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CLIMATE CHANGE IMPACTS ON NATIONAL PARKS IN COLORADO

HEARING

BEFORE THE

SUBCOMMITTEE ON NATIONAL PARKS

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

TO

CONSIDER CLIMATE CHANGE IMPACTS ON NATIONAL PARKS IN COLORADO AND RELATED MANAGEMENT ACTIVITIES

ESTES PARK, CO, AUGUST 24, 2009

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CLIMATE CHANGE IMPACTS ON NATIONAL PARKS IN COLORADO

MONDAY, AUGUST 24, 2009

U.S. SENATE,
SUBCOMMITTEE ON NATIONAL PARKS,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Estes Park, CO.

The subcommittee met, pursuant to notice, at 12 p.m., in the Board Room of Town Hall, 170 MacGregor Avenue, Hon. Mark Udall presiding.

OPENING STATEMENT OF HON. MARK UDALL, U.S. SENATOR FROM COLORADO

Senator UDALL. This subcommittee hearing will come to order.

We want to welcome everybody. I have a short statement for the record, and then I'll turn to Senator McCain, and then we'll turn to hearing from our witnesses.

The purpose of this afternoon's hearing of the Senate Subcommittee on National Parks is to consider climate change impacts on national parks in Colorado and related management activities.

As chairman of the subcommittee, I understand that the impacts of climate change are a major management challenge for the National Park Service. I wanted to hold a hearing in Colorado because these impacts are an issue of particular importance, not only for Rocky Mountain National Park and other national parks and forests, but they also reflect an emerging area of concern for our agricultural communities, for our larger economy, and even pose implications for our national security. We will not address the full scope of global climate change at this hearing, but we will endeavor to look through this through the unique lens of the national parks.

Our national parks are national treasures. They embody the diverse beauty of the American landscape, as well as our history and culture as a people. We must do all we can to preserve and protect them while also continuing to provide public access and enjoyment to future generations of Americans.

There are a number of important issues facing our national parks, from budget shortfalls to increased use and recreational pressures. They are also not immune from the larger issues facing our Nation and the globe.

To a large degree, our national parks are the canary in the coal mine when it comes to the on-the-ground effects of a warming climate, and that's especially true for our western parks and the park right down the street from this hearing room, Rocky Mountain National Park. It's clear that these impacts are real, significant, and

can have lasting effects on our resources and our ability to protect them.

So, today's hearing is focused on what is happening in parks due to climate change, how these impacts are being assessed and monitored, how these impacts my be affecting visitor experiences, and some thoughts on what we can do with the parks, directly, to help address these impacts.

A wiser person than I described the challenge with these words, "The threat to our world comes not only from tyrants and their tanks; it can be more insidious, though less visible. The danger of global warming is as yet unseen, but real enough for us to make changes and sacrifices so that we do not live at the expense of future generations. Our ability to come together to stop or limit damage to the world's environment will be perhaps the greatest test of how far we can act as a world community. No one should underestimate the imagination that will be required, nor the scientific effort, nor the unprecedented cooperation we shall have to show. We shall need statesmanship of a rare order. It's because we know that, that we are here today." That was Margaret Thatcher speaking in 1990.

Today, nearly 2 decades later, her words are still relevant and even more pressing. She was right about the challenge and right about the need for statesmanship. It's encouraging that we finally have an administration in Washington, DC, that is taking this issue seriously.

I'm also fortunate to be joined today by a leader in the United States Senate who's shown statesmanship and courage on this issue and so many other issues, and that's Senator John McCain. Senator McCain and I took a brief tour of Rocky Mountain National Park this morning and, in addition to that, yesterday, we took a wonderful hike along the MacGregor Ranch periphery and met some very interesting wildlife. Probably the most interesting wildlife are the rock climbers——

[Laughter.]

Senator UDALL [continuing]. Of whom I'm a member of that tribe. But, I know Senator McCain will speak to our experiences at some point. But yesterday and today, we had a chance to look at the climate change impacts that are occurring right in this national park.

Now, unfortunately, the sorts of things we saw, such as trees killed by a bark-beetle epidemic that's been exacerbated by the warming climate, are not limited to this park, but are being felt throughout the national park system. I'm looking forward to learning about these impacts and the challenges we face in mitigating and confronting them. I intend to work with my colleagues on this committee and in the Senate and the Congress to respond to the needs and challenges presented by climate change and the myriad of other issues affecting our parks.

Let me thank Mayor Pinkham and the Estes Park Town Board, for hosting us today, as well as Jackie Williamson, the town clerk, for all of her help getting us set up here in this important town of Estes Park.

I'm very pleased to be joined by my good friend Senator McCain. We spent the previous 2 days in Grand Canyon National Park in

northern Arizona. Senator McCain has graciously reciprocated, traveled up to our great State of Colorado. I'd like to turn to Senator McCain for his opening statement.

STATEMENT OF HON. JOHN McCAIN, U.S. SENATOR FROM ARIZONA

Senator MCCAIN. Thank you, Mr. Chairman. Thank you for calling today's hearing to highlight the mounting affects of climate change on our national park systems.

I also would like to thank the Estes Park mayor and city council, and all who made this hearing possible, and thank you, the citizens, for coming today and showing your concern on this very important issue.

I might add a small item of trivia. This is not the first Chairman Udall that I have had the honor of serving with, and——

[Laughter.]

Senator MCCAIN. I must say that, in every respect, the apple didn't fall very far from the tree, and I'm very grateful for the opportunity of serving with Senator Mark Udall.

I, again, want to appreciate—express my appreciation that Secretary of Interior Ken Salazar, as well as Senator Udall, joined us in the Grand Canyon National Park, and it's a great pleasure to be here.

We're not here today to discuss the complexities of cap-and-trade legislation or to debate national energy policy. Today's hearing rises above politics as an examination of how a warming world is reshaping our cherished national parks.

I've spent considerable time studying the issue of climate change, and a common misperception is that this is a crisis that's down the road, a future generation's problem, or that global warming is limited to the distant reaches of the Earth. I've traveled the globe to see firsthand how it's changing the lives of people in Alaska, Australia, New Zealand, South America, Norway, and other parts of the Arctic region. But, the startling reality is, you no longer need to journey to faraway places to experience the effects of climate change.

A report released last month by the United States Global Change Research Program, which is a consortium of experts from 13 United States Government science agencies, several major research institutions, offers the most up-to-date scientific findings, which reaffirm, with even greater clarity and persuasiveness, that which we already know: climate change is real. It's happening now, and it's happening right here in the United States of America.

Average United States temperature has risen by 1 and a half degrees Fahrenheit over the last 50 years. Winters are now shorter and warmer than they were 30 years ago. With the largest winter temperature rise, more than 7 degrees Fahrenheit, observed in the Midwest and northern Great Plains. In the Southwest, warming has been among the most rapid and severe, driving declines in spring snowpack and affecting measurable changes to Colorado River flow.

But, this issue has gone beyond calculating temperature averages and projecting computer models. When it comes to the visible signs of climate change in the United States, our national parks—

our national parks—have been likened to the miner's canary. Just over the past two decades, warmer and shorter winters linked to global warming have intensified bark-beetle outbreaks, as you can see every day, and doubled tree mortality rates in seemingly healthy conifer stands in much of the West, including in the Grand Canyon and the Rocky Mountain region. In the Virgin Islands National Park—the Virgin Islands National Park—abnormally elevated water temperatures in the Caribbean are contributing to coral bleaching. In Apostle Islands National Park, a loss of winter ice in the Great Lakes is disrupting fish reproduction and bird habitat. In the Sonoran Desert, longer summers and prolonged drought are fueling cactus-killing brush fires and prompting invasive plant growth at places like Saguaro and Joshua Tree National Parks.

These are but a few examples of the changes that we're seeing in our Nation's 58 national parks and over 300 national monuments, trails, and other park units.

In 2016, the National Park Service will celebrate its 100th anniversary. As our world continues to warm, we must ask ourselves, What will our parks look like in another 100 years? What will become of their native wildlife habitat? How do we adopt our management practices to preserve our parks for the enjoyment of future generations? How will already complex issues, like balancing recreation with natural beauty, become even more challenging in the face of decreased snowpack or prolonged drought?

Again, Mr. Chairman, I'm equally interested to hear from today's witnesses about the changing conditions of our national parks. Climate change necessitates that we rethink park conservation, and I thank you for raising awareness about this important issue, and I thank the witnesses for being here today.

Thank you, Mr. Chairman.

Senator UDALL. Thank you, Senator McCain.

Before we hear from this exciting and well-informed expert panel, let me speak to a few administrative issues.

This is a formal subcommittee hearing; it's not a town-hall meeting. As such, we will take testimony from select witnesses, and we will not be taking public comments or questions. However, if you want to submit written testimony for the hearing record, you may do so by sending it to the subcommittee in Washington or to one of my offices here in Colorado. We will keep the record of the hearing open for 2 weeks following today's hearing, so you could summit those comments.

Let me add one last note. This is an important hearing on the topic at hand, but if you have other comments or questions that you don't want to make a part of the official congressional record for the hearing, we have distributed comment cards throughout the room, and I'd like to hear from you. Fill it out. I have a number of my staff members here. We take your comments and your input very, very seriously.

So, with that, we're going to turn to our panel of experts. I'm going to ask each of them to summarize their written testimony in a—generally, a 5-minute timeframe. Your full written testimony will be made a part of the official committee hearing record.

Let me do this, I'll introduce each panelist in turn, so that, as you prepare to give your remarks, the audience is clearly aware of your background and your interest.

So, we'll start with Dr. Herbert Frost, who's the associate director for the—natural resource stewardship and science for the National Park Service and the Department of the Interior.

Dr. Frost, the floor is yours for 5 minutes.

STATEMENT OF HERBERT C. FROST, ASSOCIATE DIRECTOR FOR NATURAL RESOURCE STEWARDSHIP AND SCIENCE, NATIONAL PARK SERVICE, DEPARTMENT OF THE INTERIOR

Mr. FROST. Mr. Chairman, Senator McCain, thank you for the opportunity to appear before you today to present the views of the Department of the Interior on climate change impacts to the national parks across the Nation, including Colorado.

Because of the close link between this community and Rocky Mountain National Park, we are pleased that you chose to hold this field hearing here in Estes Park. Just like to also say that it was a pleasure to spend some time with you and Senator McCain this morning out in the park, to actually see the effects of what's going on there. Oftentimes, we talk about these things in boardrooms and committee rooms, and we don't get out on the ground to see what's going on, and it's a refreshing pleasure to have had that experience with you today.

Climate change is potentially the most far-reaching and consequential challenge to the National Park Service mission in our history, challenging the foundation of the national park system and the ability to leave America's natural and cultural heritage unimpaired for future generation.

Parks are already experiencing impacts from a changing climate. Warming temperatures are accelerating the melting of glaciers and snow fields in parks like Glacier and North Cascades and throughout Alaska. Alaska parks are experiencing dramatic effects. Melting sea ice threatens marine mammals and coastal communities. Thawing permafrost can destabilize buildings, roads, and facilities.

Coastal parks are also extremely vulnerable. The NPS manages 74 coastal units, encompassing more than 5,100 miles of coast, and over 3 million acres of marine resources, including beaches, wetlands, estuaries, coral reefs, and kelp forests. Sea-level rise threatens the remains of some of the earliest human-occupation sites, dating back over 10,000 years.

Here at Rocky Mountain, high temperatures and drought have triggered a bark-beetle outbreak visible in the dead and dying pine trees in the West Slope, and the skeletons of 800-year-old limber pines. Warming temperatures are also a factor in the expansion of one of the West's most noxious weeds. Cheatgrass is now found at elevations in the park up to 9,500 feet. Preliminary data suggests that picas are also being affected because they don't tolerate high temperatures.

As climate warms, mountain ecosystems become more fragmented, making it harder for other species, such as elk and bighorn sheep, to migrate, or connect to subpopulations, potentially compromising the genetic integrity and health of those populations.

To effectively respond to these challenges of climate change, the Department is undertaking a collective and coordinated strategy that builds on and expands existing partnerships.

Adaptation planning and implementation is a critical area for the future. This involves building our science information and ecosystem monitoring capacity for sound decisionmaking by park managers. Begun almost 9 years ago, the National Park Service Vital Signs Monitoring Program is strategically positioned to help parks acquire the information they need to make informed decisions so that park managers can be flexible in the face of climate change. Toward this end, the National Park Service is working with the USGS and other partners toward a scenario-planning approach designed to help manager identify—managers identify policies and actions that will be most effective across a range of potential futures. Four case studies have already been conducted, and 12 more are planned in 2010. The NPS is also leading by example in reducing our carbon footprint and promoting sustainable operations. Energy Smart Parks and Climate Friendly Parks are two of these key programs.

Climate Friendly Parks was created with the Environmental Protection Agency, in 2003, to promote sustainable operations and create climate action plans to reduce greenhouse gas emissions. Almost 60 parks, including Rocky Mountain, now participate.

The Pacific West region has a very ambitious leadership initiative that supports—that also supports reducing our carbon footprint. The 58 parks in the region have set a target of carbon-neutral for park operations by 2016, and they now generate over 4 percent of their energy from renewable resources.

Parks can also serve as a platform to effectively communicate about climate change. With 275 million visitors annually, the NPS is ideally positioned to raise awareness and provide information about solutions. A number of efforts are underway, including a monthly Web-based seminar featuring climate change experts; a climate change wildlife and wildlands toolkit for K–12 students; a series of biogeographic impact summaries with focus on national parks and refuges; and some pilot-interpretive products and training, such as those that have been developed here at Rocky Mountain.

Looking forward, the NPS has a goal of every park having climate change information available through brochures, wayside exhibits, interpretive programs and handouts and park Websites. While efforts to date are significant, much work lies ahead. The Park Service must position itself to respond to the effects of climate change on park resources and to prescribe management actions that are suitable for parks. National parks are environmental baselines to track changes, and they stand as some of the last vestiges where ecological components function naturally. In order to protect these treasured landscapes, we must take responsibility for understanding how climate change will impact the national parks, develop science-based plans for adapting, and take steps to improve the resiliency of natural systems by reducing other stresses on park.

Finally, the Department and the NPS must lead by example in minimizing our carbon footprint, promoting sustainable practices,

and communicating both the scientific evidence and the choices we make to our partners and the public.

Mr. Chairman, this concludes my statements. I'll be pleased to answer any questions.

Thank you.

PREPARED STATEMENT OF HERBERT C. FROST, ASSOCIATE DIRECTOR, NATURAL RESOURCE STEWARDSHIP AND SCIENCE, NATIONAL PARK SERVICE, DEPARTMENT OF THE INTERIOR

Mr. Chairman and members of the subcommittee, thank you for the opportunity to present testimony on the role of the Department of the Interior (DOI) and the National Park Service (NPS) in addressing climate change impacts on National Parks in Colorado and related management activities. Accompanying me today are Dr. Leigh Welling, Climate Change Coordinator for the National Park Service and Vaughn Baker, Superintendent of Rocky Mountain National Park.

Secretary Salazar has prioritized the issue of climate change within the Department of the Interior. He is in the process of designing a climate change strategy to integrate the work of each Bureau to mitigate and adapt to the effects of climate change in the pursuit of each Bureau's mission-this includes the National Park Service, Fish and Wildlife Service, United States Geological Survey, Bureau of Land Management, Bureau of Indian Affairs, Bureau of Reclamation, and Minerals Management Service. In 2008 the Department of Interior had a multi-agency taskforce that put forth a number of recommendations relating to climate change adaptation and mitigation activities. The Department works closely on many levels with the National Oceanic and Atmospheric Administration (NOAA) and the United States Forest Service (USFS) in addition to other federal agencies in coordinating activities relating to climate change.

An integration of science, adaptive management tools, and other resources across the Federal Government is essential to the DOI's mission to address climate change across all federal lands, wildlife, and cultural and natural resources (including mitigation, adaptation, and communication/engagement strategies) and to the NPS' mission to do the same. We are pleased that you chose Estes Park Colorado as the site of this field hearing. This mountain community is inextricably linked to Rocky Mountain National Park and the loss of resources due to climate change affects both the park and the surrounding towns and their economies.

Climate change is potentially the most far-reaching and consequential challenge to our mission than any previously encountered in the entire history of the NPS. In setting aside Yellowstone National Park in 1872, Congress stated that the purpose of the park was:

> preservation, from injury or spoliation, of all timber, mineral deposits, natural curiosities, or wonders, within the park, and their retention in their natural condition.

This concept of "retention in their natural condition" became the cornerstone of our National Park System when Congress passed the National Park Service Organic Act, which states that the mission of the NPS is:

> . . . to promote and regulate the use of the . . . national parks . . . which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

Climate change challenges the very foundation of the National Park System and our ability to leave America's natural and cultural heritage unimpaired for future generations. Our national park units can serve as the proverbial canary in the coal mine, a place where we can monitor and document ecosystem change without many of the stressors that are found on other public lands.

