Working Group and
Science Coordination Group of the

South Florida Ecosystem Restoration Task Force

Information Brief Series

Climate Change in South Florida

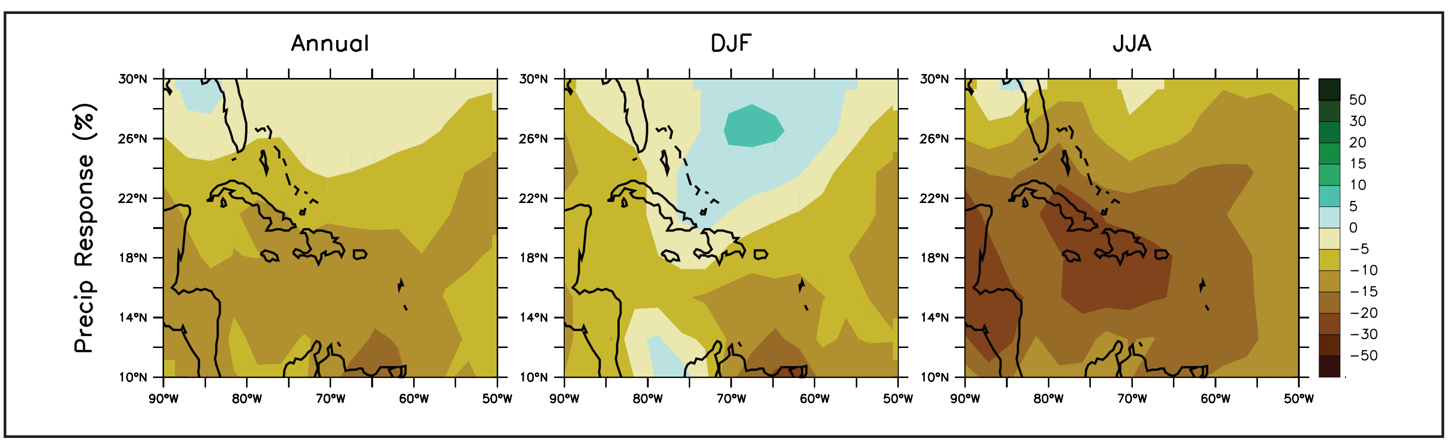
South Florida's unique position, at the interface between temperate and subtropical America, means that many of our native plant and animal species are at the edge of their physiological range, making them highly susceptible to changes in temperature, humidity, and precipitation. In addition, the Everglades ecosystem is remarkably flat, rising from sea level at Florida Bay to only about 14 feet at Lake Okeechobee, making the entire region extremely vulnerable to sea level rise, storm surge, and saltwater intrusion. Understanding the implications of climate change is critical to our efforts to restore the south Florida ecosystem, including the water resources upon which the built and natural environments depend.

The pace, extent, and magnitude of possible climate change impacts on south Florida are largely unknown at this time. This is in part because of the difficulty of scaling down from global and regional trend models to predictions at the local level, the long timeframes involved, and the confounding effects of a number of changing meteorological variables on habitats and species. Climate change projections to date do not indicate that Everglades restoration is either infeasible or futile, only that changing conditions will have to be taken into account and responded to in our science and planning processes (NRC 2008). Indeed, a recent Greater Everglades Ecosystem Restoration workshop (2008) found it likely that Everglades restoration will be an important component of our response to climate change.

