National Park Service
U.S. Department of the Interior

Rocky Mountain National Park

Climate Change in Rocky Mountain National Park

Frequently Asked Questions

March 2014

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Contents

"The knowledge necessary to make a perfect analysis of the impacts of potential courses of …management action…does not exist. It probably never will. But more knowledge is available than has yet been brought to bear on this problem. To be useful, that knowledge must be organized so it makes sense…To say we don't know enough is to take refuge behind a half-truth and ignore the fact that decisions will be made regardless of the amount of information available…"
(Thomas 1979)

This document is our first coordinated attempt to address the frequently asked questions regarding climate change and its potential impacts to the ecology of Rocky Mountain National Park. And, though we are left with more questions than answers, we continue to grow our understanding of this complex topic. Thanks to all of the researchers, citizen scientists, and supporters of Rocky Mountain National Park who help us to find ways to adapt in the face of the uncertainties of climate change.

Ben Bobowski PhD
Chief of Resource Stewardship
Rocky Mountain National Park

ON THE COVER: Subalpine fir display colorful cones near Lawn Lake in Rocky Mountain National Park. NPS photo.
RIGHT: The sun shines on Glacier Creek Trail in Rocky Mountain National Park. NPS photo.

Park-Specific Impacts

Rocky Mountain National Park is a dynamic and dramatic place which supports amazing ***biological diversity***, provides clean water to people, and acts as a living classroom that helps us better understand the natural world. The Rocky Mountain range evolved over millions of years, growing and changing, again and again. People are part of that story, and over time relied on, managed, and ultimately preserved this special place. Yet recently, humans also set in motion a process that threatens the preservation of this park and all protected areas.

Climate change is happening in Rocky Mountain National Park, and throughout the world. From the snow-capped Rockies to the cloud rainforests of Costa Rica, a winter home for the park's migratory birds, the changes we see affect the things we care about. The National Park Service mission is to preserve national parks for future generations. Our challenge now is to meet that mission in the face of a changing climate. In partnership with the American public, the National Park Service will continue to ask questions, conduct research, and take action to protect Rocky Mountain National Park into the future.

Biological diversity **is the variability, or variety, among species and their habitats. Consider that biodiversity includes all living things, including humans.**

Climate **is the description of the long-term pattern of weather in a particular area.**

Is climate change real?

Climate change is real. On average, the temperature is rising. Average global temperatures over the past 30 years was likely higher than any other time during the last 1,400 years. At the same time, the amount of carbon dioxide and other heat-trapping gases like methane and nitrous oxide in our atmosphere has risen dramatically. These increases are due primarily to human activities such as fossil fuel use, land use change, and agriculture. Climate scientists conclude that human activities are changing the Earth's climate.

The mountain pine beetle (*Dendroctonus ponderosae*) has impacted nearly 90% of forested areas in Rocky Mountain National Park. While the park has experienced outbreaks from this native beetle in the past, today's outbreak is longer, more intense, covers a greater area, and is expanding its range to higher elevations and higher latitudes than in the past. Photo by Melanie Wood.

Where can I see climate change impacts in Rocky Mountain National Park?

Take a look from Forest Canyon Lookout high on Trail Ridge Road in early summer in Rocky Mountain National Park, and you can see runoff from alpine snow fields, lakes and rivers flowing in winding paths to the forest floor below. The movement of water is one of the best indicators of change in mountain systems. Winter snowfall creates snowpack that acts as a natural reservoir, holding water in the mountains and releasing it steadily in the spring and summer. This provides a critical source of water for plants, animals, and humans during the dry summer months. With rising temperatures, the timing of snowmelt has shifted approximately 2-3 weeks earlier during the years between 1978 and 2007. The result is a longer period of low river levels and dry soil and plants in the summer. Even small changes in the amount and timing of water flow can make visible changes in the park - changes that may affect the park's mammals (page 4), plants (page 5), the mountain pine beetle (page 6), and invasive species (page 5).

Is the temperature changing in the park?

It is getting warmer in Rocky Mountain National Park. In the 20th century, the average annual temperature rose 3.4 degrees Fahrenheit (°F) in the area that includes the park. Imagine climate change is like a fever – if your temperature rose 3.4 °F, you would feel very sick. This small change also affects many plants and animals adapted to this place, and the natural services (like clean water) upon which we depend.

A weather station near Grand Lake, on the west side of the park, reports that from 1940 to 2011, the number of frost-free days increased from an average of 65 days in the middle of the last century to an average of 100 days in the most recent decade, approximately 40 more frost-free days per year. A greater number of days in which it does not freeze, over a long period of time, indicates a warming trend in this area of the park.

