Everglades

National Park Service
U.S. Department of the Interior

Everglades National Park

Climate Change

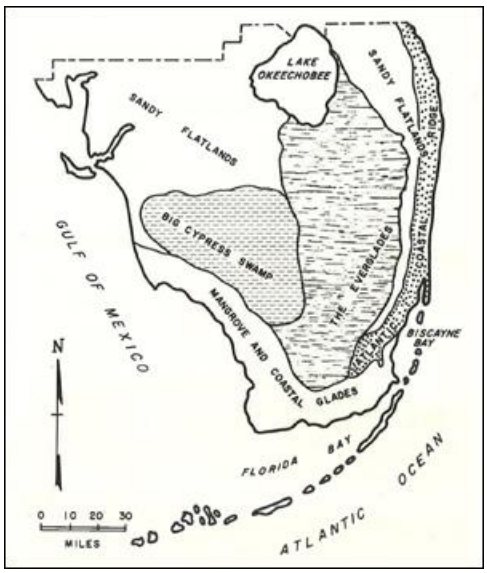
Nearly flat and perched on the edge of a rising ocean, Everglades National Park is already feeling the effects of a warming climate. Sea level rise has brought significant changes that are already being observed on the landscape, and more will likely be seen in the years ahead. The future of the park is clearly tied to the present, so what can we do *today* about climate change? Select a topic below to explore…

The Everglades Were Born From A Changing Climate

Imagine yourself visiting the Everglades 10,000 years ago, but instead of standing, you're on a boat and the only land you can see is in the distance. In fact, you would probably be quite disappointed because the Everglades don't even exist yet.

The Earth's climate is always fluctuating between glacial cycles that both alter the terrain and influence sea level over thousands of years (Lodge 2005). Florida's land mass developed during times of high sea level, when deep oceans covered the peninsula and deposited sediments and sand onto an existing mantle of ancient limestone (Lodge 2005). Periodically, this growing land mass emerged from the ocean floor as alternating periods of glaciation transferred more of the planet's water to ice on land and thereby dropped global sea level considerably.

Approximately 17,000 years ago—following the last such glaciation—the climate began to warm anew (Lodge 2005). During this warming trend, south Florida slowly developed the humid, subtropical character it enjoys today. Subsequent millennia brought the arrival of regular summer rains, feeding recently formed Lake Okeechobee. In times of abundant rainfall, the shallow lake would periodically overflow its banks and send water south, emptying into a rapidly rising ocean (Lodge 2005).



The historic communities of the south Florida ecosystem are the product of repeated cycles of climate change.

Image from Hoffmeister, John E. 1974. Land From the Sea, University of Miami Press.

The Everglades, as we know them today, find their origins about 3,200 years ago as the pace of rising seas slowed considerably from 23 centimeters (9 inches) to only 4 cm (1.5 inches) per century (Davis 1994). This slower rise in sea level allowed a buildup of mud, shells, and sand at Florida's southern coast. The resulting ridge then acted as a low dam and kept ocean water from passing over it. The natural dam also retained rainfall and overflow from Lake Okeechobee forming a freshwater environment, the Everglades (Davis 1994). Forged by thousands of years of change, a large portion of this unique landscape is now protected as Everglades National Park.

Why Protect Everglades National Park?

Everglades is but one of hundreds of national park units throughout the United States. The purpose of the National Park Service is to conserve the natural and historical objects inside parks, leaving them unimpaired for the enjoyment of present and future generations. Everglades National Park was authorized by Congress in 1934 to preserve the subtropical ecosystem and everything that lives within it. At the time, people were fascinated with the large number of wading birds that nested in the Everglades every year. In fact, the establishment of the park

marked the first time federal land was set aside for its abundance of diverse plant and animal species rather than for its scenic views.

Truman dedicating Everglades National Park in 1947.

NPS Photo

Although Everglades National Park represents only the southernmost fifth of the historic Everglades, it remains one of the largest parks (1.5 million acres) in the country. An impressive collection of nationally, and internationally, significant resources is protected within its boundaries, including the largest stand of sawgrass prairie in North America, the largest protected mangrove forest in the northern hemisphere, the vast estuary of Florida Bay, and cultural resources chronicling approximately 10,000 years of human experience. Everglades National Park is the only subtropical wilderness area in North America where, by federal law, people must make no impact on the land and ecosystem. Still, the influence of man is increasingly being felt on every acre of the Everglades in the form of human-caused climate change.