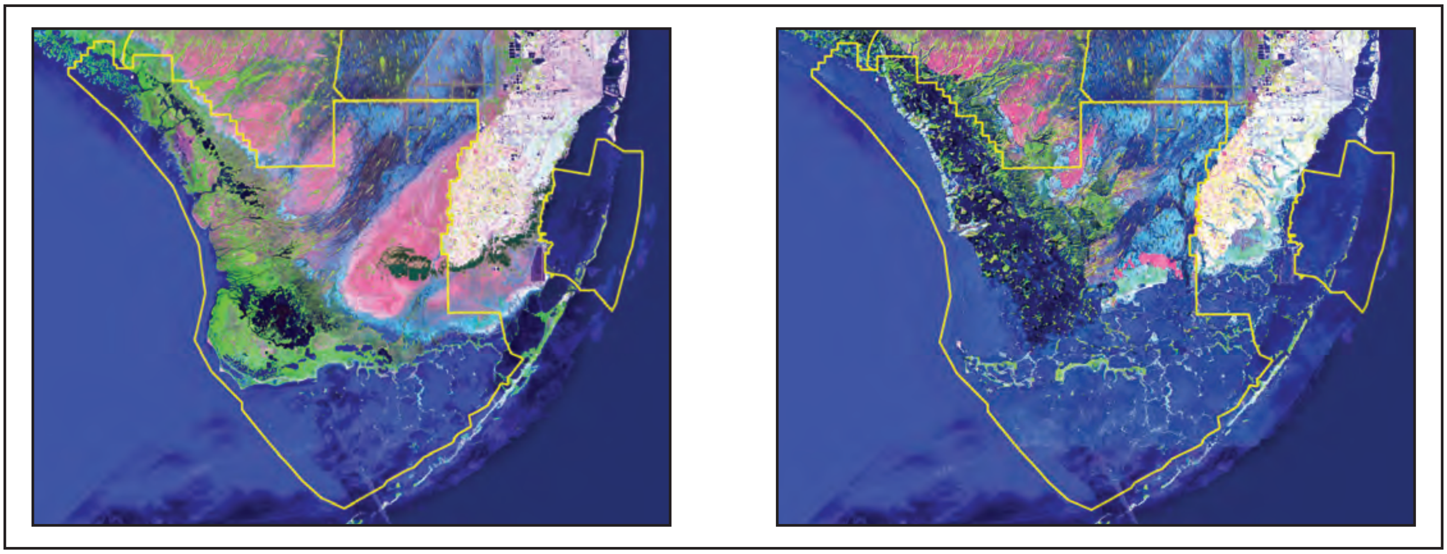
Restoration planning and water resource management will have to take into account a range of possible alterations such as: increases in temperature, changes in the pattern and volume of precipitation, changes in the overall water budget and increasing human water supply demands, changes in the return frequency and intensity of hurricanes, changes in the distribution and abundance of plants and animals in response to temperature and rainfall alterations, and the direct and indirect impacts of projected sea level rise on the built and natural system (NRC 2008).

What We Know So Far

The Intergovernmental Panel on Climate Change (IPCC) examined a series of climate simulations from modeling centers around the world for both trends and variability (IPCC 2007). A moderate greenhouse gas (CO_2) emission scenario estimates that by the end of the century, global average annual temperature will increase by 3.5 to 4.5 °F or by as much as 10 °F under a high CO_2 emission scenario. It is predicted that shifts in ocean circulation patterns will cause decreased precipitation in our region. Together, these predictions point to a future with extended droughts, uncertain recharge of Everglades wetlands, and reduced water availability in south Florida. Several studies suggest that increased sea surface temperatures in the North Atlantic may result in a higher frequency of storms and storms that are more



Precipitation changes over the Caribbean region from the MMD-A1B simulations. Annual mean, December-January-February, and June-July-August precipitation change from 1980 to 1999 and 2080 to 2099 averaged over 21 models. Figure and caption from IPCC 2007.



South Florida's habitat types and coastline in 1995 (left) and shifts projected with a 2 foot rise in sea level (right). Courtesy: Harold Wanless, University of Miami.

intense (IPCC 2007). All of these predictions suggest that the natural ecosystems and built environment of south Florida will have to respond to changing weather patterns and more extreme events than the region has historically experienced.

The magnitude and timing of sea level rise is more uncertain than projections of temperature and precipitation because of the uncertain contribution of global ice melt. Adjusted for south Florida, the 2007 IPCC projections suggest a 4 to 9 inch rise by mid-century, and from 9 to 17 inches (low emissions) or 11 to 22 inches (high emissions) by the end of the century (NRC 2008). These are considered conservative estimates because they exclude recent observations of accelerated melting of glaciers and ice sheets. A more recent Climate Change Science Compendium prepared by the United Nations Environment Program suggests that 21st century sea levels could rise by 20 to 55 inches above the 1990 level (UNEP 2009). Even the more modest projections imply a significant impact on the low-lying Everglades, the highly transmissive Biscayne Aquifer, and the near-coastal built environment.

