



Pintail duck photo by Peter LaTourette

Climate Change, Wildlife, and Wildlands

Case Study

Everglades and South Florida

Impacts at a Glance

- The Everglades and other south Florida ecosystems already are stressed by the pressures of human development. Global warming will add additional stresses, such as higher water levels, increased salinity, and warmer water temperatures.
- The sea along the Florida coast is rising 6–10 times faster than the average rate for that area over the past 3,000 years.
- Sea level in south Florida is likely to rise 20 inches above its 1990 level by the year 2100.
- Higher seas will make inland areas more susceptible to damage from storm surges during hurricanes.
- The freshwater Everglades are separated from Florida Bay by a wide ring of mangroves that act as a natural dike against the sea. The future survival of the Everglades depends in part on whether the mangroves can continue to keep pace with sea level rise.
- Warmer water could damage Florida's temperature-sensitive coral reef communities through a phenomenon known as coral bleaching.



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Rising Seas, Changing Climate

The broad, shallow river of grass that stretches south from Florida's Lake Okeechobee is the largest remaining subtropical wilderness in the continental United States. Everglades National Park is one of the crown jewels of the National Park Service. The only place in the world where alligators and crocodiles exist side by side, the park provides important habitat for a rich variety of wildlife, fish, and plants, as well as a freshwater source for south Florida's burgeoning human population.

The Everglades are home to some of the nation's most spectacular wild creatures, including the American crocodile, Florida panther, and West Indian manatee. The vast sloughs and sawgrass prairies provide crucial habitat for endangered birds such as the snail kite and wood stork, and threatened species such as the southern bald eagle, piping plover, and roseate tern.

The Everglades also are a place apart, a natural area unlike any other in North America.

The 1.5 million-acre Everglades National Park has been designated an International Biosphere Reserve, a World Heritage Site, and a Wetlands of International Importance. As Marjory Stoneman Douglas wrote in 1947, "There are no other Everglades in the world. They are, they always have been, one of the unique regions of the Earth; remote, never wholly known."

In addition to the complex and fragile Everglades ecosystem, south Florida's abundant natural treasures include cypress swamps, mangrove forests, a highly productive estuary, coral reefs, and the Florida Keys. South Florida's natural areas provide visitors and residents with some of the nation's best fishing, diving, canoeing, camping, birding, and nature study opportunities.

But south Florida also faces severe environmental challenges. Florida has one

of the fastest growing human populations in the United States, especially in the southern counties of Miami-Dade, Broward, and Palm Beach. Some 900 people move to Florida every day, with 39 million people vacationing in the state some years.

The Everglades have been called "the most endangered national park in the nation."

Water management systems for flood control, agriculture, and urban water supplies have dramatically altered freshwater flow through the River of Grass, with repercussions throughout the ecosystem. For example, the draining of the Everglades caused wood stork populations to decline by almost 95 percent from the 1870s to the 1970s. The reduced water flow has allowed saltwater to penetrate inland, contaminating freshwater aquifers, and agricultural runoff has polluted the water with phosphorus and other excess nutrients. With less freshwater flowing into Florida Bay, the bay has become saltier.

"The Everglades is a test.
If we pass, we get to keep the planet."

— Joe Podgor, Former Executive Director
Friends of the Everglades

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The increasing salinity affects life in the bay and may harm coral reefs near the cuts where bay water flows to the ocean through the Florida Keys.

Federal and state programs are underway to restore freshwater flow to the Everglades and to prevent further damage to the ecosystem. But some scientists are concerned that these efforts may not save the Everglades in the long term. These scientists recognize that the Everglades and south Florida are vulnerable to a very different threat emerging on the horizon: the rapidly rising seas and climatic changes associated with global warming.

Higher seas already are affecting the Florida coastline, and scientists expect the changes to accelerate in the decades ahead.

Visitors to the observation tower at Shark Valley in the year 2050 or 2075 might behold a very different landscape from the one they see today. University of Miami geologist Harold Wanless speculates that instead of today's River of Grass dotted with tree islands, the view from the tower might be one of mangrove-lined creeks and shallow saltwater or brackish ponds. The once-plentiful alligators and deer might be a rare sight at Shark Valley, many of them having moved inland to find better habitat with fresher water. Along the Wilderness Waterway, a popular canoe

route that runs along the western side of the Everglades, campsites and chickees (elevated camping shelters) could be flooded with saltwater.

