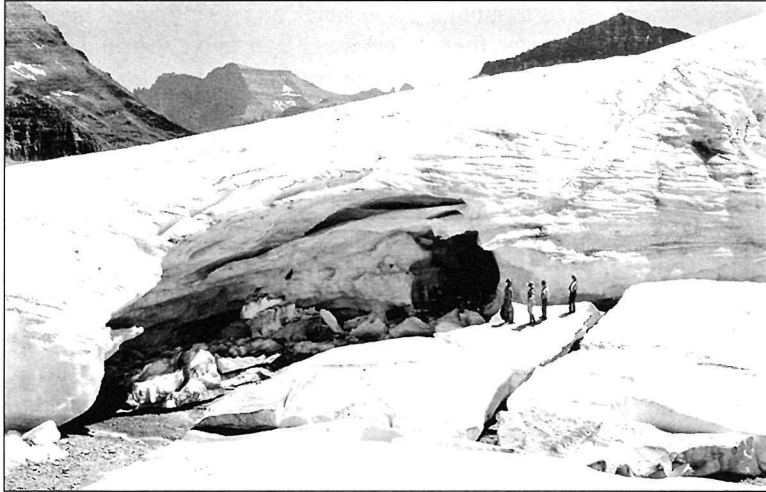




## Climate Change



Boulder Glacier in 1938 and the same location 60 years later in 1998.

### Introduction

Rapid climate change has become one of the most pressing environmental issues of the 21st century. In the last 100 years, global average temperature has increased by 1.5°F, with accelerated warming over the last two to three decades. Scientists project that by 2100 the earth's surface could warm by as much as 10 degrees. While this may not seem like much, it could bring major changes to our water cycle and to many plant and animal species that are adapted to the current climate. High latitude and high altitude environments, such as those found in Glacier National Park, are especially vulnerable.

### A Warming Climate

While Earth's climate changes naturally, the rapid rate of warming over the last century is unprecedented in human history. The 6 hottest years on record since the 1890s, in rank order, are 2005, 1998, 2002, 2003, 2006, and 2004.

Scientists link the rapid rise in Earth's surface temperature to the build-up of certain gases in the atmosphere, such as carbon dioxide, methane, and nitrous oxide. These are known as greenhouse gases (GHGs) because they trap heat. Without GHGs life on Earth

would not be possible. However, too high of concentrations can also be detrimental.

The rise in GHGs over the last century is strongly correlated to our warming climate. Many human activities, especially those related to consumption of fossil fuels, result in the emission of GHGs to the atmosphere. Therefore, any actions or choices that can result in a reduction of these emissions will put us on a more sustainable path toward stewardship of the resources we are charged to protect.

### Melting Mountain Glaciers

For many people, the glaciers are a key reason the park holds special significance and are a feature they expect to see when they visit. Glaciers are formed when more snow falls in winter than melts in summer. As snow accumulates over many seasons and years, it becomes ice. The weight of snow and ice causes the bottom layers to eventually move, fashioning a frozen river that slowly moves across the landscape, eroding and shaping unique landforms.

The amazing mountains and valleys of Glacier National Park were sculpted by the advance and retreat of glaciers over a nearly 2 million year period known as the Pleistocene Epoch. The last major continental-scale glacial period ended around 10,000 years ago. This was the beginning of the Holocene Epoch, a warm period during which life became adapted to the warm interglacial climate.

More recently in the park's history, there has been regional cooling that advanced the alpine glaciers. In 1850, at the end of what is known as 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 26, many of which are mere remnants of what they once were.

Rapid retreat of mountain glaciers is occurring worldwide. While Earth's climate has undergone cooling and warming cycles in the past, the rate and magnitude of the 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.

### Water Towers of the World

Mountain glaciers are more than just scenery, they are an integral part of the ecosystem, providing cold water to mountain and downstream environments. Mountains have been called "water towers of the world." More than 50% of the world's fresh water supply comes from runoff in mountain environments. While much of the runoff from mountains comes from rain and melting snow, alpine glaciers are an important contributor to mountain streamflow. Globally, glacial meltwater provides one-fourth of the water in mountain streams.

By providing a dependable source of cool, fresh water, glaciers are essential to the health of aquatic and riparian ecosystems. They also provide fresh drinking water for downstream populations and dilute pollutants that are generated mostly in lowland areas. As climate warms and glaciers melt, mountain systems, and the downstream communities they serve, are losing an important source of fresh water.

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## Stream Regulators

Mountain streams in Glacier National Park are fed by alpine glaciers and snowpack. In summer, once it becomes warm enough to melt the snowpack, a rush of water comes down the mountains from glaciers to join the streams and rivers. Then, for the rest of the warm season, mountain streams are augmented by a constant flow from melting glaciers and snowfields. When rain is sparse, as in the late summer and during drought years, mountain glaciers may be the primary source of water flow in some mountain streams.