Everglades National Park was set aside to protect a landscape of national significance and the assemblage of life within it.

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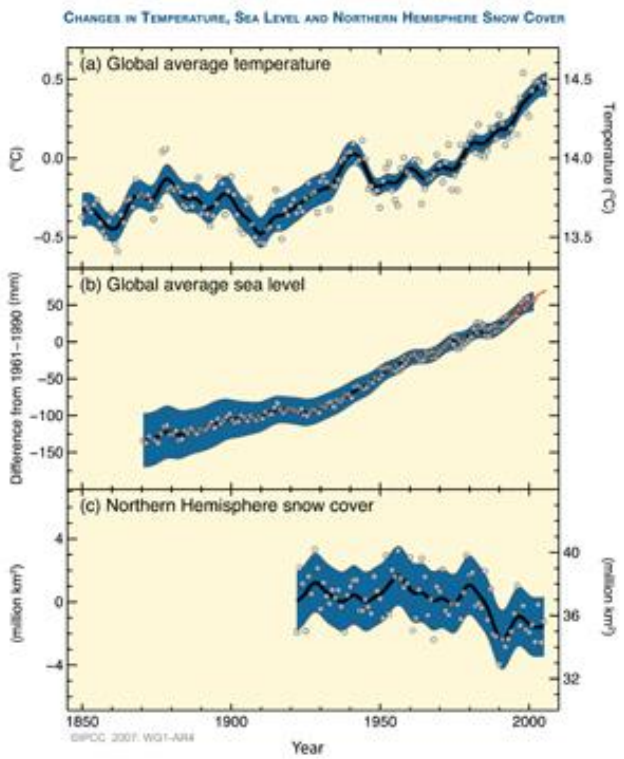
What We Know About Climate Change

Over the last 150 years, scientists have observed an increase in global temperature (IPCC 2007). There is a very high degree of confidence and agreement among scientists that the higher global temperature is caused by human activities that increase greenhouse gases in the atmosphere (IPCC 2007). Greenhouse gases are expected to cause further warming of the global climate with rates that could be greater than what was experienced in the 20th century (IPCC 2007). Warmer temperatures in turn influence other aspects of the climate system, such as precipitation, that

many living things depend upon (IPCC 2007 and Gonzalez 2011). Actually, changes in some species' normal life-history patterns due to climate change have already been observed at National Parks throughout the United States (Gonzalez 2011). For example, winter ranges of bird species have shifted northwards in over 50 parks, small mammals' habitats have shifted upslope in Yosemite, and conifer tree mortality has risen in four parks (Gonzalez 2011).



a) shows observations of global average surface temperature; (b) shows global average sea level from tide gauges, (the red line is from satellite data); (c) shows Northern Hemisphere snow cover for March and April. The differences are calculated from the 1961-1990 averages.

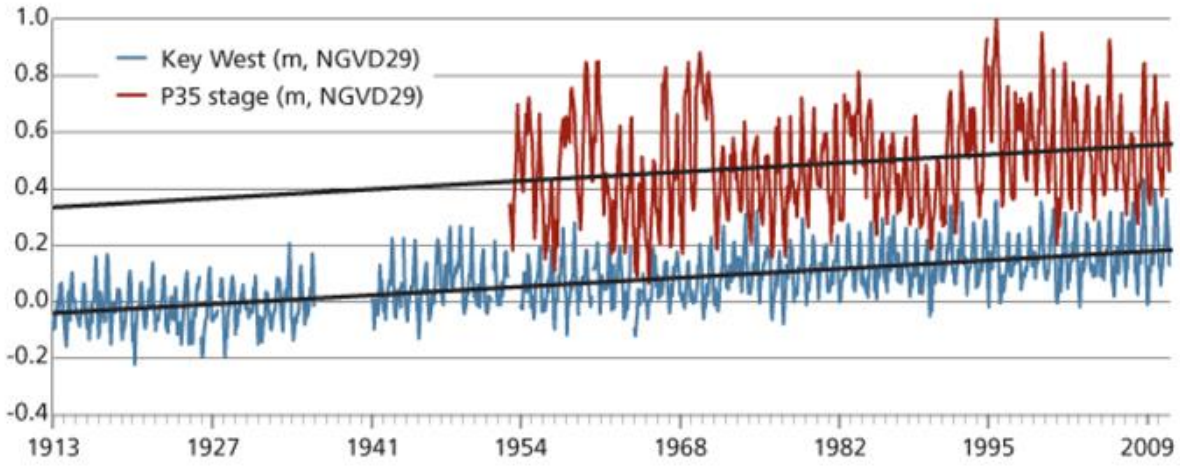
Figure from the IPCC Assessment Report 4, Working Group 1 Summary for Policymakers

