PREDICTING ECOLOGICAL CHANGES IN THE FLORIDA EVERGLADES UNDER A FUTURE CLIMATE SCENARIO

SPONSORED BY UNITED STATES GEOLOGICAL SURVEY, FLORIDA SEA GRANT AND THE CENTER FOR ENVIRONMENTAL STUDIES AT FLORIDA ATLANTIC UNIVERSITY

February 14 & 15, 2013

Florida Atlantic University ♦ Boca Raton, Florida

MEETING SUMMARY

USGS science for a changing world

FAU FLORIDA ATLANTIC UNIVERSITY

Sea Grant Florida

BACKGROUND

Significant changes in climate and sea levels have been predicted which will have major implications for the success of regional projects, such as Everglades Restoration. This technical meeting, sponsored by the Center for Environmental Studies at FAU (CES), the U. S. Geological Survey (USGS), and the Florida Sea Grant, was planned by an inter-agency steering committee in order to assess our ability to forecast potential changes in ecological attributes of the Everglades under a future climate scenario. The intent of the meeting was to facilitate discussions and develop pathways for understanding the consequences of climate change and sea level rise and building a sound scientific basis for managing changing environments. The specific purpose of the meeting was to have experts in Everglades ecosystems:

- Predict how key attributes may respond in specific future climate scenarios that include increased temperature, altered rainfall and runoff, higher evapotranspiration, rising sea level, and elevated atmospheric CO_2;
- Identify gaps in scientific information leading to unacceptable levels of uncertainty in both climatic and ecological predictions, including changes in environmental parameters needed by ecologists to predict how these ecosystems may respond; and
- Consider options for future resource management and scientific needs and capabilities to support management adaptations.

This technical meeting is best seen in the context of a series of workshops held over the past three years, which dealt successively with the current and future impacts of sea level rise, climate change and variability on the hydrology of the Everglades. Following a March 2012 workshop, which primarily focused on the technical issues of downscaling and subsequent hydrological forecasting, it became clear that a more interdisciplinary and South Florida focused approach was a logical next step.

As preparation, a webinar was held in August for key Florida ecologists on the process and findings of the hydrology workshop. Fifty professionals were involved in the webinar and follow up discussions. The organizing committee, which included six federal agencies, water management representatives and five universities, came to consensus that a scientifically based scenario approach would provide a distinct target that could direct coordinated ecological attention to a discrete set of hypothetical conditions.

The South Florida Water Management District (SFWMD) used a set of climate change and sea level rise scenarios to run the South Florida Water Management Model (SFWMM), the premier regional-scale, hydrologic model for the region. This run was completed by December and made available for the hydrologists and ecologists to utilize two months prior to the February 2013 meeting. The organizing committee also believed that the presence of agency managers would enhance the impact of the presentations and discussions. The proviso was that the managers commit to attending the entire two days. A large number made this commitment and, together with four representatives from the National Research Council, greatly enhanced the process and outcomes.

CLIMATE SCENARIO RUNS

Current projections of climate change and sea level rise have made the concept of "stationarity", previously used in traditional planning efforts, no longer appropriate. Using the SFWMM, a study was undertaken to provide a set of climate change and sea level rise scenario runs. These runs would be the basis for conversations among scientists and decision makers in order to identify the future work necessary to understand the implications of potential changes in the climate and sea level on Everglades Restoration. The results of this analysis should not be viewed as definite projections of what will occur, but as examples of what could happen in the greater Everglades region.

SFWMM - The Model

The SFWMM is a regional-scale computer model that simulates the hydrology and management of water resources system from Lake Okeechobee to Florida Bay, covering an area of 7,600 square miles. The model simulates the major components of the hydrologic cycle in South Florida on a daily basis using climatic input. The components include rainfall, evapotranspiration, infiltration, overland and groundwater flow, canal flow, canal-groundwater seepage, levee seepage and groundwater pumping. The SFWMM also incorporates water demands of all sectors and simulates current or proposed water management control structures and operational rules. The output of the model includes a myriad of performance measures covering urban, agricultural and environmental sectors that had been the basis of previous planning efforts.