As climate warms, this pattern is changing. With a warming climate, less winter precipitation falls as snow but more of it falls as rain. Also, spring comes earlier. The longer warm season will allow even more snow and ice to melt. Earlier, warmer summers mean

spring runoff from mountains happens earlier in the year, and often in a bigger rush of water downstream. In the Pacific Northwest region, spring runoff is now happening up to two weeks earlier than it used to. A concern with global warming is the possibility of more spring floods due to the pulses of rain combined with melting snow and ice.

As mountain glaciers melt and spring runoff happens earlier, there is less water later in the season. Larger streams may become warmer and have lower flow. With no glacial meltwater to augment them, some streams may become ephemeral, drying up late in the season. This will have major consequences for stream ecology.

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## Biological Diversity

Glacier National Park is a highly varied landscape that is home to a rich diversity of plants and animals. One reason for this is the steepness of the terrain. With high mountains and low valleys, dense forests and open meadows, and numerous wetland habitats, Glacier can provide a home to an amazing array of species. But as climate changes, ecosystems will change too. Exactly how our current warming climate will affect Glacier's biotic communities is an active area of scientific research.

Climate helps determine what flora and fauna exist in a habitat. Every species has temperature and moisture ranges within which they can survive and thrive.

Glacier's weather and climate can be highly variable from high to low elevations and also between the east and west sides of the Continental Divide. The cool, harsh high alpine environments support very different species than the milder conditions usually found at lower elevations. East of the divide tends to be colder and drier than west because the Pacific maritime climate delivers moisture and heat from west to east.

The temperature range, rain, wind, and other climatic conditions that each part of the park receives helps to define the kinds of organisms found there. While not static, these microclimates create diversified and distinct communities within the landscape.

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## An Altered Landscape

As climate changes, plants and animals adapted to current conditions and locations will either need to adapt to survive in different conditions or "follow" the temperature range in which they can survive. The ability of populations to adapt or move when climate changes depends on many factors, one which is the rate of change. The current warming climate is accelerated by human activities and it is unclear how, or even if, most modern species can adapt well enough to survive.

In a warming climate, vegetation zones will tend to migrate northward and/or upslope to higher elevations. Alpine treeline studies help scientists understand how this process takes place. Studies from Glacier suggest forest patches at high elevations are getting denser and are beginning to invade alpine meadows.

Of major concern is the potential loss of alpine and subalpine environments that provide prime habitat for plants such as Jones Columbine and White Mountain Avens, animals like bighorn sheep and mountain goats, and winter hibernation space for bears. Species living here cannot migrate to higher ground.

While some species may be able to move and adapt to climate change, the current rapid rate of warming may present significant difficulties for others. Some vegetative communities, such as old growth forests, are not capable of migrating quickly. In other cases, migration may not occur due to lack of suitable corridors that connect current locations to higher or more northern territories where the plants can become established and thrive. Roads, urban and industrial areas, and agricultural fields all present obstacles to the migration potential of plants and animals. Species that cannot adapt or move, will not survive.

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## Changes In Disturbance Regimes

Climate change will affect not only the types of plants and animals that can survive in certain areas; it will also impact processes that shape the landscape such as fire. For example, changes to temperature and precipitation patterns affect soil moisture as well as the length of the overall fire season. Scientists have recently linked the earlier spring warming and longer summer dry periods to an observed increase in large

fires (>400 ha) in the west since the mid-80s. While fire is an important shaper of Glacier's landscape, too intense or too frequent fires may make it more difficult for native species to return. Disturbance by fire may also create an ideal environment for non-native invasive species to thrive.

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## Management Strategies

Now that the impacts of global warming are beginning to be understood, managers are taking the issue very seriously. While there are many decisions that will have to be made regarding resource protection, ultimately, greenhouse gas emissions, especially carbon dioxide, must be reduced.

One strategy that Glacier has taken is to become a "Climate Friendly Park". This initiative is a partnership between the National Park Service and the Environmental Protection Agency to promote sustainable practices that reduce greenhouse gas emissions and educate the public about what they can do to help.

As a Climate Friendly Park, Glacier has developed a list of action items to become more energy efficient and is implementing a series of education and interpretation products to raise awareness of the issues. Some of the actions include employee transportation alternatives like a bicycles for on the job local travel, a propane-powered bus for commuting to work, a web-based carpooling program, a solid waste recycling plan, and monitoring energy use in buildings. Visitor transportation options and "green" construction options are also underway in conjunction with the Going-to-the-Sun Road rehabilitation project.