As a result of warmer temperatures, scientists have observed a rise in global sea level and this has important consequences for south Florida (IPCC 2007). Sea level measurements are similar throughout the south Florida region and some even date back to the 1840s, making it one of the longest records in the U.S. (Maul 1993). The average rate of sea level rise from the monitoring station in Key West is 13 cm (5 inches) per century for the period from 1846 to 1992 and is consistent with the global estimate of about 12 cm (4 ¾ inches) per century from the 1990 Intergovernmental Panel on Climate Change First Assessment Report (Maul 1993). This accelerated rate of rise—brought about by human-caused warming—threatens to outpace the ability of plants, animals, and processes of the Everglades, which are already being affected by sea level rise in many ways, to adapt.

Sea Level Rise In Everglades National Park

The environment of south Florida and the Everglades is unique because of its low elevation and subtropical climate. Along the coast, seasonal pulses of freshwater from the north meet the constant fluctuation of the tides that nurture several distinct ecosystems, including buttonwood forests. These coastal communities are home to many rare and endangered plants such as tropical orchids and herbs, some of which are found only in south Florida (Stabenau 2011). Unfortunately, these species' special home is in danger because the habitat is changing, in part, due to sea level rise—causing the salinization of groundwater and the soils above (Stabenau 2011). It is unclear whether or not these species can tolerate the increased salinity that will come as sea level continues to rise due to climate change.

Scientists measure water levels throughout the park—including the many inland, freshwater habitats. The water level in these areas varies with changes in rainfall and freshwater flow as well as influences from ocean tides. Over the last 50 years, the scientists have observed an increase in the water level at some inland, freshwater sites in the park that is consistent in pace with the observed increase in regional sea level (Stabenau 2011). Though it is presently unclear why this correlation exists, and what implications it might have for the freshwater environments of the Everglades, it does suggest the influence of sea level rise may reach far inland.



Graph shows that the rate of marsh water-level rise in the park is similar to the rate of sea level rise observed in Key West. The black line is the trendline for the timeseries.

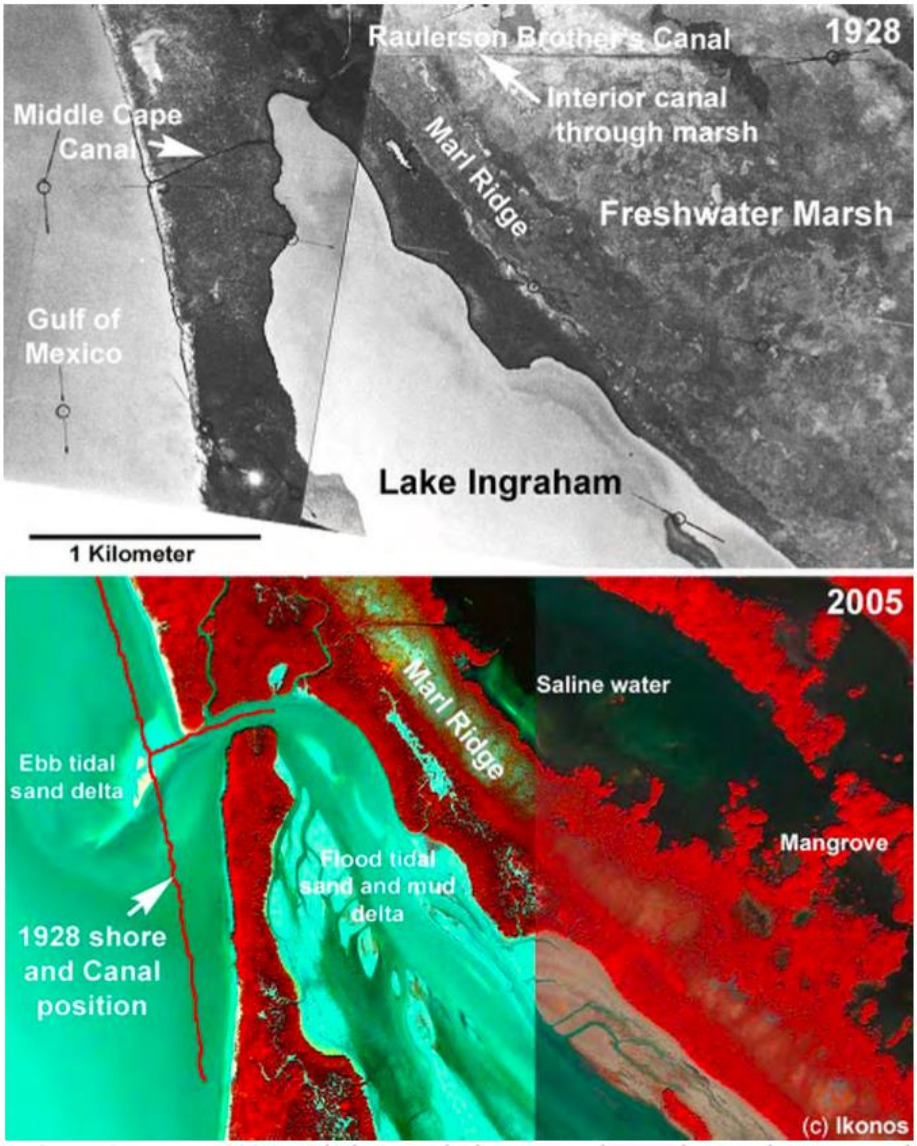
Figure from Stabenau, Erik, Vic Engel, Jimi Sadle, and Leonard Pearlstine 2011. "Sea-level rise: Observations, impacts, and proactive measures in Everglades National Park." Park Science 28:26-30.

