



Hot Topic Brief

Monitoring Climate Change in the Rocky Mountain Network

The Earth is currently experiencing a period of rapid climate change where global temperatures are rising and the extent of mountain glaciers and snow pack is decreasing. The Rocky Mountain Inventory & Monitoring Network (ROMN) includes a wide range of biophysical environments, ranging from mountain peaks down through evergreen and deciduous forests to Western grasslands. The six units of the network include Glacier National Park, Grant-Kohrs Ranch National Historic Site, Little Bighorn Battlefield National Monument, Florissant Fossil Beds National Monument, Great Sand Dunes National Park and Preserve, and Rocky Mountain National Park. While the environments may differ among the parks, all the units in ROMN are experiencing similar trends in climate. The Western United States has seen average temperatures increase over the past century. Large variability in precipitation records make estimations more difficult, but in some areas of the West it is thought to have increased by as much as 50% since 1900. Regional models predict these trends will continue.

In order to meet the challenge of responding and managing national parks in the face of global climate change, it is critical that the NPS has high quality monitoring and inventory data to track changes as they occur.

This newsletter highlights some of the Rocky Mountain Network activities that relate to climate change.



Monitoring an alpine wet meadow in Rocky Mountain National Park, August 2008.

Weather or not? The Rocky Mountain Network's Weather & Climate Protocol

During the past 40 years, the Western United States has warmed between 1 and 3°C¹. Scientists have compared this and other recent climate changes to past climate records derived from glacial ice, lake sediments, tree rings, and fossil corals and have found that the magnitude and speed of this change is unprecedented. The Intergovernmental Panel on Climate Change has attributed much of these changes to human impacts on the atmosphere and expects

that the climate will continue to change in the coming century¹. Since national parks are protected areas, there is a unique opportunity to examine the effects of climate change on ecosystems without confounding other human disturbances, such as land-use change. It is important to monitor such changes and maintain high quality records of weather and climate in the national parks because they can have profound effects

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Weather & Climate Protocol (continued)

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on resource management and visitor experience. For example, scientists have found that changes in precipitation and the timing of snowmelt can increase the severity and frequency of fires in Glacier National Park². To help meet this challenge, the Rocky Mountain Inventory & Monitoring Network (ROMN) is completing a protocol to monitor weather and climate in all six ROMN parks. The protocol is being developed in collaboration with the Greater Yellowstone, Southern Plains, and Sonoran Desert networks.

The Weather & Climate Protocol will provide data on direct measures of climate across different temporal and spatial scales as well as data on climate responses (such as streamflow). The most common way to monitor weather is at a local scale by maintaining a weather station with instruments such as thermometers and rain gauges. Weather stations provide valuable information about past and current climate for a particular point. The limitation of such weather stations is that they provide data from only this one location that may or may not be representative of the entire park or region. In the Weather & Climate Protocol data from many weather stations will be aggregated and adjusted for elevation and distance from the park to derive a park-wide index of daily temperature and precipitation. In addition to the park-wide indices, we will determine the status and trends in snowpack, regional palmer-drought severity indices, daily stream flows, monthly temporal and spatial patterns in precipitation, minimum and maximum temperatures (using the Parameter-elevation Regressions on Independent Slopes Model)³.

The protocol is expected to produce a number of products to meet different needs. For each park, we will produce annual reports summarizing seasonal

trends in climate and comparing the current year to the average conditions in the past 30 years. The goal of these reports is to allow managers, ROMN staff and other researchers to identify how climate may affect processes within the park. For example, managers may notice that an insect outbreak occurred in a year characterized by dry and hot conditions. Another example is that regional drought may reduce the probability of invasion by exotic plants⁴. Other types of reporting include a web page with links to real-time observations.

Another long-term goal of the Weather and Climate Protocol is to understand how global climate affects park resources. Local weather and regional climate records from parks can provide some insight, however trends and cycles in global climate indices may be better suited to predicting ecological patterns. Ecologists have used global indices to predict fluctuations in animal population size, fire frequency, and flowering times!

We have begun to examine the relationship between climate within the parks and some of the most well known global indices. Ultimately, we may be able to provide the parks with reasonable forecasts of the likelihood of drought, fire, or high stream flows based on changes in these global indices.