The Scenarios

Based on the available information for South Florida, six different scenarios were developed. These scenarios were compared to a 2010 baseline which included no change. The scenarios included the following assumptions:

- 10% decrease in rainfall
- 10% increase in rainfall
- 1.5° Celsius increase and 1.5 foot sea level rise with increased coastal canal levels
- 10% decrease in rainfall, 1.5° Celsius increase and 1.5 foot sea level rise with increased coastal canal levels
- 10% decrease in rainfall, 1.5° Celsius increase and 1.5 foot sea level rise with no increased coastal canal levels
- 10% increase in rainfall, 1.5° Celsius increase and 1.5 foot sea level rise with increased coastal canal levels.

These simulations were provided to several teams of researchers and they were asked: What are the implications of the hydrology and ecology for Lake Okeechobee, freshwater wetlands and coastal and marine ecosystems based on these simulations? The product of their research was presented on Day 1 of the technical meeting.

DAY 1

Predicting Ecosystem Change in Response to These Specific Climate Change Scenarios

Lake Okeechobee

In a future scenario with increased rainfall and increased evapotranspiration, there may be counter-balancing effects on the lake's water budget and no marked effects on hydrology. A scenario with reduced rainfall and increased evapotranspiration likely would result in a large change in hydrology. Water levels in the lake will decline by more than 6.5 feet compared to a base condition, and extreme low levels will persist for multiple years. Such conditions would dramatically alter the lake's littoral plant community, might eliminate entirely the submerged vegetation, and severely impact the lake's ecosystem services. The lake would be unlikely to serve as a viable habitat for sport fish or wading birds, as a habitat for Everglades Snail Kite, or as a reliable source of water for downstream users if the future holds both increased evapotranspiration and decreased rainfall.

Freshwater Wetlands

Four separate groups of researchers looked at the impacts of how our Freshwater Wetlands might respond to climate changes projected by the model output. One group analyzed how the Everglades landscape might respond and determined that there would be major impacts to soils, vegetation, fish, wildlife, invasive species and that increased drought conditions would lead to reduced peat production, an increasing rate of peat loss and increased risk of fire. Another group analyzed the fish and aquatic fauna and determined, among other findings, that decreased rainfall scenarios dramatically decreased aquatic fish production with likely implications for apex predators that depend on these for prey. Yet another group of researchers analyzed plant species and community responses and found that the Everglades are currently declining due to changes in the range of water-level fluctuations over a wet-dry cycle, and this cycle may be exacerbated by a decline in rainfall and increase in ET. The final group researched the landscape scale responses to biogeochemical factors and, among their findings, determined that decreased rainfall and increased evapotranspiration would lead to more frequent drying events and organic soil oxidation and release of mercury and sulfate from soil, and an increase of methylmercury production.

Coastal and Marine Ecosystems

Increasing sea-level by 1.5 feet will make Florida Bay salinity more like that of the ocean, with salinity increasing in fresher areas and decreasing in hypersaline areas. This salinity response will be influenced by the potential growth or erosion of the bay's western mud-banks, which are biogenic and currently inhibit water exchange with the Gulf of Mexico. Both salinity and temperature strongly affect biota; higher summer temperatures may negatively affect seagrass habitat and fish. The Florida Keys' coral reef already has experienced negative effects. The most dramatic future changes likely will occur in coastal wetlands. Current rates of soil elevation accretion are far less than the workshop scenario's sea-level rise rate. If inundated by the sea, coastal systems will expand and be disturbed by increased nutrient and turbidity releases from the former Everglades.

DAY 2

Evaluating Information Needs and Uncertainty Scenarios – Breakout Groups

Meeting participants were divided into three breakout groups, each one having a diverse mix of scientists and resource managers. All three groups were asked to answer three questions and record the results for presentation back to the full group with discussion. The three questions addressed in the breakout groups were:

- *Question 1: In evaluating the response of the various ecosystem components to climate change, what research gaps existed that led to lower than acceptable certainty in your projections?*
- *Question 2: In evaluating the response, what additional information (from model output, etc.) would have helped you make your projections?*
- *Question 3: What are the greatest needs by management?*

In addition to dynamics identified within each break-out group, the groups were asked to consider dynamics associated with ecosystem feedbacks that span the boundaries of: 1.) Lake Okeechobee, 2.) Freshwater wetlands and 3.) Coastal and marine ecosystems. The ideas discussed in these break-out groups have been synthesized into a list of ***Considerations for Restoration and Resource Decision Makers*** which are detailed on the last page of this document.