DOI and the NPS are rising to this challenge, and today my testimony will focus on four major areas. First, our observations of the effects and potential future changes related to climate change in national park units. Second, the actions and programs we have underway to prepare for the current and anticipated changes from climate change. Third, some of the actions the NPS plans to undertake in the coming years. Fourth, some other considerations related to climate change.

THE EFFECTS OF CLIMATE CHANGE IN NATIONAL PARK UNITS

Parks are already experiencing some dramatic impacts that may be resulting from climate change. Warming temperatures may be accelerating melting of mountain glaciers in national parks such as Glacier and North Cascades while perennial snowfields throughout Alaska are disappearing. Reduced snowpack and changes in the timing and amount of stream flow affect aquatic communities. Alaskan parks are seeing some of the earliest impacts of possible climate change—melting sea ice threatens marine mammals as well as coastal communities, while thawing permafrost can destabilize buildings, roads, and facilities and disrupt the structural basis of large regions of interior lands. In Yosemite and Great Basin National Parks, we have documented high-elevation species, such as the pika and alpine chipmunk, moving upslope, thereby reducing the effective area for their survival; this upslope migration may be attributable to changes in climate.

Here at Rocky Mountain National Park (park) high temperatures and drought have contributed to a bark beetle outbreak unprecedented in the park's history. The effects are noticeable in the red lodgepole, limber, and ponderosa pine trees most visible on the west slope and in the skeletons of 800 year-old limber pines. Dead trees have replaced much of the green canopy that shaded park campgrounds. The park has committed to removing approximately one million hazard trees over the next five years to ensure human safety around buildings, parking lots, and other developed areas. The USFS is tackling this problem outside of park boundaries.

Fire frequency and intensity may also be related to climate change. NPS data indicates that fire ignitions are occurring both earlier and later in the season now and the average duration of time that a wildfire burns has increased from less than 10 days to more than a month. Fires in some places may be increasing in frequency and intensity, threatening native plant communities and contributing to the spread of invasive exotic species (Westerling et al. 2006). Wildland fire frequency and intensity can have a significant impact on cultural resources, as hotter fires and our efforts to fight them directly damage buried archeological sites.

Ongoing climate changes are expected to include modified patterns of precipitation and runoff, and changes in hydrologic regimes and the availability of water to park ecosystems. Recent literature on climate change suggests: increased precipitation, streamflow, and runoff in the Northwestern and Eastern United States will increase flood risks; warming temperatures will reduce mountain snowpack, and cause earlier spring snowmelt runoff across the Western United States and Alaska; and drought severity and duration will intensify in the Western and Southwestern United States. (IPCC 2007)

Here in Colorado it is expected that the amount of precipitation stored as snowpack will decrease, and annual snowmelt will commence earlier in the spring with the overall effect of decreasing the volume of water available annually for storage in Colorado River basin reservoirs (IPCC 2007). It is also thought that there will be increased year-to-year variability in basin hydrologic conditions and decreased certainty as to the amount of annual water production (Guido 2008 and Knowles et al 2006). Given the present allocation of Basin water resources and the ever increasing demand for water in the Southwest, even moderate decreases in streamflow will present challenges to both water and park resource managers.

Coastal parks are extremely vulnerable to climate change. The NPS manages 74 coastal units encompassing more than 5,100 miles of coast and three million acres of submerged resources including beaches, wetlands, estuaries, coral reefs, and kelp forests. These parks attract more than 75 million visitors every year, and generate over $2.5 billion in economic benefits to local communities. The United States Climate Change Science Program Synthesis and Assessment Product on Coastal Sensitivity to Sea Level Rise (2009) states:

> Critical coastal ecosystems such as wetlands, estuaries, and coral reefs are particularly vulnerable to climate change. Such ecosystems are among the most biologically productive environments in the world.

These coastal ecosystems are significant habitats for the production and health of recreationally and commercially valuable fish and shellfish, they provide important environmental services, and offer beautiful landscapes for marine recreation and wildlife watching. A major finding of the United States government's recently-released landmark report, Climate Change Impacts in the United States (2009), is that these ecosystems are predicted to undergo significant stress as a result of climate change

Shorelines and park boundaries will change as sea level rises resulting in a net loss where parks cannot migrate inland. At Everglades National Park, rising seas may overwhelm the mangrove communities that filter out saltwater and maintain

the freshwater wetlands. Indeed, changes have already been observed as coral bleaching and disease caused by increased sea surface temperatures led to the loss of more than 50 percent of reef-building corals in the Virgin Islands park units since 2005 (IPCC 2007, Hoegh-Guldberg 1999, Buddemeier 2004). Increasing the resilience and adaptive capacity of coastal ecosystems will be critical to maintaining their enormous biological value and ecological services to the Nation and local communities. NPS's Organic Act uniquely positions us to work cooperatively with other federal agencies, states, local agencies and the public to address the cumulative impacts of overfishing, pollution, and coastal development that increase the vulnerability of these valuable ecosystems to the effects of climate change.

While some impacts from climate change are already measurable, the long-range effects of climate disruption on park natural and cultural resources, infrastructure, and visitor experience are just beginning to be understood. The policy implications for protecting species in a rapidly changing climate are complex and without precedent.

Cultural resources will also be significantly affected by climate change, primarily due to increased erosion from rising seas and more intense storm (and hurricane) surge. Rising sea levels are already damaging archeological sites, historic structures, and cultural landscapes such as Fort Jefferson in the Dry Tortugas and Jamestown. Sea level rise and storms threaten the tangible remains of some of the earliest human occupation sites, dating back over 10,000 years, along the west coast, as well as associated Native American burial grounds at places like Channel Islands National Park and shell middens on the Gulf Coast of Everglades National Park. Alternately, decreasing lake levels expose vulnerable archeological resources and critical park infrastructure in places like Lake Mead National Recreation Area. Our Nation's maritime history, including lighthouses from Massachusetts to Oregon, historic forts including Fort Jefferson and Fort Sumter, and historic coastal communities also face threats from rising seas and more intense storm surges.

The 1980 Alaska National Interest Lands Conservation Act (ANILCA) created 10 Alaskan parks and expanded parklands by 43 million acres. It also recognized the critical importance of access to subsistence resources found in parks, including fish, game, and plants, to both Native and non-Native residents of rural Alaska, and directly linked this access to their continued physical, economic, social, traditional, and cultural existence. While the threats that climate change poses to salmon, caribou, and seals may be viewed as threats to natural resources, they also clearly challenge our ability to provide appropriate subsistence opportunities to local rural residents around our units in Alaska.

Many questions exist regarding how physical processes, species populations, and ecosystems will respond to a changing climate. The science of predicting the complexities of these interactions over relatively long periods of time is highly uncertain, yet the NPS is committed to working with our sister agencies within the Department to understand and monitor the effects of climate change on park resources and ecosystems. The focus of the climate change discussion has largely shifted from the evidence to what we can do about it. As stewards of our Nation's natural and cultural heritage, we have an obligation to act now.

THE EFFECTS OF CLIMATE CHANGE AT ROCKY MOUNTAIN NATIONAL PARK

Twenty years ago cheatgrass, one of the west's most noxious weeds, occurred only below 8,000 feet. It is now found at elevations in Rocky Mountain National Park up to 9,500 feet (Pilkington 2009). Although climate change is likely not the only factor in its expansion, this weed overwinters as a seedling and is therefore poised to take advantage of the warm spring weather typical of our changing climate.

Ungulates are also responding to changes in their environment. This year the park embarked on a plan to manage elk and vegetation. The plan was needed because with the absence of predators and loss of historical migration routes elk have been overbrowsing in their park winter range. Elk winter range includes riparian areas that historically were centers of biodiversity and beaver constructed water storage. Restoring wetlands to full health is crucial to helping many species adapt to changing conditions because healthy ecosystems are generally more resilient to change. Scientists studying climate change and public lands repeatedly note the importance of minimizing other ecological stressors, such as overbrowsing and air pollution (Julius 2008).

Published evidence indicates that recent warming may have resulted in a pulse of nitrate appearing in a watershed monitored within the park. This nitrogen release is believed to be a sign that old ice, perhaps thousands of years old, is melting from between the rocks in alpine watersheds exposing weathering products previously covered by ice (Baron 2009). To date, rock glacier ice has helped buffer

streams during drought periods. With climate warming hydrologists expect that this ice will melt completely and late season stream flows will be greatly diminished (Baron 2009).

Our trees are also rapidly changing. United States Geological Survey (USGS) biologists used long-term records from late successional land to document significant trends in earlier tree death without the compensating growth of young seedlings. Although work continues to more definitively tie tree death to climate change, foresters are very concerned about these findings because North American forests are generally shown in climate models as carbon sinks. Tree death, whatever the cause, results in carbon release. The widespread pattern of tree death, including death due to insect attacks and fire, means that models may need to be adjusted to reflect another net source of greenhouse gas (van Mantgem 2009).

Pikas, or rock rabbits, delight park visitors every year but are especially sensitive to warming. Because of their warm coats, they are unable to tolerate temperatures above 78 degrees Fahrenheit for even an hour. Last year seven known historic locations for pika in the park were checked and pikas were still present in five locations but missing in two, the lowest (and warmest) sites. Although investigations continue, this preliminary data suggests pikas are being affected (Peterson 2009). As climate warming proceeds, alpine environments will likely become smaller and more fragmented, making it harder for true alpine species, such as pika, to migrate or connect with others of their kind.

Rocky Mountain National Park is a Climate Friendly Park with a commitment to reduce greenhouse gas emissions by 17 percent below the 2005 level of 3,540 metric tons by 2017. In 2007 the park formed a Green Team. The team provides an interdisciplinary approach to assist in implementing sustainable practices, promoting environmentally responsible behavior, and to help the park serve as a role model for environmental stewardship. Important outreach through DoYourPartParks.org and messaging in various venues (including podcasts, park newspaper, and shuttle buses) continues to inform park visitors and staff about ways they can minimize impacts to their Climate Friendly Park.

The park has recently qualified for DOI-NPS energy audit funding to identify priority energy efficiency and renewable energy projects. With the approved funding, the audit will be conducted by a utility company, audit contractor, or through the University National Park Energy Partnership Program. The park is working to partner with Colorado universities and/or the National Renewable Energy Laboratory to refine energy efficiency and renewable energy project designs.

An aggressive in-park program and funds provided under the American Reinvestment Recovery Act (ARRA) are changing the park's fleet. In the past three years the park has purchased 10 hybrid vehicles. GSA ARRA funds will be used to replace up to 57 of the park's 141 low efficiency park vehicles with higher efficiency vehicles. The park's shuttle system was expanded in 2005 and again in 2008 to add/connect the Town of Estes Park to the park's hiker shuttle and the Alpine Visitor Center tour.

A partnership with Larimer County has converted the park's recycling system to single-stream recycling, allowing for more materials to be recycled. Also, multiple efficiencies to park facilities have been implemented including: tankless on-demand hot water heaters, solar lighting tubes, energy efficient lighting, recycled asphalt used on park roads projects, energy efficient generators at Alpine Visitor Center, the Green Rehabilitation of the park's employee laundry facility, and more.

THE EFFECTS OF CLIMATE CHANGE AT MESA VERDE NATIONAL PARK

Over the past two decades, Mesa Verde National Park has experienced the impacts of several events; some natural and some that may be tied to human-induced climate change impacts, the results of which may affect the integrity of the park's ecosystem. Since 1989, the park has endured six wildfires covering approximately two-thirds of the park's acreage. NPS staff surveys suggest that several species have either declined or disappeared from this habitat. In areas that have not burned, persistent record-breaking drought has weakened trees to the point where many that survived the wildfires have succumbed to forest pathogen outbreaks. This has led to a situation where continuing drought leads to wildfires, which weakens trees' defenses and in turn leaves them vulnerable to disease and increased insect damage. This cycle can fuel more fires. Also, these fires have damaged historic structures and threatened the loss of archeological sites according to NPS data.

Due in part to the deforestation caused by wildfires, Mesa Verde has experienced two waves of establishment and proliferation of invasive non-native weeds (Floyd et al 2006). Biologists have identified some highly aggressive colonizers such as thistles, knapweeds, pepperweed, cheatgrass, and other species. The large amount of

park acreage impacted by the recent wildfires provided these species with the perfect opportunity to spread throughout the park. Invasive weeds can alter an area by, among other things, disrupting the natural food web, promoting soil erosion, and interfering with natural plant succession. Rapid deforestation promptly followed by non-native weed infestation can quickly convert rare native forests into an impaired landscape. These impacts have also affected such federally-listed species as the Mexican spotted owl and its habitat (Johnson et al 2008).

The park has made some important efforts to slow down the spread of invasive weeds. Direct control of weeds with mechanical, chemical, and biological control tactics have been applied in some areas in some years. Several larger areas burned in recent wildfires have been treated by aerially seeding with native grasses to quickly reestablish competitive native species. This has been proven to be very cost effective if done promptly after wildfires. But, in the long-term, the park's forests may not fully recover if the extreme heat and dry conditions become the new normal.

THE EFFECTS OF CLIMATE CHANGE AT COLORADO NATIONAL MONUMENT AND GREAT SAND DUNES NATIONAL PARK AND PRESERVE

At Colorado National Monument, a National Weather Service station has been collecting climate information since 1942. Records indicate a 3 to 5 degree Fahrenheit rise in temperature during that time. The long-term research being conducted at the park includes impacts to old growth pinion and juniper forests in addition to broader ecosystem impacts. This extensive inventory and monitoring work feeds into the NPS Inventory and Monitoring Network databases.

Great Sand Dunes National Park and Preserve is undertaking many projects that address potential climate impacts to the park's ecosystems. Those include acid rain monitoring and monitoring wet and dry depositions in the form of snow chemistry which will give vital information in regards to air quality conditions. The park is partnering with USGS to look at the response of pikas to climate change as well as monitoring white pine blister rust occurrence.

CURRENT CLIMATE CHANGE ACTIONS AND PROGRAMS

To effectively respond to the challenges of climate change, the DOI is undertaking a collective and coordinated strategy that builds upon and expands existing partnerships such as those between NPS, other bureaus, parks, regions, and national program offices. Building the capacity to respond to climate change will involve identifying, linking, prioritizing, and implementing a range of short and long-term activities. The complex and cross-cutting nature of this issue will require an unprecedented level of cooperation across the DOI Bureaus, other federal and state agencies, the entire NPS, and our partner organizations.

Because climate change has been identified as one of highest priorities for the NPS, many actions and activities have already been undertaken at parks and within regions. The NPS is now in the process of developing a strategic framework for action that will detail short and long-term actions in three major areas: mitigation, adaptation, and communication. The NPS has hired a Climate Change Coordinator and created six working groups—Legal & Policy; Planning; Science; Resource Stewardship; Greenhouse Gas Emission & Sustainable Operations, and Communication. We will use the information from these groups to develop a strategic framework for action that will address park, regional, and national-level needs and concerns.

Over the past three years, the NPS has hosted or participated in a series of regional and interagency workshops to explore climate change impacts and coping strategies. In conjunction with the Environmental Protection Agency in 2003, the NPS initiated the Climate Friendly Parks Program to promote sustainable operations in parks and create climate action plans to reduce greenhouse gas emissions; almost 60 parks, including Rocky Mountain National Park, now participate. The NPS also requires Environmental Management System Plans that help parks track and reduce their environmental impacts and set targets for sustainable park operations. The NPS adopted an Ocean Park Stewardship Action Plan in 2006 to guide actions to reduce ocean-related climate change impacts. Finally, NPS formed a service-wide Climate Change Response Steering Committee to foster communications, provide recommendations, and serve as an advisory body to NPS leadership.

Successful approaches to mitigating climate change impacts require the very best science, not only in physical and biological disciplines, but also in social, and cultural sciences. Since 1999, the Cooperative Ecosystem Studies Units (CESU) Network has provided the NPS with a mechanism to collaborate with leading research institutions, including universities, NGO's and State and federal partners to provide the necessary science for sustainable adaptive management of NPS resources. Since

1999, 17 CESUs have been established covering all regions of the country, with a total of 250 partners including 13 federal agencies. The program has been highly successful in funding cutting edge collaborative research and providing technical assistance and capacity building to the NPS, as well as State and local agencies and other federal partners.

LOOKING TO THE FUTURE-MITIGATION, ADAPTATION, COMMUNICATION

While efforts to date are significant, much work lies ahead. The NPS must position itself to respond to the effects of climate change on park resources and to prescribe management actions that are suitable for parks. Building an effective response to the threats posed by climate change will require action in three interrelated areas: mitigation, adaptation, and communication. These efforts will necessarily involve strong intra-and interagency cooperation and leadership. We need to build on the collective knowledge that is available to create new solutions for protecting resources and resource values.