What's Happening to Cape Sable?

One of the most drastic changes in landscape in Everglades National Park, and one that is complicated by sea level rise and inland effects, is seen in the Cape Sable area. The Cape is a large coastal landmass located at the southwestern tip of Florida that was once characterized by an expansive interior freshwater marsh and associated freshwater lakes. In the early 1900s, settlers determined to use the area for agriculture began draining the freshwater out to the ocean so the land could dry (Wanless 2005). It turns out, the canals they built—coupled with the effects of hurricanes and the manipulation of water farther north—have transformed the coastal system of Cape Sable, and much of this alteration has been aggravated by climate change.

Scientists have used certain clues buried in the geology of the landscape to estimate sea level long before humans had instruments to do so. This analysis shows that sea level rise in south Florida was relatively slow over the past 3200 years (Wanless 2005). But our modern instrumentation has recorded an accelerated rate of rise over the past century, which has had visible impacts on Cape Sable. The canals are now a pathway for salty ocean water and sediments to travel inland, especially during high tides or with the help of strong wind and surge from tropical storms (Wanless 2005). In recent years, the interior freshwater marsh has disappeared almost entirely, and nearby lakes have filled almost completely with marine

sediments. Changes along the Cape also have implications for the mangrove trees that live at the waters edge. In response to rising seas and increased flooding, the trees have been moving inland as the habitat becomes more suitable. And along the coast, high tides and storm surges have helped wash away sediments awry from their roots and have contributed to erosion along Cape Sable (Wanless 2005). While many wonder whether coastal plants and mangrove forests will be able to keep pace with sea level rise, others are beginning to notice similar changes further inland.



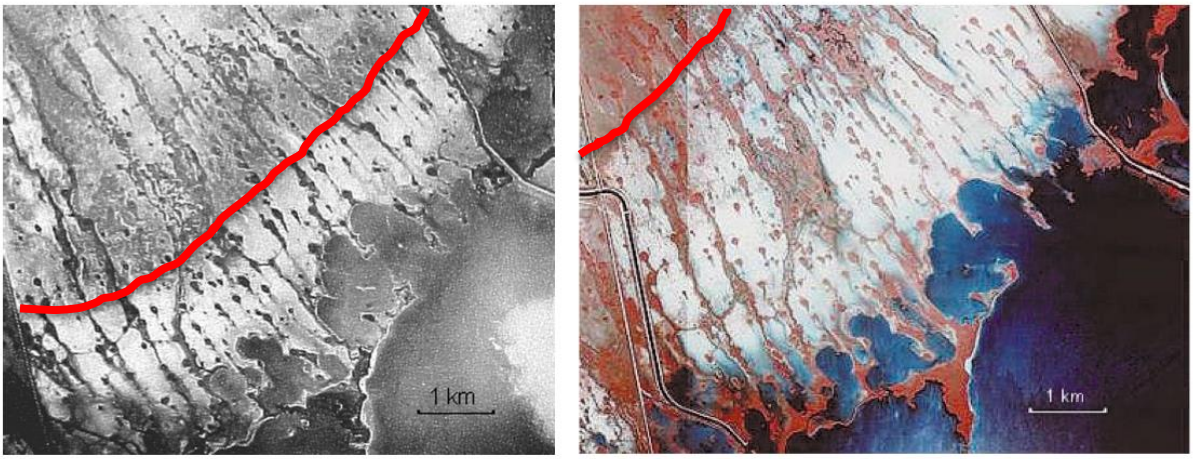
These images show the expansion of Middle Cape Canal, the retreat of the shoreline, and the conversion of freshwater marsh to saline water and mangroves from 1928 to 2005.