Considerations for Restoration and Resource Decision Makers

Climate change will affect the outcome of Everglades restoration in a number of ways: through direct and indirect consequences of sea level rise and associated saltwater intrusion into the peninsula; through increased temperature and evapotranspiration that will impact the availability of water for both the natural and urban environment; and perhaps through changes in the amount, timing and distribution of rainfall. Rising seas may threaten the integrity of coastal peat soils and flood coastal plants. Increased temperature and longer-lasting droughts may severely reduce available freshwater. In addition, fire, exotic species and disease may interact with these changes to have unexpected adverse impacts to Everglades flora, fauna and ecosystem services.

The workshop identified that these effects of climate change must be carefully considered and that those effects which are deemed likely to influence the outcome of Everglades restoration must be taken into consideration in the planning and implementation of regional projects. The workshop also identified that major uncertainties exist, from those associated with climate projections to those about specific changes in ecological structure and function. These uncertainties must be prioritized and then reconciled with timely research that can support decisions by resource managers.

The following list provides some examples of research and management needs.

Scientific Information and Understanding Gaps:

- Major factors determining the availability of freshwater in the greater Everglades are the future rainfall and the magnitude of evapotranspiration. Currently, evapotranspiration is estimated as a simple generic function of temperature. Site-specific relationships between all climate variables, including air temperature and evapotranspiration, need to be developed. Better rainfall scenarios also need to be developed.
- There is a potential for large-scale peat collapse and land loss due to intrusion of salt water at the southern end of the Everglades. To understand the magnitude and timing of these impacts, research is needed regarding the status and dynamics of factors influencing elevation change - especially the magnitude and variability of salt-water intrusion.
- The Florida Bay mud-banks are barriers that protect the Bay and the Everglades from wave energy and storm surges. Information is needed regarding how they will be affected by climate change, including their current elevation, rates of erosion, sedimentation, and net elevation change.
- Integrated hydrologic-ecological models are needed to evaluate current status and dynamics in response to climate change scenarios.
- Information is needed about how key processes like peat accretion and loss, and viability of seed banks, will be affected by prolonged periods of drying.
- We need to understand the vulnerability and resilience of populations to changing patterns of landscape connectivity.
- We need to learn how to build ecosystem resilience. We need to gain understanding of community and ecosystem dynamics and management influences on these dynamics sufficient to identify mechanisms that increase resilience. This need includes research to identify tipping points and to develop early-warning indicators.
- We need to understand the role of fire, invasive species and disease as they influence ecosystem responses to climate change.

Scientific Applications: A Path to More Effective Ecosystem-Based Management

- There is a need for improved communication, outreach and education, which engages both managers and the general public. Scientific understanding of the impacts of climate change must be communicated openly and honestly.
- We need to expand the scope of ecosystem analysis to encompass societal needs and dynamics, including economics and water demands. For South Florida, integrated ecosystem-human system planning and analysis should include consideration of the entire Kissimmee-Okeechobee-Everglades system and the adjacent marine system.
- Adaptive management is a recommended approach to build resilience needed to deal with climate change. A better understanding of the ecosystem resilience to change is also necessary.
- In collaboration with managers and the public, we must build an understanding of the importance of environmental variability in natural ecosystems, including recognition of the importance of pulsed events.
- Management decision support should incorporate indicators that minimize the risk of reaching critical tipping points.
- One recommended focus for management is the appropriate delivery of freshwater flows to coastal wetlands, which provide a critical defense of the Everglades landscape and water supplies in the face of sea-level rise. For South Florida, sea-level rise appears likely to be the element of climate change that will most strongly and quickly alter our environment and society.

A follow up workshop with researchers and managers is needed to clearly identify the most pressing research issues – i.e., to develop a roadmap for essential research to provide greater certainty about how climate change will affect Everglades restoration, and how undesired responses might be overcome or mitigated with science-based adaptive management.

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