The effects of future sea level rise on the Everglades are uncertain. The freshwater Everglades are separated from the sea by a broad ring of mangroves. The mangroves' roots trap sediments, building thick layers of peat that have created a wide, low dike against the sea. If this natural barrier can continue to grow vertically in pace with sea level rise, the Everglades may be relatively unaffected by the rising tide. But if the sea rises faster than the mangroves, or if large tracts of mangrove forest are damaged by hurricanes and fail to recover, much of the freshwater Everglades might disappear during the next 100 years, replaced by saltwater wetlands and shallow bays.

Scientists do not know which is the more likely scenario. In the face of such uncertainty, many environmentalists and policymakers believe we should "hope for the best but plan for the worst," and take precautionary action to slow global warming and sea level rise.

The Rising Tide

How does global warming lead to sea level rise? A warmer climate causes water at the surface of the ocean to expand and adds large quantities of freshwater runoff from melting glaciers and ice sheets. In areas where the land is sinking, as it is along much of the southern Atlantic and Gulf coasts, the effects of rising seas are even more pronounced.

South Florida's sea level has risen about 12 inches since 1846. It is still rising today, at a rate that is equivalent to 8-16 inches per century. That rate is 6-10 times faster than the average rate of sea level rise along the south Florida coast during the past 3,000 years.

If the current trend were to continue without any additional global warming, the sea along the south Florida coast would climb another 3 inches by 2025 and 10 inches by 2100. But the global warming predicted for the decades ahead is expected to accelerate sea level rise. During the next 25 years, the sea is likely to rise 5 inches rather than 3. By 2100, the best available science indicates that south Florida seas will be approximately 20 inches higher than they were in 1990. There is even a 5 percent chance that the sea will rise by as much as 36 inches.

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Rising seas may cause the Everglades system to drain more sluggishly. Saltwater may move up rivers and into aquifers, contaminating freshwater ecosystems and groundwater. Mangroves may spread inland and invade formerly freshwater marshes. Rising sea levels in conjunction with storms are likely to increase coastal flooding and erosion, causing more particulate matter, dissolved organic matter, and nutrients to flow into bay waters, affecting animal and plant life in the bays and coral reefs.

Looking beyond the next century, EPA researchers estimate that the sea in south Florida probably will rise 30 inches above 1990 levels by the year 2150. At those levels, most of Everglades National Park could essentially become an extension of Florida Bay. South Florida's key deer, alligators, panthers, and other wildlife

What is Global Warming?

The Earth's climate has changed in the past, and will continue to change naturally in the future. Ice ages, long warm periods, and short-term fluctuations in temperature and precipitation are all elements of the global climate's natural variability.

Today, the average global temperature is rising. Is that natural? Some of the temperature increase can be explained by natural factors. But many scientists believe that a portion of the warming trend may be caused by humans. Human activities are creating a buildup of greenhouse gases—primarily carbon dioxide, methane, and nitrous oxide—in the atmosphere. The heat-trapping property of these gases is undisputed. Although scientists do not know exactly how the Earth's climate responds to increases in greenhouse gases, they do know that the current warming trend is consistent with changes that would be expected from the increase in greenhouse gases.

Scientists generally believe that the burning of fossil fuels and other human activities are the primary reason for the increased concentration of carbon dioxide in the atmosphere. Fossil fuels burned to run cars and trucks, heat homes and businesses, and power factories are responsible for almost 99 percent of U.S. anthropogenic carbon dioxide emissions and about 20 percent of our nitrous oxide emissions. Of the carbon dioxide emissions, industrial activity accounted for 33 percent in 1997. Personal and commercial transportation accounted for 30 percent, and residential and commercial energy use accounted for 19 and 16 percent, respectively. Increased agriculture, deforestation, landfills, industrial production, and mining also contribute a significant share of carbon dioxide, methane, and other greenhouse gas emissions.

Average global temperatures at the Earth's surface have increased 0.6–1.2°F since the late 19th century. The 10 warmest years in the 20th century all occurred in the last 15 years. Snow cover in the northern hemisphere, floating ice in the Arctic Ocean, and the areas covered by mountain glaciers have all decreased. Globally, sea level has risen 4–10 inches during the past century. Worldwide precipitation over land has increased by about 1 percent, and the frequency of extreme rainfall events has increased throughout much of the United States.