MITIGATION-LEADING BY EXAMPLE

Our collective carbon footprint must be understood to be managed responsibly. In the area of mitigation, the NPS is leading by example in reducing our carbon footprint and promoting sustainable operational practices. The Climate Friendly Parks Program and the Energy SmartPARKS Program are two of the key ways that NPS is mitigating GHGs through these areas of emphasis:

Emissions Inventories.—Parks quantify and track their emissions and identify specific areas where reductions can be most readily achieved. An online tool—the Climate Leadership in Parks (CLIP) Tool created in 2005, allows parks a new and simplified way to do this assessment and to guide them through the process.

Climate Action Planning.—Parks use the CLIP tool to identify carbon reduction goals and actions to follow through on these goals. Sixty parks are now in the process of completing these plans.

Energy Conservation.—Significant portions of GHG emissions in parks come from transportation, building energy consumption, and waste management. Mitigation solutions include sustainable design and construction, adaptive "green" reuse of historic structures, use of high-mileage and alternative-fuel vehicles, solid waste reduction, and alternative transportation systems that integrate all modes of travel within a park, including land and water-based vehicles.

Renewable Energy.—An increasing number of parks are generating and using clean renewable energy such as photovoltaic systems and geothermal heat exchange. The Energy SmartPARKS program is a partnership with the Department of Energy that is focusing on generating renewable energy and showcasing sustainable energy practices in parks. Currently, NPS-wide, 3.8% of energy in parks comes from renewable sources.

Regions are also moving forward with their own climate change initiatives. For example, the Pacific West Region (PWR) of the NPS has a very ambitious Climate Change Leadership Initiative that promotes Climate Friendly Parks. The overall objective is to support Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management, by setting GHG targets. The 58 parks in the region have set a target of carbon neutral for park operations by 2016 and now generate over 4% of their energy from renewable sources.

The NPS has made carbon management, energy conservation, and renewable energy a major focus for our future. Accordingly, we have set a goal to significantly exceed the federal requirements for reducing total energy use in NPS operations and having some of our energy come from renewables by 2016, the 100th year anniversary of the establishment of the National Park System. Additionally, the NPS has set a goal of having all parks identify their carbon footprint and have climate action plans in place before 2016.

SAFEGUARDING AND PROTECTING PARK RESOURCES-ADAPTATION PLANNING

While mitigating the cause of climate change is essential, scientific evidence demonstrates that even if we stopped emitting greenhouse gases today, our past actions have already committed the planet to some degree of change. Because of processes in the atmosphere and oceans, it will take carbon dioxide and temperature on the order of centuries to stabilize once GHG emissions are under control. Other responses, such as sea level rise, can take millennia. We have to start planning for adaptation options now—while we simultaneously work to stabilize emissions.

For adaptation planning and implementation, our highest priority is to support ecosystem integrity and the resilience of species and communities to respond to changing conditions. As climate change causes shifts in weather, we will see changes in water availability, fire, and community structure and composition. Park vegetation and wildlife will need to adapt to these new regimes or have the ability to migrate. By building resilience and reducing other ecosystem stressors, the NPS will help to reduce the extent of some of the most deleterious impacts on park resources from climate change. For example, the NPS needs to be aggressive in its actions to prevent the intrusion of invasive species, eradicate where feasible, and control the spread when prevention and eradication efforts fail. The NPS also will undertake measures to restore natural ecosystems, making them healthier and more resilient to the effects of climate change. Examples include our on-going efforts to restore major ecosystems such as the Everglades, and the establishment of marine reserves in units of the National Park System.

A critical component for adaptation planning and implementation involves building our science information and ecosystem monitoring capacity for sound decision-making by park managers. National park units represent a wide range of ecosystems scattered across the Nation, embracing a broad spectrum of diverse and natural environments of North America. Parks present a tremendous opportunity to observe the effects of climate change on resource conditions that scientists and managers have documented over decades. Begun almost nine years ago, the NPS Natural Resources Challenge Initiative has funded parks across the Nation to conduct inventories and initiate vital signs monitoring of natural resources under the NPS's jurisdiction.

The combination of these sources of information, long-term legacy monitoring data, and new inventories has provided timely examples of the possible effects of climate change now visible in parks. The NPS Inventorying and Monitoring (I&M) Program's primary goal is to collect, organize, and make available natural resource data. This program includes 32 networks serving more than 270 parks. The Vital Signs Program, which is part of the I&M Program, is strategically positioned to help parks acquire the information they need to make informed decisions and to employ adaptive management so that we can be flexible in the face of change. In addition, NPS has also been funding baseline documentation, including condition assessments of its cultural resources and ethnographic studies that include data on natural resources utilized and monitored by native groups. This data provides critical information for evaluating the potential and real impacts of climate change on cultural resources. Information from these programs also informs state policymakers and assists scientists in looking at regional and national trends.

Planning for climate change presents a major challenge for park superintendents, their staff, and NPS programs. Resource management decisions must be based on future expectations. However, in an era of climate change, the future will be characterized by highly consequential and unprecedented changes that cannot be predicted with as much accuracy and precision as we would like. Consequently, the NPS is utilizing a scenario planning approach that uses the best available science to explore a range of plausible "multiple working futures" and consider appropriate actions within them. Adaptation also involves rethinking infrastructure and preparing people for those changes that are inevitable. To respond to climate change, park infrastructure may need to be adapted to better perform or maintain functionality. This also includes rethinking park planning issues such as zoning and the design or location of buildings and roads. Scenario planning is being specifically designed to help managers identify policies and actions that will be most effective across a range of potential futures and to promote tactical adaptation responses that are compatible with the NPS mission.

The NPS has made scenario and adaptation planning a major goal for the next ten years to ensure parks are prepared for building resilience into ecosystems and ensuring future visitor facilities are sited in appropriate locations.

PARKS SERVE AS MODELS OF SUSTAINABILITY AND PLACES TO COMMUNICATE CLIMATE CHANGE INFORMATION

There is a great need at this time for messages that communicate the complexities of climate change and the actions that can be taken. With 275 million visitors annually, the parks can serve as models of sustainability and platforms to effectively communicate information about climate change. Parks can thus be the catalyst for visitors to do their part for climate friendly parks. The NPS's interpretive and education programs strive to connect people to the parks, with opportunities for all vis≥itors to form their own intellectual, emotional, and physical con≥nections to the meanings and values found in the parks' stories. Effective interpretive and edu-

cational programs encourage the development of a personal stewardship ethic and broaden public support for preserving and protecting park resources so that they may be enjoyed by present and future generations. The public has come to expect high-quality and up-to-date resource information when they visit parks.

The NPS is ideally positioned to raise awareness on climate change and provide information about solutions that are being implemented across the NPS and the Department. A number of efforts are underway to tell the story about climate change and impacts to national parks. These efforts include a monthly web-based seminar series featuring climate change experts on science, communication, and management topics and interpretive training using a decision-tree for developing knowledge around aspects of climate change. The information will be used to frame interpretive programs and answer visitor questions. The NPS has developed a "Climate Change, Wildlife and Wildlands Toolkit" (in conjunction with other federal agencies) to be used by interpreters in parks, zoos, aquariums, and science centers and by outdoor and classroom educators across the country. In addition, summaries of climate change knowledge for specific bioregions—a series of 11 bioregional documents—are being created in partnership with the United States Fish and Wildlife Service that summarize the cur≥rent state of knowledge about climate change and impacts to protected areas, with a focus on national parks and refuges.

Looking forward, the NPS has a goal of every park having climate change information available through brochures, wayside exhibits, interpretive programs and handouts, and park websites. The Climate Friendly Parks Program has encouraged this and currently, there are many examples such as Point Reyes National Seashore, Glacier National Park, Apostle Islands National Lakeshore, Everglades National Park, Dry Tortugas National Park, and Kenai Fjords National Park where climate change information is readily available to the public. The NPS is currently developing and supporting a new and exciting "Visitor—Do Your Part Program" which will have visitors voluntarily measure and reduce their carbon footprint.

The NPS may also utilize the national preservation programs, such as Preservation Assistance and the National Center for Preservation Technology, to develop and disseminate information on sustainability, historic preservation, guidance for adaptive reuse of historic buildings and addition of renewable energy sources into historic areas.

OTHER CONSIDERATIONS

In the future, collaboration with gateway communities, private partners and state, local and federal agencies will be a key element to successful mitigation, adaptation, and communication measures. Much of our carbon footprint results from visitor services and movement in and around parks. Thus, our ability to mitigate GHGs is uniquely tied to our gateway communities and the transportation decisions we make. The NPS will need to complement natural mechanisms that mitigate and adapt to climate change through strategic approaches including: ensuring wildlife and stream corridors are established to enable wildlife to migrate if necessary; promoting and protecting healthy reefs, mangroves and coastal wetlands that can minimize damage to coastal communities; and protecting and restoring forests that can reduce soil erosion and mudslides brought on by changing weather patterns and catastrophic events.

At present, the Vital Signs Monitoring Program is well-established as a key source and supplier of reliable, organized, and retrievable information about parks. Climate change monitoring efforts by other DOI bureaus, such as the USGS, will also be a valuable tool in understanding climate change effects on NPS landscapes. By building on the successful network approach of these programs, the NPS will likely gain additional capability to collect, analyze, and report data on the condition of key natural and cultural resources in parks and how they are changing or may change as a result of climate change.

Coastal and riverine parks are extremely vulnerable to climate change impacts, especially sea level rise and storm surges, and these are high priority areas for developing and implementing adaptation actions. For example, shallow estuaries are significant for the long-term production and health of many commercial species of fish, including salmon and steelhead trout. The survival of these natural resources are also critical to maintaining viable cultures that depend on them such as the salmon and shellfish critical to Northwest tribes and the reefs that support Pacific Island cultures. These important habitats could dramatically change as sea level continues to rise. The impacts of rising sea level also reach surprisingly far inland. The Hudson River, for example, is tidal more than 100 miles inland, at Albany, New York. Implementation of adaptation plans will be critical to ensure facilities and coastal systems such as estuaries and tidal rivers continue to function.

CONCLUSION

Our national park units are environmental baselines to track change, and they stand as some of the last vestiges where ecological components function naturally. National parks also serve as core essential habitats as well as critical habitats for source populations of species. To succeed in its mission in the face of climate change, the DOI and NPS must lead by example in minimizing our carbon footprint and promoting sustainable operational practices. We must take responsibility for understanding how climate change will impact the national parks and take appropriate steps to protect these national treasures. An unprecedented level of collaboration and cooperation with other agencies and partners is required to ensure that scientific information is collected in order to better protect resources, and effectively expand the teaching of the benefits and necessity of natural and cultural resource conservation across the Nation and the world.

Thank you for the opportunity to present this testimony. I will be pleased to answer any questions you and other members of the subcommittee might have. Bibliography

Senator UDALL. Thank you, Dr. Frost.

We'll next hear from Dr. David Schimel, who's the senior scientist for the National Center for Atmospheric Research, known to many of us as NCAR, and the CEO for the National Ecological Observatory Network.

Dr. Schimel, welcome. We look forward to hearing your testimony.

STATEMENT OF DAVID SCHIMEL, PH.D., SENIOR SCIENTIST, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH, AND CHIEF EXECUTIVE OFFICER, NATIONAL ECOLOGICAL OBSERVATORY NETWORK, INC., BOULDER, CO

Mr. SCHIMEL. Thank you, Chairman Udall and Senator McCain. Thank you very much for inviting me to testify in Estes Park today.

I will discuss 2 items in this testimony: first, the effects of climate change in the Rocky Mountain region—and I do have some charts here that illustrate some of the consequences; and second, how we can forecast these impacts better to provide improved information for decision support for resources managers.

I'm going to discuss the likely to very-likely consequences of climate change. The first chart shows the observed temperature trend, and you can see that Colorado sits in a region that has experienced larger-than-average temperature changes over the past century. The second chart shows the observed precipitation trend, again showing that the historical record shows clearly that the effects of climate change are not yet to come, but, in fact, are occurring right now. Again, Colorado sits in that southwestern region that has experienced very significant decreases in precipitation over the past century.

The next chart shows the model-based extension of this for about the next 30 years. These are the results from NCAR's community climate system model to 2030. Again, you can see that it projects continuing, and fairly substantial, warming. Colorado is in one of the parts of the Lower 48 that would experience the greatest warming. Again, the models suggest that the trend in precipitation will continue as a drying trend for the next century or more. Although these results, in contrast to the results that are often shown out to 2100, show the sort of time horizon that our resource management strategies are going to need to deal with.

The next chart shows the impact of these combined trends on water availability. I'd just like you to focus on that dark red area. Those are areas that, based on these sorts of model projections, show decreases in runoff available to the Colorado River system of about 25 percent; again, over the next 50 years. So, these are near-term results.

Senator MCCAIN. Why would you see increases in Alaska and parts of the Midwest?

Mr. SCHIMEL. So, the effects of climate change on the hydrologic cycle, on the water cycle in the atmosphere, are very complex. To summarize, warmer temperatures mean more evaporation, more evaporation means it's going to rain more somewhere, but not everywhere, because circulation patterns change. So, the consensus of model results for North America basically shows the eastern part of the United States and the high latitudes receiving more precipitation, and the areas that are affected most by the monsoon and the El Nino patterns receiving decreasing precipitation. With warmer temperatures, that's a double-whammy that results in decreased runoff available for the major river systems.

The consequences of these changes in climate are profound. We've heard about some of them, and they include disturbances that affect biological resources, the mountain pine beetle, wildfire, and other pests and pathogens that are becoming increasingly evident; obviously, changes to water resources for human consumptive use, as well as in-stream and biological use.

One of the dramatic effects that we're beginning to see comes from results from a recent NCAR study that took advantage of ground-based and NCAR's airborne research platform, the NCAR C–130, to look at carbon uptake by Rocky Mountain forests. The results here show that one of the results of warming is to reduce the length of the snow-covered season and increase the length of the typically very dry summer.

Next slide please.

If you look at the results, it shows that with a 1-month change in the length of the snow-covered season, or, if you will, a 1-month-longer summer period, the amount of carbon uptake by Colorado's forests might be cut in half, dramatically reducing the—if you will, the subsidy that society receives from these forests, in terms of taking fossil-fuel carbon out of the atmosphere.

Finally, we know, from studies in Rocky Mountain Park and elsewhere in Colorado, that many of our most prized wildflower species and alpine plants are endangered by this same change in the timing of the snow-covered, versus the summer, season. The possibility is that our alpine ecosystems could change, with some species increasing in abundance, including, as Dr. Frost said, cheatgrass up to very high elevations, while other species could cease to grow, perhaps forever.

These climate-driven changes pose dramatic challenges to resource managers. Climate is changing, and the impacts of climate change are evident in these current observations. However, our existing monitoring systems, while useful for many purposes, are not optimized for detecting the impacts of climate change on ecosystems, and we do need to continually evaluate both the observations that are made and the source of analysis systems that are in

place to take this very large suite of observations—current, planned, and future potential observations—to produce an integrated assessment of what's happening and what could happen—not just the climate, but its impacts on living and physical resources—to support decisionmaking by park managers and other natural resource managers in the Rocky Mountain region.

I thank the Senators for the opportunity to provide testimony here, and I'm ready to answer any questions.

[The prepared statement of Mr. Schimel follows:]

PREPARED STATEMENT OF DAVID SCHIMEL, PH.D., SENIOR SCIENTIST, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH, AND CHIEF EXECUTIVE OFFICER, NATIONAL ECOLOGICAL OBSERVATORY NETWORK, INC., BOULDER, CO

Chairman Udall and Senator McCain, thank you for inviting me to testify in Estes Park today.

My name is Dr. David Schimel and I will discuss two items in this testimony: (1) the effects of climate change in the Rocky Mountain region, and (2) the status of forecasting climate change impacts so that resource managers can better adapt to these future impacts.

Today I represent two Colorado-based climate research organizations, the National Center for Atmospheric Research (NCAR), a world leader in modeling the climate system, and the National Ecological Observatory Network (NEON), Inc., a new NSF major facility designed from the ground up to observe climate impacts and other environmental changes. I am a Senior Scientist at NCAR currently serving as CEO of NEON, Inc. I am also a Co-Convening Lead Author of the United States Climate Change Research Program's Synthesis and Assessment Product 4.3 (SAP 4.3), which addressed the "Effects of Climate Change on Agriculture, Land Resources, Water Resources and Biodiversity in the United States." SAP 4.3 was a primary source for the science on agriculture, water resources and ecosystems in the USGCRP's recent Global Climate Change Impacts in the United States report. SAP 4.3 covered a number of issues affecting Colorado's national parks and provides the foundation for my remarks. This said, the views expressed in today's testimony are my own, but I believe they reflect peer-reviewed assessments closely.

