Working Group and
Science Coordination Group of the

South Florida Ecosystem Restoration Task Force

Information Brief Series

New Science: Advancing Understanding of the South Florida Ecosystem

The Comprehensive Everglades Restoration Plan (CERP) was approved by Congress in the Water Resources Development Act of 2000. CERP is a framework for restoration, preservation, and protection of the Everglades ecosystem that also provides for other water-related needs of the region, including water supply and flood protection. CERP is the centerpiece of a broader restoration effort in south Florida. A key premise of Everglades restoration is that the best available scientific information will guide our decisions. Since 2000, considerable learning has taken place through applied research and monitoring, including the refinement of models and sampling methodology. Important new information now informs our understanding of how water flows through the system and how depths and durations of flooding influence Everglades ecology, fine-tuning knowledge of the functional characteristics of the Everglades and the restoration needs of different parts of the landscape.

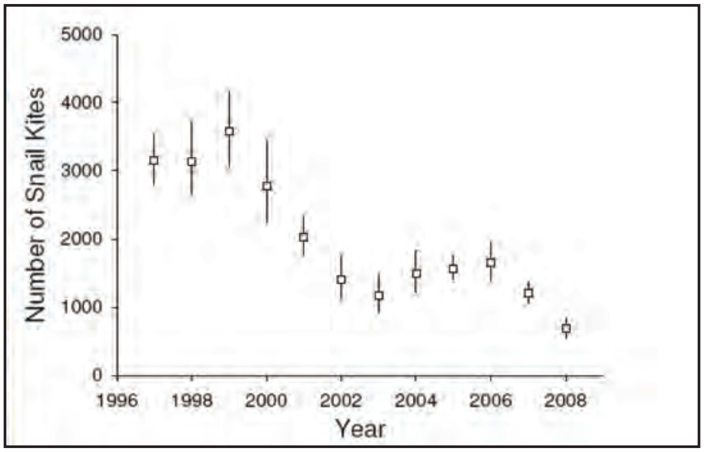
Understanding of the Natural System Evolves; Without Ecosystem-wide Restoration, Degradation Continues

Our fundamental understanding of the natural, pre-drainage Everglades ecosystem has evolved since the year 2000. There are now several lines of evidence that indicate that some Everglades marshes were wetter and the southern estuaries were fresher in the past than was understood previously. And, additional focus on flow and the rate of change of water levels has led to increased understanding of the role dynamic water movement plays in shaping landforms and ecology on virtually all scales, from the formation and maintenance of tree islands and ridge-and-slough topography across the broad landscape to the survival and growth of apple snails in the Water Conservation Areas (WCAs). The Everglades is not in balance, and ecosystem-wide restoration is urgently needed to prevent further degradation. Ongoing monitoring, research, and recent opportunities to assess response to both drought and flood events have documented further declines in ecosystem health.

Fresher and Wetter: Recent paleoecological studies conducted in Florida Bay and Biscayne Bay show that estuarine animal communities that existed around the beginning of the 20th century were typical of a lower, more stable salinity pattern than is associated with the managed system today. The differences in salinity patterns are not fully explained by rising sea level (Wingard 2007). A recent assessment of the relationship between water levels in Everglades National Park (ENP) and salinity in Florida Bay indicates that the volume of freshwater required to achieve the historical salinities is larger than the pre-drainage hydrologic simulation models have predicted (Marshall et al. 2009). Paleoecological studies of pollen and seeds from sampling sites in Shark River Slough provide evidence for greater extent of water lily sloughs prior to the implementation of water management practices of the 20th century (Bernhardt and Willard 2009, SFWMD 2008, Willard et al. 2001). Water lily is associated with open water slough characterized by greater water depths or longer periods of inundation than that found in the present-day sawgrass prairies.

Flow and Velocity: It is the flow of water that connects the upstream and downstream components of the ecosystem, links habitats, and supports biological functions that maintain diversity. In Everglades marshes, flowing water is required to transport fine sediment and organic matter and thereby shape the land into the linear ridge-and-slough systems and flow-sculpted tree islands that defined the pre-drainage system. Flow velocities in impounded areas of today's system are not sufficient to support these physical and biological processes and maintain the characteristic landforms of the historic Everglades (Larsen et al. In review).

Rise and Fall of Water Critical: Extreme high and low water levels can damage aquatic vegetation and wildlife that depend upon it. In addition, the timing and rate of change of water levels (recession or ascension) are critical to ecological functions in Lake Okeechobee and the Everglades marshes. Gradual changes in water depth are necessary to support foraging and reproduction of birds, alligators, and other species. For example, in marshes and lakes, reproduction of apple snails, the principal prey of the imperiled Everglade snail kite, is dependent on the timing and rate that water recedes. Rapid or extreme increases in water level can inundate and destroy snail egg masses. However, if water recedes too quickly young snails will hatch into conditions that are too dry, and they will perish or their growth will be impaired (Darby et al. 2008). The estimated population of the snail kite has decreased dramatically over the last decade, reduced by half and half again (Cattau et al. 2008). Shifting water management regimes and natural climate patterns may affect quality of marsh habitats or apple snail abundance, and these factors may have contributed to the decline of the kite. Cape Sable seaside sparrow populations also are highly sensitive to water levels, remain imperiled and have not regained numbers documented in past decades.