References

1. IPCC (2007) Climate change 2007: synthesis report. Contribution of working groups I, II, and III to the fourth assessment report of the intergovernmental panel on climate change [Core writing team, RK Pachauri, and A Reisinger (eds.)] IPCC, Geneva, Switzerland, 104 pp.
2. Pederson, GT, ST Gray, DB Fagre, and LJ Graumlich (2006). Long- duration drought variability and impacts on ecosystem services: a case study from Glacier National Park. *Earth Interactions* 10: 1-28.
3. PRISM Group, Oregon State University, <http://www.prismclimate.org>
4. Alpert, P, E Bone, C Holzapfel (2000) Invasiveness, invasibility and the role of environmental stress in the spread of non-native plants. *Perspectives in Plant Ecology, Evolution and Systematics*. 2000; 3(1):52-66.

Definitions: What is the difference between weather and climate?

Weather refers to short-term variations of the atmosphere. At any given time and place, it is described by temperature, moisture, wind, and barometric pressure. Weather is predictable up to approximately 14 days; beyond two weeks, it is chaotic and therefore unpredictable!

Climate refers to longer-term atmospheric variations (>2 weeks). Climate is a statistical aggregation of individual weather events that manifest themselves as averages (e.g., temperature), totals (e.g, precipitation), and counts (number of days of sunshine). Predicting longer-term variations in climate requires understanding how the atmosphere interacts with the earth's other major systems (biosphere, hydrosphere, cryosphere, and lithosphere), all of which vary and change at different spatial and temporal scales.

Climate change is any long-term significant change in the "average weather" of a region or the earth as a whole.

Global climate indices describe regular and often predictable modulation in atmospheric or sea surface temperatures and pressure over wide regions. The Southern Oscillation Index, which describes the alternation between El Nino and La Nina in the southern pacific ocean, occurs every 4-7 years and is the most famous of the global climate indices.

Linking Monitoring to Climate Change Research

The Rocky Mountain Inventory and Monitoring program is supporting the national initiatives in climate change by providing expertise and programs in three areas: inventories, monitoring, and ecosystem assessment.

Inventory efforts such as Vegetation Maps and NPS species lists can provide critical baseline information for the existing resources in parks.

The ROMN **monitoring** program is developing protocols to establish the status and understand trends in 12 high priority vital signs. The vital signs include.

- Wet and Dry Deposition
- Weather and Climate
- Water Chemistry
- Surface Water Dynamics
- Freshwater Communities
- Invasive/Exotic Aquatic Biota
- Groundwater Dynamics
- Wetland Communities
- Invasive/Exotic Plants
- Vegetation Composition, Structure, and Soils
- Focal Species: Beaver, Elk, Grizzly Bear, and GRSA Endemic Insects
- Landscape Dynamics

Our active field and data protocols include:

- Vegetation Composition, Structure, and Soils: Grassland, shrubland, and woodlands
- Vegetation Composition, Structure, and Soils: Alpine tundra
- Weather and Climate
- Snow Chemistry
- Wetland Ecological Integrity
- Stream Ecological Integrity

A secondary objective of the ROMN is to develop quantitative methods for the **assessment** of ecosystem integrity and health through the development of bioassessment models that will incorporate reference condition distributions and identify both temporal and spatial departures from these distributions within a park.

Park specific monitoring

As of 2009, the following protocols will be active in each park:

FLFO

Weather and Climate
Vegetation Composition, Structure and Soils (VCSS): Grassland, Shrubland, and Woodlands
Stream Ecological Integrity

GLAC

Weather and Climate
Stream Ecological Integrity
VCSS: Alpine Tundra
Snow Chemistry

GRSA

Weather and Climate
Wetlands Ecological Integrity
VCSS: Alpine Tundra
Snow Chemistry

GRKO

Weather and Climate
VCSS: Grassland, Shrubland, and Woodlands
Stream Ecological Integrity

LIBI

Weather and Climate
VCSS: Grassland, Shrubland, and Woodlands
Stream Ecological Integrity

ROMO

Weather and Climate Protocol
Wetland Ecological Integrity
VCSS: Alpine Tundra
Snow Chemistry



Jason Smith, Resource Specialist at GRKO monitoring periphyton in the Clark Fork River, October 2008

Our monitoring protocols will document changes in the status and trends of priority vital signs. According to the Intergovernmental Panel on Climate Change¹, we are likely to see the following changes in some ROMN parks:

Vegetation: Grassland, shrubland, and woodlands & Alpine Tundra

Disturbances such as wildfire and insect outbreaks are increasing and are likely to intensify in a warmer future with drier soils and longer growing seasons. The length of the vegetation growing season has increased an average of 2 days/decade since 1950 with most of the increase resulting from earlier spring warming.

Weather & Climate, Snow Chemistry

Warming and changes in the form, timing and amount of precipitation, will very likely lead to earlier melting and significant reductions in snowpack in the western mountains by the middle of the 21st century.