Although it is impossible to predict future changes in climate with certainty, many scientists believe that the continued addition of greenhouse gases to the atmosphere is likely to raise the Earth's average temperature by several degrees in the next 100 years. Rising global temperatures are expected to raise sea level and change precipitation and other local climate conditions. Changing regional climate could alter forests, crop yields, and water supplies. It also could threaten human health and harm birds, fish, and many types of ecosystems.

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would be squeezed into a shrinking habitat bounded by the shoreline advancing inland from the south and west, suburban development expanding from the east, and agricultural development in the north.

Changes in Store

In addition to the rising seas, scientists expect global warming to lead to changes in temperature and precipitation that will affect plants and wildlife.

Although it is impossible to predict with certainty the future climate of a small region, computer models suggest that the overall climate in Florida may warm and that extremely hot days in summer may become more frequent. A warmer climate could allow heat-loving pest species, such as the invasive Australian *Melaleuca* tree, to expand their range northward in Florida. However, if warmer winters lead to fewer frosts, tropical plants and trees

that are vulnerable to cold temperatures may benefit.

Increases in the atmospheric concentration of carbon dioxide, one of the primary greenhouse gases responsible for global warming, may affect competition and dominance among plant species. Carbon dioxide generally promotes plant growth, but not all species respond alike to higher concentrations of the gas.

Many people wonder if global warming will affect rainfall, hurricanes, or the severe weather events associated with El Niño and La Niña. Rainfall has indeed declined in the Keys and parts of south Florida over the last 100 years, while increasing in central Florida and the Florida Panhandle. But scientists do not know to what extent these changes are related to global warming. If rainfall continues to decline in the future, water supplies for south Florida residents could be threatened. Past droughts have led to

mandatory water restrictions in the region, a situation that could be exacerbated in the future as sea level rise causes saltwater to infiltrate aquifers.

Scientists also are not certain whether global warming would affect the frequency and severity of hurricanes and tropical storms, or if it would change the frequency and strength of El Niño and La Niña events. El Niño has been linked to the drought and subsequent wildfires that occurred over much of Florida during 1998.

We do know that global warming and sea level rise will add yet another stress to south Florida ecosystems already threatened by urban development, agriculture, air and water pollution, water management practices, and invasions by exotic species. Some researchers are concerned that climate change and sea level rise could help push endangered species like the Florida panther and key deer even closer to extinction, because the



photo: National Park Service

“Competition [for diminishing freshwater resources] will surely result in a no-win situation for humans and the Everglades under a scenario of global warming and rising sea level.”

— Intergovernmental Panel on Climate Change, 1995

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photo: National Park Service

remaining populations of these species may be squeezed between the rising sea and human populations. There are 16 endangered and six threatened wildlife species in the four national parks and preserves of south Florida.

Florida Bay

Florida Bay is the world's largest sea grass bed and a nursery ground for at least 22 species of commercially and recreationally harvested fish. The bay is a crucial nesting area for American crocodiles and provides year-round habitat for manatees, ospreys, bald eagles, and wading birds.

Florida Bay will be affected by climate change and sea level rise. The bay is likely to become deeper than it is now. As storms superimposed on higher sea levels cause

What Can Be Done?

Prevention of human-induced climate change also is an important strategy. Some global warming probably will occur no matter what we do, because some of it is natural. But also, humans have become dependent on fossil fuels. The burning of fossil fuels emits greenhouse gases, which may remain in the atmosphere for years, decades, or even centuries, exacerbating the natural warming. But we as individuals can take action now to reduce our own consumption of fossil fuels by improving energy efficiency and using alternative energy sources. (See "Searching for Solutions" on pages 8–9 and "What People Can Do" on page 9).

increased erosion of the coastline, Florida Bay's waters may become cloudy with eroded sediments. During the next several centuries, many of the undeveloped keys that currently dot the waters of Florida Bay may disappear as the sea rises.

Plants and animals that live in the bay are sensitive to changes in the proportion of fresh to salty water. During the 20th century, water management projects in south Florida increased the salinity of Florida Bay by diverting freshwater that formerly flowed in from the Everglades. Salinity is especially high in drought years. High salinity may have played a role in recent mass die-offs of more than 100,000 acres of seagrasses in Florida Bay. Highly saline water from Florida Bay also can harm coral reefs in the Keys.