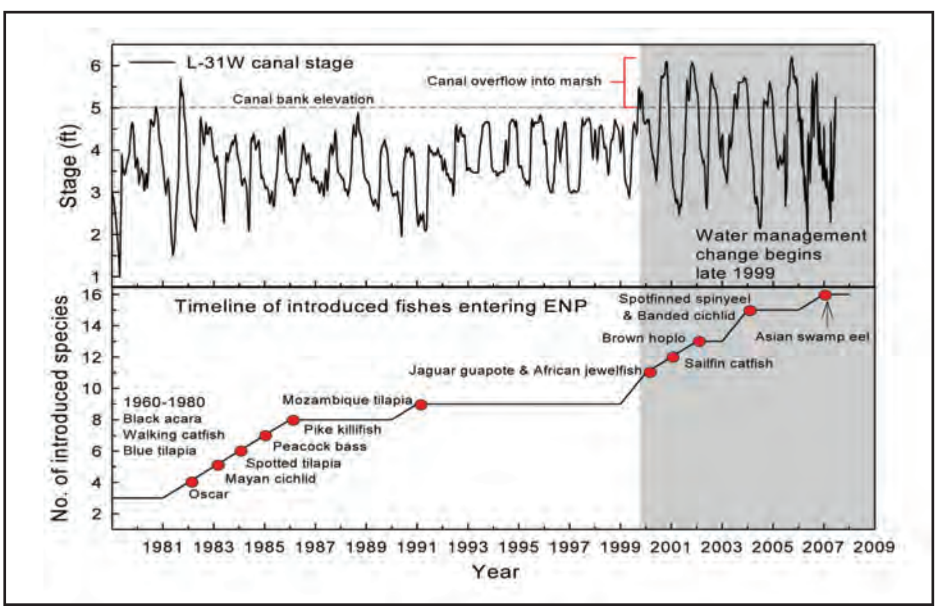
Modeled Snail Kite population size (Cattau et al. 2008).

Loss of Landscape Features: Tree islands are critical features in the Everglades landscape, producing biodiversity "hotspots" of native plants and animals, and serving as refuge for terrestrial species during periods of high water (NRC 2008). Within the impounded WCAs, upstream marshes tend to be over-drained, while downstream marshes experience prolonged flooding. Studies have documented a multi-decadal decline in the number (54% decrease) and areal extent (67% decrease) of tree island habitat, due to the influence of both high and low water levels, and to increased fire frequency (Sklar 2007). If restoration is further delayed and altered water management regimes continue, tree islands will remain more vulnerable to fires in drier areas and flooding in downstream areas, and their resilience to natural hydrologic variability may decline, potentially leading to flooding stress when historic water depths are ultimately restored (NRC 2008).

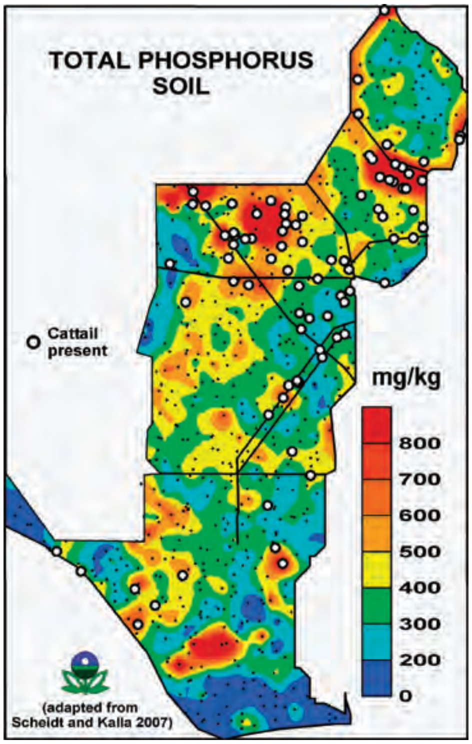
Invasive Plants and Animals:

Invasive exotic species are a serious and growing threat to the south Florida ecosystem. More than 30 invasive exotic plant and 150 invasive exotic animal species are known to occur in the region, and the numbers are increasing (NRC 2008). Several of these pests were recognized in 2000 and remain a persistent challenge, while new species, including Burmese pythons and Old World climbing fern (*Lygodium*), have emerged as major threats to the achievement of restoration goals. The spread of many invasives, such as exotic fish, is clearly linked to canals and other human-altered landscape features.