1. Likely to Very Likely Effects of Climate Change in the Rocky Mountain Region

There is documented evidence that our climate is changing, and changes in climate are already affecting land and water resources in the Rocky Mountain West. Observations clearly show warmer temperatures (as illustrated in Figure 1)* and reduced precipitation (seen in Figure 2), which are affecting our natural resources in the region. Colorado is two to three degrees Fahrenheit warmer than a century ago.

Winter snowpack is declining and the length of the snow-covered season is decreasing. The longer snow-free seasons are not leading to a longer growing season as one might expect, but instead are resulting in more summer drought because snowpack is such an important source of water for plant growth in higher elevations. These observations correspond to recent results from climate models that show continuing warming and drying in the United States West. One example of such a model can be seen in Figure 3 below.

Based on past observations and today's climate model projections, we can identify a number of key climate change impacts on resources in the Rocky Mountain region and in Colorado's national parks, including:

- Increases to biological disturbances such as wildfire, mountain pine beetles, and other pests and pathogens that flourish in warmer, drier conditions.
- Changes to water resources. Observed changes include reduced runoff and streamflow as well as reduced snowpack. Models project these trends to continue, putting additional stress on groundwater and in-stream water in the parks (see Figure 4).
- Reduction of forest carbon sinks because warmer summers and earlier snowmelt lead to less tree growth and higher forest mortality, and thus less carbon storage (as illustrated in Figure 5). Observations just south of Rocky Mountain National Park (RMNP) show that a one-month change in the timing of snowmelt reduced carbon capture in forest ecosystems by one-half.

*All figures have been retained in subcommittee files.

- Loss of native plant species. Earlier snowmelt also affects which plants grow during what seasons in alpine meadows. Alpine ecosystems could change as some species increase in abundance. Other plants could cease to grow, possibly forever.

The climate change impacts described above will affect wildlife and biodiversity in natural areas. In addition, they will affect natural landscapes in the parks and recreational activities such as fishing and skiing.

2. Climate Impacts Forecasting

To adapt to a rapidly changing environment, natural resources managers need access to information on climate impacts and forecasts on potential future climate scenarios.

While models of climate are constantly improving, there is no organized, integrated observing system and corresponding climate services center for delivering information about climate impacts. Instead, there is a multitude of observing systems, each designed for one or more of yesterday's problems, and a correspondingly fragmented analysis and/or forecast system. The integration of observations and modeling of climate impacts needs the kind of coordinated attention and emphasis that weather and climate models currently receive. With such an approach, forecasting of climate impacts can achieve the maturity of physical weather and climate science.

The Nation has established organizations that provide usable information about climate change to resource managers. However, research and infrastructure to support management of organizations that study the impacts of climate change are in their early development and supported only on a piecemeal basis. As noted in SAP 4.3, "existing monitoring systems, while useful for many purposes, are not optimized for detecting the impacts of climate change on ecosystems."

Even with improved observations, we do not have a center or service charged with producing usable analyses and forecasting information utilizing these data. In addition, there is no clear plan to implement and sustain the generation and dissemination of regional-to continental-scale environmental information products. For future products to be accepted in decision-making, a service must also systematically document how the information was produced and the degree of confidence associated with each analysis or forecast. In the current environment, critical information for natural resource decision-making and adaptation to climate change is hard to obtain. Most forecasting of climate impacts is done by individual researchers and is not reliably available to resource managers. Thus, providing usable information about the spectrum of potential future changes to the stewards of a major national treasure like Rocky Mountain National Park is extremely difficult.

New efforts such as NSF"s NEON project and the USGS' Climate Effects Network are beginning to address this gap in information. Colorado is a national center for integrating climate science with climate impacts, and those of us who work in the state on these global problems are motivated by proximity to Rocky Mountain National Park and Colorado's other natural resources. NEON is developing a national network of climate impact observation sites, which have been selected to span the major wildland and managed ecosystems of the United States, including sites in or very near a number of national parks. NEON is coordinated with NOAA's climate observations, but also complements them with detailed measurements of the biological consequences of climate change.

In conclusion, climate is changing and the impacts of climate change are evident in current ecosystem observations. Critical natural resources in the national parks are under stress as a result of the changing climate, and today's models suggest these changes will intensify, further complicating the already complex set of issues facing park resource managers. Although we have a system in place for observing the current climate, today's observing systems, analyses and forecasts are inadequate for providing park resource managers with the decision support they need for the future. Colorado's federally funded laboratories offer the country a unique collection of facilities for integrating climate science with climate impacts assessments. Those of us working within the state on these global problems are motivated by Colorado's natural resources and stand ready to contribute to improved natural resource management in the face of climate change.

I thank the Senators for this opportunity to provide testimony and am ready to answer any questions.

Senator UDALL. Thank you, Dr. Schimel.

I next want to recognize Ms. Alice Madden, who's the climate change coordinator for Governor Ritter. I'd also note, for Senator

McCain's interest, that Ms. Madden is a recovering elected official, John. She served as State——

[Laughter.]

Senator UDALL [continuing]. House Majority Leader for a number of years with great distinction. But, she's found her way clear, and is now gainfully employed.

[Laughter.]

Senator UDALL [continuing]. Leader Madden, it's great to have you here. Thank you for joining us.

STATEMENT OF ALICE MADDEN, CLIMATE CHANGE COORDINATOR, OFFICE OF THE GOVERNOR, DENVER, CO

Ms. MADDEN. Thank you, Mr. Chairman. Good afternoon. Thank you for inviting me here today.

Senator McCain, welcome to Colorado. We are really please to have you here.

Senator MCCAIN. Thank you.

Ms. MADDEN. I happened to see the interview of you with George Stephanopoulos on the amazing brim of the Grand Canyon, and what you said about Glacier National Park, that, you know, sort of jokingly, they might have rename the park, I really think encapsulated the stunning consequences in a way that people can grasp. So, thanks for having me here today.

Senator MCCAIN. Thank you.

Ms. MADDEN. Each of our national park system units within Colorado will have its own unique potential consequences, from retreating glaciers in Rocky Mountain National Park to compromised river flows in the Black Canyon on the Gunnison or Dinosaur National Park; but because climate change does not honor or consider lines drawn on a map, I was asked to address related natural resource management issues facing us across Colorado. I'll begin with forest health.

Within recent years, it's really become pervasive in communities and the media coverage, and this is because of the visual aspect of this. We all know evergreens are suppose to be green, not red. Our best evidence tells us that bark beetles and other diseases have killed more than 2.5 million acres of various pine forests. Some estimates of our lodgepole mortality are as high as 90 percent.

While the majority of this impact has been observed on the West Slope, beetles are expected to spread across the front range in coming years. Foresters are now quite concerned about the ability of compromised forests to support wildlife habitat, protect watershed quality, store carbon, and provide timber and recreational opportunities. Local government officials are concerned about impacts to community safety. Utility operators wrestle with strategies for maintaining the integrity of water diversions and conveyances and power-line rights-of-way. Extensive areas of overly dense, evenly aged, and diseased forests have contributed to widespread concern in the past decade about the risk of catastrophic fires. This increased risk called significant implications for the health of ecosystems in our national park units and for adjacent communities, their watersheds, infrastructure, and residents.

Next, I want to talk a little bit about water management. The importance of sound water resource planning in Colorado, and all

of the Southwest, cannot be overstated. Many factors make this a most complicated undertaking: our relative aridity, our rapid and sustained population growth, our role as a headwaters State for four rivers, and the discrepancy between where most of our population resides, and where most of our abundant supplies originate. Our water managers are highly skilled in managing water supply to meet domestic, commercial, industrial, agricultural, and environmental needs in the face of routine uncertainty due to Colorado's highly variable climate and precipitation patterns, which are, in turn, a function of the State's complex topography and location near the center of the continent. But, increased warming will make an already complex job even tougher.

So, to aid water managers in addressing future uncertainties, the Colorado Water Conservation Board commissioned a team of researchers to synthesize climate modeling important to water supply planning. The first-ever Colorado-specific analysis was published late last year, and I have copies to be included with this testimony as part of the record.

There's far too much in this to try to summarize, so I just want to recognize a couple of significant shifts. I'm not the scientist at this table, I will certainly say that. We may see fewer extreme cold months, more extreme warm months, and more strings of consecutive warm winters. We'll see seasonal shifts in when, and in what form, we receive our precipitation. We think there'll be less snowpack, and there'll be a change in runoff—to earlier in the spring—and late summer flows may be reduced.

This is a fitting segue into our winter sports. This might be debated, but we say we're the Nation's winter sports capital. We have a 2-percent market share, and it brings in an estimated $2 billion in annual revenue. Individual ski resorts are currently taking stock on how certain scenarios may affect their bottom line. But the National Conference of State Legislatures has concluded that climate change could lead to the loss of $375 million and more than 4500 jobs annually by 2017 if the number of tourists just drops by 1 percent.

But, I'd like to touch, just for a moment, on some of the broader measures that we've taken to combat the consequences of climate change. As you're aware, most of our electricity production is used to heat, cool, and light our built environment. Besides reducing greenhouse gases, there's many benefits to making a building more efficient. You're using less energy, utility bills decrease, people get to save a little bit of money, jobs are created to do the work; it's truly the low-hanging fruit of potential action. So, we've worked hard to create realistic incentives for our citizens to choose to make these improvements, such as utility rebates and long-term-interest loans programs. We've aggressively sought to increase the use of both solar and wind power on both small and large projects. We're fortunate to have really significant geothermal potential in this State, which could be used as a baseload for electricity. We think our additional greenhouse gas reductions will be achieved by increasing the use of our abundant natural gas resources, and Governor Ritter is supportive of research being conducted on burning coal more efficiently and, of course, on carbon capture and sequestration. We're supporters of myriad research projects being con-

ducted by the National Renewable Energy Labs, and our wonderful—we have an embarrassment of riches of national labs in Colorado, and we have great research universities. So, we have created a collaboratory, so those entities can work together and make sure that they get those ideas right out into the marketplace. We're particularly excited about, things like next-generation biofuels and battery storage.

We have two Smart Grid pilot projects in this State, one of which has a pilot—within it has a project testing vehicle-to-grid technologies.

We've learned along the way that addressing climate change can help create a sustainable energy future, which has the added benefit of creating a sustainable economy. Our new energy economy has flourished here in Colorado, and we have great faith that melding America's natural resources with our intellectual sources and entrepreneurial spirit will help lead the world to develop and adopt the solutions needed to adopt these serious problems.

Thanks for having me today, and I'm happy to answer questions later.

[The prepared statement of Ms. Madden follows:]

PREPARED STATEMENT OF ALICE MADDEN, CLIMATE CHANGE COORDINATOR, OFFICE OF THE GOVERNOR, DENVER, CO

Mr. Chairman, thank you for the invitation to address the Subcommittee regarding climate change impacts to national parks in Colorado and related management activities.

National Park System units in Colorado bear graphic testament to climate change through the ages, from the remarkable, abandoned Cliff House in Mesa Verde to the vanishing glaciers in Rocky Mountain National Park. Other park system units, like Black Canyon of the Gunnison National Park and Dinosaur National Park, feature magnificent rivers whose flows could be severely compromised by projected climate change impacts.

But just as climate warming in Colorado is occurring within larger regional, continental, and global contexts, the future management of our national parks in Colorado will occur within a larger mosaic of land and resource use and protection, land ownership, and social-economic conditions.

Therefore, my comments today will go beyond our national parks to focus broadly on key natural resource management, use, and protection issues facing Colorado for which climate warming has or could have important implications.

These include forest management, water management, and recreation. I'll leave to experts from the National Park Service and other organizations the more focused assessment of how climate warming may be affecting the various units of the National Park System in Colorado.

FOREST HEALTH

I'll begin with forest health issues, which in recent years have come to pervade community discussions and media coverage throughout Colorado. This is because bark beetles and, to a lesser extent, wildfire and land development are causing dramatic changes to Colorado's forests.

Bark Beetles.—Recent aerial survey data collected by the United States Forest Service and Colorado State Forest Service indicate that bark beetles and other diseases have killed more than 2.5 million acres of lodgepole, ponderosa and limber pine forests. Some estimates of total mortality in Colorado's extensive lodgepole forests are as high as 90%. Meanwhile, spruce bark beetle has killed about 374,000 acres of high-elevation spruce forests. Sudden Aspen Decline Syndrome has impacted over half a million acres of aspen, and in the southwest, the ips beetle has killed approximately 1.5 million acres of pinyon pine forests in southwest Colorado. While the majority of this impact has been observed on the West Slope, beetles are now having a marked effect on the forests of Rocky Mountain National Park and are expected to spread across the Front Range in coming years.

Clearly, something unusual is happening. Outbreaks of bark beetles in Colorado's forests occur naturally and with some regularity, but the current infestation, which began approximately 10 years ago, is the largest in recorded history both in Colorado and in the western United States. Moreover, beetles are attacking trees in places where widespread infestations have never before been recorded.

In testimony presented in June to this subcommittee's counterpart in the House of Representatives, Rick Cables, Regional Forester for the Rocky Mountain Region of the U.S Forest Service, noted that this most recent infestation has prompted concern among foresters and forest ecologists that resulting tree mortality may impair ecosystem functions and compromise the ability of forests to support wildlife habitat, protect watershed quality, store carbon, and provide timber and recreational opportunities (both developed, e.g., skiing, and undeveloped, e.g., hunting and fishing). Local government officials are concerned about impacts to community safety and infrastructure. Electric and water utility operators wrestle with strategies for maintaining the integrity of water diversions and conveyances and power line rights of way. State and federal recreation managers worry about impacts to trail systems and campgrounds. To the average Colorado resident or visitor travelling through our state's forested areas, these land management concerns may not be foremost in their thinking, but their reaction to the aesthetic impacts to the appearance of large areas of formerly green forests are no less real.

Many factors likely have contributed to the current bark beetle problem. Decades of policy promoting fire suppression—pre-dated by large scale human disturbances like mining-era logging and stand-replacing fires—have resulted in large areas of forest that are overly dense and characterized by trees of similar advanced age. This is particular true of lodgepole forests. When further stressed by drought and elevated temperatures such has have occurred across most of Colorado on average over the last 10-15 years or so, these forests have become more susceptible to large scale beetle infestations. In turn, elevated temperatures—including longer, warmer summers and fewer periods of intensely cold winter weather—have favored explosive bark beetle population growth and the resulting widespread infestation. Of real concern in relation to possible future climate warming, these dead and dying forests are slowly changing from carbon sinks to carbon sources, thereby further contributing to factors that appear to be leading to widespread re-structuring of forested landscapes.

Wildfire.—Some of the same factors that have contributed to large scale beetle infestations have also likely contributed to increased incidence of large, catastrophic fires Colorado experienced around the turn of the century. While the most notable of these was the Hayman Fire, the largest on record in Colorado, other large fires like the Missionary Ridge fire also occurred in this period. Although climatic conditions in recent years have not provided conditions necessary to promote large, catastrophic fires, extensive areas of overly dense, even-aged and now diseased forests have contributed to widespread concern in the past decade about risk of catastrophic fires seriously altering Colorado's forested landscapes and the human and natural communities they support. The anxiety of our mountain residents have only been intensified by the relentless and truly startling advance of insect pests and the forest mortality associated with them.

These fears are real and are driving many actions to protect our communities, infrastructure, and watersheds.

To the extent that climates models predicting warmer temperatures and reduced or altered precipitation regimes prove to be correct, wild land fires could increase and become more severe. This increased risk holds significant implications for the health of the ecosystems in our national park units and for adjacent communities, their watersheds, infrastructure and residents.

WATER RESOURCE MANAGEMENT

The importance of good water management and sound water resource planning in Colorado cannot be overstated. Many factors combine to make water resource management and planning a most intricate and serious undertaking. These include:

—our state's relative aridity;
—our rapid and sustained population growth;
—future demands associated with new fossil fuel energy development;
—our role as a headwaters state for four major interstate rivers;
—and the discrepancies between where most of our population resides and where our most abundant supplies originate.

We're fortunate in that Colorado water managers are among the most accomplished in their field. These individuals are expert in managing water supplies to

meet domestic, commercial, industrial, agricultural, and environmental needs in the face of significant and routine uncertainty. This uncertainty comes from Colorado's highly variable, year-to-year climate and precipitation patterns, which themselves are a function of the state's complex topography, high elevation, and location near the center of the North American continent.

But even these highly skilled professionals, who are used to managing under variable and uncertain conditions, will find it doubly challenging to manage water supplies effectively should climate models that predict increased warming prove accurate.

What we think we know.—To aid water managers in addressing future uncertainty associated with climate change, the Colorado Water Conservation Board commissioned a team of researchers under the auspices of the National Oceanic and Atmospheric Administration's Western Water Assessment to synthesize climate modeling important to water supply planning. This first-ever Colorado-specific analysis was published late last year and is included with this testimony as part of the public record. It is entitled Climate Change in Colorado: A Synthesis to Support Water Resources management and Adaptation.