Scientists are not certain how global warming will affect the salinity of Florida Bay. On the one hand, sea level rise would increase the bay's salinity by adding more

seawater to the bay. Warmer temperatures would increase evaporation, making the bay even saltier. But if global warming also causes precipitation to increase, more freshwater could enter Florida Bay during the rainy season. Under that scenario, seagrasses and other plants and animals in the bay could be harmed, since too much freshwater is as harmful as too little.

The Keys

Productive coral reefs, seagrass beds, and mangroves make the Florida Keys one of North America's unique natural ecosystems and a top destination for scuba diving, snorkeling, and sport fishing.

Sea level has fluctuated many times since the formation of the ancient coral reef that is now the upper and middle Keys. Today, sea level is rising. At Looe Key, a spectacular reef system, land is visible only during some low tides. Back in 1744, when

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a British ship ran aground, the captain later described to the admiralty an island—Looe Key—that measured 350 meters long and 75 meters wide.

The Florida Keys will be strongly affected by future sea level rise. Some may simply disappear from the map. Much of the land in the Keys is extremely low-lying—between zero to around three feet above current sea level. These areas would be severely flooded if predictions of an 18-20 inch rise in sea level during the next 100 years prove accurate.

The Keys already are experiencing rapid sea level rise. Measurements at Key West indicate that sea level has risen about one foot since 1846, and currently is rising at a rate of approximately 15 inches per 100 years.

Higher areas will be more vulnerable to damage from storm surges than they are

today. From 1900 to 1994, 36 percent of all U.S. hurricanes hit Florida.

Coral Reefs

The largest living coral reef in the contiguous United States lies seaward of the Florida Keys. This coral ecosystem is more than 130 miles in length, making it the third largest coral reef tract in the world. Extending south from Miami to the Dry Tortugas, the reefs are home to more than 5,500 marine species. The reefs also act as a natural buffer to protect the Keys against catastrophic storm surges from hurricanes.

Climate change could threaten the reef through warmer ocean temperatures, changes in the salinity of water from Florida Bay, and increases in the water's sediment load from coastal erosion.

Corals worldwide can tolerate temperatures only a few degrees higher than normal high temperatures for their particular region. As a result, global warming could exacerbate a phenomenon known as "coral bleaching." Increases in water temperature of one degree Fahrenheit or more for as little as one month often result in extensive coral bleaching, which occurs when warming waters or other stresses cause the expulsion of algae that normally live with the coral. The algae are important for the health of the reef because they provide corals with much of their food and oxygen. Ultimately, the loss of these algae may kill the coral.

A number of stresses or environmental changes may cause bleaching, including disease, excess shade, increased levels of ultraviolet radiation, sedimentation, pollution, salinity changes, and increased temperatures.



photo: George Genity, USFWS

"Coral reefs are projected to be among the most sensitive ecosystems to long-term climate change."

— Rafe Pomerance
U.S. Deputy Assistant Secretary of State for the
Environment and Development, March 5, 1999

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Mangroves

Rapid sea level rise could harm low-lying mangrove communities, affecting the many important environmental functions they provide. Mangrove communities filter out pollution, stabilize sediments, and hold nutrients—all functions that help to protect the shoreline from coastal erosion. Florida's mangrove forests also provide food, nesting, and nursery areas for many animals—including more than 220 fish species, 24 reptile and amphibian species, 18 mammal species, and 181 bird species.

Mangrove trees have special salt-filtering roots that allow them to obtain freshwater from saltwater. The trees produce peat by trapping sediments in the water, and the process of building peat normally allows mangroves to keep up with rising sea levels. Some researchers believe that mangroves can withstand a sea level rise of only four to five inches per century—considerably less than that projected for the next 100 years. But others believe the picture is more complicated, and that mangroves in some areas may have little trouble keeping up with sea level rise. In general, the response of mangroves to sea level rise depends on the type of mangroves, their environmental setting, the amount of freshwater available to maintain root growth, and the sediment supply.

Mangrove communities in south Florida already are affected by a number of stresses, including invasive Brazilian Pepper plants, hurricanes, agricultural runoff, and human development. Climate change and a rise in sea level pose new stresses to an ecosystem already in danger.

Searching for Solutions

To address the threat of global warming, south Florida could improve the health and resiliency of its natural ecosystems, prepare for rising sea levels and other changes, and work to limit future sea level rise and global warming by reducing greenhouse gas emissions.

