National Park Service
U.S. Department of the Interior

Climate Change Response Program

Climate Change Response Program Newsletter

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SCIENCE • ADAPTATION • MITIGATION • COMMUNICATION

Are Pikas in Peril in National Parks?

The American pika (*Ochotona princeps*) is a charismatic indicator species of the potential effects of climate change on mountain ecosystems due to its sensitivity to summer heat and reliance on winter snowpack for insulation from harsh winter temperatures.

As a steward of pika populations in more than a dozen parks the National Park Service seeks to understand the vulnerability of pikas and other mountain species to climate change in order to better prepare for the ecological changes anticipated in the coming decades.

Pikas in Peril (PIP) is a Climate Change Response Program (CCRP) funded collaborative research program directed by scientists from the NPS, Oregon State University, University of Idaho, and University of Colorado-Boulder, with additional support from the Rocky Mountain and Pacific Northwest Cooperative Ecosystem Studies Units. Since 2010, PIP has been trying to uncover just how vulnerable pikas are to climate change in 8 NPS units.

The team developed a unique place-based approach for study design, capitalizing on the innate ability of the national park system to provide multiple different park study areas for "peeling back the onion layers" on complex, context-dependent questions like climate-biota relationships.

The results are (mostly) in, and the answer to the burning question "will pikas be adversely affected by climate change?" is "it depends..." It turns out, concerns about inevitable loss of pikas across all areas are probably not warranted. Rather, the species appears likely to persist in several of the studied parks and likely to decline in others.

To be sure, the study results confirm that accelerated warming projected across all the study areas will depress pika populations over time, but local mediating factors, including topography and habitat connectivity, have a very strong influence in models, counterbalancing regional climate stress in some parks.

For example, in Rocky Mountain National Park, gene flow and connectivity is currently high, but low elevations and south-facing aspects become impediments to gene flow over time as warming occurs, resulting in an increasing likelihood of pika extirpation by the end of the century. But in Grand Teton National Park, connectivity remains high in spite of climate change and the population is likely to persist over time, suggesting that this park will be an important refuge for the species.

For more information on the project visit the *Upper Columbia Basin Network's website*, which hosts the PIP web page and serves up publications, reports, and shorter resource briefs.

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Where Can I Find Climate Change Information About My Park?

Are you looking for climate change related information for your park? One source to check is the *NPS Climate Change Response Resources website*.

There are about 1000 park-specific briefs discoverable on the page including:

- 121 Eastern Forest Vulnerability briefs
- 289 Recent Climate Exposure briefs
- 340 Park Visitation and Climate Change briefs
- 180 Climate Change Summaries for Foundation Documents

Use the search bar at the top of the main web page to find climate-related products produced by the Climate Change Response Program for your park, or see the topic-specific tabs.

Of course, there are many other sources of information on climate change for your park and region. Search the *NPS Integrated Resource Management Applications (IRMA)* site for other park-related documents. Also check the *National Climate Assessment* for regional and national syntheses on climate change and related effects.

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Warming Temperatures Likely to Alter Visitation

Climate change will affect not only natural and cultural resources within national parks, but also visitation patterns. Where, when, and how many people visit parks is likely to change with continued warming. For example, visitors may avoid extremely warm months in low-lattitude parks and the visitation season may extend across additional weeks to months at northern parks. Whether park visitors shift their behavior in response to climate change will depend on multiple environmental and socioeconomic factors. However, understanding potential change in visitation based on historical trends and future patterns is a crucial first step for park managers and local communities to anticipate, plan for, and proactively affect future visitation.

Recently published research (*Fisichelli et al. 2015*) sought to understand the temperature/visitation relationship in 340 units of the U.S. national park system, from Guam, Hawaii, and Alaska to the contiguous 48 states and islands in the Caribbean. Researchers evaluated the historical relationship between long-term average monthly air temperature and visitation (1979-2013), and the modeled potential future visitation (2041-2060) based on two warming-climate scenarios and two visitation-growth scenarios. Park specific summaries are available at the *NPS Climate Change Response Resources website*.

The research presented here is not a forecast of what the future will be but rather a projection of how visitation may change. The models are tools to help managers envision potential future changes and begin thinking about management implications. The study uses a single explanatory variable, monthly average air temperature, and yet captures a large amount of the variation in visitation patterns across the system as a whole and at many individual parks. Many factors will alter and constrain actual future visitation patterns, including population changes, economic trends, and leisure time availability.

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Study Highlights

- Long-term historical monthly visitation across the National Park System is strongly tied to mean air temperatures (Figure 1)
  - 95% of parks show a significant relationship between visitation and air temperature
  - 69% of the variation in visitation across the system is associated with air temperature
  - Visitation increases with warming temperatures, but only to a point; visitation declines as monthly average temperatures exceed roughly 80°F
- Similar to other species, human visitors to parks are likely to alter their behavior in response to climate change
- Based on the historical relationship of air temperature and visitor use, the NPS and most individual parks show increases in potential future (2041-2060) visitation with warming temperatures
  - 8-23% increase in total annual visitors
  - 2-4 week expansion of the visitation season, on average, at individual parks
- Some parks with already very warm months are projected to see decreases in potential visitation and/or shifts in the timing of visitation to cooler months.