In general, this synthesis of our scientific understanding of a variety of global and regional climate models downscaled to Colorado concludes with the following key points:

1) Climate models project Colorado will warm by 2.5 degrees by 2025, relative to the 1950-1999 baseline, and 4 degrees by 2050.

2) By 2050, models indicate that temperatures on the eastern plains will shift westward and upslope, bringing into the Front Range, where 80 percent of the state's population resides and is projected to reside, temperature regimes that today occur near the Kansas border.

3) Modeled winter projections show fewer extreme cold months, more extreme warm months, and more strings of consecutive warm winters. By 2050, the January climate of the eastern plains is expected to shift northward by about 150 miles. In all seasons, the climate of the mountains migrates upward in elevation, and the climate of the desert southwest progresses up into the valleys of the western slope.

4) Model projections do not agree whether annual mean precipitation will increase or decrease in Colorado by 2050. When results are averaged, the models show little change in annual mean precipitation by 2050, although a seasonal shift in precipitation does emerge. Combined effects of a northward shifting storm track, potentially wetter storms and a global drying of the sub-tropical regions may result in more mid-winter precipitation throughout the state, and in some areas, a decrease in late spring and summer precipitation.

5) Projections show a precipitous decline in lower-elevation (below 8200 feet) snowpack across the West. Modest declines (10%-20%) are projected for Colorado's high elevation snowpack (above 8200 ft). The timing of runoff is projected to shift earlier in the spring and late-summer flows may be reduced. These changes are probably going to occur regardless of changes in precipitation.

6) Runoff in the Upper Colorado River Basin could decline in the mid-to-late 21st century by 6%-20%.

What we need to know better.—The list is long though we are learning more and more each year. For example, though the effects of climate change on the Colorado River Basin has been the focus of several studies, we know comparatively little about the impact of climate change on the Rio Grande, Platte, and Arkansas rivers. More work needs to be done here.

Though the Colorado River Basin has been studied in greater depth than other basins, we still can only speculate about the practical consequences of climate change. For example, at this point, we don't know how compliance by Upper Basin States with the Colorado River Compact might be affected by reduced future flows at Lee's Ferry due to warming temperatures, reduced lower elevation snowpack, and altered precipitation regimes in the Upper Basin.

Supported by the CWCB report, Colorado water managers are now fully engaged in the process of improving our understanding of the vulnerability of our water supplies to climate change. Within the next several months, we will have completed a Colorado River Water Availability Study and the Joint Front Range Climate Change Vulnerability Study.

RECREATION

Wildlife-related recreation.—Our understanding about the specific future impacts of climate change to Colorado's fish and wildlife populations and habitats or on the

angling, hunting, and wildlife viewing opportunities they support is also still evolving. Still less well understood are the considerations that should drive management of wildlife populations and habitats under different climate change scenarios, and which adaptation strategies will be most efficacious. The knowledge that we do have is still somewhat theoretical and derived from largely anecdotal observations of ecological change or extrapolated from broader principles of ecology.

That said, information and knowledge is beginning to be developed at a rapid pace with potentially real ramifications for managing wildlife, habitats, and ecological systems. For example, the Colorado Division of Wildlife is working with a broad spectrum of governmental and non-governmental organizations to assess species and habitat vulnerability. Our goal is to have a preliminary understanding of species and habitat vulnerability and adaption responses and requirements within about one year. This knowledge will help ensure a sound understanding of the adaptation requirements of natural systems, and will help to prioritize and target future habitat protection and management actions to the greatest extent possible to address risks to wildlife posed by climate change.

In the meantime, the Division of Wildlife will continue to work with its partners in the public and private sectors to acquire, protect, and restore habitats in priority areas throughout the state to ensure that other threats to wildlife and associated recreational opportunities are minimized.

Winter Sports.—As the Nation's winter sports capital—with 23 percent of the skiing and snowboarding market share and an estimated $2 billion in annual revenue—Colorado could have much at stake should the worst of the scenarios described by climate models materialize. Under some scenarios, we could experience considerably shortened seasons (especially in the spring) and less rideable terrain. Individual ski resorts are currently taking stock on how certain scenarios may affect their bottom line. But in a report published last year, the National Conference of State Legislatures concluded that climate change could lead to the loss of $375 million and more than 4,500 jobs annually by 2017 if the number of tourists coming to Colorado ski resorts is reduced by just 1 percent.

AN OVERVIEW OF RITTER ADMINISTRATION INITIATIVES

Governor Ritter published a Climate Action Plan in 2007. It sets aggressive goals to reduce green house gas emissions (GHG) by 20% from 2005 levels by 2020 and by 80% by 2050. We well know we must be prepared to face some inevitable changes and the plan discusses adaptation measures around water, wildlife and forests.

I would like to touch very briefly on some of the other proactive measures we have taken to combat the consequences of climate change. Similar to emission numbers we see for the United States, over a third of the GHG emissions in Colorado are from electricity production so we have concentrated much of our efforts on that sector. We believe we can get to over 50% of our reduction goals in this sector through efficiency measures. As you are aware, most of our electricity needs are used to heat, cool and light our built environment. There are many benefits to making a building more efficient: less energy is needed; utility bills decrease; jobs are created to do the work. It is truly the low hanging fruit of potential action. We have worked hard to create realistic incentives for our citizens to choose to make these improvements such as utility rebates and long term, low interest loan programs.

We believe approximately 30% of the GHG emissions from the electricity sector can be addressed by increasing the use of renewable energy. We have aggressively sought to increase the use of both solar and wind power on both small and large scale projects. Colorado is 11th in wind power potential, sixth in solar power potential and we are fortunate to have significant geothermal potential which can be used as a base load source of electricity. Colorado has high heat sources at shallow levels which makes this a very realistic option. The remaining percentage will likely be reached by a combination of increasing the use of our abundant natural gas resources and new technologies around burning coal more efficiently and capture and sequestration.

Our second area of focus has been the transportation sector which accounts for about 1/3 of Colorado's GHG emissions. We are supporters of myriad research projects being conducted by the National Renewable Energy Lab in Golden and our research universities. We have created a "Collaboratory" among these entities that accelerates getting new ideas right out into the market place.

There is much work to be done but there is great potential in the commercial scale production of highly efficient biofuels and concentrated natural gas. Advances in battery storage will increase the attractiveness of electric and hybrid vehicles. We have the first smart grid city in the Unites States which includes a pilot project testing vehicle to grid technologies.

The state also has a very aggressive greening of government program. Governor Ritter believed if we were trying to encourage the citizens of our state and businesses to take action-then the state should lead the way. Utilizing performance contracting, we have made many of our state building vastly more efficient. Both the Governor's mansion and the state capitol are LEEDS certified.

In the interest of time, I will stop here but I just wanted to share with you a few of the ways we are addressing climate change in Colorado. We learned along the way that addressing climate change can help create a sustainable energy future which has the added benefit of creating a sustainable economy. The New Energy Economy has flourished in Colorado and we have great faith that America's intellectual resources and entrepreneurial spirit will help lead the world to develop and adopt the solutions needed to address to this serious problem.

Senator UDALL. Thank you, Ms. Madden.

The important testimony of the panel will be wrapped up by Mr. Stephen Saunders, who's president of the Rocky Mountain Climate Organization.

Welcome, Stephen. We look forward to hearing your testimony.

STATEMENT OF STEPHEN SAUNDERS, PRESIDENT, ROCKY MOUNTAIN CLIMATE ORGANIZATION, DENVER, CO

Mr. SAUNDERS. Thank you, Mr. Chairman. Thank you, Senator, for coming here.

There is no question in my mind that human-cause change to the climate is the greatest threats that our national parks have ever faced. We've never lost a national park before. Dry Tortugas' highest point is no more than 3 feet above sea level. Ellis Island National Monument's highest point is no more than 3 feet above sea level. The government, Senator McCain, in the report that you referred to that came out this year, says that, on the course we're going, the sea level will rise 3 to 4 feet by the end of the century.

Those parks are in danger of being lost. Most of Everglades is under 3 feet. Most of Biscayne is under 3 feet. Sequoia National Park——

Senator MCCAIN. Bangladesh is less—Bangladesh—most of Bangladesh is less than 3 feet.

Mr. SAUNDERS. Worldwide, this is problem, too, for sure.

Sequoia National Park may lose all of its sequoia. Joshua Tree National Park may lose all of its Joshua trees. Glacier National Park may lose all of its glaciers. Virgin Islands Coral Reef National Monument may lose all of its coral reefs. This is the greatest threat that we've ever faced in our national park system.

It's certainly true here. Rocky Mountain National Park will have less ice, less snow, less water, more wildfire, less meadows, less wildflowers; it is going to be a very different park.

So, if we now are saying that this is the greatest threat that we've faced—and I welcome Dr. Frost's statement for the Department that it is potentially the greatest threat; I would just edit the word "potentially" out, but that's a small difference compared to the differences we have had—if this is the greatest threat the Park Service has faced, what do we do about that? Mr. Chairman, I'd suggest a couple of things. One is that the National Park Service has not done its job yet, and there are reports by GAO, and others, saying that.

The National Park Service is a marvelous agency, and the people that are in that agency are prepared to do more. They're waiting for a new director, who needs Senate confirmation. Once Jon Jarvis

is confirmed and gets there, I think the Park Service is going to embark, finally, on developing the proper plan for how the Park Service addresses this issue. I would urge you, sir, to hold an oversight hearing as soon as Jon has been confirmed and has a chance to develop plans. There's no more aid to an agency trying to do its work than to know that an oversight hearing is looming before it.

The other question's about resources. Fifteen, 20 years ago, we said the greatest threat to the National Park Service was the backlog of maintenance needs. We set up a Fee Demo Program, as we call it, where we let the parks keep the entrance fees in the park to deal with the backlog that they need to deal with, the visitor needs and all that. That's been a great program.

One of the superintendents that I've talked to, from a park that I won't name, has suggested now is a time to let the Park Service use some of the entrance-fee money to deal with climate change. Right now, they can only deal with the visitor impacts, and climate change is in a different category. I think that's an excellent idea, that if the Park Service and other agencies were able to use some of that money to deal with the education of the people coming to the parks about threats faced by the park, to deal with assessing the impacts, dealing with the impacts, able to use some of that money to reduce the emissions from the park's operations itself, that would be something that would really help provide the resources that the Park Service will need to be dealing with this.

With that, I'll be happy to let you ask all of us questions.

[The prepared statement of Mr. Saunders follows:]

PREPARED STATEMENT OF STEPHEN SAUNDERS, PRESIDENT, ROCKY MOUNTAIN CLIMATE ORGANIZATION, DENVER, CO

Thank you for the opportunity to testify before you today. I am Stephen Saunders, president of the Rocky Mountain Climate Organization, a Denver-based group working to bring about action to reduce the contributions and vulnerabilities of the interior American West to human-caused climate change. Our group is a mainstream coalition, with partners that include 13 local governments; Denver Water, the largest water provider in Colorado; five businesses, from the Aspen Skiing Company to Wright Water Engineers; and six nonprofits, from the Colorado Association of Ski Towns to Western Resource Advocates.

In 2006, the Rocky Mountain Climate Organization prepared, and released with the Natural Resources Defense Council, a report, "Losing Ground: Western National Park Endangered by Climate Disruption." It addressed national parks in the 11 western states, and identified 12 that we believed to be at the greatest risks. RMCO is again working with NRDC on an updated and expanded report, for release later this year, on the effects of climate change on national parks across the country, not just in the West. I am a principal author of both reports.

Also relevant to my testimony today is my service from 1998 to 2001, during President Clinton's second administration, as the Deputy Assistant Secretary of the United States Department of the Interior over the National Park Service and the United States Fish and Wildlife Service.

Of course, climate change is a global phenomenon, with global causes and effects. But its effects on national parks are a very appropriate focus. Our national parks preserve the very best of our natural and cultural heritages. To continue to provide for their continued enjoyment by future generations-to fulfill the central purpose of the parks-we have to understand and then address the threats to them. In figuring out how to address a changed climate in our national parks, we also will learn some of what we need to know to address it everywhere. That, too, is in the best tradition of our national park system.

Human disruption of the climate is the greatest threat our national parks have ever faced. If we continue adding heat-trapping gases to the atmosphere in the way we now are, we could, for the first time, lose entire national parks. Both Dry Tortugas National Park and Ellis Island National Monument are barely above the

current sea level, less than the three feet that the United States government has said is an appropriate planning scenario for human-caused sea-level rise in this century. Most of Everglades National Park is also less than three feet above the sea level, and the rest is not much higher. All three parks could be lost to rising seas. Glacier National Park could lose all its glaciers. Joshua Tree National Park could lose all its Joshua trees. Saguaro National Park could lose all its saguaros. Virgin Islands Coral Reef National Monument could lose all its coral reefs. Mount Rainier National Park was recently closed for six full months because of heavy downpours and flooding, examples of the extreme weather now occurring more often.

How much the climate continues to change, and how much the national parks suffer these kinds of impacts, is still up in the air-more precisely, up to what we put in the air. Both climate disruption and its impacts on parks will be far greater if we continue stumbling into a high-emissions future. Or we can choose a lower-emissions future and avoid the worst projections of future climate change and its effects. Time is already running short, but it is still possible to bring down emissions sharply enough to ward off unacceptable changes. As the United States government recently said in an important, new overall report on climate change, that will require stabilizing atmospheric levels of heat-trapping gases about where they now are, adding no more additional pollution than can be removed by natural processes.

I am convinced we can and will do that. One of the many, many reasons to do so is to avoid unacceptable effects on the national parks that Americans love. Let me describe just some of those impacts, with a particular focus on national parks in Colorado. Let me point out at the outset that in our 2006 report, "Losing Ground," we identified both Rocky Mountain and Mesa Verde national parks as among the 12 western parks most at risk to the effects of an altered climate.

In Colorado and the rest of the interior West, many of the impacts of climate change flow from its two key manifestations-as a result of heat-trapping gases, it will be both hotter and drier here. Not all regions will get drier. Generally, the wetter parts of the globe are expected to get wetter and the drier parts drier. Here, we already are seeing reductions in snowpack, earlier snowmelt, and reduced streamflows. Of particular significance is the projection of scientists that the flows of the Colorado River, which begins in Rocky Mountain National Park, will be diminished by perhaps 4 to 14 percent in this century.[1] This is of great significance not only to the one-tenth of all Americans who depend on the Colorado River for water supplies, but also to the ecosystems of the national parks in the Colorado River basin, the largest such concentration in the national park system.

Plant communities.—The greatest impacts of climate change in Rocky Mountain National Park, as in many parks, probably will be large changes in the park's plant communities-especially a loss of forests, a loss of tundra, a loss of meadows, and a loss of wildflowers.

We already are losing today's forests in Rocky Mountain because of a changed climate. To begin with, the Intergovernmental Panel on Climate Change has warned us that it is "very likely" that pest and disease outbreaks in forests will be increased by global warming. A prominent example is the mountain pine beetle epidemic now in the process of killing virtually every mature lodgepole pine tree in Rocky Mountain National Park. The National Park Service has acknowledged that the mountain pine beetles' "prevalence is likely a direct effect of climate change."[2] Our forests are now susceptible to a widespread outbreak of beetles, because we have huge stands of the mature trees the beetles favor, in large part because of previous fire-fighting efforts. Some type of outbreak of mountain pine beetles, a natural occurrence in these forests, is inevitable in these conditions. But the extent of the current episode and the speed with which it has spread are not natural. They have been made possible by human-caused climate change. The warmer winters we already are experiencing have removed the periods of deep winter cold that have served as natural checks on beetle populations. Warmer temperatures in their active seasons have allowed the beetles to both go higher up the mountains and expand their populations more quickly than is natural. In particular, in lodgepole forests between 9,500 and 11,000 feet high, beetles used to take two years to complete their life cycle; now they are able to produce a new generation in a single year.[3] This has enabled this epi-

[1] M. Hoerling and others, "Reconciling projections of Colorado River streamflow," Southwest Hydrology 8, no. 3 (2009), pp. 20–21, 31.

[2] Continental Divide Research Learning Center, Rocky Mountain national Park, National Park Service, "Climate change in Rocky Mountain National Park: Preservation in the face of uncertainty," 2008, http://www.nps.gov/romo/parkmgmt/upload/climate__change__mountain2.pdf.

[3] Colorado State Forest Service, Colorado Department of Natural Resources, "2006 Report on the Health of Colorado's Forests," p. 15, http://csfs.colostate.edu/pdfs/06fhr.pdf.

demic to spread so far and so fast, including over mountain ranges that used to serve as natural barriers stopping or slowing previous outbreaks.