Images from Wanless, Harold R. and B. M. Vlaswinkel 2005. "Coastal landscape and channel evolution affecting critical habitats at Cape Sable, Everglades National Park, Florida." Report to Everglades National Park.

How Are the Saline Glades Changing?

While Cape Sable is unique, changes in plant communities in the park are not limited to that environment. Paralleling the shoreline in extreme southeast Florida is a clearly distinct vegetation community known locally as the saline glades. The saline glades is a long, linear zone of sparsely-vegetated marsh, much of which occurs within Everglades National Park. Because this area receives little freshwater flow and lies just out of reach of the tides, it is unfavorable to the growth of most inland and coastal plant species (Ross 2000). The zone is best characterized by the few plants species that can survive there: stunted red mangroves, sawgrass, and spike rush.

Over the past 50 years, the coastal vegetation of red mangroves has expanded its range inland (over 1 km in some areas) and has displaced other freshwater species (Ross 2000). The red mangroves are able to grow farther inland because the exchange of fresh and saline water in the marsh has been influenced by roads, canals, and sea level rise. Roads block the flow of fresh water from the north into the saline glades and canals reroute fresh water away from the area (Ross 2000). Storm surge and overwash from extreme high tides also deposit salt into the soils, making the area inhospitable to freshwater species, and rising seas have helped extend this reach farther inland. This increasingly salty environment makes it easier for saline species to grow, and reduces the overall area of freshwater marsh (Ross 2000). The increased sea level has also brought similar changes elsewhere in south Florida.



1940 **1994**

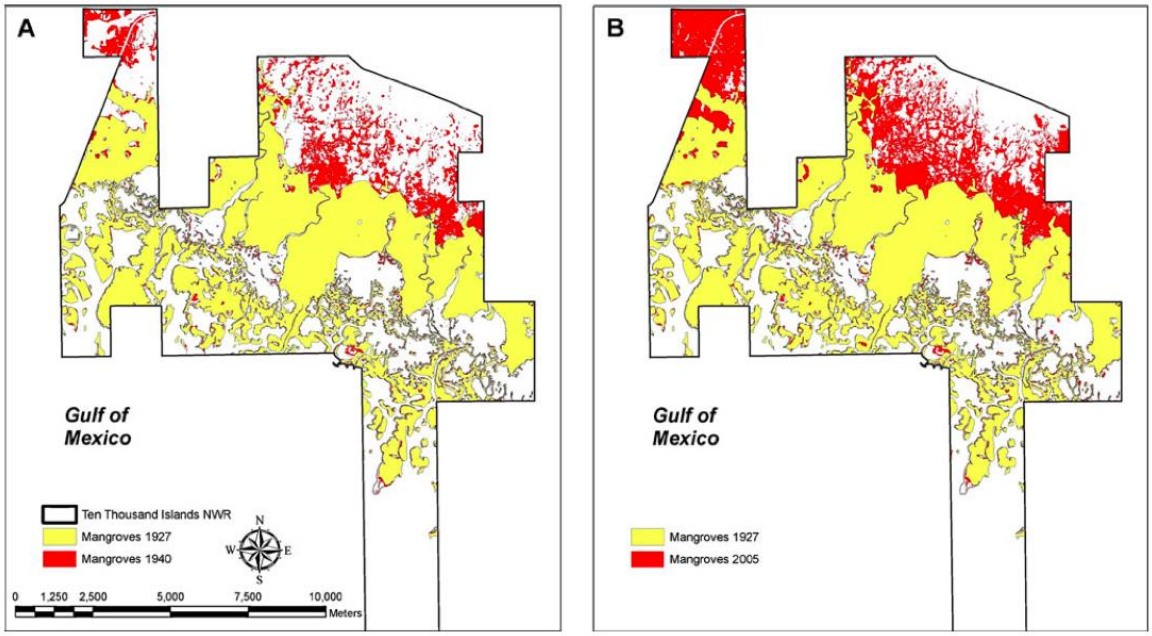
The red line in the photographs show the interior boundary of the saline glades has moved inland from 1940 to 1991.