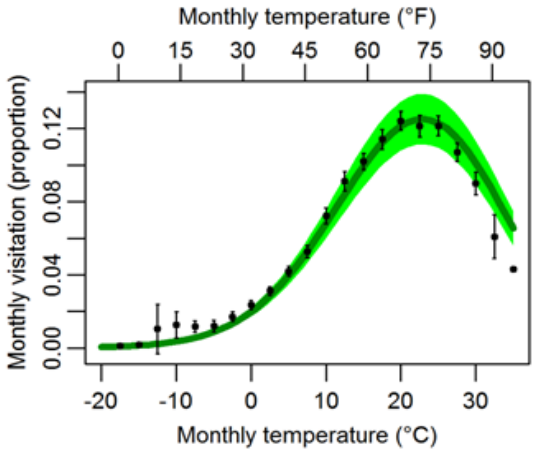

Figure 1. Relationship between historical (1979-2013) monthly average temperature and visitation across the U.S. national park system.

National Park Assets At Risk from Sea Level Rise

In advance of the two-year anniversary of President Obama's Climate Action Plan, Secretary Jewell released a report revealing that national park infrastructure and historic and cultural resources totaling more than $40 billion are at risk of damage from sea-level rise caused by climate change.

Scientists from the National Park Service and Western Carolina University reported on an examination of 40 parks—about one third of those considered threatened by sea-level rise—and the survey is on-going.

Specific projections of sea-level rise vary by site and time, but scientists expect a one meter rise in sea level to occur over the next 100 to 150 years. In some select areas of Alaska, relative sea level is decreasing because as land-based glaciers and ice sheets melt, land mass is actually rising faster than sea-levels. Both phenomena make changes in sea level a useful standard to assess vulnerability across the diversity of coastal area national parks.

"Many coastal parks already deal with threats from sea-level rise and from storms that damage roads, bridges, docks, water systems and parking lots," said Director Jarvis. "This infrastructure is essential to day-to-day park operations, but the historical and cultural resources such as lighthouses, fortifications and archeological sites that visitors come to see are also at risk of damage or loss."

Authors of *Adapting to Climate Change in Coastal Parks: Estimating the Exposure of Park Assets to 1 m of Sea-Level Rise*, examined 40 of the 118 national parks considered vulnerable to sea-level rise by NPS using data from many sources. Results from analysis of an additional 30 coastal parks will be released later this year.

Called "assets," the infrastructure and historic sites, museum collections, and other cultural resources of the 40 parks were categorized as high- or limited- exposure to risk of damage from one meter of sea-level rise.

More than 39% of assets in the subset of parks, valued at more than $40 billion, are in the high exposure category. Low-lying barrier island parks in the NPS Southeast Region constitute the majority of the high exposure category. At Cape Hatteras National Seashore in North Carolina, the current replacement value of rebuilding lighthouses, visitor center exhibits, and historic structures in other areas—all of which are rated as high-exposure assets—would be almost $1.2 billion. That value does not include billions for loss of lands and tourist income.

More than one-third of assets in the Northeast Region are in the high-exposure category. From the Statue of Liberty in New York to the landmark structures at Boston National Historical Park and Fort McHenry in Baltimore, many of these areas have great historical and cultural significance.

Although one meter of sea level rise may not seem like a lot, Jarvis explained that it would be part of a cascade of effects. "Coupled with sea level rise, big storms have that extra volume of water that can damage or destroy roads, bridges, and buildings, and we saw what that looks like - again - with Hurricane Sandy in 2012," the NPS director noted.

Many national park areas in the Northeast were damaged by Hurricane Sandy. The storm shuttered the Statue of Liberty for eight months and forced NPS staff to remove much of the Ellis Island museum collection when the heating, ventilation and air conditioning system was flooded with sea water. Those exhibits have yet to be returned while repairs continue.

The NPS lead scientist on coastal geology, Rebecca Beavers, said, "When we look back at Hurricane Sandy, a quick reassessment of the methodology in this report suggests that we were conservative in labeling an asset as 'high exposure.' Although reality may deal even more harsh circumstances as Sandy illustrated, information from this report provides a useful way to help determine priorities for planning within coastal parks."

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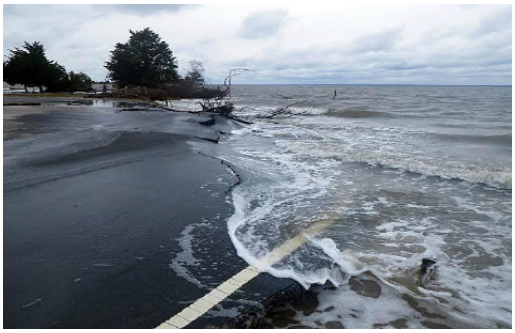

Bayside Picnic Area at Assateague Island National Seashore after Hurricane Sandy. NPS photo.