Also recently linked to a changed climate is a rapid dieback of aspen trees that scientists have labeled "sudden aspen decline." Beginning in 2004, people began to notice that aspen trees in Colorado, particularly in the southwestern part of the state, were dying in large numbers and that the dead trees were not regenerating as usual through new trees growing from the roots of the old. This aspen dieback has increased rapidly, with the affected acreage in Colorado having increased fourfold between 2006 and 2008. Aspen die-off has also been observed in northern Arizona, southern Utah, and Montana. Research by the United States Forest Service has linked the sudden aspen decline in Colorado to the hotter and drier conditions that represent an altered climate in the interior West.[4] The emblematic aspens of the West, including those near here in Rocky Mountain National Park, could be at risk.

A loss of other kinds of forests has occurred in Mesa Verde National Park and elsewhere in the Southwest, where a combination of hotter and drier conditions and another beetle, the piñon ips bark beetle, has led to widespread forest dieback in the piñons of the piñon-juniper forests that are of the dominant forest type of the Colorado Plateau. In just the two years of 2002 and 2003, beetles killed 90 percent of the piñon pines in studied portions of Mesa Verde and of Bandelier National Monument in New Mexico. Researchers have attributed the underlying cause of the piñon die-off to climatic factors, as sustained heat and drought left the trees particularly vulnerable to bark beetles. More trees died than during an even drier period in the 1950s, pointing the researchers to the higher temperatures of the recent drought as the key factor in the extent of the recent forest die-off.[5]

Perhaps most ominous, a recent study of undisturbed forest plots across the West found that all types and ages of trees are dying at higher rates, "with regional warming and consequent drought stress being the most likely drivers." Led by two United States Geological Survey scientists stationed in Sequoia and Kings Canyon national parks, a team of researchers examined records of 76 undisturbed forest plots in which all individual trees had been counted in census records going back as far as 1955. The studied forests were in Yosemite and Sequoia/Kings Canyon national parks in California and elsewhere across the West, including in Colorado. Almost all plots had experienced an increase in overall tree mortality, including both young and old trees. In the Northwest, the tree mortality rate had doubled in 17 years; in the interior West, in 29 years. The researchers believed that higher temperatures and drier conditions-again, manifestations of a changed climate-were the reasons for the accelerated tree deaths.[6] This study builds on earlier work by the same two USGS researchers showing increasing tree mortality in Sequoia/Kings Canyon and Yosemite national parks. Based on that work, they warned:

> if forests in the Sierra Nevada are as sensitive to increasing evaporative demand as our findings imply, they may now be poised for die-back during otherwise normal periods of reduced precipitation, similar to the recently documented die-back in the piñon-juniper woodlands of south-western North America. But even in the absence of periods of significantly reduced precipitation, continued temperature-driven changes in mortality rate have the potential to dramatically alter forests.[7]

A loss of mountaintop tundra may well be another change in plant communities resulting from a hotter climate. For Rocky Mountain National Park, home to the largest expanse of alpine tundra in the United States outside of Alaska, one group of scientists projected that warming of 5.6 F could cut the park's area of tundra in half and that of 9 to 11° F of additional heat could virtually eliminate it, as forests move upslope.[8] In Glacier National Park, where there has been an effort to study changes in the extent of tundra, scientists using repeat photography have docu-

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[4] J. J. Worrall and others, "Rapid mortality of Populus tremuloides in southwestern Colorado, USA," Forest Ecology and Management 255 (2008): 686–696, http://www.fs.fed.us/r2/fhm/reports/sad_2008.pdf

[5] D. D. Breshears and others, "Regional vegetation die-off in response to global-change-type drought," Proceedings of the National Academy of Sciences 102, no. 42 (2005): 15144–15148.

[6] P.J. van Mantgem and others, "Widespread increase of tree mortality rates in the western United States," Science 323 (2009): 521–523.

[7] P.J. van Mantgem and N.L. Stephenson, "Apparent climatically induced increase of tree mortality rates in a temperate forest," Ecology Letters 10 (2007): 909–916.

[8] N. Hobbs and others, "Future impacts of global climate on Rocky Mountain National Park: Its ecosystems, visitors, and the economy of its gateway community—Estes Park" (2003), pp. 16–17, http://www.nrel.colostate.edu/projects/star/papers/2003_final_report.pdf.

mented that trees just below timberline have already begun to grow more upright and have filled in forest edges.[9]

Other changes in plant communities include a loss of mountain meadows, which exist where the combination of heavy snow cover in the winter and a short growing season in the summer keep tree seedlings from surviving. Scientists have predicted that a hotter climate will reduce snow cover and extend the growing season, shrinking alpine meadows. I know of no studies yet in Rocky Mountain National Park, but scientists have already detected a loss of mountain meadows in Glacier, Olympic, Sequoia/Kings Canyon, and Yosemite national parks.[10]

Scientists also have documented how higher temperatures suppress the growth of mountain wildflowers. Researchers at the Rocky Mountain Biological Laboratory near Crested Butte, Colorado-the official wildflower capital of the state-have found that using heat lamps to warm mountain test plots by 4°F leads to a substantial reduction in wildflowers and their replacement by sagebrush, normally found in lower-elevation, dryer areas.[11]

To step back from the scientific studies and put this in its proper perspective, earlier this month I sat on a log at the edge of Mill Creek Basin in Rocky Mountain National Park, reveling in that meadow and its profusion of wildflowers, set off against a backdrop of aspens and, behind them, a pine-forested mountainside. I thought that I had better let this scene really soak into my memory, because each of those elements-the meadow, the wildflowers, the aspens, and the pines-are already being disrupted by the changes we are making in our climate. I feared that my children may not be able to enjoy such a scene in their adult lifetimes.

Wildlife.—An altered climate also will change the wildlife species in our parks. At particular risk are alpine species that can run out of higher elevations to climb to find cooler conditions. Rocky Mountain National Park's tundra along Trail Ridge Road has what has long been one of the most accessible and famous populations of white-tailed ptarmigan in the country. In just two decades, however, the numbers of this local population have been cut in half, and researchers predict their extinction in the park by mid-century if temperatures rise as predicted.[12] I've been going up there for over three decades, and I certainly notice the change in the ptarmigan numbers. Pikas, little known across much of the country but well known to visitors to Trail Ridge Road, are not able to survive even short periods of temperatures above 75°F or so. Across the West at elevations lower than on Trail Ridge Road, some local pika populations have already disappeared.[13] The United States Fish and Wildlife Service is currently considering whether pikas should be listed for protection under the Endangered Species Act because of the threat to them of a hotter climate. In Yosemite National Park, about half of small mammal species are now found at different ranges of elevation than early in the last century; on average, the range of the mammals is now about 500 yards higher.[14]

Mountaintop species are not the only vulnerable ones. In Mesa Verde National Park, the Mexican spotted owl-a threatened species-is disappearing from the park. The park's chief of natural resources attributes this to the drier conditions so far this century-conditions consistent with the hotter and drier effects of climate change in the interior West.

Fishing.—Some of the best trout fishing in the western United States is in our national parks, including Rocky Mountain. But trout are cold-water fish, and higher temperatures could lead to losses of western trout populations exceeding 60 percent in certain regions by 2050.[15] At Yellowstone, the extreme heat of July 2007 led the

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[9] D.B. Fagre, "Spatial changes in alpine treeline patterns, Glacier National Park, Montana," http://www.nrmsc.usgs.gov/research/treeline__rsrch.htm.

[10] D.B. fagre and D. L. Peterson, "Ecosystem dynamics and disturbance in mountain wildernesses: Assessing vulnerability of natural resources to change," Climatic Change 59, nos. 1–2 (2003): 74–81. C. Milar and others, "Response of subalpine conifers int he Sierra Nevada, California, U.S.A., to 20th-century warming and decadal climate variability," Arctic, Antarctic and Alpine Research 36 (2004):181–200.

[11] T.J. Perfors, J. Harte, and S. Alter, "Enhanced growth of sagebrush (Artemisia tridentate) in response to manipulated ecosystem warming," Global Change Biology 9, no. 5 (2003): 736–742. F. Saavedra and others, "Changes in flowering and abundance of Delphinium nuttalianum (Ranunculaceae) in response to a subalpine climate warming experiment," Global Change Biology 9, no. 6 (2003): 885–894.

[12] Hobbs and others; see note 1.

[13] E. A. Beever and others, "Patterns of apparent extirpation among isolated populations of pikas (Ochotona princeps) in the Great Basin," Journal of Mammalogy, 84 no. 1 (2003): 37–54.

[14] C. Mortiz and others, "Impact of a century of climate change on small-mammal communities in Yosemite National Park, USA," Science 322(5899)(2008): 261–264.

[15] United States Global Change Research Program, Global Climate Change Impacts int he United States (2009, p. 87.

National Park Service to close 232 miles on 17 prime fishing rivers during afternoons. The high temperatures killed enough trout to produce the largest fish kill in the park's history. A park biologist predicted that it would become the norm for the future.

Overcrowding.—As temperatures soar with a changed climate, to escape the oppressive heat people may well flock to cooler mountain parks, overcrowding them. In Rocky Mountain National Park, a survey of park visitors suggests that under the climate conditions projected by 2020 enough visitors would come more often and stay longer to increase the number of visitor days each year by more than one million-nearly a one-third increase.[16] So far, there has been little attention paid by the National Park Service or others on how higher temperatures may increase summer visitation to cooler parks, national seashores, and national lakeshores-or on how that increased visitation can be accommodated. In Canada, researchers concluded that heat-driven increases in visitation to Canadian national parks could be so large that "parks that already report visitor-related ecological stress would require more intensive visitor management, perhaps including strategies such as de-marketing, visitor quotas, and variable pricing for peak periods."[17] I am not advocating those particular measures, just using these suggestions to illustrate that the effects of increased visitation could be significant enough to necessitate real responses of some kind.

More wildfires.—The United States government, in its overview report this year on climate change, noted, "In the western United States, both the frequency of large wildfires and the length of the fire season have increased substantially in recent decades, due primarily to earlier spring snowmelt and higher spring and summer temperatures." Wildfires can disrupt summer vacations for park visitors. In the summer of 2002, when hot and dry conditions combined to produce Colorado's worst fire season in history, the number of July visitors to Rocky Mountain National Park dropped by nearly 100,000 from the previous year, even without any fires in the park itself. Two years earlier, in Mesa Verde National Park, two back-to-back fires burned more than half the park and closed it to visitors for nearly three weeks.

I am afraid that I could go on at even greater length, detailing other ways in which climate change is affecting our national parks, from a loss of glaciers, snowfields, and opportunities for winter recreation to a loss of historical and archaeological resources. Instead, though, let me turn to what the National Park Service should be doing about all this.

Recommendations for NPS actions.—When it comes to protection of the resources and values of the national parks, the National Park Service has an obligation under law, its own policies, and its long, proud tradition of environmental stewardship to take a leading role. "The Service will use all available authorities to protect park resources and values from potentially harmful activities," the NPS Management Policies boldly declares. Sadly, the NPS has not yet followed its creed and exercised its authorities to address human disruption of the climate and its effects, the greatest threat ever to park resources and values. As the United States Government Accountability Office concluded in 2007 about the Park Service and other federal natural resource management agencies, they:

> have not made climate change a priority, and the agencies' strategic plans do not specifically address climate change. Resource managers focus first on near-term, required activities, leaving less time for addressing longer-term issues such as climate change. In addition, resource managers have limited guidance about whether or how to address climate change and, therefore, are uncertain about what actions, if any, they should take. In general, resource managers lack specific guidance for incorporating climate change into their management actions and planning efforts. Without such guidance, their ability to address climate change and effectively manage resources is constrained.

Too often, the NPS has so far just looked the other way when it comes to climate-change impacts. In preparing in 2000 a management plan for Dry Tortugas National Park, at risk of being totally submerged by rising seas, the Service wrote about climate-change risks and what to do about them: "These external forces are beyond the scope of this plan."

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[16] R.B. Richardson and J.B. Loomis, "The Effects of Global Warming on Mountain Tourism: A Contingent Behavior Methodology," prepared for Hobbs and others; see note 1.

[17] B. Jones and D. Scott, "Climate change, seasonality and visitation to Canada's national parks," Department of Geography, University of Waterloo, Waterloo, Ontario (2005), p. 2, http://lin.ca/Uploads/cclr11/CCLR11-132.pdf.

Fortunately, change is already underway at the National Park Service. President Obama's choice as NPS Director, Jon Jarvis, when he was Regional Director of the Service's Pacific West Region, established the strongest record of leadership on climate of any senior NPS manager. I hope and expect that Director Jarvis will bring the same vision to his management of the entire Service, and am confident that if he does he will be met by enthusiastic support from other NPS managers and employees. I know that frustration is widespread within the Service about its failure so far to take a leading role in addressing climate change. With proper leadership, I believe that the National Park Service will live up to its proud history in taking on this major challenge.

But I certainly do not think that Congress, or the American people, should just blindly trust that there will be the needed changes. It seems entirely prudent to me for this Subcommittee to hold a thorough oversight hearing on what I expect will be major new Park Service plans to address climate change, once Jon Jarvis is confirmed and he and Secretary Salazar have had a chance to develop those new plans.

An agenda of actions that would be appropriate for the National Park Service in addressing a changing climate and its effects on national parks includes the following.

Making climate change a priority.—Human-caused changes in the climate are the greatest threat ever to national parks, and the National Park Service should act accordingly. Particular recommendations are:

- The NPS Director should issue a Director's Order making it clear that addressing climate change and its impacts is among the highest priorities throughout the Service. The Order should launch action on some of the particular recommendations outlined below.
- The NPS should amend its Management Policies to incorporate specific references to management responsibilities with respect to climate change and its impacts in parks.
- The Park Service should have a separate NPS climate change office within the Service, to ensure crosscutting support for Service actions to address climate change and its impacts in parks. The Administration requested a modest $800,000 for such an office for next fiscal year, but the House appropriations bill would block that new office.

Expanding scientific knowledge.—Identifying and monitoring climate change effects on key resources of national parks are not only essential for protection of those resources, but also important for a broader understanding of climate change effects in the world at large. National parks are areas with spectacular resources, usually much less affected by human activities and other stresses than other lands; the parks provide some of our very best opportunities to learn how climate change is affecting and will affect natural and cultural resources. Much of the research I have cited above, such as about a loss of today's forests, represents not just what we know about those effects in national parks, but all of what we know about those effects anywhere. Specific recommendations:

- The NPS should identify in every park the resources and processes at risk from climate change. This need not await full park management planning efforts; it can be accomplished through summaries of the literature, guided research, gatherings of experts, and simple brainstorming. Climate Friendly Parks workshops (see below) are a beginning.
- The NPS should review its Inventory and Monitoring Program, in which every national park has established a number of vital signs for monitoring change over time; these should be reviewed to ensure they adequately include the impacts of climate change. If not-and I fear that will nearly always be the case-the vital signs and the monitoring plans should be updated.

Planning and managing to protect resources.—According to the Service's Management Policies, "NPS managers must always seek ways to avoid, or minimize to the greatest degree possible, adverse impacts on park resources and values." To do this in the case of climate change and its impacts, specific recommendations are:

- The NPS should develop park-specific and resource-specific plans for protection of the resources most at risk in individual parks.
- The NPS should be innovative in considering and using a broad array of tools, including unconventional ones, to preserve resources most at risk in individual parks. Protected corridors to allow migration of species between areas of changing habitat may often be necessary, which would require cooperative action with other land managers. Experience with ecosystem-wide approaches such as the one by different federal agencies through the Greater Yellowstone Coordinating

Committee should be examined for lessons that can be applied to deal on a landscape-wide scale with climate change and its impacts.
- The NPS should plan for different possible future scenarios-plausible conditions that could occur but may not. To await certainty in what the future will bring may take away the ability to address it in a sufficient and timely manner.
- The NPS should consider the combined effects of climate change and of other stresses on park resources and values and work to reduce those other stresses when doing so may ease the effects of climate change.

Reducing emissions.—National parks are among the most important places to concentrate efforts to reduce emissions of heat-trapping gases, because successful actions there can inspire the millions of Americans visiting the parks to make and support similar efforts elsewhere. Specific recommendations:

- The NPS should work to reduce the emissions from its own operations, on a Service-wide basis, as undertaken in the Pacific West Region through Regional Director Jarvis's Climate Change Leadership Initiative.
- The NPS should give an even greater priority to reducing emissions from visitor activities than from its own operations, as emissions from visitor activities dwarf those from NPS operations.
- The NPS and Congress should review the Federal Lands Recreation Enhancement Act to consider the use of funds from national park entrance and recreation fees to address climate change and its impacts in national parks, so long as information on those expenditures and their purposes and accomplishments is communicated to park visitors.