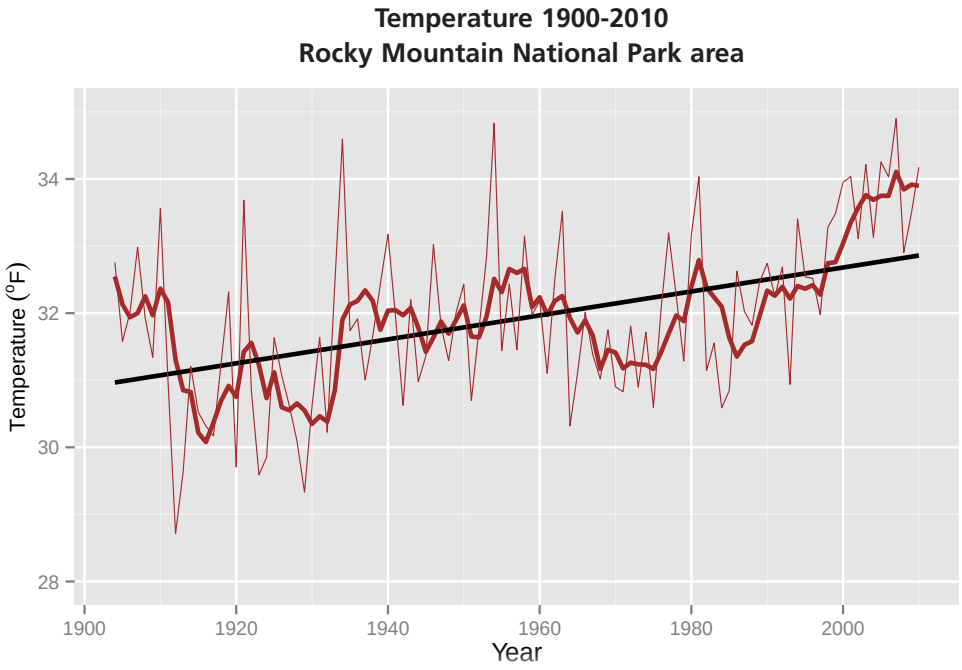


Figure 1 In the 20th century, the area including Rocky Mountain National Park experienced a warming trend. The five-year rolling average (thick red line) allows the viewer to look beyond annual variability to focus on long-term trends. (Analysis of PRISM data, original source Daly 2008)

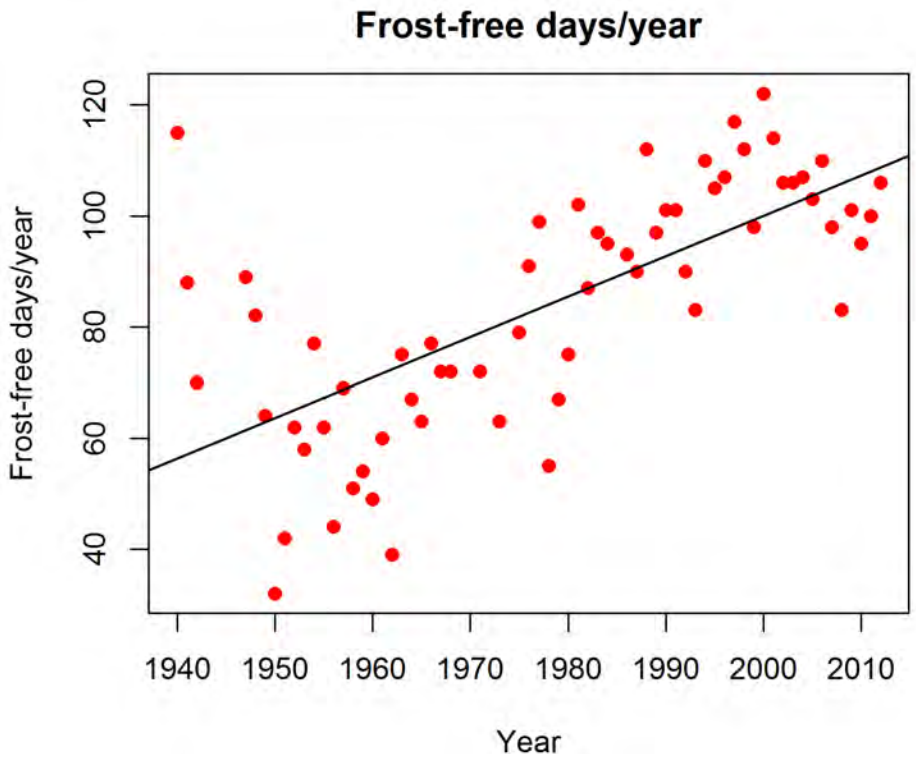


Figure 2 A weather station near Grand Lake, CO shows that the average number of frost-free days on the west side of Rocky Mountain National Park has increased by approximately 40 more days per year.

What are the impacts of climate change at high elevations?

The alpine tundra of Rocky Mountain National Park is a unique and special place. Low temperatures, frozen soil, and year-round snow create an environment in which only specialized plants and animals can thrive. Soils in the tundra create an environment in which layers of snow provide insulation and essential moisture for plants year-round. In turn, alpine wildlife such as pikas, ptarmigans, and marmots rely on these plants for survival.

Warmer temperatures and changes in the amount and timing of snow may drastically change the landscape in these areas. Already we are beginning to see snow melt earlier in the spring. As temperatures rise, exotic new plants may begin to take hold in this soil, changing the composition of plant and animal communities at these elevations. Alpine wetlands and the plants and animals that depend upon them are particularly vulnerable to changes in temperature and moisture.

**The high elevations of Rocky Mountain National Park are particularly vulnerable to the effects of warming from climate change.
Photo by Will Elder.**

How can climate change be a problem when it snows so much?