Wetland Ecological Integrity

Changes in precipitation, snowpack, and monsoon seasons may decrease surface and ground water availability. As a result, wetlands and their associated flora and fauna will likely diminish in number and extent

Stream Ecological Integrity

Climate change is likely to make it more difficult to achieve existing water quality goals. Coldwater fish habitat, aquatic insects and other invertebrates living in streams will be reduced.

Landscape Dynamics.

North American animals are responding to climate change, with effects on migration and geographic range.

1. Field et al., 2007: North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Pary et al., Eds., Cambridge U Press, Cambridge, UK. 617-652.

Managing parks in the face of change

One of the most common questions to park managers is “What are you doing about climate change?” After reading the previous articles, we hope that the first answer will be “taking inventory, monitoring, and assessing the current state of park resources”. Beyond that, what can parks do? Below we outline the recommended adaptive management strategies of the U.S. Climate Change Science Program¹ and how the ROMN programs can assist in meeting these management goals.

Reduce human stresses that hinder the ability of species or ecosystems to withstand climatic events.

All ROMN field protocols call for measuring anthropogenic disturbances at every site we visit. These data will provide information on the range, spread, and severity of disturbance in your park.

Restore or rehabilitate ecosystems that have been lost or compromised.

Bioassessment models for ecosystem integrity and health are being used to develop reference condition

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distributions for wetlands and streams. These references can provide a target for restoration projects.

*Protect a **representative** portfolio of variant forms of a species or ecosystems so that, regardless of the climatic changes that occur, there will be areas that survive and provide a source for recovery.*

Identification of representative examples of ecosystems will require detailed knowledge of what type of habitats are in the park. The ROMN vegetation, stream, and wetland protocols can all be used to describe the variation among sites within a park. For instance, over 150 wetlands have been characterized in ROMO!

Replicate more than one example of each population such that if one area is affected by a disturbance, another replicate area can provide insurance against extinction and a source for recolonization of affected areas.

Vegetation inventory and maps provide data on the spatial distribution of different habitat types and can be used to determine which communities are in need of replication.

*Protect **refugia** which are areas that are less affected by climate change than others and can be used as sources of “seed” for recovery or as destinations for climate-sensitive migrants.*

Analyzing trends across sites and ecosystems over time will help identify those areas that are less affected by climate change.

Relocate organisms from one location to another in order to bypass a barrier (e.g. a road).

The Landscape Dynamics Protocol which is in development for 2010, will allow managers to see where barriers and isolated fragments may exist in their parks.

1. CCSP, 2008: *Preliminary review of adaptation options for climate-sensitive ecosystems and resources*. U.S. Climate Change Science Program [Julius and West (eds.), J.S. Baron et al. (Authors)]. U.S. EPA, Washington, DC, USA

News & Highlights

In the parks:

Fossil trees, insects, and pollen, like those found in FLFO, provide researchers with some of the best descriptions or ‘proxy records’ of past climate.

ROMO and GLAC are NPS climate-friendly parks!

GRSA is installing 10 new wells on the border of the park to track groundwater discharge. As part of the ROMN wetland protocol, they could also be used to monitor climate-driven changes in water availability.

In the network:

Scientists at the USGS and their partners from U.S. Forest Service and Trout Unlimited are examining how climate change may be impacting the habitats of native fish species throughout the Rocky Mountains and the interior western United States. The goal is to provide tools that will help managers predict potential climate change induced impacts on native fish.

The stream inventory & monitoring program has found 12 to 15 new species of diatoms in GLAC, these may serve as an index for climate changes!

A GLORIA site to monitor temperature and vegetation change in the tundra has been run in GLAC for 5 years and was started in GRSA and ROMO in 2008.

The ROMN will be publishing five prototype annual climate reports this year for GRKO, GLAC, GRSA, LIBI, and FLFO.

In the nation:

The DOI has just established a Climate Science Effects Network, coordinated by the USGS, to meet the goal of integrating science, monitoring, and modeling information on climate change.

The United States Climate Science Program (<http://www.climatescience.gov>) integrates federal research on climate and global change.

The National Park Service in collaboration with the U.S. Fish & Wildlife Service is publishing a series devoted to understanding the state of knowledge for regional impacts of climate change. Their publication on Western Mountain Systems will be coming soon.

A recent paper in Science magazine, Phillip J. van Mantgem, et al. (2009) Widespread Increase of Tree Mortality Rates in the Western United States. Science 323, 521, explains that while recruitment has not changed, tree mortality has increased since 1955 and a likely cause is warmer and drier conditions.