Expanding Climate Friendly Parks.—Fifty-three national parks (out of 391) have held an initial workshop in the Climate Friendly Parks program, NPS's most visible climate-change initiative to date. That program is a partnership between NPS and the United States Environmental Protection Agency to help those parks protect their natural and cultural resources from climate change. Twenty-three have conducted an inventory of their emissions of heat-trapping gases, and 16 have action plans to reduce their emissions. That is a start, but clearly more can be done. Recommendations:

- The NPS should make a national commitment and develop a schedule to expand the Climate Friendly Parks program to all parks (with exceptions only for those few parks with small enough operations and visitation where doing so would not make sense.)
- The NPS should post online summaries of all Climate Friendly Parks workshops in particular parks. (Not all now are posted.)
- The NPS should post online all emission inventories and climate action plans for parks for which they are completed. (Not all now are posted.)

Communicating with others.—With 275 million visitor-days of visitation to national parks in 2008, the NPS has an enormous, unique opportunity to communicate what climate change may do to us and what we can do about it. Recommendations:

- NPS officials, beginning with the Director, should speak out publicly about the threats that climate change and its impacts pose to national parks. The NPS Management Policies state that when park resources and values are at risk from external threats, "It is appropriate for superintendents to engage constructively with the broader community in the same way that any good neighbor would. . . When engaged in these activities, superintendents should promote better understanding and communication by documenting the park's concerns and by sharing them with all who are interested."
- NPS should require concessionaires in a position to provide environmental education to park visitors (and many are required to do so) to provide information on climate change and its effects in national parks and what NPS and the concessionaires are doing to address them.

Partnering with other agencies and organizations.—Much of the best work done in national parks to understand climate change and its effects is done by others besides the NPS, including the United States Geological Survey, universities, and others. Cooperation with other federal, state, and local natural resources agencies and land managers can also be more important than ever in dealing with the broad-scale effects of climate changes. A recommendation:

- The NPS should continue and even expand its cooperative efforts with other researchers, land management agencies, and others to address climate change and its effects in national parks and surrounding lands.

Exercising international leadership.—The National Park Service is the best-known and most respected natural resource management agency in the world. A recommendation:

- The NPS should exercise leadership in promoting cooperation and communication among natural resource management agencies around the world in how to address climate change and its impacts in protected areas.

In taking these actions, the National Park Service will need support from this Subcommittee, Congress as a whole, and, especially, the American people. We Americans deeply love our national parks, and have always rallied around when they have been in peril. Now, more than ever, is such a time.

Senator UDALL. Thank you, Mr. Saunders, for that insightful and compelling testimony, and duly noted that an oversight hearing would make great sense.

In the regular order, if we were in Washington, DC, I would recognize Senators in turn for anywhere from 5 to 10 minutes. I want to be a gracious host, so I want recognize Senator McCain initially for something on the order of 10 to 15 minutes, and we will have a series of conversations and questions over the next 50 minutes or so that's left in the hearing.

So, let me recognize the great Senator from Arizona, John McCain.

Senator MCCAIN. Thank you very much, Mr. Chairman.

I want to thank the witnesses again. This has been extremely helpful.

Ms. Madden, thank you for your continued service to the State of Colorado. You stated the Upper Colorado River Basin could decline in the mid- to late-21st centuries, by 6 percent to 20 percent. What does this do to activities on the Upper Colorado River Basin?

Ms. MADDEN. Again, There's folks to my left and right who know this more in detail than I do. The report I referred to goes into that into much further detail.

I do want to note that one of the authors shares the same last name as your neighbor there. Randy Udall, is also an author of this, as is Stephen Saunders. So, Stephen might be able to answer that a little better.

But, there's many things that we don't know at this point in time, and we're developing more studies on what's going to go on in the Colorado River Basin and our other river basins. As it becomes—if drought areas affect different parts of the State, it'll effect timing and——

Senator MCCAIN. Has it already affected the ski industry?

Ms. MADDEN. Yes, it has, in the sense that when they're making snow, they can't afford for that snow to melt. So, they have to wait until they know any snow that they make will stay frozen. So, it means that the season starts a little bit later and it ends a little bit sooner.

Senator MCCAIN. Thank you.

Dr. Schimel, have you seen effects on climate change from overseas, specifically China?

Mr. SCHIMEL. If you're referring to the transport of material, one of the very complex impacts on the hydrology, the water resources, of Colorado is the deposition of dust on snow. The deposition of dust on the snowpack darkens it and makes it melt more quickly. We have seen a dramatic increase in the amount of dust deposited

on the Colorado snowpack over the past century and a half, and much more dramatically, even, in recent decades.

There are several primary sources of this material. The first one is dust originating from land use in the Four Corners area, but one of the significant sources of dust is, in fact, transpacific transport of dust from the Asian continent. This is one of the better examples of the complex, interwoven nature of the global environment.

So, yes, we do see consequences—very difficult to quantify at this time—but we do see consequences of material being transported globally.

Senator MCCAIN. Ms. Madden, have you seen any results yet that you could report on the Smart Grid test project?

Ms. MADDEN. Yes. Just to the point that Dr. Schimel just made, I took a trip to Tanzania this summer, and worked on some issues around this black soot that travels, and it's largely among many other sources, but there's a significant source coming out of open fires. So, there's been some work to allow people in Africa and Asia to have more efficient cookstoves, so they're not creating that black soot that then, of course, attracts the sunlight and melts ice faster.

The Smart Grid—one is in Boulder and one is in Fort Collins—Xcel has put over a $100 million into Boulder to do this, and one of the things that they're seeing, and other studies have also proved out, is, when people have that information about how much energy they are using, they get a little competitive about it, and they want to bring it down, which is great. So, these monitors allow you to see how much energy you're using, where it's—where you're getting it from, and perhaps even doing things like telling your dishwasher to go on at 2 a.m., when the grid—when the supply on the grid is much less demanding.

The vehicle-to-grid pilot project allows your car to become a little distributed-generation resource, and puts energy back onto the grid. Fort Collins has a district that they're actually calling the "zero energy district." Their program's called FortZED, for "zero energy district." So, both those cities are really moving things along; and, matter of fact, I think that they are farther along than any other place in the United States.

Senator MCCAIN. Dr. Frost, have you got any stimulus money for this effort—research or addressing climate change?

Mr. FROST. No, sir. Park Service received, I think, around $750 million of stimulus money, and the majority of that went to work on our maintenance backlog. The other portion went—indirectly, yes, we did get a little bit of money to work on some invasive-species issues; so, again, trying to remove stresses from the environment. Then, the rest of the money went help restore some abandoned mine lands. that's so——

Senator MCCAIN. Obviously you could use some climate change money, then.

Mr. FROST. Yes, we could. I will not argue with you there.

[Laughter.]

Senator MCCAIN. When Jon Jarvis is confirmed by the Senate—and we all look forward to having that happen soon, as—when he was the Pacific West regional director, he instituted a goal to have the parks within the region to have carbon-neutral park operation

by 2016. Would that be a good idea, to expand that to the rest of the country?

Mr. FROST. It would be wonderful. Let me just relate a quick——

Senator MCCAIN. Do you think it can be done?

Mr. FROST. I think it'll be difficult, but I think, as a leader of conservation and as a teacher of—as a teacher to our kids, the Park Service should step up to the challenge. It may take us a few years to do it, but I think it's a worthy goal and one that we should set.

Mr. SAUNDERS. Senator, may I chime in on that? Just to point——

Senator MCCAIN. Yes.

Mr. SAUNDERS [continuing]. Out that Jon Jarvis has done a great job, and that's one of the things that's encouraging about his being picked to be the whole Park Service director. However, they did take the date out of that goal, just last month, so they no longer have a goal of doing that by 2016.

Senator MCCAIN. Is that because he left?

Mr. SAUNDERS. No, he hadn't——

[Laughter.]

Mr. SAUNDERS [continuing]. He hasn't actually left yet. I have not had much of an exchange yet with people about the changes, other than I understand that they just found it was hard to be able to get there in the case of all 56 parks in that region, or something. So, now they have a vision, without a date, of having the Park Service operations be carbon-neutral "sometime."

Senator MCCAIN. I think history shows, unless we give a date-certain, that date never arrives.

Mr. Saunders, I don't mean to be too parochial, I know this is a very big issue, but we've just traveled around the Rocky Mountain National Park, here. With Chairman Udall, it's always an enlightening and enjoyable educational experience, but an exhausting endurance test, also——

[Laughter.]

Senator MCCAIN. As you know, but I've been very——

Senator UDALL. Takes one to know one.

Senator MCCAIN. Obviously, one of the most striking issues is this pine-beetle issue.

Mr. SAUNDERS. Yes, sir.

Senator MCCAIN. What—it's a unbelievable. Every home in America should see what's happening; every citizen should see what's happening here. Do you have any specifics, besides the whole issue of climate change, as to how, perhaps, we could address this—what may turn out to be one of the most devastating thing that's ever happened to our national parks, at least here?

Mr. SAUNDERS. I'm afraid I don't have an answer for what we do to deal with the changes in the ecosystem. The first thing that I would say, though, is that, I certainly hear people that say, "Mountain pine beetles are a natural part of the forest." That is true, just as the seas are a natural part of the world. If we—in a few years, or in Everglades or someplace, and we see that the seas have risen higher up than ever before, and spread farther over the land than ever before, I would not think that's a natural phenomenon any-

more. I would look at that, and I would think, "That is nature that we have knocked out of kilter." That's how I——

Senator MCCAIN. We've never——

Mr. SAUNDERS. That's how I——

Senator MCCAIN. We've never seen an infestation of this scale, have we?

Mr. SAUNDERS. No. That's how I look at the bark beetles. Yes, bark beetles are a natural part of the forest. But, because we have warmed up the winters, and we've warmed up the summers, the beetles are now going higher than they ever have before, they are reproducing at a quicker rate. Above 9,000 feet, it used to take them 2 years to have a single generation; now they do it in a single year. At lower elevations, it used to be one generation per year, and now we are seeing two generations per year. Their period is longer. We used to have very deep, cold periods that would knock back the populations during the winter. We've lost that natural check on their population. So, it is no longer a natural phenomenon, it's something that started out as a natural phenomenon.

I, like you, wish that everybody would see that, and I wish that the National Park Service and other agencies were doing a better job of explaining to people why it has reached the scale that it has now reached. I think that would do a whole lot. As Dr. Frost pointed out, there are 275 million visitor days of visitation to the national parks every year. The National Park Service has an enormous opportunity to educate people. The national parks are a place where our impacts are the most visible. If we are doing a proper job—we, the whole country, are doing a proper job of pointing out the consequences as they happen, I think our attitudes will change. Once our attitudes change, our actions will change, and we will be more interested in meeting our energy needs in ways that don't destroy our forests.

Ms. MADDEN. May I add on to something——

Senator MCCAIN. Please.

Ms. MADDEN [continuing]. Here. Thank you.

When you look at these, they almost look like matchsticks, which is a really scary thought. I mean, they're—you just know there's going to be, you know, one of two results: they're going to fall down or they're going to light on fire. So, we've been looking at these as potentials for energy around biomass. A lot of our—a large portion of our forests are on Federal land. So, I think the State and the Federal forest services have to work together about how we're going to deal with these, and if there's any real potential for using these for biomass.

One story in Colorado—we had one of the last coal-burning boilers in a grade school, I think probably in the United States, and it broke down in the middle of the winter, and we were able to quickly create a new boiler system made out of beetle-kill highly efficient wood pellets. So, it was really just this very holistic approach to this.

So, I think there's great answers. Of course, you know, there's—it's very complicated how we would be able to get this wood, and use it, and where you produce it, and do you haul it on trucks, all those things. But, I think, using a least some portion of this as biomass is perhaps a good solution.

Senator MCCAIN. I thank you. I thank the witnesses.

Thank you, Mr. Chairman.

Senator UDALL. Thank you, Senator McCain.

Let me address some questions, and we'll continue this conversation. Then if Senator McCain has additional questions, I'll yield to him again.

Dr. Frost, to follow up on what Senator McCain had to say and what Mr. Saunders had to say about the beetle-kill situation, would you tell us a little bit about what the park is doing? Are you thinning? Are you using other treatments? Is the process effective? To put a final question in the mix, what kind of funding do you have, and is it adequate?

Mr. FROST. Always comes back to money, doesn't it?

The park is responding. The Park Service, as you well know, is a little bit different than the Forest Service and the BLM. How we're responding to the beetle-kill is, trying to protect health and human safety. The parks identified about a million trees that need to come down, and they're primarily around campgrounds and visitor services areas, so——

Senator UDALL. What was the term you used, "If you sit, stand, or sleep as a visitor, the Park Service is focused on mitigating or eliminating the danger in those"——

Mr. FROST. Right——

Senator UDALL.—"settings"?

Mr. FROST [continuing]. That's our high priority. We don't have plans to do any other types of removal activity—sort of, out in the back-country. The Park Service policies state that we want to encourage natural processes. While, the natural—as Dr. Saunders has stated, the outbreak of beetles may—beyond a natural process. We want to try and maintain those processes as much as we can in national parks. So, we are not—we don't have plans to thin the forests, to cut the trees down, but to—but, where it is responsible, where it is for health and human safety and close to our neighbors, that we are making plans in order to do that.

In terms of funding, I don't think there's any—well, I'm pretty sure there is not line item in the Park Service budget that has to deal with beetle-kill. Superintendents deal with this on a regular basis; they redirect funds from other projects, so other things don't get done. That's the way we've done business for many, many years. I suspect we could use some of our fee money, because it is related directly to fee services. I assume that that has happened in parks across the country.

Senator UDALL. I assume, on pretty good authority, that there's an increasing interest, on the group of political subdivisions, to coordinate, whether it's the Forest Service at the national level or it's our State forester, county of Larimer, even the town of Estes Park—there's a much greater awareness that potential fire events don't respect boundaries, that Mother Nature has evolved and developed in a way that didn't take into account the need for human political——

Mr. FROST. Right.

Senator UDALL [continuing]. Entities, but that there's much that's happening there. I know there could be more, and I look forward to playing a role to encouraging, to cajoling, to even sternly

saying to the various parties, "Look, you've got to work together and combine these resources." I think just, for example, in the eastern edge of the park, as you travel down to the northern area of Boulder County, there are homeowners and others who are concerned about kill-trees in the park itself, and that you're working to find a way to assuage their concerns.

Mr. FROST. Definitely. I would suggest that our fire-attack process may change in these areas, that we may put these—as opposed to a let-burn policy in some of our back country, we would put these fires out fairly quickly in order to not have a huge event that could come into the front country and cause a lot of damage.

Senator UDALL. If I could continue this line of discussion, and I want to extend an opening to each of you on the panel to comment, and also in the spirit of Senator McCain, who's always forward-looking—what happened in the past, happened in the past; now we have new challenges in front of us. Is there anything, in hindsight, that the Park Service could have done to mitigate these impacts on the park or in the surrounding communities?

Mr. FROST. Whoa, that's a great question. I don't know, maybe I could turn to Superintendent Baker——

[Laughter.]

Mr. FROST. I mean, that's a tough—it's really——

Senator UDALL. We'll ask Vaughn that question for the record.

[Laughter.]

Senator UDALL. I know he'd—otherwise, he'd feel left out.

Mr. FROST. That's a tough question, Senator. I mean, we often say hindsight's 20/20, but, you know, climate change is such a large issue, and there—and the beetle outbreak is larger than climate change. It has to do with how we've fought fires over the past 100 years. We have even stands of forest, so we have this monoculture out there. So, as opposed to having a distributed—you know, more of a distributed age class of trees, we have this mature growth out there. So, we don't have new recruits coming up. It's how we've managed our—a variety of other things.

So, it's not just the beetles, it's—the beetles is a key part, but it's a variety of other of our management techniques.

So, could have we prevented it? I don't know if we could have prevented it, in the context of a larger climate change issue, but we sure could have changed things. We hope that, as our stands do change over time, that we manage forest fires differently, we manage disease outbreaks differently, we——

Senator UDALL. When you say "stands," you mean stands of trees, not——

Mr. FROST. Stands of trees, yes.

Senator UDALL [continuing]. Political stands or——

Mr. FROST. No, no, no. That would be——

Senator UDALL. Yes.

Mr. FROST [continuing]. Your job, not mine.

Senator UDALL. All right.

[Laughter.]

Senator UDALL. Dr. Schimel, you care to comment?

Mr. SCHIMEL. Yes. I think that your question bears on an issue that's of great concern. If we look at the efforts that we're making to understand the physical climate system, we have large national

investments in integrating a wide range of observations—from surface observations, airborne, satellite observations—into models that provide some degree of predicative capability, fairly well understood for the weather, in its early days for climate. But, when we look at the issue of forecasting potential impacts of climate change, things like the pine-beetle outbreaks still come as surprises to us, because we aren't investing very much resource in attempting to forecast the ecological consequences of climate change. As we begin to develop more targeted observing systems, the potential that we'll be able to forecast these phenomena, that today come as surprises, becomes a real possibility.