Living in one spot on the planet, it is not easy to grasp global climate change. Weather can be so chaotic—the spring of 2013 was cool and very snowy, while the spring of 2012 was warm and very dry. Weather is the mix of conditions from one day to the next, or even one year to the next. Climate, on the other hand, is the average weather pattern in a place over many years. Scientists examining the average weather conditions over a long period of time (i.e. climate) see a warming pattern emerging.

What kinds of species are affected by climate change in the park?

We are working to understand exactly how climate change is affecting the park's species. There are many factors involved, and we need long-term information to understand how everything fits together. By identifying the changes that we see in the park, and anticipating future changes, we can protect the resources in this special place.

One of the species scientists study is the American Pika (*Ochotona princeps*), which lives in the park's alpine areas. The pika cannot survive above 75 °F for more than a few hours. To regulate its body temperature it lives only in high-altitude rock piles that provide cool air during hot summer days. Scientists are concerned that as mountainsides become warmer, pikas will need to move higher to escape the heat. As they move higher in elevation, these populations become more isolated from each other and eventually, they may run out of room entirely. A study began in the park in 2010 to understand where pikas live and how warming may affect these populations.

Species like the American Pika (*Ochotona princeps*), that live only on high, rocky mountainsides, may be sensitive to even small changes in the climate.
Photo by Will Elder.

Warmer temperatures are one thing, but why does it matter if it's a *little less cold*?

Mild winters and longer growing seasons… doesn't sound so bad, right? Unfortunately, even a couple of degrees rise in average temperature can have major effects on the plants and animals we love, and the basic ecosystem functions upon which we all depend. A weather station at Grand Lake, on the west side of the park, reports that the number of frost-free days has increased approximately 40 days since the middle of the last century (Figure 2). Why does that matter?

While many plants cannot survive temperatures below freezing, others are specially adapted to this environment. The plants and animals that thrive in this environment rely on certain natural events to happen at specific times of the year, and in a specific order. This is nature's calendar, and the study of its timing is called phenology. For example, flowers that bloom in the spring provide a critical food supply for the park's butterfly populations. When spring comes early, flowers may bloom early as well. Later when the butterflies appear, their flower food may already be gone, significantly changing how the complex elements of our natural system fit together.

What about non-native invasive species?

As the climate changes in Rocky Mountain National Park, new species will find that they are well suited to the new environment. One such species is cheatgrass (*Bromus tectorum*). Twenty years ago, cheatgrass was limited to the lowest elevations of the park. Today, you can find cheatgrass at higher elevations, even as high as 9,500 feet in Upper Beaver Meadows. Cheatgrass spreads easily once it is established and is quite flammable and therefore increases fire danger. As temperatures rise, non-native species such as cheatgrass become new competitors for the park's native plant species, taking up light, space, and nutrients, and changing the look of some park landscapes.

ABOVE: Wildflowers native to the park (top to bottom): Fairy Slipper (*Calypso bulbosa*); Heartleaf Arnica (*Arnica cordifolia*); Colorado Columbine (*Aquilegia caerulea*); Narrow-leaved Paintbrush (*Castilleja linariaefolia*). Photos by Melanie Wood.

LEFT: Invasive species that are well suited to a new climate, such as cheatgrass (*Bromus tectorum*), become new competitors with the park's native plant cover. NPS photo.

What's up with all the dead trees in the park?

Mountain pine beetles (*Dendroctonus ponderosae*) have made an impact in nearly 90% of forested areas in Rocky Mountain National Park. This bark beetle is native to the Rockies. Under normal conditions, beetles provide a valuable service to the forest by killing older trees, which gives young, healthier trees greater access to light, space, water, and nutrients. Beetle outbreaks can foster forest regeneration and turnover. However, today's outbreak is different than in the past.

Why is the current pine beetle outbreak so dramatic?

Today's pine beetle outbreak is longer, reaching higher elevations and higher latitudes, and killing more trees than in the past. This outbreak is more dramatic for several reasons.

Winters are warmer. Very cold winter temperatures kill beetles and help to regulate population sizes. A series of cold snaps curbed the last beetle outbreak in the 1980s. However, the number of very cold days (below -20 °F) has declined over the last century (Figure 3), and most recently there have been several years without any days below -20 °F!

Summers are longer. Beetle reproduction depends on temperature; a longer period of warm temperatures allowed some beetles to speed up development and reproduction, further increasing the population.

It has been very dry. Trees with a lot of moisture sometimes push pine beetles out with tree sap, but drought makes this more difficult, leaving trees more susceptible to attack.

Fire suppression across North America, or years of putting out forest fires, resulted in a forest full of old trees, the pine beetle's favorite food. Beetles currently impact forests from Canada to Mexico, and California to the Dakotas.

Warmer winter temperatures mean that a greater number of mountain pine beetles (*Dendroctonus ponderosae*) survive the winter season, contributing to a longer and more severe pine beetle outbreak that is changing the landscape on trails and in campgrounds throughout the park. NPS Photo.

