



CLIMATE CHANGE IN MOUNTAIN ECOSYSTEMS



A Focus on Mountain Ecosystems

Climate change is widely acknowledged to be having a profound effect on the biosphere with many and diverse impacts on global

resources. Mountain ecosystems in the western U.S. and the Northern Rockies in particular are highly sensitive to climate change. In fact, the higher elevations of the Northern Rockies have experienced three times the global average temperature increase over the past century. These same ecosystems provide up to 85% of the water humans depend on as well as a host of other ecosystem services such as snow-based recreation, timber, unique flora and fauna, and critical habitat for rare and endangered species such as bull trout and grizzly bear. Climate change poses special problems for mountain protected areas, such as national parks and wilderness areas, because most of the land area within their boundaries is at higher elevations. What will be the effects of continued climate change on mountain resources and our national parks? How should managers monitor and react to climate change? To answer these questions, the Climate Change in Mountain Ecosystems (CCME) program of the Northern Rocky Mountain Science Center has been monitoring, conducting research, and modeling ecosystem responses to climatic variability since 1991, first at Glacier National Park but eventually throughout the western U.S. in collaboration with other scientists. Coordination with scientists around the world have led to mountain research networks to expand our understanding of how mountain

ecosystems respond to climate change.

Areas of Current Research

- **Glacier Research**
- **Snow and Avalanche Research**
- **Mountain Ecosystems Research**
- **Landscape Change Photography**
- **Western Mountain Initiative**

Glacier Research



J Newton photo

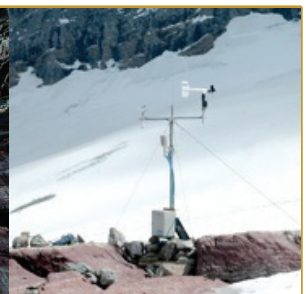


J Newton photo

As Glacier National Park's namesake glaciers recede, CCME staff are monitoring many of the park's glaciers to determine the causes of change, assess their ecological and hydrological effects, and predict future changes and effects. Intensive research to determine the mass balance of Sperry Glacier will determine whether small cirque glaciers like Sperry can serve as reliable indicators of current climate variability. Analysis of aerial photography, repeat photography, and glacier margin surveys document the rapid retreat of these mid-latitude glaciers as increasing temperatures influence mountain ecosystems world wide.



J Newton photo





Snow and Avalanche Research

Since 1991, CCME staff have conducted snow surveys throughout Glacier National Park.

These data have contributed to regional climate change and hydrologic models. Snowpack characteristics have also been evaluated in relation to avalanche forecasting and plowing of GNP's Going to the Sun Road efforts. Studies of natural snow avalanches reveal connections with large-scale climate and wildfire patterns as well as the influence on the creation of characteristic habitat vulnerable to climate change.

Mountain Ecosystems Research



Mountain ecosystems, with their topographic complexity and strong environmental gradients, allow CCME researchers the opportunity to study climate change impacts in highly sensitive environments. Particularly in mountain protected regions, such as national parks,

interdisciplinary and integrated approaches to researching both the mechanisms of and responses to climate change provide managers with information critical to making resource decisions. The CCME program examines the breadth of ecosystem research from examining the ecological significance of specific avalanche paths, to examining mountain ecosystem responses to climatic variability across regional landscapes. Collaboration across disciplines, agencies, and institutions has created a program that seeks to answer timely climate change questions.



Boulder Glacier

Landscape Change Photography

Repeat photography is being used by the CCME program to document landscape change. Glaciers have been the primary focus of this park-wide survey and this collection of repeat photographs, available for download on the CCME website, have been used to illustrate the effects of climate change in venues across the globe. These powerful images, with their inherent ease of interpretation, have become icons of climate change. Researchers will continue to expand the collection of repeat photographs of glaciers as well as panoramic photos from fire lookouts in an effort to document landscape change in this period of dramatic climate warming.

Western Mountain Initiative

Understanding and predicting the responses of climate variability and change at a regional scale is the objective of the six research programs collaborating on the Western Mountain Initiative (WMI). CCME research

pertaining to glacier recession, analysis of snowpack trends, and paleo-reconstructions of regional snowpack, help define thresholds, sensitivities, and resilience of western mountain ecosystems to climate variability as part of WMI.



CLIMATE CHANGE IN MOUNTAIN ECOSYSTEMS

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