Denali Climate Anthology Goes Online

A new online anthology of essays by five accomplished local authors about the effects of a changing climate on the lives and landscape they treasure in Interior Alaska is available online.

The *Denali Climate Anthology* features works commissioned from writers Christine Byl, Julie Collins, Carolyn Kremers, Tom Walker, and Erica Watson. The free, online collection includes photo galleries, video, and audio clips.

"What this project was about was to tell real stories," said Deputy Superintendent Eric Smith during opening remarks at a public reading in June at Tonglen Lake Lodge, south of Denali National Park and Preserve. "I really appreciate that these guys have taken time to produce some very quality products."

The writers were asked to describe effects ranging from rising temperatures, vegetation changes, thinning glaciers, melting permafrost and shrinking wetlands. The collection also includes a forward by nature writer and environmental philosopher, Kathleen Dean Moore, from work she donated as a writer-in-residence at the park in 2013.

"We do a really good job of telling our stories to our constituency. We don't do as good of a job speaking to diverse audiences that maybe hold different viewpoints than we have," Smith said.

"We're not going to argue with people about what the cause is. But it's real, it's happening," he said.

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NPS Photo by Alex VanDerStuyf

Climate Friendly Parks: By The Numbers

Since its inception in 1916, the NPS has been a world leader in protecting natural and cultural resources for current and future generations. Today, the NPS faces a new challenge, one that extends beyond traditional boundaries, and as we approach our Centennial Anniversary we must be prepared to recognize and respond to new climate and sustainability challenges.

My Green Parks, a branch of the Climate Friendly Parks Initiative, helps parks and individuals to visualize their GHG emissions, and helps to develop ways to reduce these outputs.

To date Climate Friendly Parks have saved:

- 1,512,728 kWh of electricity
- 4,284,910 gallons of water
- 708,473 pounds of waste
- 7,025,605 pounds of CO_2
- 159,298 gallons of fuel
- $946,732 of taxpayer dollars

But the savings don't need to stop here! Small actions you take make a big difference. The vehicles we drive; the products we purchase; the food we consume; the energy we use to heat and cool our buildings; and how we interact with the land all have direct links to our ability to preserve the very places and resources we protect for future generations.

With more than 20,000 employees and over 288 million annual visitors to the nation's parks, the NPS can make a huge difference, and that can start with you! Navigate to the My Green Parks page to find out how you can make a big difference, with small actions.

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CLIMATE Friendly PARKS

SOCC Supports Sustainability for Hundreds of Parks

The *Sustainable Operations and Climate Change* (SOCC) branch of the Park Facility Management Division (PFMD) supports parks and programs in reaching agency-specific and federal government-wide sustainability goals – including those outlined in the latest Executive Order (EO), EO 13693 *Planning for Federal Sustainability for the Next Decade*, implemented through the National Park Service (NPS) Green Parks Plan (GPP). While support is geared toward specific sectors such as fleet operations, sustainable facilities, and pollution prevention, the SOCC efforts support broad categories of climate change response including adaptation, mitigation, and communication.

For over a decade, the SOCC has provided climate change and sustainability training and educational opportunities to staff from over 176 park units across the Service via the *Climate Friendly Parks* (CFP) program. The goal of the program is to assist NPS employees in understanding the effects of climate change on the resources they manage, measure park-based GHG emissions, consider adaptation strategies, and develop messages to educate park visitors about climate change as well as park sustainability initiatives. This interdisciplinary program is coordinated with staff across regions, national programs (e.g., Inventory & Monitoring Networks, Climate Change Response Program), and several divisions across agency directorates (e.g., PFMD, Air Resources Division).

To date, the program has welcomed 123 member parks from all regions of the agency. Member parks include sites that have completed all required milestones of mitigation for recognition as a member park.

"Our most successful accomplishments as a member of the CFP program has been in our ability to reach more visitors and employees with the additional 'green' and climate change programs. By reaching out beyond the boundaries of the park we will have the greatest impact on making the entire community more sustainable and climate friendly." -Anonymous from Annual Survey

In 2012, the NPS released the *Green Parks Plan* (GPP) which provides a sustainability vision for agency operations and supports Servicewide mitigation initiatives and efforts, including those of the Climate Change Response Plan. Within the GPP, a 35% greenhouse gas (GHG) reduction goal is identified by 2020 based on a 2008 baseline. To mitigate agency impacts to our environment, we must first understand GHG emissions caused by our operations. To do so, staff measure and monitor emissions generated from park operations by conducting park-based and agency-wide inventories. Since 2002, the SOCC has assisted staff in conducting park-specific GHG inventories via the Climate Leadership in Parks (CLIP) Tool, which calculates emissions based on daily operations, including emissions caused by energy use, fleet operations, water treatment and use, and employee commuting. These CLIP Tool inventories, as well as annual agency-wide inventories provide a tracking mechanism to help the NPS better monitor our impacts as well as the benefits of our sustainability actions. Inventories also help determine if federal and agency reductions goals are being achieved. Read some *success stories* from parks across the country.