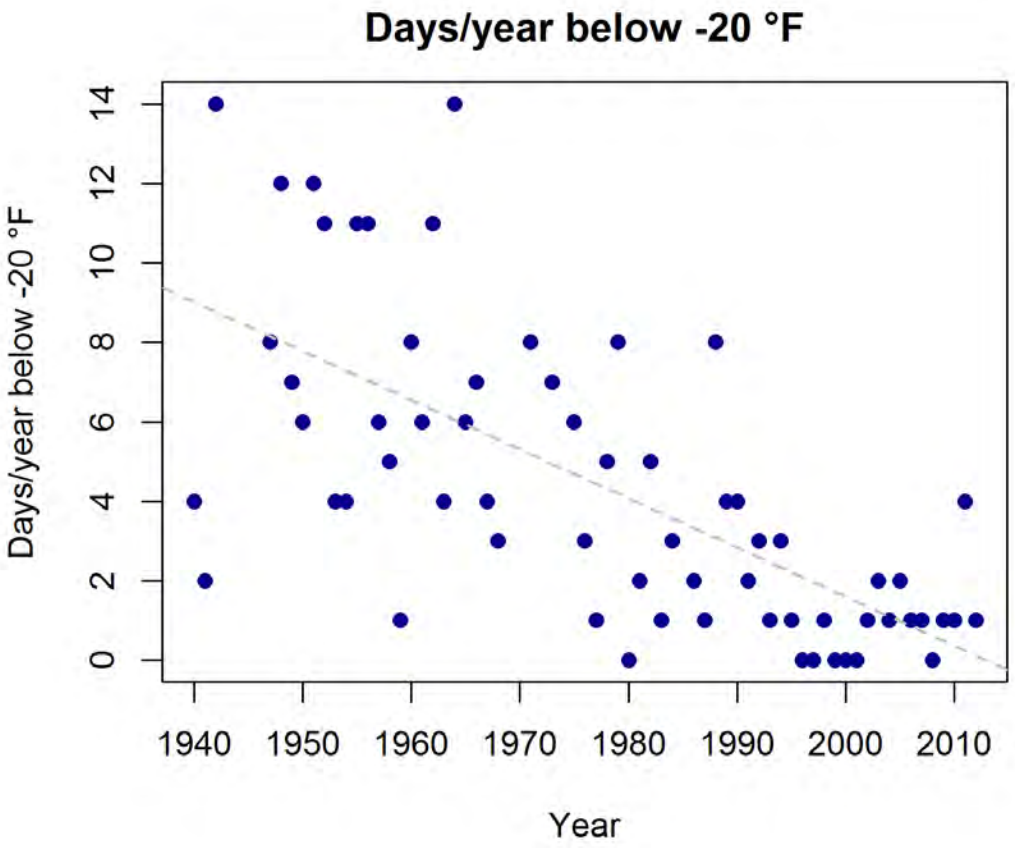


Figure 3 The number of very cold days (below -20 °F) has declined over the last 70 years on the west side of Rocky Mountaion National Park. Most recently, the park has seen several years without any days below -20 °F!

Are Rocky's glaciers melting?

The glaciers at Rocky Mountain National Park are not well studied, but available data suggest the glaciers are not significantly growing or shrinking. Glaciers in this park are different than glaciers found in areas like Glacier National Park or North Cascades National Park, which are rapidly melting over recent decades. This is because Rocky's glaciers are found only in small, north facing, high-elevation areas that are largely protected from the warming effects of the sun and summer temperatures. Also, the park's glaciers are on the eastern side of the continental divide, so they benefit from large quantities of wind-transported snow delivered by strong westerly winds as well as direct snowfall. For these reasons, the available information indicates that glaciers in the park are thus far protected from the dramatic melting trend seen in other parts of the world.

Climate Science Basics

What is the greenhouse effect?

Greenhouse gases are colorless gases like carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) that allow sunlight to reach the surface of the Earth and warm it up. These gases act like a blanket for the planet by preventing some of the sun's heat from re-radiating out into space (Figure 4). Many greenhouse gases are natural and make Earth habitable – without a natural greenhouse effect, the temperature of the Earth would be about 0 °F! However, human activities over the past two centuries, such as burning fossil fuels and clearing forests, have added more CO_2 and other greenhouse gases to the atmosphere. That makes the "blanket" thicker, and the Earth gets warmer than it would be naturally.