Images from Ross, M., J. Meeder, J. Sah, P. Ruiz, and G. Telesnicki 2000. "The Southeast Saline Everglades revisited: 50 years of coastal vegetation change." Journal of Vegetation Science 11:101-112.

How Else Is South Florida Affected?

In addition to effects of sea level rise in Cape Sable and the saline glades, changes also exist outside of Everglades National Park. Northwest of Everglades National Park in the Ten Thousand Islands National Wildlife Refuge, mangroves have expanded and grown inland into what were previously freshwater environments (Krauss 2011). And in the southernmost Florida Keys, freshwater pine forests are shrinking and are being replaced by plants that live in saltwater (Ross 1994).

In both cases, plants are responding to the conversion from freshwater to saltwater environments because of sea level rise (Krauss 2011 and Ross 1994). These observed changes are important because they show that the consequences of sea level rise are occurring throughout south Florida and may indicate what these coastal habitats will be like in the future. From these changes, already observed, scientists may learn how to best manage our coastal ecosystems over the long term.



The location of mangroves move inland from 1927 to 1940 (A) to 1927 to 2005 (B).

Images from Krauss, Ken W., Andrew S. From, Thomas W. Doyle, Terry J. Doyle, and Michael J. Barry 2011. "Sea level rise and landscape change influence mangrove encroachment onto marsh in the Ten Thousand Islands region of Florida, USA." Journal of Coastal Conservation 15:629-638.

Not only are natural resources affected by climate change, but so are the many cultural resources in south Florida. These include various artifacts and shell works originating with Native Americans, shipwrecks, pioneer homesteads, and even a Cold War era Nike Missile site.

Sandfly Island in the Ten Thousand Islands Archeological District of Everglades National Park is an important cultural site currently impacted by climate change. It consists of 22 acres of prehistoric networks of earth and shell mounds–or middens–that are approximately 3,000 years

old (Paul O'Dell, personal communication, April 26, 2013). Water erosion and wind damage over the years have made parts of the Sandfly Island shoreline and its tidal creek banks collapse. This further exposes the fragile archaeological site to sea level rise and increased salinity that can harm the artifacts. These sites allow scientists to examine human history, but the artifacts may be less useful in the future if they are washed away or too damaged to analyze.

In 2012, using a high resolution 3D laser-scanner, scientists were able to collect data such as artifact locations and shell orientations from the eroded Sandfly Island banks. These data can show how many and what types of artifacts exist now and can then be compared to data collected in the future (Paul O'Dell, personal communication, April 26, 2013). The park would likely benefit from information like this for the hundreds of other cultural sites that exist. However, the challenge for cultural resource managers is to balance the acquisition of additional site inventories with working to protect known cultural resources.

Archaeologists collect data from the shell middens at Sandfly Island. This embankment composed of ancient shell is at risk of erosion from sea level rise.

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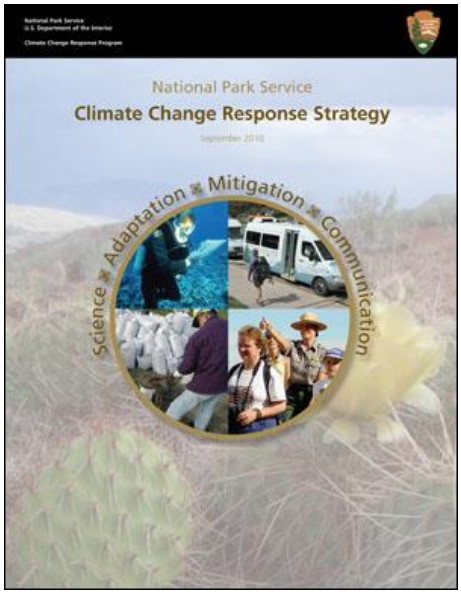
The Climate Change Response Strategy



One of the first efforts that Everglades National Park made to address climate change was participating in the Climate Friendly Parks Workshop in 2005. The park realizes it is at risk from the effects of climate change and developed several commitments to reduce greenhouse gases. The plan for new management of transportation and facility operations is available here.