While parks reduce greenhouse gas emissions, they also must consider what to do about currently ongoing and future climate change impacts, referred to as climate change adaptation. Adaptation is a critical part of the *NPS Climate Change Response Strategy*. Virtually all of NPS operations need to adapt. The question is, how? As part of the Climate Friendly Parks Workshops and other park planning processes, parks are learning how to develop and implement strategies that protect assets and infrastructure from the impacts of climate change.

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Fort Wadsworth, Gateway National Recreation area, site of the first Climate Friendly Parks Workshop.

Conservation Blueprint: Version 2.0

The South Atlantic Landscape Conservation Cooperative (LCC) released Version 2.0 of the *Conservation Blueprint* on June 12th. The Blueprint is a living spatial plan for conservation actions needed to sustain the region's natural and cultural resources for current and future generations—a shared vision for the future of the South Atlantic. The first version of the Blueprint, released in 2014, combined expert input with partner plans to generate a subwatershed-scale prioritization. Blueprint 2.0 uses indicators for terrestrial, freshwater, and marine environments to produce a totally data-driven prioritization at a much finer 200 meter pixel resolution. Blueprint 2.0 identifies priority areas for shared conservation action—including highest and high priority categories, as well as a medium priority class that captures potential restoration opportunities.

The Blueprint can serve as a landscape-scale climate adaptation plan. It explicitly models sea level rise and urbanization, calling for conservation action in priority areas predicted to transition as a result of those threats. It also includes climate-resilient biodiversity hotspots as an indicator, using data from The *Nature Conservancy's Southeast Terrestrial Resilience Project* to capture areas of unique geomorphology predicted to serve as climate refugia and sustain biodiversity into the future. A connectivity analysis further identifies corridors linking large patches of highest priority area, which follow major river pathways as well as connecting upland areas. This corridor network spans different climate gradients, highlighting opportunities for wildlife to migrate inland and to higher elevations in response to climate change.

Partners have already used the Blueprint to attract national fire resilience funding to the region, compete for coastal wetlands protection and climate-smart wildlife management grants, provide landscape-scale context for public lands planning, and prioritize fish passage efforts. Others are working to incorporate the Blueprint into local land acquisition criteria, ecosystem-based fishery management, and bobwhite quail habitat restoration. Through a transparent process, a science-based plan, and a user-friendly product, the South Atlantic LCC intends the Blueprint to eventually become a "gold standard" for large landscape conservation tools.

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Adaptation Planning for Northern Forest Ecosystems

A climate change adaptation planning project is underway encompassing seven national park units along the transition zone from temperate hardwoods to the south and the boreal forest to the north. Models projecting forest type changes have this transition line moving northwards. The boreal forest of parks like Voyageurs and Isle Royale may transform into oak savanna ecosystem, such as found in southern Minnesota and Illinois. Ramifications for birds, mammals, and vegetation in these parks are being explored. The project is a partnership between the Natural Resources Research Institute/University of Minnesota Duluth, University of Minnesota Twin Cities Department of Forest Resources and the National Park Service. The seven units include Voyageurs NP, Grand Portage NM, Isle Royale NP, Apostle Islands NL, Pictured Rocks NL, Sleeping Bear Dunes NL, and St. Croix NSR.

The project uses climate models coupled with land cover and ecosystem data to project how species found within the park boundaries may respond to a changing climate. As the habitat transitions, some species will move out of the area while others may move in and still others may stay in place in remnant pockets of current habitat or expand current range in the new habitat. In addition to looking within individual park units, the project looks beyond the boundaries to identify the closest available habitat. Distance, barriers to seed spread, and movement of animal species will have implications for future park management.

Projections to the beginning of the 22nd century seem far away but models show that profound effects may be seen within 50-60 years. Put in perspective, children completing junior ranger badges today will experience very different park landscapes when they return with their senior passes as retirees.

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Predicting Permafrost

Scientists from the Permafrost Laboratory at the University of Alaska Geophysical Institute are mapping present-day and predicted future permafrost across five arctic parks (Arctic Network/ARCN) using NPS data on soils and vegetation, plus climate data from global models of future warming.

Permafrost is ground that stays below freezing year-round, and it underlies most of ARCN. If mean annual air temperatures in ARCN increase about 2 °C by the year 2050 as expected, the permafrost model predicts that the thickness of the seasonal thaw layer will increase and permafrost will get warmer, but most of the permafrost present today in ARCN will remain frozen. In contrast, the more southerly parks Denali and Wrangell-St. Elias National Parks and Preserves showed widespread permafrost thaw by 2050. However, if an additional 2 °C of warming occurs between 2050 and 2100 as expected, the model predicts that much of the permafrost in ARCN will start to thaw. Thaw at that extent would have profound effects on vegetation and wildlife.