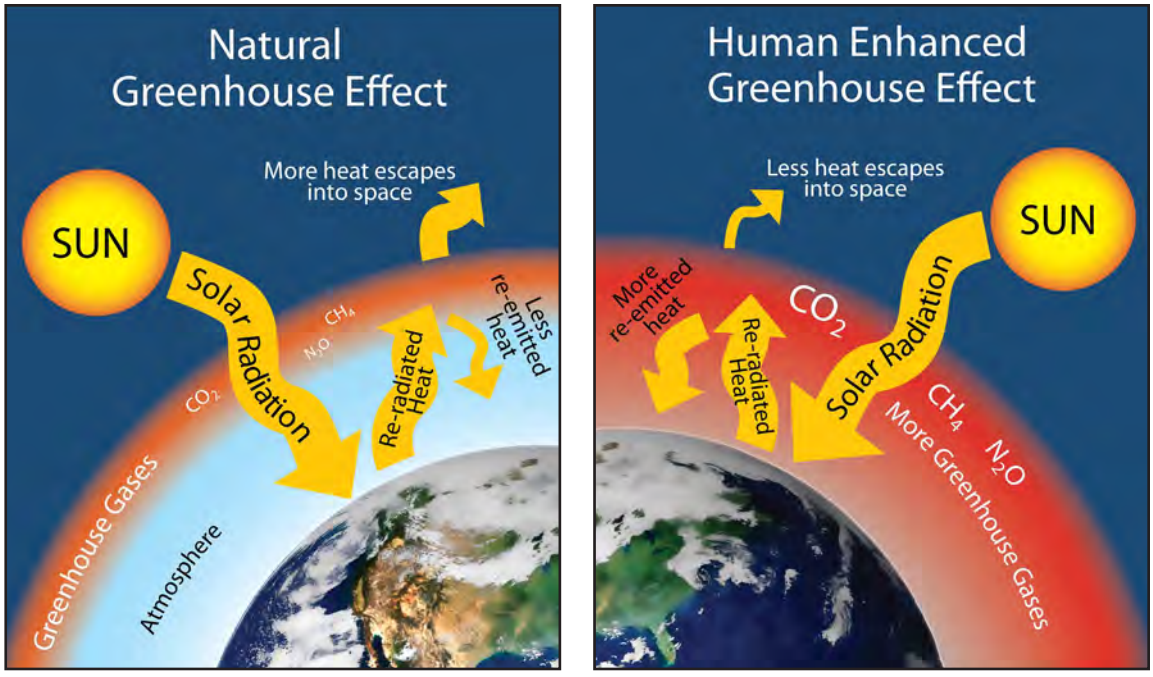


Figure 4 Human activities increase the amount of greenhouse gases in the atmosphere, trapping more heat and raising the temperature of the planet. NPS image.

How much has atmospheric CO2 changed in recent decades?

In the 1950s, the Mauna Loa Observatory in Hawaii began collecting and monitoring changes in the atmosphere. These data tell us that the amount of carbon dioxide in the Earth's atmosphere has increased from a value of about 310 ppm (*parts per million*) in the 1950s to 400 ppm in 2013. This is a big change in a short amount of time! Climate scientists estimate that the Earth's atmosphere has not experienced a CO2 level of 400 ppm in at least the last 800,000 years.

How do we know how much CO2 was in the atmosphere before the 1950s?

To find out how much carbon dioxide was in the atmosphere before we began taking direct measurements of the air, scientists rely on data from air bubbles trapped in polar ice cores. These ice cores provide a continuous record of carbon dioxide levels up to 800,000 years ago. These data show that until the Industrial Revolution, the average CO2 hovered in the 250-300 ppm range. Since then, carbon dioxide levels have steadily risen, corresponding to a rise in CO2 emissions from the burning of fossil fuels by humans.

Parts per million **(ppm) or parts per billion (ppb) is the ratio of the number of greenhouse gas molecules to the total number of molecules of dry air. For example, 300 ppm means 300 molecules of a greenhouse gas per 1 million molecules of dry air (IPCC 2007)**

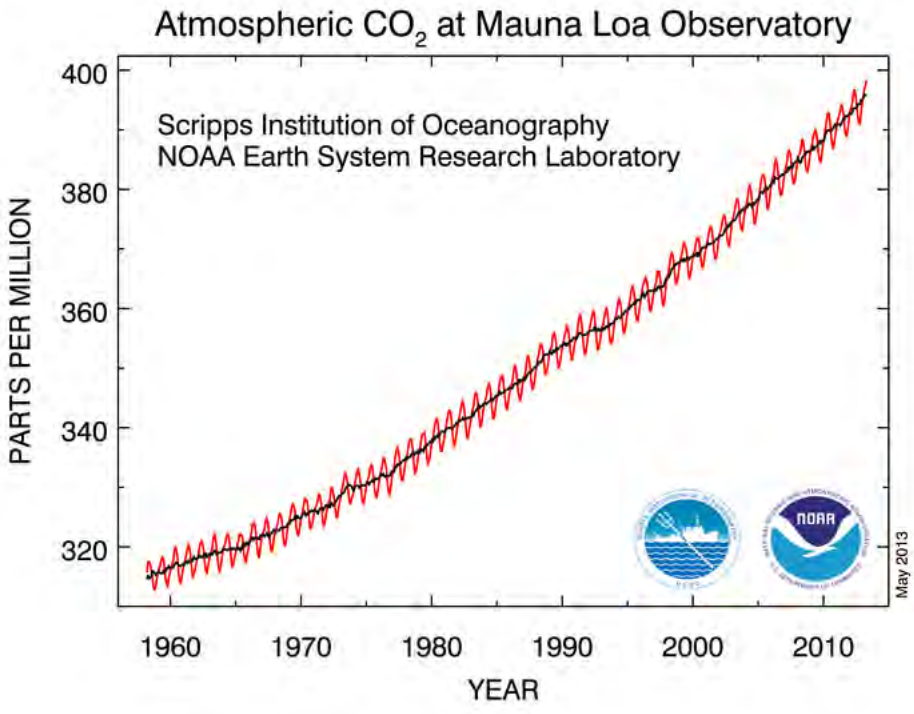


Figure 5 Measurements of carbon dioxide concentrations (shown by the red curve) at the Mauna Loa Observatory in Hawaii show that carbon dioxide in the atmosphere is approximately 22% higher today than it was in the 1950s. (Mauna Loa Observatory 2013)

Changes in climate happen naturally over time. How do we know current warming isn't natural?