Increasing concentrations of CO_2 into the world's oceans has already begun to alter their chemistry, leading to acidification. For the marine organisms that incorporate calcium carbonate into their shells/skeletons, this reduces the amount of available habitat where these organisms can thrive. Ongoing ocean acidification has already harmed a wide range of marine organisms and altered the food webs that depend on them (UNEP 2009).

Mangrove forests along the coast of Everglades and Biscayne National Parks are projected to shrink in extent and shift inland due to sea level rise. If sea level rises too rapidly, mangroves, which may protect shorelines from storm surge, may not be able to keep pace and this important community could be lost. Photo by Brett Seymour, NPS.

Natural System Adaptation

Existing studies of species responses to potential climate change in south Florida are limited (Pearlstine et al. 2009). Some broad categories of potential effects include: 1) direct responses to temperature increases; 2) responses to drought, fire, sea level rise, and other environmental changes; 3) the loss of species synchronization; and 4) direct loss of habitat. Species particularly at risk include those that are sensitive to temperature and humidity changes (e.g., amphibians), sensitive to salinity (e.g., coastal and inland plant communities), or dependent on hydrologic regimes (e.g., many wading birds). Climate change may impact the overall abundance and distribution of invasive species and the effectiveness of control programs. Within nearshore waters, blue-green algae blooms will potentially increase as a result of increased water temperatures and decreased freshwater inflows.

South Florida native plant and animal communities will have to adapt to the combined effects of multiple climate change variables, in addition to existing stressors (habitat fragmentation, invasive species, pollution, disease expansion, etc.). Because of this, natural system adaptation should be understood as the need to reduce ecosystem vulnerability and promote resilience. For most species, this can be promoted through the preservation of large and spatially connected habitats, with natural buffer zones and corridors to enhance population stability and facilitate recovery following disturbances. Large-scale connectivity is needed to support viable populations and allow habitats and species to migrate in response to climate change. The restoration of sheetflow throughout the Everglades is also important since this can reinstate widespread organic soil deposition, provide an important means for carbon sequestration, and also maintain a freshwater head to mitigate the effects of sea level rise and saltwater intrusion. The protection and maintenance of our existing coastal ecosystems will specifically require open land up-gradient of these areas, to allow these communities to migrate in response to rising sea level. Special attention should also be given to the preservation of coral reefs, seagrass beds, and mangrove communities since they may provide natural barriers to storm surge and are critical to maintaining coastal biodiversity.

Built System Adaptation

With almost 1,350 miles of coastline and the majority of its population living near the coast, Florida is especially vulnerable to sea level rise and other impacts of climate change. The range of likely impacts to the built system include alterations in agricultural production, the occurrence and spread of diseases, and alterations to water supply and wastewater, transportation, building, tourism, and energy sectors (CUES 2008). Increased temperatures and declining rainfall point to the need for increased regional water storage. Saltwater intrusion is already a problem at wellfields located in coastal areas. We will have to locally raise groundwater levels (which increases the risk of flooding), relocate wellfields to inland areas, and/or seek alternative water supplies. Increased storm surges and sea level rise also reduce the flood control capacity of coastal water management structures and will necessitate retrofitting of pumping facilities.

Existing side by side, coastal urban development and the Everglades ecosystem are both vulnerable to the impacts of climate change. Photo by SFWMD.

Ongoing studies at the state, regional, and county level are underway to assess vulnerabilities to climate change and to identify and prioritize needed actions. While specific strategies will likely vary by community, they will generally include the following (CUES 2008):

- Buildings and Infrastructure: strengthen building codes, revise placement/design of infrastructure, improve stormwater management, and retrofit roads and bridges;
- Coastal Defenses and Economies: conserve land, restore natural wetlands, renourish beaches, and add breakwaters and seawalls where appropriate; and
- Land Use and Growth Management: adopt local comprehensive plan amendments that support built system adaptation, define hazard areas and zoning ordinances, revise coastal construction criteria, and preserve land for wildlife population migrations.

Managing a Changing Ecosystem

Management of our ecosystems under anticipated climate change scenarios will call for new and innovative collaboration across organizations and levels of government. Below are some examples of efforts already underway.