It's a different sort of thought process than we've usually used in natural resource science, where most of this sort of modeling has been done in a very investigator-oriented sort of a way. But, the problems are complex, they require drawing in all sorts of information. The beetle problem is a beautiful one, because it's an effect of climate, it's an effect of 100 years of land-use history, it's an effect of the—exacerbated by the recent drought, and so on. Right now, we don't have the capability to integrate information about all those different sorts of stresses on the system to say what might be the next surprise after the mountain pine beetle.

Senator UDALL. So, again, I hear you suggesting——

Senator MCCAIN. Looks like Mr. Saunders has a——

Senator UDALL [continuing]. We'll go to—that you're saying, "Let's look at applying all of this data, let's look at even more sophisticated modeling." But, it has to be of use to people in communities, has to be of use to policymakers, has to be of use to the State forester and many others who are on the front lines.

I know Senator McCain chaired the Commerce Committee for a number of years. He knows the importance of our research institutions and of actually turning that data into something that's useful to people on the ground.

Mr. SCHIMEL. That's right. Right now, the effort to do this sort of forecasting is being done by individual researchers or small research groups, and the value added to turn that into information that can be used by resource managers happens in at best, a haphazard way, if it happens at all. So, the transfer of—well, first of all, there's not that much ecological forecasting being done; and to the extent that it is, it gets into the hands of managers in a very haphazard sort of a way.

Senator UDALL. We'd welcome further thoughts and comments, and I know you'll be forthcoming with us.

Mr. Saunders.

Mr. SAUNDERS. There is, again, a resource question, as there always is here, in terms of what the Park Service can understand, what the Park Service can forecast, what the Park Service may do in planning how to adapt. I mentioned a long-term idea about getting more money from the entrance fees. A short-term thing, that is waiting for you when you get back to Washington, is the spending bill for the next fiscal year. The Park Service requested $10 million for a new climate change initiative for fiscal year 2010. The House committee bill allows that full $10 million, but prohibits the Park Service from setting up a climate change office.

I think the Park Service should have a climate change office, myself; not that that one office is going to be the sole answer, but to have, in the Washington headquarters or somewhere in the system, one central place where all of the climate change information is coming together and being shared and all that, strikes me as making excellent sense.

On the Senate side, the Senate committee bill struck $2 million out of that $10 million, did not prohibit the climate change office from taking place, but lowered the dollar amount.

If this is the largest threat the national parks system faces, $10 million does not strike me as very much money to be trying to figure out how we're going to deal with this. This bill is not done. Certainly it would be crazy for Dr. Frost to come before you and criticize what your friends elsewhere are doing, in terms of the budget for next year, but let me just point that out to you; that may be something that, having seen firsthand all that there is to deal with, maybe you can go back and help move that small bit of funding along.

Senator UDALL. Let me turn back to Senator McCain. If he doesn't talk about and ask questions about water, I will.

Senator MCCAIN. Mr. Saunders, to follow up on your comment, I was surprised, when were talking about $780 billion of stimulus funding, that more of it did not go to this issue. I think it creates jobs. I think addressing the issue of climate change, if you appreciate the enormity of it, is going to create a lot of jobs in the future, and we'd better get a hold of it. So, I'll go back and we'll look at this process of—and I'm not sure why the Park Service should be prevented from establishing a climate change office.

I don't have anything more, Mr. Chairman, except to say that I thank the witnesses. I thank them for their hard work.

I guess while I'm here, I should, on behalf of the citizens of the state of Arizona, thank you for the water.

[Laughter.]

Senator MCCAIN. My predecessor in the Senate, Senator Barry Goldwater, used to say that, "In Arizona, we have so little water that the trees chase the dogs."

[Laughter.]

Senator MCCAIN. From the projections on the Colorado River flow, that may be more true than humorous.

So, I do want to thank the witnesses. I want to thank the people of Estes Park, and the great job they do in creating such a wonderful environment here; and what a great experience it was to spend the night at the Stanley Hotel. I didn't see a single ghost, but——

[Laughter.]

Senator MCCAIN. Maybe I didn't stay long enough.

I thank you, Mr. Chairman. I thank the witnesses.

Senator UDALL. Thank you, Senator McCain.

Let me direct a couple more questions to the panel. I did mention water, and Senator McCain did. We thought about taking him over to the Grand Lakes side, and we thought he'd be so excited to see the headwaters of the Colorado River, we didn't predict what he might do, although John was also excited to hear about the moose and the wolverine sighting. I found something out, I didn't know that there are otters in Rocky Mountain National Park; because

Senator McCain had the insight to ask one of the rangers about the otter population.

But, I want to direct this question to Dr. Frost and others who might comment—since we're, as I've said, literally at the headwaters of Colorado River and acutely affected by a warming climate, are there vegetation or soil management techniques that could be employed to reduce water loss so that we can be good partners with our friends in the lower-basin States, and also take care of our own needs, obviously?

Mr. FROST. Again, going to back to some of my earlier comments, you know, we try to keep natural processes in force, and to reduce stressors, and we need to continue to do that, in the face of a changing climate.

You know, if we have a massive beetle kill and we have a fire, we have a potential of a huge loss of erosion and water going, you know—water and soil running downstream, and that soil goes into reservoirs that clogs up the reservoirs, the storage capacity is reduced. So, we need to—you know, we need to continue to try and reduce the stressors on our environment as much as we can to—especially in parks, and try and encourage those natural processes. In areas that are—that have been—had some damage, we need to, you know, aggressively restore those areas. Those types of projects would have been great projects for stimulus money, to go through those areas that have been degraded in national parks, and to get them back into functioning ecosystems.

So, that's our primary goal in national parks, is to keep those natural systems functioning in a way that will produce those ecosystem services that we could never pay for. I mean, and that's really the key, is—the ecosystem of our national parks provides so much service to us that we take for granted, and our goal is to just keep those systems functioning the best to our ability.

Senator UDALL. Other panel members, comment on how we enhance water supplies, or at least maintain the levels that we've come to depend on, here in the West.

Mr. SCHIMEL. Just to mention this point about dust on snow, that is one of the major impacts increasing the rate of runoff and making it more difficult to capture that water for later consumptive use. So, land management that minimizes at least the continental United States source of dust to the Rockies could fairly substantially improve the job of the water managers today.

Senator UDALL. Have not the Western Governors been working on that challenge? Do they not have a policy now that, at least, is in its nascent stages of being developed?

Mr. SCHIMEL. That is exactly correct, yes.

Senator UDALL. Leader Madden, you——

Ms. MADDEN. Thank you. I just want to brag a little bit about what Dr. Schimel does, and who—and he's associated with NEON. They have 60 observatory sites around the Nation?

Mr. SCHIMEL. Planned.

Ms. MADDEN. Planned sites around the Nation. Because we really—we always need the data to rely on, and I think NEON is, just, a pretty spectacular entity that he's responsible for starting. So, I want to just thank him.

You know my world, it's politics and policy. In the State, there's a group of folks who sort of, you know, run the water show, and we call them "water buffalos." They're better at stopping bills then they are at actually passing bills, and we have a tough time moving this whole policy forward, because it's just—we have a prior appropriation system which, you know, the—they say, you know, "Whiskey's for drinking, and water's for fighting, in Colorado," and you see that every time you try to make some sort of changes. So, we've slowly made some changes in the State legislature around—making sure that we're conserving this resource.

It is very tough, and I think, as we work more regionally, that'll become very—

Senator MCCAIN. What is the rationale for the opposition?

Ms. MADDEN. One, just being afraid of change. You know, we have the system that works. We have very old water rights in the State and people are afraid that they're going to mess with them. Even things, just like, when water passes through the State, if you conserve water, maybe it won't—or if you conserve water, it might change when—what time of year it leaves the State. So, you know, there's political, there's science, there's all kinds of reasons that people are afraid of any sort of change.

We were able to pass a bill, just—if a new neighborhood is going up, they had to prove they actually had water for it. That was fought, initially.

So, I think it's just being afraid of change. We are a headwaters State for four different rivers, so the buck stops here, literally, with that water. We have to send a certain amount both east and west. So, Colorado's going to have to come to grips with conserving water. But, I think the more we can work regionally, the better we'll all be.

Senator UDALL. Mr. Saunders, do you have a comment——

Mr. SAUNDERS. No——

Senator UDALL [continuing]. Directed to water?

Mr. SAUNDERS [continuing]. Thank you.

Senator UDALL. Following on what Alice had to say, and the good doctors, we did just pass this new law, you can collect rainwater. Am I correct? I think—as you know, Arizona has similar statutes. First in time, first in right. The rainwater doesn't belong to anybody, but the watersheds themselves. So, that's an important step for—there are also cost models that need to be changed, from what I understand—where we reduce costs, the more water you use. It's a similar challenge we face in the world of electricity production, where we have an opportunity to create cost models where you actually make money, as a utility or as a water utility or as a water provider, if you use less. There's some creative ways in which to do that.

Senator McCain and I got to talking about tamarisk, and some of the experiments that are occurring with tamarisk. There are other national park units were tamarisk is a scourge. I hate to say that about any living thing, but it's——

Mr. FROST. There's lots of them out there.

Senator UDALL. There's lots of them. Would you care to comment on tamarisk and the efforts underway to restrict its range and perhaps make it more difficult for tamarisk to thrive?

Mr. FROST. There are a variety of efforts going on. You know, tamarisk is, again, one of these invasive exotic species that we talk about, sort of, in generalities, and this one of the things that have really taken over. It was originally brought into the country, you know, as a water—as a stabilizer of river banks. So, it was planted everywhere in order to stabilize these river banks. What it has done is, now it's sucking water out of the ground faster than we can talk. So, I know, in the Grand Canyon—if you take a float-trip down the Grand Canyon, there used to be willows down there. You know, the big willow tree that John Wesley Powell sat under, is—you almost can't see it anymore cause of tamarisk. I mean, you see tamarisk—I've seen tamarisk, like, this big, which is just extraordinary. It's just sucking water up. It's replacing the native vegetation. It has consequences for wildlife. Tackling a problem of that magnitude is extraordinary.

So, what the Park Service has done, initially, is to keep the spread of tamarisk going up from the drainages. You know, water in the Grand Canyon is a critical substance; and where you have seeps and springs, you know, it's like 1 percent of the land mass, but, like, 90 percent of the biodiversity. If you get tamarisk and exotic species in there——

So, the Park Service is taking a very aggressive stance in the national—in Grand Canyon—to work up those drainages and keep it contained. We're not—we don't have the capacity, right now, to eliminate that in the main stream of Colorado. But, if we can keep it contained and keep it out of the side drainages—and actually, that's where the big push is going on.

There's other areas in—I think, at Glen Canyon, where they're actually doing—they've got some beetles that they've released, from Asia, that are native predators of tamarisk, and they've done a lot of trials to make sure that they're not going to kill native—other native species. But, they let these beetles out, and they go through and the devastate the tamarisk stand. Sometimes you have to go back and do some follow-up.

There's also—there's a volunteer group in Glen Canyon that—this guy—and I can't remember his name; I wish I could—but, he lives, dies, and breathes to pull exotic species around Glen Canyon. He'll put together a volunteer group, jump on a boat, go up the reservoir, and they'll just spend a day, or a week, 10 days, out in the field, and do nothing but pulling weeds. It's inspiration like that, that is just tremendous, that helps us address these problems in ways that we couldn't do it by ourselves, because of lack of manpower and lack of funding.

Senator UDALL. Yes, I note those volunteer organizations that are affiliated with, I think, almost every national park unit, would be a real resource. I see a number of the lovers of Rocky Mountain National Park here in the audience, who've, at times, slapped me on the back and at times, slapped me upside the head——

[Laughter.]

Senator UDALL [continuing]. When you thought I haven't been doing the right thing on behalf of Rocky Mountain National Park.

Let me ask one last question, give each one of you a change to comment, and then we'll see if Senator McCain has any final words, and we'll bring the hearing to close.

Dr. Frost, Dr. Schimel, Ms. Madden, Mr. Saunders, you all implied, and in some cases were specific, about the threats that you see from climate change in relationship to the West and in Colorado, and I'm going to put Arizona on that list, as well. Can you explain why Colorado, why Arizona, based on these models, would be affected more significantly than some other areas of our country—or of the world, for that matter?

Mr. FROST. I think "location, location, location" is part of the deal, is, you know—Arizona—you look at the Southwest, it's where those—it's how the weather patterns have developed over time, and the models suggest that those weather—as those weather patterns change, it's going to get dryer, hotter, and droughts are going to be extended. In—and so, it's—to me, it's just a fact of location, you know. If Colorado happened to be in—this doesn't make any sense but——

[Laughter.]

Mr. FROST [continuing]. If Colorado happened to be in Montana——

[Laughter.]

Mr. FROST [continuing]. They'd be another—they'd be a different suite of problems. So, I think, the problems are unique to Colorado and Arizona, but a lot has to do with the location, the terrain—the physical terrain, the type of vegetation, and then, obviously, the impacts that humans have had on the environment. Iin fact, it may not be as bad in some areas, because the human impact hasn't been as great as in other areas.

Senator UDALL. Dr. Schimel, you care to comment?

Mr. SCHIMEL. Scientifically, the impacts of climate change on natural resources tend to be at a maximum when the effect of warming is combined with drying. Within the United States, Colorado and Arizona are in that zone that's experiencing both warmer temperatures and less precipitation. Models project that those two trends will continue. That means that the impact on vegetation, on in-stream organisms, fish, insects, and the plants that depend on the streams, are going to be very dramatically affected.

There are two other aspects of the environment. One is the alpine environment, Islands in the Sky. As tree line pushes up, as temperatures warm, and the temperature becomes warmer at high elevations, those are environments that, literally, will be pushed off the tops of the mountains—not move north or somewhere else, but they have nowhere to go.

Finally, of course, Colorado is part of the grassland region, as well. The grasslands of Colorado were devastated during the Dust Bowl, and again in the droughts of the 1950s. That's likely to happen again. If there's extensive warming and drying in the Great Plains, we'll see both the native grasslands and our agricultural systems there having to cope with a very, very stressful sort of combination of impacts.

Ms. MADDEN. I would just say that cultures and economies develop around the way things are, and, if you're lucky, you can maybe have some visionaries who see into the future, and you can slowly change things. These changes have come on hard and they've come on fast. I don't think we were prepared, and I don't think we've acted quickly enough, politically. I think everyone now

seems to be concerned and very on the ball, and I just hope that we can take the political actions that are necessary to change this.

I—you know, I live in a world where I want to know what I've accomplished by the end of the day, and so my focus is really around things like fuel-switching and increasing what we use for natural gas, energy efficiency, reaching into our existing housing stock, and making sure all of our buildings are more efficient, increasing the use of renewable energy, and just, then, knowing that we have reduced the greenhouse gas emissions in this State. These are things that can be done fairly quickly. I think it's incredibly important, and we have a real responsibility to do it.

Senator UDALL. Stephen, do you have a——

Mr. SAUNDERS. You've——

Senator UDALL [continuing]. Final comment?

Mr. SAUNDERS [continuing]. You've heard us say, several times, that here "climate change" means being both hotter and dryer. They work back and forth. Because we're hotter, we're going to be dryer. The scientists say if we have a 10-percent reduction in the precipitation, we'll have a 20-percent reduction in the stream flow. That's because the rate of evaporation is going to go up.

Because we are dryer, we're also going to be hotter. A human body cools from sweat evaporating. A planet cools, also, from the evaporation of the water. If we have less water to evaporate, the heat stays in the ground, if you will. So, those two things play back and forth and make each other worse.

Senator UDALL. Thank you for taking the time to be with us today.

I want to thank everybody in the audience for taking time to come and participate as a citizen.

When I was so fortunate to represent the 2nd Congressional District in the House of Representatives, initially I represented the lower third of the park in Boulder County, then the district changed to—John, I represented three-quarters of the park, including the west side. Now, I have the great fortune—it's all mine. I represent——

[Laughter.]

Senator UDALL [continuing]. All of Rocky Mountain National Park in the United States Senate.

The town of Estes Park, thank you for your gracious hospitality.

Again, I want to thank my good friend, one of the people I look to for mentorship and wisdom, who's a patriot, who's dedicated himself to a cause greater than his own self-interest, and that's Senator John McCain. He took the time to come to Colorado to see, firsthand, what's happening here, and I look forward to our partnership continuing as we face a lot of the challenges that our Nation has, but also, I think—what I love about John McCain is, he sees opportunities in those challenges. That's what I see in this great climate change challenge we face.

John, I don't know if you wanted to add anything else, but——

Senator MCCAIN. I do not, Mr. Chairman, except to thank you again, and thank the witnesses, and thank everybody for coming today.

Senator UDALL. The subcommittee on National Parks stands adjourned.

[Whereupon, at 1:18 p.m., the hearing was adjourned.]

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