What is "*peer review*" and why is it important? Peer-reviewed papers have been evaluated by several independent and qualified scientists and found to have used legitimate scientific methods. It tells the reader that someone with the right qualifications checked the facts.

The industrial activities upon which modern humans depend have raised the level of greenhouse gases like carbon dioxide and methane to higher levels than at any point in at least the last 800,000 years. These heat-trapping gases create a warmer world. While natural variations such as volcanic eruptions or changes in the sun have altered the Earth's weather and climate significantly in the past, recent changes in climate cannot be explained by natural processes alone. Climate scientists have concluded that most of the global warming since the mid-20th century is due to human-caused increases in greenhouse gases, rather than natural causes.

For more information on key indicators of climate change, visit: http://climate.nasa.gov/key_indicators.

Are climate scientists still debating this issue?

Climate scientists agree it is very likely that most of the global warming since the mid-20th century is due to human-caused increases in greenhouse gases, rather than natural causes. This is the position of the Academies of Sciences from 19 countries, the hundreds of scientists that participate in the Intergovernmental Panel on Climate Change, plus many other scientific organizations that study climate science. Ninety-seven percent of *peer-reviewed*, published climate papers on human-caused global warming support this position.

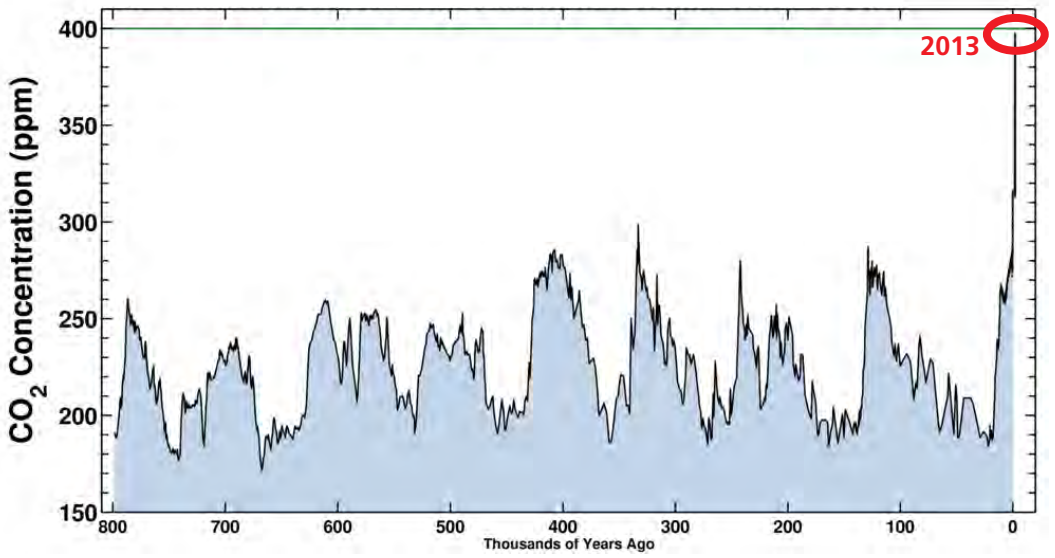


Figure 6 By combining data from polar ice cores and direct measurements of the atmosphere, scientists estimate that atmospheric CO2 hovered between 250-300 ppm up until the Industrial Revolution, when it began its dramatic rise to 400 ppm in 2013. This graph shows data from ice cores before 1958, and data derived from the Mauna Loa Observatory after 1958. The year 2013 is represented by the "0" on the X axis. (Carbon Dioxide Information Analysis Center 2013)