- The US Fish and Wildlife Service (FWS) and the US Geological Survey (USGS) are collaborating with the Massachusetts Institute of Technology on a stakeholder based alternative futures study for refuges in south Florida to support strategic habitat conservation planning. The FWS, USGS, National Park Service, and University of Florida are partnering on a 3-year project to develop climate envelope models for terrestrial vertebrate threatened and endangered species. The USGS is developing an integrated model of climate change impacts on coastal habitats and species in the Everglades as well as a model of sediment elevation and accumulation in response to hydrology, vegetation, and disturbance in the southwest coastal Everglades. These models will be supported by a series of sea level rise models. The USGS is also establishing regional climate change research hubs with the first possibly being located in Florida, and FWS is establishing Landscape Conservation Cooperatives (LCCs) focusing on climate change mitigation, adaptation, and engagement.

- The Florida Fish and Wildlife Conservation Commission (FWC) hosted a climate change summit "Florida's Wildlife: On the Frontline of Climate Change" in October 2008. Information from the summit is being used to develop an overall approach for integrating climate change into FWC's mission and operations. FWC has created internal teams to address fish and wildlife adaptation, outreach, operations, policy, research, and monitoring.
- The US Army Corps of Engineers (Corps) released a new Engineering Circular that provides interim guidance for incorporating sea level change projections into Corps projects and recommends a multiple scenario approach to deal with uncertainties (USACE 2009). The Corps is also working with partner agencies on a series of technical reports to facilitate collaborative information sharing, specifically regarding climate change sensitivity data and model development.
- The South Florida Water Management District is preparing a white paper to identify the potential impacts of climate change on water resources management in south Florida. The agency is also investigating historical data and climate model projections to identify past and future trends and uncertainties.
- Florida Atlantic University (FAU) has produced two recent reviews, Florida's Resilient Coasts and Southeast Florida's Resilient Water Supply (CUES 2008, 2009). Along with Florida Gulf Coast University, FAU has drafted a plan for assessing climate change adaptation needs in south Florida urban and natural systems, including education and outreach.
- Miami-Dade County's Climate Change Advisory Task Force, a diverse, multidisciplinary group representing private and public sector stakeholders, has recommended development of topographic models of sea level rise scenarios and monitoring of climate change "vital signs." Broward County's Climate Change Task Force recently hosted the Southeast Florida Regional Climate Leadership Summit, in partnership with Monroe, Miami-Dade, and Palm Beach counties, to develop regional collaboration and a coordinated climate change strategy.
- The initial volume of the fifth IPCC report is expected in 2014 and will provide updated long range climate change forecasts (including updated sea level rise forecasts) relevant to selection of long-term regional climate change adaptation strategies for the Everglades and south Florida.

Conclusions and Next Steps

While there is uncertainty in the specifics of how climate change will manifest in south Florida, it is only prudent that we prepare now for the significant changes that lie ahead. Most importantly, we must recognize that the traditional planning method of assuming "stationarity," that future climate is likely to be similar to past climate, is obsolete.

Everglades restoration is an important adaptation response to climate change. The impending natural resource alterations that will likely result from climate change should not be viewed as an excuse for delay or inaction, but rather as motivation to avoid irreversible losses and restore the health and natural resilience of the ecosystem (NRC 2008).

A major theme for future land and water management in the face of climate change will be to restore and maintain the resilience of the Everglades ecosystem. Ecosystem resilience can be enhanced through increased water flows through the Everglades and increased storage. Increased flows into the southern estuaries will reinstate widespread organic soil formation and maintain the freshwater head in order to mitigate the effects of sea level rise and saltwater intrusion. Increased water storage will retain excess wet season runoff, increase overall water availability, and reduce the effects of drought in both the natural and built environments.

Land use and infrastructure planning in developed areas will require a long-term approach that recognizes increasing water levels. Gravity-based drainage infrastructure will be less effective at higher sea levels, increasing the risk of flooding, and placing greater emphasis on alternative water supplies.

An integrated cross-agency approach is critical to success. Logical next steps for coordination include exploring common planning factors (sea level rise, precipitation, etc.), resolving which models are best suited for the Everglades ecosystem, and reducing uncertainty through regional resolution of larger scale climate change models. Other steps could improve tools for local and regional decision-making, such as climate change risk assessment methods. Further research could include evaluating the benefits of Everglades restoration in terms of carbon sequestration. Outreach activities could help further the understanding that climate change is a long-term trend, not a one-time event.

Complete information on the references cited in this document can be found online at the following location: http://www.sfrestore.org/climate_change.html