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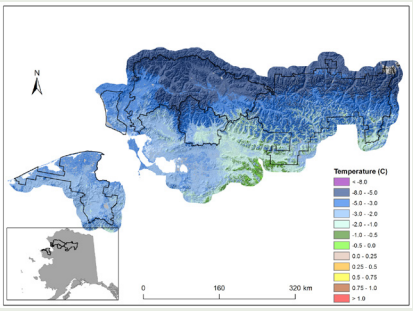
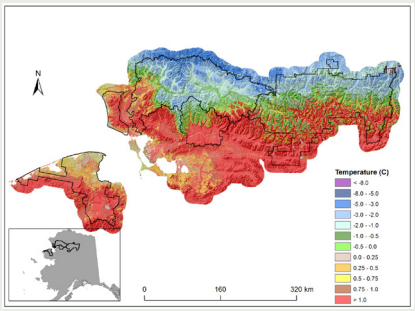


Present-day average ground temperature above permafrost across Arctic Parks.



Predicted average ground temperatures above permafrost in Arctic Parks from years 2091-2100.

Old Lakes, Unique Fish May Aid in Future Management

Isle Royale National Park, Sleeping Bear Dunes National Lakeshore and Voyageurs National Park each contain many inland lakes and a diversity of fish communities. The distribution patterns of fish species across these three parks provide clues about the original composition and origins of inland lake fish communities both in the parks and throughout the region.

A recent study by the USGS and the NPS estimated the ages of a group of inland lakes in each park, and then examined the current fish communities in those lakes to gain a better understanding of how the lakes were shaped by glacial history. This, in turn, may help to understand how the lakes and their fish communities may be changed by human-driven influences in the future.

Estimating the ages of inland lakes provides a historical context for the fish communities. Older lakes generally host populations of fish that have been present since the land emerged and created inland lakes out of what were once Great Lakes bays. These old, relatively pristine "heritage communities" and the "heritage species" they contain merit preservation because they are unique components of the regional biodiversity.

Lakes in the three parks range in age from about 100 to nearly 12,000 years old. Nine faunal assemblages—specific combinations of fish species within a lake's larger fish community—were identified among the three parks.

Because Isle Royale is in Lake Superior, which moderates the climate and stops colonization of park lakes by thermally tolerant and warm water species, the inland lake fish communities there are the most similar to those likely present at the end of the last ice age. Voyageurs is at about the same latitude as Isle Royale but has experienced greater changes in fish communities, primarily because of its inland location and historic drainage connections to the upper Mississippi Basin during the retreat of glaciers. Further south, where a warmer climate prevails, lakes at Sleeping Bear Dunes are more conducive to warm water species. These fish moved from the Mississippi Basin to colonize bays on the precursors to modern Lake Michigan during the late Pleistocene, about 13,000 years before present. Many of those bays became inland lakes as glaciers retreated and the land rebounded.

What can park managers do with this information? North American freshwater fishes exhibited a limited ability to adapt to the climate changes that occurred throughout the last ice age and since the retreat of the glaciers. Faced with an unprecedented rate of expected climate change in the 21st century, there is a potential for cool- and coldwater fish, many of which are heritage species, to become locally extinct. Generally, heritage lakes can support coldwater fish. Lakes with heritage communities and sufficient habitat to allow these fish species to survive could be designated as "refuge lakes."

There are four heritage lakes at Isle Royale and three potential heritage lakes at Voyageurs. (Sleeping Bear Dunes has no refuge lakes, and there are no coldwater species left there.) Unique heritage species in non-refuge lakes could be relocated to refuge lakes, if park managers believe this could keep a species from becoming locally extinct.

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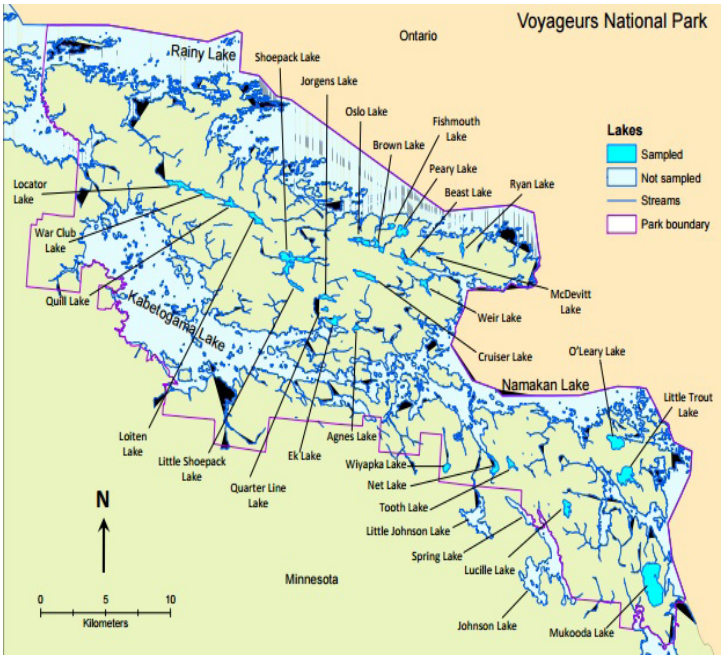