Taking Action

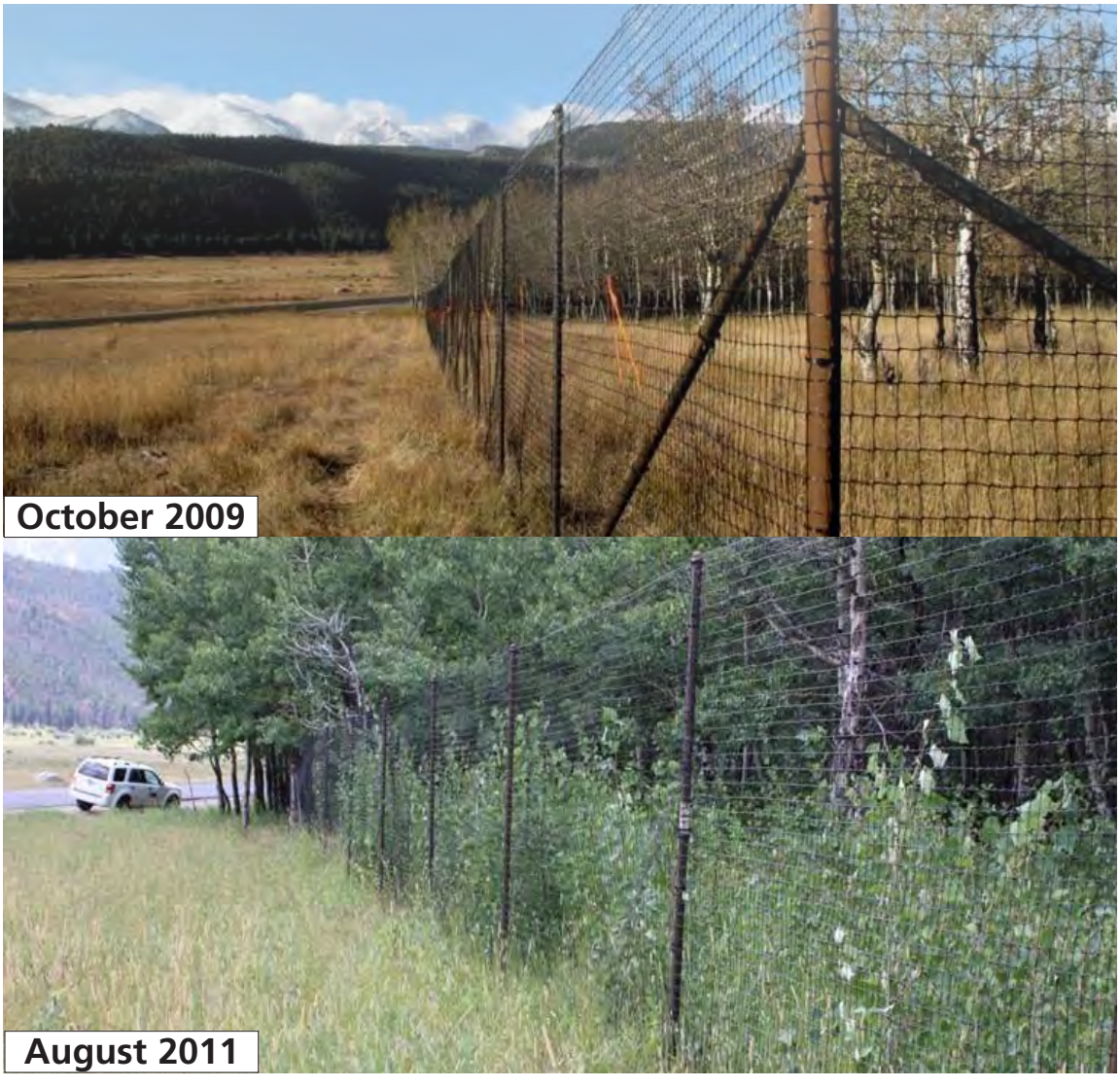
What can managers do about climate change?

Park managers are working to understand and anticipate how climate change will affect Rocky Mountain National Park. This means a lot of long-term research, monitoring, and careful decision-making, as managers learn how to plan for a future that will not look like the past. This process is called climate change adaptation, and it is conducted with the best available science and in collaboration with our partners and the public.

One action that managers can take, right now, is to remove other threats to plants and animals so that they can better adapt to a changing climate. For example, a major driver of change in Rocky Mountain National Park is from animals like elk, deer, and moose. When the herds get too big, they eat plants like willow and aspen faster than these species can grow back. When these plants disappear, we lose important riparian habitat that is home to beavers, birds, and frogs. Park managers constructed fences called "elk exclosures" to protect some of these *riparian* areas and allow the willow and aspen to regrow, enhancing biological diversity and increasing the *adaptive capacity* of these important areas to other stressors, such as climate change.

Riparian **is an area between dry land and a river or stream.**

Adaptive capacity **is the ability to adjust and change in response to changing climatic conditions.**



In 2009, as part of the Elk and Vegetation Mangement Plan, park managers built fences called "elk exclosures" to allow willow and aspen habitat to recover from overgrazing by elk and moose. The 2011 photo displays the new vegetation growth in this area of the park. These management actions enhance biological diversity and increase the resilience of these important areas to other stressors, such as climate change. NPS photo.

What else is the park doing to meet this challenge?

Rocky Mountain National Park is taking big steps to reduce waste, recycle, and cut down on energy use. In fact, the park reduced total energy used annually by 30% since 2003, and in 2010 succeeded in diverting more than 40% of solid waste from landfills through recycling! The park's green team is committed to serving as a role model for environmentally responsible behavior. You can follow their example by depositing glass, aluminum, and most plastics (stamped #1-#7) in the mixed recycling containers found throughout the park.

The park shares what we have learned with our communities and park visitors, and enlists their help to do more. We offer a climate change program for park visitors; volunteers conduct citizen science; and students of all ages visit the park to learn about this new and important field of research and management action. Climate change is a long-term issue, and the work is a long term undertaking. We know more now than we did 10 years ago, and we will know much more 10 years from now. The key is to keep asking questions, and keep learning! Ask a ranger about climate change!

Over 40% of the park's solid waste was diverted to be recycled in 2010. NPS photo.

I'm not into politics. Isn't climate change really just a political issue?