Climate change poses challenges for the National Park Service to leave park resources unimpaired for future generations. The Service created a Climate Change Response Strategy that designed goals and objectives to address climate change. It utilizes four components: science; mitigation; adaptation; and communication to guide activities.

Monitor the Environment

Park scientists operate an almost 90-foot tower to measure the interactions of carbon between the atmosphere and plants in mangrove communities.

NPS Photo

An important part of being able to notice if our environment is changing is to know what it was like in the past. There are many scientists who continually measure these changes over time. These observations are made across a wide array of indicators, including coral health, nesting of wading birds, vegetation communities, fish abundance and diversity, hydrology and water quality, threatened and endangered species, and cultural sites.

Changes in the environment often lead to management challenges and questions about how to deal with the changes. Original and targeted research is often necessary to address these questions. The park employs many experts that work daily to resolve important management questions, and encourages research by third-party agencies and institutions on park resources.

Adapt To Climate Change

A view south from the plug at East Cape Canal looking towards Florida Bay. Note the difference between the silted tidal water to the south of the plug, and the clearer freshwater behind it.

NPS Photo

During the 20th century, several canals were dug to drain the freshwater marsh of Cape Sable. Over the past century, these canals—in tandem with sea level rise—brought pronounced change to the once exclusively freshwater environment. In an effort to stop the intrusion of salt water to Cape Sable, the park has plugged some of the canals. The most recent technology was implemented in 2011 with hopes to increase resilience from sea level rise as a result of climate change.

The Comprehensive Everglades Restoration Plan (CERP) is a multibillion dollar project authorized by Congress in the year 2000. Since then, the effort has increasingly been viewed as south Florida's preeminent adaptation strategy against

climate change. Expected to take about forty years to complete and managed by the U.S. Army Corps of Engineers and the South Florida Water Management District, CERP aspires to increase freshwater storage, improve water quality, and re-establish the natural water flow through the greater Everglades ecosystem. If successful, these efforts will help protect subterranean aquifers from salt water intrusion, delay the impacts of sea level rise along the coast, and buy precious time for wildlife to deal with their changing environment.

The C-111 canal pump stations became operational in early 2013.

Image credit to the Army Corps of Engineers

There are two recent restoration projects that will improve water flow in Everglades National Park. The first is the C-111 canal pump stations to the east of the park. The C-111 canal has drained water from the Park into Florida Bay for decades. Now, a pump station redirects water from the C-111 canal to a detention area that helps prevent the loss of water from Taylor Slough and the eastern portion of the park.

The second is the L-29 canal, levee, and one mile bridge on Tamiami Trail. The canal and levee just north of Tamiami trail have stored water and provided urban flood protection for decades. However, the canal, levee, and Tamiami Trail road have blocked water from flowing south into Everglades National Park. This reduction in natural water flow, and negative impact on the park, is addressed by raising a one mile portion of Tamiami Trail so that water can flow freely into the park without damaging the road.

Everglades National Park, the South Florida National Parks Trust, and the University of Miami's School of Architecture developed this prototype for a semi-permanent Eco-Tent.

NPS Photo

During the 1950's, a visitor center, lodge, marina, and campground was constructed at Flamingo. These facilities provided services to visitors for many years, but were heavily damaged by hurricanes Katrina and Wilma in 2005. What was left of the buildings was removed and, therefore, some visitor services were lost. The park is making an effort to provide similar visitor services again while being mindful of potential impacts from hurricanes and climate change in the future.

To minimize the risk of future loss, the park is experimenting with a combination of both elevated and semi-permanent structures in the redevelopment of Flamingo. A prototype "Ecotent" was unveiled on December 19, 2012 for use during the winter season and to illicit feedback from visitors. When in use, the tent rests on a raised wooden platform and will be disassembled and stored to avoid damage during the

hurricane season. This prototype allows Flamingo to increase visitor services and rebuild in a sustainable manner.

Mitigate Our Contribution to Climate Change

Climate change is primarily caused by the increase of greenhouse gases in the atmosphere from human activities. To address climate change, the National Park Service is committed to reducing its carbon footprint, the total amount of greenhouse gases produced by an organization and all of its activities. Everglades National Park employs various methods to decrease their carbon footprint-mitigation strategies-such as using alternative energy.

One of the solar lights at the Ernest Coe Visitor Center parking lot.

