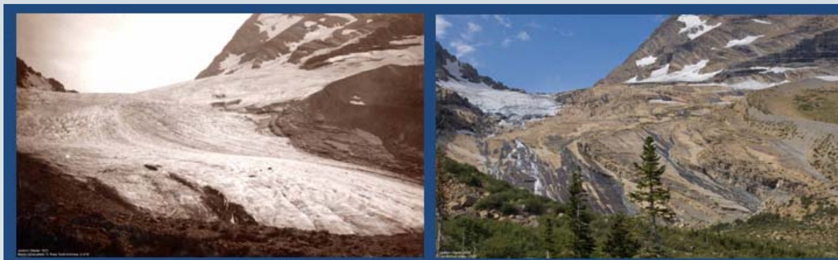
Northern Rocky Mountain Science Center
U.S. Department of the Interior
Geological Survey

Retreat of Glaciers in Glacier National Park



1911 Morton Elrod photo Courtesy of K. Ross Toole Archives, UM

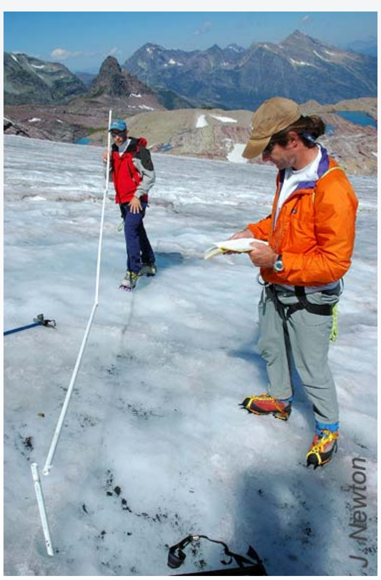
2009 Lisa McKeon photo USGS

Jackson Glacier, Glacier National Park

In Glacier National Park (GNP), MT some effects of global climate change are strikingly clear. Glacier recession is underway, and many glaciers have already disappeared. The retreat of these small alpine glaciers reflects changes in recent climate as glaciers respond to altered temperature and precipitation. It has been estimated that there were approximately 150 glaciers present in 1850, and most glaciers were still present in 1910 when the park was established. In 2010, we consider there to be only 25 glaciers larger than 25 acres remaining in GNP. A computer-based climate model predicts that some of the park's largest glaciers will vanish by 2030. This is only one model prediction but, if true, then the park's glaciers could disappear in the next several decades. However, glacier disappearance may occur even earlier, as many of the glaciers are retreating faster than their predicted rates.

WHAT IS A GLACIER?

A glacier is a body of snow and ice that moves. Glacier movement is detected by the presence of crevasses, cracks that form in the ice as the glacier moves. Glaciers are dynamic – changing in response to temperature and precipitation. A glacier forms when winter snowfall exceeds summer melting. It retreats when melting outpaces accumulation of new snow. A commonly accepted guideline for glacier activity and movement is that a glacier must be 0 .1 km^2 (100,000 m^2), or about 25 acres in size. Below this size, the ice is generally stagnant and does not move, unless it is on a steep slope.



USGS and University of Montana scientists measuring melting rates on Sperry Glacier, GNP.

While the glaciers that carved GNP's majestic peaks were part of a glaciation that ended ~12,000 years ago, current glaciers are considered geologically new, having formed ~7,000 years ago. These glaciers grew substantially during the Little Ice Age (LIA) that began around 1400 A.D and reached their maximum size at the end of the LIA around A.D. 1850. Their maximum sizes can be inferred from the mounds of rock and soil left behind by glaciers, known as moraines, which provide a scientific baseline for comparison to current glacial extent.

WHY ARE THEY MELTING?

Glaciers, by their dynamic nature, respond to climate variation and reveal the big picture of climate change. Unable to adapt, like living creatures, GNP's relatively small alpine glaciers are good indicators of climate, the long-term average of daily weather conditions. While occasional big winters or frigid weeks may occur, the glaciers of GNP, like most worldwide, are melting as long term mean temperatures increase. Glaciers are like a visual checking account of the status of the cold part of the ecosystem. Analysis of weather data from western Montana shows an increase in summer temperatures and a reduction in the winter snowpack that forms and maintains the glaciers. Since 1900 the mean annual temperature for GNP and the surrounding region has increased 1.33°C, which is 1.8 times the global mean increase. Spring and summer minimum temperatures have also increased, possibly influencing earlier melt during summer. Additionally, rain, rather than snow, has been the dominant form of increased annual precipitation in the past century. Despite variations in annual snowpack, glaciers have continued to shrink, indicating that the snowpack is not adequate to counteract the temperature changes.