Many efforts are underway to restore the Everglades and prevent further harm, including the massive program for “replumbing” the Everglades, the Everglades Forever Act, the South Florida Ecosystem Restoration Task Force, the Florida Governor’s Commission for a Sustainable South Florida, and other federal, state, and tribal ecological restoration efforts. These programs may help improve the ability of the Everglades and other south Florida ecosystems to adapt to climate change. A healthier Everglades with improved freshwater flow would be less vulnerable to



photo: National Park Service

the stresses of a changing climate, and would slow the invasion of saltwater.

A number of initiatives to protect coral reefs also are underway. For example, the U.S. Coral Reef Initiative, launched in 1996, supports efforts to conserve and sustainably manage coral reefs and related ecosystems such as seagrass beds and mangrove forests.

Regional and local planning and zoning policies could take into account the implications of future sea level rise. New development could be set back far enough to allow wetlands to move inland naturally as the sea rises. For example, some states prohibit new houses in areas likely to be eroded in the next 30-60 years. Other states have implemented some version of

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“rolling easements” in which landowners are allowed to build but only on the condition that they will remove the structure if and when it is threatened by an advancing shoreline.

Programs to help endangered species recover and to help restore ecosystems also could factor in future sea level rise. Conservation officials could try to ensure that species have somewhere to move when the sea rises—a challenge in south Florida where so much land already is developed.

Slowing Climate Change

Today, action is occurring at every level to reduce, avoid, and better understand the risks associated with global warming. Many

What People Can Do

We all add greenhouse gases to the atmosphere whenever we use energy from fossil fuels. Residential energy use accounted for 19 percent of overall CO₂ emissions from the combustion of fossil fuels in 1997, and motor vehicle use accounted for approximately 20 percent. Here are a few actions that people can take to reduce their emissions.

- If you live in south Florida, you can help restore freshwater flow through the Everglades by saving water: avoid excessive watering of your garden or washing of your car, use low-flow toilets and showerheads.
- Use mass transit, carpool with friends, or ride a bike whenever possible.
- When it's time to replace the family vehicle, consider one that gets more miles per gallon than your present vehicle.
- If you have a small boat for fishing and recreation, run it with “human power” when possible.
- When it's time to replace an appliance, look for the Energy Star® label identifying energy-efficient models.
- When buying or building a new house, an ENERGY STAR model gives greater quality and comfort as well as lower monthly costs. For more information, go to the Energy Star Homes web site, www.epa.gov/homes.
- Buy products that feature reusable, recyclable, or reduced packaging to save the energy required to manufacture new containers and reduce greenhouse gas emissions from landfills.
- Encourage your company to join EPA programs such as ENERGY STAR BuildingsSM and Waste Wi\$e recycling programs, and to buy office equipment with the ENERGY STAR label.
- Plant trees, which absorb carbon dioxide from the air.
- Educate others. Let friends and family know about these practical, energy-saving steps they can take to save money while protecting the environment.
- Encourage scientific research and public discussion on global warming and solutions such as energy efficiency and alternative energy.

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cities and states across the country have prepared inventories of their greenhouse gas emissions, and a number of them are pursuing programs and policies that will result in reductions of those emissions.

At the national level, the federal government is working in partnership with businesses, states, and local governments to address global warming. In addition, the U.S. Global Change Research Program coordinates the world's most extensive research effort on climate change.

For More Information

- The Florida Coastal Management Program at 850-488-1554, or Florida Sea Grant (Miami-Dade County) at 305-361-4017 can provide background information on south Florida and its coastal environment.
- The U.S. Environmental Protection Agency's Global Warming site includes detailed information on climate change, impacts, and actions.
www.epa.gov/globalwarming/
- EPA's fact sheet on Climate Change and Florida includes information on potential impacts.
<http://www.epa.gov/globalwarming/impacts/stateimp/florida/index.html>
- EPA's Coral Reef Protection web site describes efforts underway to protect Florida's coral reef ecosystem.
<http://www.epa.gov/owow/oceans/coral/>

- The latest U.S. *National Assessment of Climate Variability and Change* gives a detailed report on the potential effects of global warming in the United States.
<http://www.nacc.usgcrp.gov/>
- Check out the ENERGY STAR web site for a directory of energy-efficient products for your home.
<http://www.energystar.gov>
- The National Park Service's web site provides links to south Florida's national parks, preserves, monuments, and seashores.
<http://www.nps.gov/>
- The U.S. Fish and Wildlife Service's web site provides information on wildlife refuges in south Florida.
<http://www.fws.gov/>