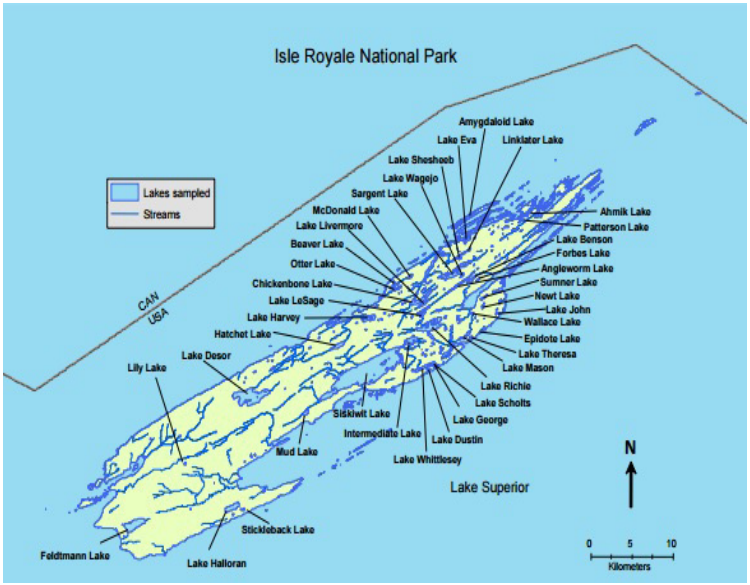

Maps of inland lakes in Isle Royale National Park (inset), Voyageurs National Park, and Sleeping Bear Dunes National Lakeshore.

Exterior Lighting Improvements at Fort Christianvaern

Christiansted National Historic Site, on the island of St. Croix in the US Virgin Islands, completed a project in May to replace their exterior lighting with sustainable lighting. The project helps advance the goals in the *Green Parks Plan* to "Preserve Outdoor Values" and "Be Energy Smart," as well as addressing the *Call to Action* to "Go Green." The project surpasses mere energy efficiency concerns by also taking into account dark night skies, wildlife, carbon footprint, public safety, and human health considerations, while reducing operational costs. The project resulted in the replacement of metal halide bulbs with light-emitting diode (LED) lights and fixtures.

The project focused on Fort Christiansvaern and its grounds, located on the waterfront of downtown Christiansted. Through collaboration between Natural Resources Stewardship & Science's (NRSS) Natural Sounds and Night Skies Division, Southeast Region, and the Flex Park Base Sustainability program aimed at assisting parks achieve sustainability goals and projects, the park acquired a full rendering, lighting design, and fixture replacement for the two most visible sides of Fort Christiansvaern and the area lamp posts. Christiansted NHS contracted with Aleut for the design, rendering, and replacing of fixtures.

Completion of the project resulted in the replacement of 12 flood lights and 12 pole mounted lights, as well as removal of one floodlight. The new floodlights are about a fourth the size of their predecessors, resulting in a much lower impact to the historic viewshed. The flood lights were also installed with visors, to limit the amount of light scatter above the fort walls.

The park looks forward to the costs savings by using LED high efficiency lights. The wattage requirements for the flood lights dropped from 250 to 50 Watts; the pole mounted lights dropped from 175 to 26 Watts per fixture. This decreased the power demand to 17% of the previous need for these 24 fixtures. In an area where electricity costs 42¢/kWh, almost four times the national average, energy savings convert into large dollar values quickly. Further cost savings will be recognized by the park through a reduction in replacement costs, due to the long life cycle of LED lights.

The park is now pursuing means to replace the rest of their exterior lighting fixtures. Not only will this save the park money, reduce energy and emissions, protect the night skies, and improve the viewshed, it will also increase security through better illumination of park buildings at night. In an area where vandalism is an ongoing problem, improved lighting that produces less glare and shadows is expected to greatly help protect the park's resources. Additionally, sustainable outdoor lighting will provide opportunities for local economic growth and enhanced community relations through astronomy-based tourism and other night programming options for the park.

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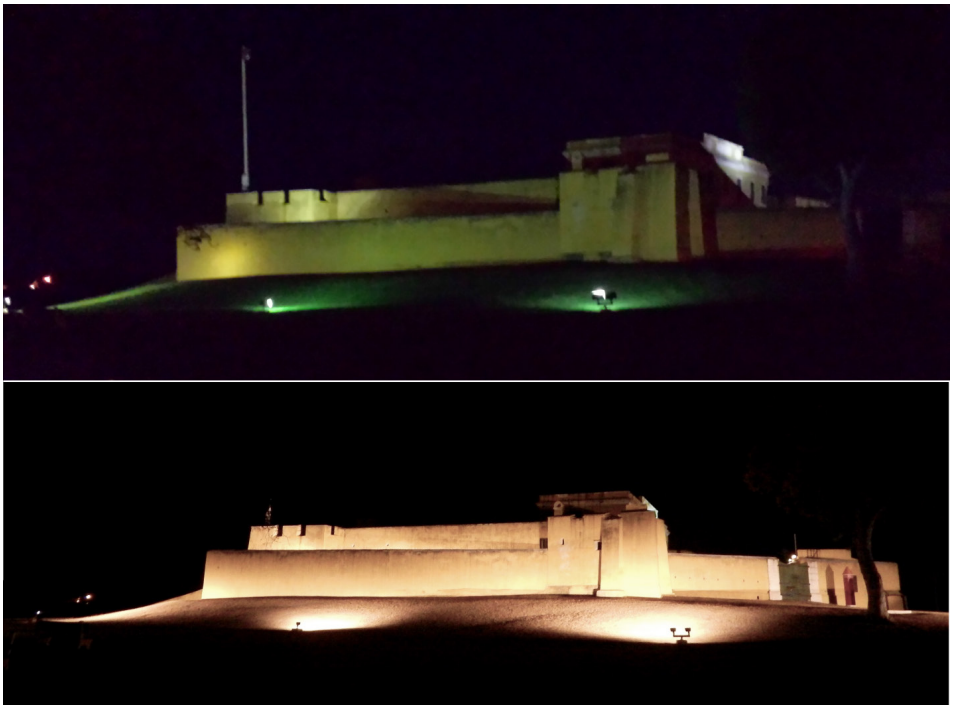

