



# Resource Bulletin

## Global Climate Change and Melting Glaciers

### Global Warming

Global warming is one of the most pressing environmental issues of the 21st century. For many years, scientists have been studying this phenomenon and the evidence is now clear. Earth's climate is warming and mountain ecosystems like those found in Glacier National Park are seeing some of the most dramatic changes.

In the last 100 years, global average temperature increased by 1.6 degrees Fahrenheit with accelerated warming over the last two to three decades. The 1990s were the hottest decade, not just of the last century, but of the last millennium! The 5 hottest years of record since the 1890s, in rank order, were 2005, 1998, 2002, 2003, and 2004. Scientists predict that by the end of the 21st century Earth will experience a warming trend of 2-10 degrees. While this may not seem like much, it could bring major changes to Earth's ecosystems, especially those at high altitudes and latitudes like Glacier National Park.

While Earth's climate is known to have changed in the past due to natural causes, the warming trend over the last few decades is primarily the result of human activities. Of major concern is the buildup of carbon dioxide and other "greenhouse gases" in the atmosphere.

Greenhouse gases hold heat in the atmosphere that would otherwise radiate back out into space. While the greenhouse effect is what has made life on Earth possible, these gases are now increasing at an alarming rate. Since the beginning of the industrial revolution, the carbon dioxide concentration in the



Grinnell Glacier, shown in the middle foreground, has retreated dramatically in recent years and has split off from Salamander Glacier, on the upper right. The smaller Gem Glacier on the upper left is also still visible.

atmosphere has increased by 30%. Human activities that release carbon dioxide are burning of fossil fuels, harvesting and burning trees, and land conversion to cities and agriculture.

### Melting Mountain Glaciers

Glaciers are formed when more snow falls in winter than melts in summer. As snow accumulates over many seasons it becomes ice. The weight from snow and ice causes the bottom layers to move, fashioning a frozen river of snow and ice that slowly flows across the landscape, eroding and shaping it into unique landforms. When this process is reversed, the glaciers retreat back up the mountain. The advance and retreat of glaciers is strongly tied to temperature and precipitation and is a simple,

but effective, way to monitor climate change.

The amazing mountains and valleys of Glacier National Park were sculpted by the action of glaciers over hundreds of thousands of years of glacial advance and retreat. In 1850, at the end of the Little Ice Age, there were an estimated 150 glaciers in the park. By 1968, these had been reduced to around 50, 37 of which had been named. Today the number of glaciers in the park is 27, many of which are mere remnants of what they once were.

Rapid retreat of mountain glaciers is not just happening in Glacier National Park, but is occurring worldwide. While Earth's climate has undergone cooling and warming cycles in the past, the rate and magnitude of change we

are witnessing today has not occurred since human civilization began. If the current rate of warming persists, scientists predict the glaciers in Glacier National Park will be completely gone by the year 2030.

The total loss of glaciers will certainly be a major change for Glacier National Park. For many people, the glaciers are one of the reasons the park holds special significance and are a feature they expect to see when they visit. Glaciers are also an important natural resource, providing vital functions for the ecosystem.

## Glacier's Management Strategy

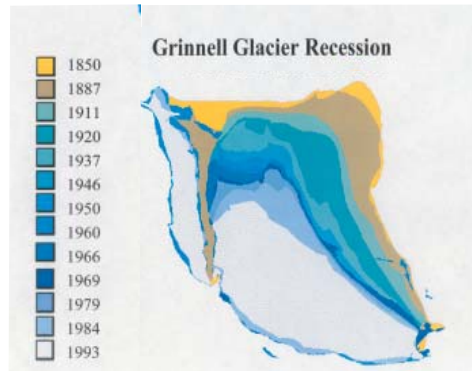
Now that the impacts of global warming are beginning to be understood, managers are taking the issue very seriously. Ultimately, greenhouse gas emissions, especially carbon dioxide, must be reduced. The National Park Service, in partnership with the Environmental Protection Agency, held a workshop in Whitefish, MT for park personnel in December 2003 to discuss the issues relating to climate change in the park and what steps the park can take to respond to this threat.

