Climate Change in South Florida

Our planet is undergoing an unprecedented change in climate. Greenhouse gases are rapidly accumulating in the atmosphere. As a result, global temperatures are increasing, sea level is rising and the ocean is becoming more acidic, weather patterns are becoming more extreme and less predictable, and natural ecosystems are predicted to undergo changes at an alarming rate.

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 storm surges 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.

What We Know So Far

The Intergovernmental Panel on Climate Change (IPCC) recently examined a series of climate simulations from modeling centers around the world for both trends and variability (IPCC 2007). A moderate greenhouse gas (CO₂) emission scenario estimates that by the end of the century global average annual temperature will increase by 2 to 2.5 °C (3.5 to 4.5 °F), or by as much as 5.5 °C (10 °F) under a high CO₂ 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 the 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 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.

Currently, global sea level is primarily a function of ocean temperature and salinity, but 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 2007). These are considered conservative estimates, because they exclude recent observations of accelerated melting of glaciers and ice sheets. 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.
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 affect 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 decreasing 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, 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 protection and maintenance of coastal wetlands 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 and mangrove communities, since they provide natural barriers to storm surges, and are critical to maintaining coastal biodiversity.

Built System Adaptation

With almost 1,200 miles of coastline and the majority of its population living near the coast, Florida is more vulnerable to sea level rise and violent weather patterns than any other state (Governor Christ, Serve to Preserve Summit on Global Climate Change 2007). The range of likely impacts to the built system...
include, alterations in agricultural production, the appearance and spread of diseases, and alterations to water supply and wastewater, transportation, building, tourism, and energy sectors (Center for Urban and Environmental Solutions 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. To stave off intrusion, we will have to either locally raise groundwater levels (which increases the risk of flooding) or relocate wellfields to inland areas. 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.

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 (Center for Urban and Environmental Solutions 2008):

- **Buildings and Infrastructure**: strengthen building codes, revise placement/design of infrastructure, improve stormwater management, retrofit roads and bridges.
- **Coastal Defenses and Economies**: conserve land, restore natural wetlands, beach nourishment, add breakwaters and seawalls, where appropriate.
- **Land Use and Growth Management**: comprehensive plan amendments, define hazard areas and zoning ordinances, revise coastal construction criteria, preserve land for animal population migrations.

### Confronting Change

The range of possible climate change impacts on the natural communities and built environment of 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, and the confounding affects of a number of changing meteorological variables on the complex of habitats and species. The 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 adapted to in both 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 the response to climate change.

Our 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).

### Managing a Changing Ecosystem

Management of our ecosystems under anticipated climate change scenarios will call for new and innovative collaborations across organizations and levels of government. One approach is to explicitly envision the conditions ahead through future scenario development. Below are some examples of a number of efforts that are already underway.

- **The US Fish and Wildlife Service and the US Geologic Survey** are collaborating with the Massachusetts Institute of Technology on a stakeholder based alternative futures study for refuges in south Florida to provide input for strategic habitat conservation planning.

- **The US Army Corps of Engineers** is working with partner agencies to develop a series of technical reports focused on climate change. The first technical report, due in FY2010, will identify potential climate change impacts on the CERP, coordinate interagency plans for development of regional and local scale dynamic models required to address potential sea level rise and other climate change variable, and help coordinate interagency plans for collection of climate change sensitivity information needed for future adaptation studies. A second technical report is planned to summarize climate change sensitivity data and model development actions.
completed through FY2011. Subsequent regional planning studies with extensive public involvement are anticipated to develop and evaluate climate change adaptation strategies for the Everglades and south Florida using scenarios with low, intermediate and high rates of sea level rise and related global change parameters.

- The US Geologic Survey is developing an integrated model of past and future impacts of climate change 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 the development of a series of sea level rise models.
- Florida Atlantic University has produced two recent reviews, Southeast Florida’s Resilient Water Resources and Florida’s Resilient Coasts: Policy Framework for Adaptation to Climate Change. In addition, Florida Atlantic University, working with Florida Gulf Coast University, has drafted a plan for assessing climate change adaptation needs in south Florida urban and natural systems, including an education and outreach program.
- The initial volume of the fifth IPCC report will be released in early 2013 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 Recommendations

While there is uncertainty in the specifics of how climate change will manifest in south Florida, it is only prudent that we begin preparing now for the significant changes that lie ahead. Most important, we must recognize that the traditional planning method of assuming “stationarity,” that future climate is likely to be similar to past climate, is obsolete. We face serious implications on a number of vital fronts:

- Landscape Impacts: direct effects on existing infrastructure and ecosystems (coastal watersheds, coastal ecosystems, droughts)
- Water Supply Availability: including urban, agricultural, and environmental supplies and accelerated saltwater intrusion due to higher sea levels
- Flood Control Capability: discharge structures will have less capacity potentially causing increased flooding in urban areas
- Restoration: Flooding of coastal CERP projects and mangrove areas, temperature changes modifying the ecology of the Everglades. Can peat accretion keep up with sea level rise? Will we have enough freshwater to meet restoration needs?

Water resource managers face new information needs that must be met in order to plan and manage wisely and effectively in the changing environment:

- Which operational and planning decisions are likely to be unaffected by climate change?
- Which decisions are likely to be affected and could benefit from adaptation strategies in the short-term?
- Which decisions are likely to be affected but for which adaptation strategies could be deferred without serious consequence?

Our south Florida restoration efforts should focus on increasing water flows through the Everglades and into the southern estuaries to maintain the freshwater head needed to offset sea level rise and saline transgressions. Similarly, increased water storage is needed to retain excess wet season runoff, increase overall water availability, and reduce the affects of droughts in both the natural and built environments. 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 natural resilience of the ecosystem (NRC 2008). An integrated cross-agency approach is critical to the success of such efforts.

Literature Cited