NPS Photo

At the Ernest Coe Visitor Center, the Park uses solar power to light the parking lot when dark. Operating lights on solar energy helps decrease the contribution of greenhouse gases from the use of fossil fuels. Being in the sunshine state certainly makes it easy for the Park to harness sustainable solar energy.

One of the solar powered water heaters at the Flamingo campgrounds.

NPS Photo

At the Flamingo campgrounds, the Park uses solar powered heaters to provide hot water for showers. Hot water was not available until the solar heaters were installed in 2010, so they also offer an improved service for you, our visitors. The high percentage of sunny days in Florida makes this an ideal way to contribute to the Park's energy conservation goals.

A biodiesel tram at Shark Valley.

NPS Photo

In 2012, Shark Valley Tram Tours replaced its fleet of petroleum diesel trams with biodiesel trams. Biodiesel fuel is made from vegetable oil, animal fats, or recycled restaurant grease and must meet certain standards in order to be used. The biodiesel trams are more fuel efficient than the old diesel trams and get about 2 to 3 times more miles per gallon.

Using biodiesel fuel significantly reduces the emission of greenhouse gases and harmful pollutants, bringing the Park closer to achieving its goal to make operations more sustainable. It was a long process to get these wonderful biodiesel trams, thank you Shark Valley Tram Tours Inc.!

Additional mitigation strategies include:
-Replaced most of the park's vehicles with hybrid cars
-Replaced old air conditioning systems with higher energy efficiency systems
-Adopted an energy conservation strategy for all park facilities

Park employees accept delivery of their first hybrid vehicles in 2008.

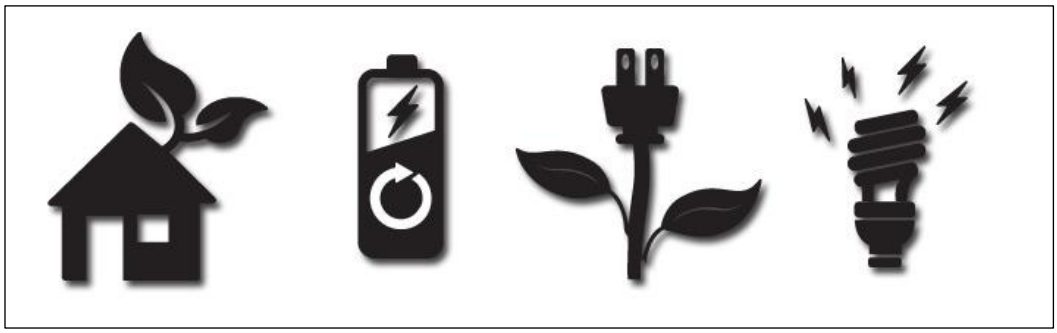
NPS Photo

What Can You Do?

The actions you take to decrease your carbon footprint can have an influence all the way from Glacier National Park to the lowlands of the Florida Everglades.

Some actions you can take at home and in your community are:
-Recycle
-Carpool
-Take public transportation when convenient
-Raise the air conditioner one degree or lower the heater one degree
-Install energy efficient compact fluorescent lights (CFLs) or light emitting diodes (LED light bulbs)
-Turn off appliances when not in use (examples: fans, lights, computers, cable box, etc.)
-Unplug appliances when not in use (examples: hair dryers, toasters, etc.)
-Weatherstrip windows and doors

Don't forget to share with your family and friends ways they can help protect national parks like Everglades!



Learn More About Climate Change

Several articles and supplemental links are provided on the webpage, http://www.nps.gov/ever/naturescience/cclearnmore.htm.

Glossary

Adaptation - to adjust to changes in the environment caused by climate change

Carbon footprint - the total amount of greenhouse gas emissions that one's activities produce

Climate change - changes in climate over time caused by human activities

Glaciation - time periods in Earth's history where ice mass on the planet is increased

Greenhouse gas - gases in the atmosphere that absorb and emit radiation and cause the atmosphere to warm by the greenhouse effect

IPCC - the Intergovernmental Panel of Climate Change, an international group of expert scientists that assess the most current knowledge of climate change information

Mitigation - to decrease one's contribution of greenhouse gases to the atmosphere

Saline - water that contains salt, like that of estuaries or the ocean

Sea level - the average level of the ocean's surface over a given area

Storm surge - a sudden rise in the level of ocean water, usually caused by tropical storms/ hurricanes and/or strong winds and can cause flooding

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