The two-day workshop, Climate Friendly Parks: Moving From Knowledge to Action, was aimed at park staff, concessioners, and

park partners. An assessment of greenhouse gas emissions from Glacier was conducted prior to the workshop to provide background on what the primary activities are that can be targeted for emissions reduction. The single greatest contributor to carbon dioxide emissions in the park is transportation. Other significant sources are energy use in buildings and solid waste disposal.

An important outcome of the workshop included organization of the Glacier Green Team. The Team meets quarterly to discuss issues relating to sustainable environmental practices in the park. Another outcome of the workshop was development of an action plan that outlines steps we can take toward sound environmental management of our operations.

Many of the ideas from the action plan have recently been integrated into Glacier's Environmental Management Plan, which was completed in May 2006. A number of the actions from the plan have already been taken to reduce greenhouse gas emissions and raise awareness of the issues. These include employee transportation alternatives like the Red Bike Program and bus and carpooling initiatives, as well as a recycling plan, and monitoring energy use in buildings. Visitor transportation options are also being planned in conjunction with the Going-to-the-Sun Road rehabilitation project.



The size of Grinnell Glacier has receded dramatically over the last hundred and forty years. The white area shows the extent of the glacier in 1993; the colored areas show the glacier's extent for years prior to that.



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#### Resources for More Information

Glacier National Park staff:

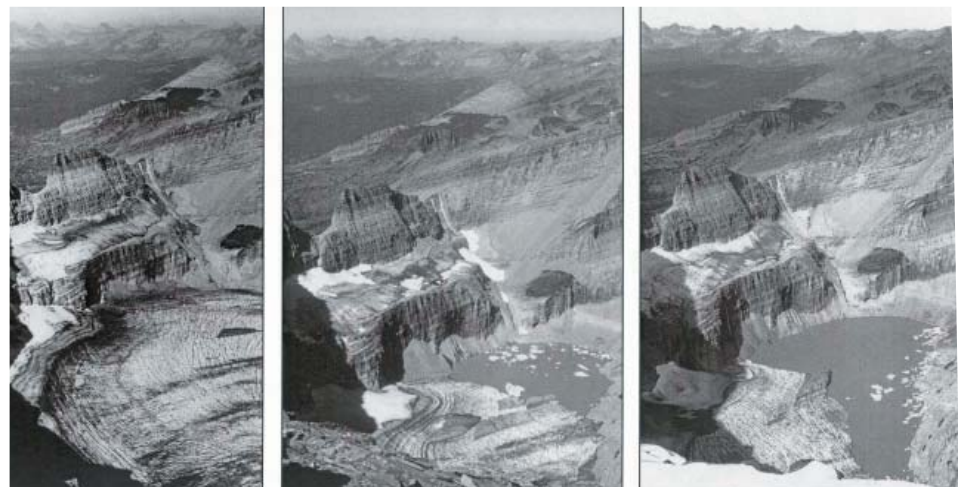
Leigh Welling, Director, Crown of the Continent Research Learning Center  
Dan Fagre, Ecologist, USGS Glacier Field Station

Documents and web sites:

Glacier National Park Global Climate Change  
<http://www.nps.gov/glac/resources/bio7.htm#Global>

Ecological Significance of Long-term Climate Changes in Montane Ecosystems, and Global Climate Change  
[http://nrmisc.usgs.gov/research/climate\\_changes.htm](http://nrmisc.usgs.gov/research/climate_changes.htm)

Glacier National Park Green Team: <http://www.glac.nps.gov/glac/office/greenteam.cfm>



Repeat photographs of Grinnell Glacier taken from Mt. Gould show the rapid retreat of the glacier and the formation of a glacial lake; dates from left to right are 1938, 1981, 1998.