Fort Christianvaern, before and after lighting improvements.

Permafrost Thaw and Arctic Streams

Recent warming in the Arctic has accelerated permafrost thaw, which can considerably alter the structure and function of terrestrial and aquatic ecosystems. Several new studies have documented impacts of thaw on watershed hydrology.

Despite recent advances in our understanding of thaw effects on aquatic ecosystems, little is known about the effects on fish habitat, behavior, and productivity. To address this uncertainty, scientists from the USGS and the Arctic Network Inventory and Monitoring Program (ARCN) are beginning a new five-year study in the Agashashok River basin of Noatak National Preserve titled Hydro-Ecological Responses to Permafrost Degradation in Arctic Streams, funded by the USGS Changing Arctic Ecosystems program.

The Agashashok is located in the boreal-arctic transition zone, and remote sensing observations indicate that permafrost is actively thawing in portions of the watershed. An important goal of this study is to link hydrological processes, biogeochemistry, and fish ecology in a landscape undergoing dramatic change.

Researchers will integrate a variety of methods to better understand the effects of thaw on aquatic ecosystems and fish, including field observations and measurements, hydrologic modeling, and a fish energetics model. By combining these approaches, they hope to quantify thaw effects on fish metabolism in species such as Arctic Grayling and Dolly Varden. Model forecasting will help researchers to assess the vulnerability of aquatic resources under future climate warming scenarios. Findings from this research could be used to guide watershed management decisions.

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Predicting Plant Responses to Drought

A new U.S. Geological Survey study shows how plants' vulnerability to drought varies across the landscape; factors such as plant structure and soil type can either make them more vulnerable or protect them from declines.

Recent elevated temperatures and prolonged droughts in many already water-limited regions throughout the world are likely to intensify according to future climate model projections. This warming and drying can negatively affect vegetation and could lead to the degradation of wildlife habitat and ecosystems. It is critical for resource managers and other decision-makers to understand where on the landscape vegetation will be affected so they can prioritize restoration and conservation efforts, and plan for the future.

To better understand the potential detrimental effects of climate change, USGS scientists developed a model to evaluate how plant species will respond to increases in temperature and drought. The model integrates knowledge about how plant responses are modified by landscape, soil and plant attributes that are integral to water availability and use. The model was tested using fifty years of repeat measurements of long-living, or perennial, plant species cover in large permanent plots across the Mojave Desert, one of the most water-limited ecosystems in North America. The report, published in the *Journal of Ecology*, is available online.

Results show that plants respond to climate differently based on the physical attributes of where they are growing in the Mojave Desert. For example, deep-rooted plants were not as vulnerable to drought on soils that allowed for deep-water flow. Also, shallow-rooted plants were better buffered from drought on soils that promoted water retention near the surface. This information may be helpful for resource managers to minimize disturbance in areas that are likely vulnerable to water shortages.

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Saving Water - Saving Energy: Grand Canyon

Grand Canyon National Park recently embarked on the restoration of the Tuweep Water Catchment System. Although this rainwater collection system was originally built in 1935, it served its useful life and was in need of repair. This passive water harvesting system is the sole source of potable and non-potable water used to support operations at the Tuweep Ranger Station. The site is remote and two and one half hours from the nearest water source. A primitive dirt road to access this backcountry site is often impassable during winter or monsoon seasons.

The catchment system is 4,150 square feet and is constructed of half-inch corrugated, 24 gauge steel panels. The replacement steel panels and trough are coated with Kynar™ to provide safer drinking water, overall resistance of the metal compounds to solar decay, and a smooth shedding surface for water conveyance during a rain event. The roof surface is comprised of three terraces sloped to collect rainwater into an 80-foot steel trough at the downslope edge. The trough and end caps were also replaced in-kind and fabricated true to their historic form.

Water flows from the trough into a 1x2x4 foot collection box mounted directly underneath the trough and then is piped to a concrete storage cistern below. Two "first flush" diverters were added at the collection box to remove any accumulated sediment and prevent contaminants from entering the storage cistern.