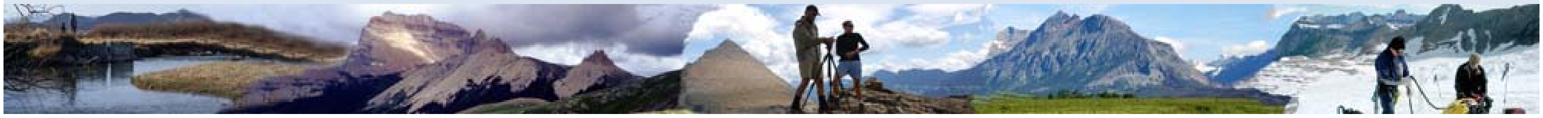
WHAT ARE THE EFFECTS OF LOSING GLACIERS?

The loss of glaciers in GNP will have significant consequences for park ecosystems as well as impacting landscape aesthetics valued by park visitors. While winters will still deposit snow in the mountains, this seasonal snow will not function the same as glacial ice since it melts early in the summer season. Glaciers act as a "bank" of water (stored as ice) whose continual melt helps regulate stream temperatures and maintains streamflow during late summer and drought periods when other sources are depleted. Without glacial melt water, summer water temperatures will increase and may cause the local extinction of temperature sensitive aquatic species, disrupting the basis of the aquatic food chain. Such changes in stream habitat may also have adverse effects for the threatened native bull trout (*Salvelinus confluentus)* and other keystone salmon species.

More information & references: http://www.nrmsc.usgs.gov/research/glacier_retreat.htm

Other impacts of climate change in GNP:

- Mountain snowpacks hold less water and have begun to melt at least two weeks earlier in the spring. This impacts regional water supplies, wildlife, agriculture, and fire management.
- Loss of alpine meadows will put some high-elevation species at risk as habitats become greatly diminished or eliminated.
- Mountain pine beetle infestation will likely spread further, causing areas of forests to die which will impact wildlife and stream habitat, wildfire risk, and recreation use.
- Fire frequency and burned area may be increased as fire season expands with earlier snowpack melt out and increasing number of hot days.
- Large fires may greatly impact regional air quality, increase risk to people and property, and negatively affect tourism.



Parkwide Named Glacier Comparison

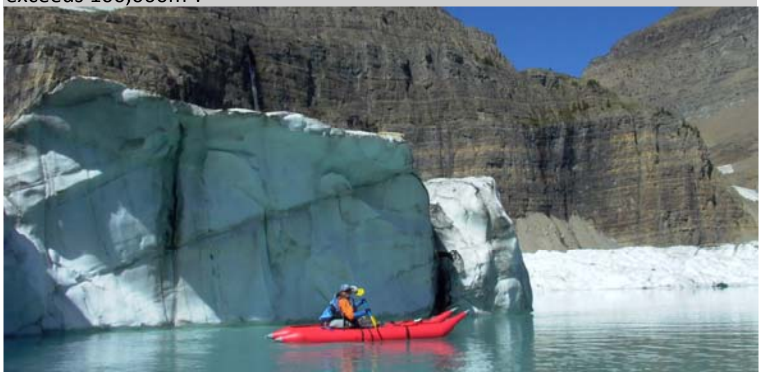
Glacier area data determined by aerial photo analysis in conjunction with Portland State University.

Glaciers that no longer exceed 100,00m² in area

Glacier Name	1966 Area (m²)	2005 Area (m²)	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 derived from aerial photos.

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



USGS scientist Lindsey Bengtson paddles along the margin of Grinnell Glacier to complete a GPS margin survey.

Glaciers that exceed 100,000m² in area

Glacier Name	1966 Area (m²)	2005 Area (m²)	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 derived from aerial photos.

The Northern Rocky Mountain Science Center is located in Bozeman, Montana and includes three field stations in Montana and one duty station in Wyoming. For more information on NOROCK's research, please visit http://nrmsc.usgs.gov or contact the Center Director: Jeff Kershner 406-994-5304 or jkershner@usgs.gov