In the United States, the dialogue around climate change can seem very political. The ways in which we interpret climate science, and our attempts to tackle this challenge, have been met with debate across industry, non-profit organizations, and our representatives in government. Watching the news, it is easy to think that global warming is a "black and white" issue in the minds of most people – either you believe it is a problem, or you don't. But an ongoing survey project shows that, in fact, the majority of Americans fall somewhere in between (Figure 7). This allows us to move past climate change as a political topic to focus on the science, so that we can start sharing information and inspiring action. You don't have to be a scientist or a politician to understand how climate change works, or to take action to protect the things that you care about.

I can't do anything about climate change, so why should I care?

Consider all the reasons you might care about this issue. Perhaps it's the scenery or the wildlife. Perhaps it's the tradition of an annual camping trip or a special picnic spot. Perhaps it is pride in knowing national parks belong to you, and a desire to share them with the generations that come after you.

There are many important things that you can do to make a difference on climate change. Whether you are leading the charge, or are thinking about that first step, there are big and small things you can do to address this issue. Every action is a step in the right direction, and an example for others to follow. Read below to learn more.

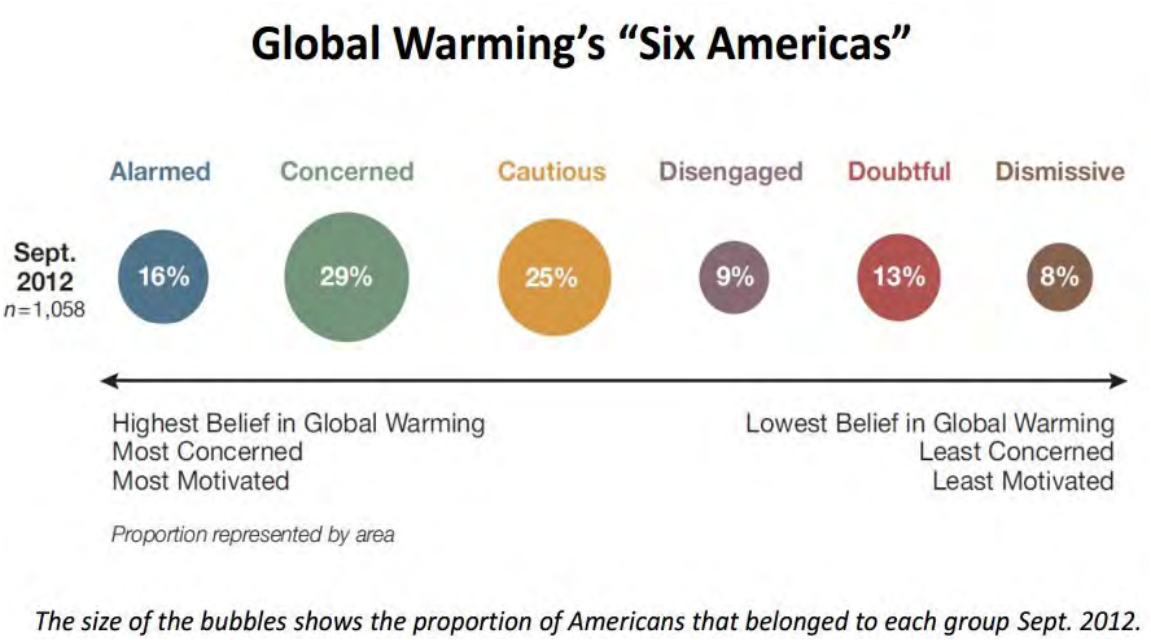


Figure 7 A nationwide study asked Americans about their belief, concern, and motivation with respect to "global warming." The results show that the majority of Americans fall somewhere in the middle. (Leiserowitz et al. 2012)

What can I do to help?

It is amazing how much impact one small action can make, when it is performed by many people. Buy local products that are sourced and manufactured in environmentally friendly ways to influence economic practices. Reduce, reuse, and recycle your products and waste. Carpool or use public transportation. Challenge yourself to reduce your energy consumption by 10 percent this year. For more tips, visit http://www.nps.gov/subjects/climatechange/getinvolved.htm.

You can also become a citizen scientist and help scientists better understand climate change effects and improve habitat for native species at Rocky Mountain National Park. Volunteer to educate youth about science, improve science literacy across the country, and get involved in your local community. Talk to your family and friends about what you've learned. When you take action, you inspire others to do the same!

A high school student participates in a survey of biodiversity at Rocky Mountain National Park. Photo by Will Elder.

How can I learn more?

To learn more about climate change talk to your local park ranger, and visit the pages below.

Volunteer at Rocky Mountain National Park! http://www.nps.gov/romo/supportyourpark/index.htm

National Park Service Climate Change Webpage: www.nps.gov/subjects/climatechange

Fun for Kids! http://climatekids.nasa.gov/

Key Indicators of Climate Change: http://climate.nasa.gov/key_indicators

NOAA Climate Change Page: http://www.noaa.gov/climate.html

NASA Climate Change Page: http://climate.nasa.gov/

The White House Council on Environmental Quality Climate Change Task Force: http://www.whitehouse.gov/administration/eop/ceq/initiatives/adaptation

U.S. Department of Energy Fuel Economy: http://fueleconomy.gov/feg/drive.shtml

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