The historic wooden structure supporting the catchment system was stabilized and restored with in-kind wood planks as needed. Original juniper logs driven into the ground as pillars were still in good shape and retained as part of the original structure. This work was completed by park staff and volunteers.

This water catchment system not only provides much needed water to this remote site, it also provides cost savings. Without having to transport water to the Tuweep Ranger Station, the park enjoys the cost savings of transportation, as well as the mitigation of GHG emissions of transport vehicles.

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Melting Snowpack Reveals Treasures from the Past

With recent Arctic warming, areas of permanent snow and ice aren't looking so, well, permanent. Globally significant archaeological and paleoecological discoveries have been made recently as ancient artifacts have been found beneath melting alpine snow patches and ice fields. Across the North, these frozen time capsules have yielded complete arrows with wood shafts and delicate feather fletching, skin clothing, and bark containers that date to as much as 8,000 years ago. Such perishable items decayed long ago in typical archaeological settings, but the cold temperatures in snow patches provide excellent preservation. Snow patch sites can also contain rich assemblages of plant and animal remains that shed light on long term environmental change.

These "natural freezers" are now shrinking, leaving any preserved artifacts susceptible to rapid degradation. The central Brooks Range within Gates of the Arctic National Park (GAAR) has excellent potential for snow patch finds but—due to the ruggedness and remoteness of the area—snow patches are not well-inventoried. To learn more about what we might be losing, GAAR archaeologists are working with Molly Tedesche, a PhD student in snow hydrology and a 2015 George Melendez Wright Young Leaders in Climate Change intern. Tedesche is modeling snow patch areas in GAAR with high archaeological probability using satellite imagery, high-resolution terrain data, and caribou telemetry data. In late July, Tedesche and GAAR archaeologists will conduct field visits to snow patches in the park to survey for archaeological and paleoecological materials, map the snow patches, and collect observational snow and ice data. The information gathered will also help focus future studies on the most vulnerable of these resources.

For updates on the snow patch survey and to learn about the people who might have visited these places long ago, visit their website.

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Snowpack archeology expedition.

Climate Change Response Program
Natural Resource Stewardship and Science

This quarterly newsletter celebrates the latest initiatives and accomplishments by National Park Service sites and programs in response to climate change.

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South Florida and Sea Level Rise

President Obama's visit to Everglades National Park in April highlighted the threat of climate change, providing a much needed emphasis on a problem that threatens the long term prospects for the region's unique ecosystems. What will South Florida's protected landscape look like in the near future? While there is a lot of uncertainty, the changes in the global climate may not bode well for the region. Historically, climate change has been a slow, gradual process. However, South Florida's rapid development over the last one hundred years almost guarantees that the impact of a rapid rise in sea level will be severe. Looking back at sea level rise and how it affected wildlife communities in what is now the Big Cypress National Preserve might provide clues to what lies in store.

Undoubtedly, rising sea levels will affect threatened and endangered species profoundly and perhaps spell serious trouble for species that are currently stable. Though much of the region is under protection and management, extensive development on Florida's crowded coasts and agricultural interior accentuate the hemmed-in condition of tens of thousands of animals. These species, already surrounded on all sides, might find themselves slowly squeezed in a vise between the effects of sea level rise and unchecked human development. In the past, habitats that were at the time unhindered by human development allowed for better migration and adaptation. A hundred years of rapid development have created isolated pockets in which two interdependent species, the Florida panther and white-tailed deer, have to survive. Canals, roads, drainage routes, and the expansion of agriculture and metropolitan areas into the interior created not only habitat reduction, but impassable barriers into safer habitats as well.

Already a last stand for the Florida panther, the pressure exerted by habitat loss, as well as sea-level rise in the Big Cypress region could be insurmountable. On the other hand, white-tailed deer, whose numbers are kept in check by panthers, could experience unchecked growth at a time while habitat is disappearing. Neither species can thrive in areas which might transform into salt marsh or estuary, environments that will likely expand if liberal estimates of yearly sea level rise are accurate. In one hundred years the remaining habitat of Florida panthers and white-tail deer in South Florida could be completely curtailed.

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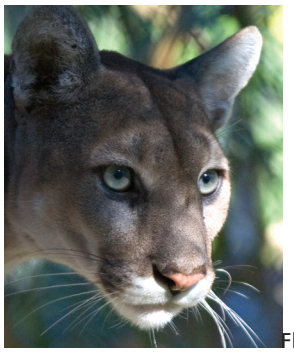
Florida Panther.

Monthly Webinar Series

Join CCRP for presentations by leading climate change scientists and communicators on the second Tuesday of every month from 2:00 to 3:30 PM EST.

October 8| George Melendez Wright Initiative for Young Leaders in Climate Change (YLCC), featuring a panel of climate change participants from the Summer 2015 YLCC season.
Register for the webinar here

GEORGE MELENDEZ WRIGHT
YOUNG LEADERS
IN CLIMATE CHANGE

November 12 | Archeology, Climate, and Historical Ecology of California's Channel Islands featuring Torben Rick, Chair, Human Ecology & Archaeobiology, Smithsonian National Museum of Natural History.
Register for the webinar here

Torben Rick