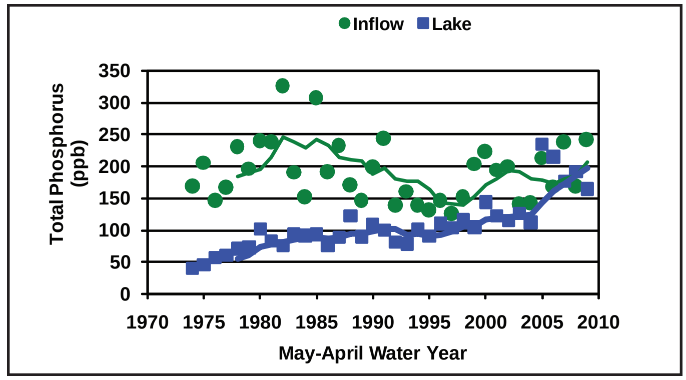
Water Quality: Source control programs and stormwater treatment areas (STAs) in the Everglades Agricultural Area have removed over 3,200 metric tons of total phosphorus. However, soil phosphorus levels still exceeded restoration targets in a greater proportion of the Everglades marsh in 2005 than in 1996 (49% versus 34%), indicating that degradation has spread (Scheidt and Kalla 2007). Mercury concentration in prey fish has dropped compared to the late 1990s, but still exceeds concentrations considered to be protective of birds and mammals in 67% of the Everglades marsh area. Sulfate, a factor exacerbating the biological effects of mercury, exceeded target levels in more than half of the Everglades marsh (Scheidt and Kalla 2007). Recent studies also point to copper in water and soil as a contaminant of concern in south Florida (Schuler et al, 2008).



Note the overflow of the canal bank and the corresponding increase in the number of exotic fishes in Everglades National Park (Kline et al. 2008).



Soil phosphorus in the Everglades. Restoration target is 400 mg/kg (Scheidt and Kalla).



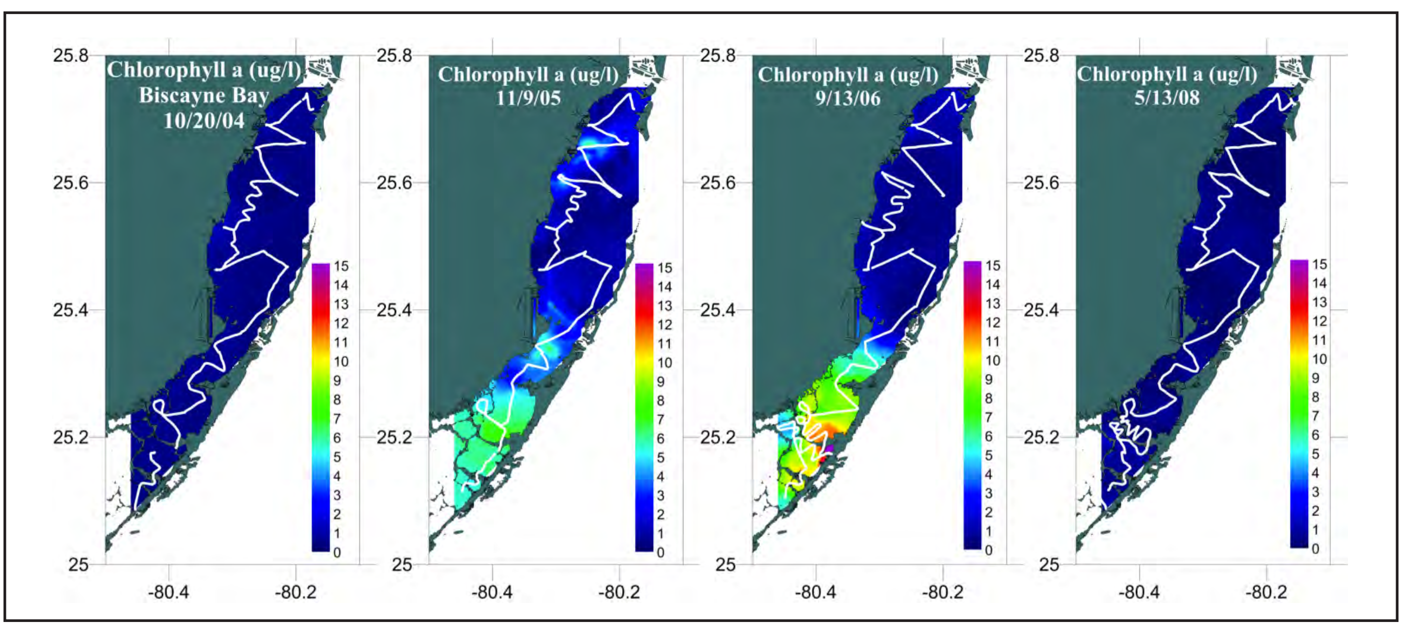
Total phosphorus concentrations in Lake Okeechobee (SFWMD).

Water quality continues to decline in Lake Okeechobee, with total phosphorus concentrations in the water increasing. Phosphorus concentrations and loading rates to the Lake vary, but exceed restoration goals, particularly in wet years. Phosphorus that has accumulated in the Lake sediments and in soils in the watershed can be released to the water at levels sufficient to maintain elevated total phosphorus levels for many years.

Estuaries: Estuaries, the highly productive coastal margins of the system, serve as aquatic nurseries for fish, avian, and invertebrate species and yield large economic benefits. They are stressed by unnatural water deliveries and nutrient releases, which impair their resilience. Damaging freshwater releases and extreme salinity variation in the northern estuaries, Indian River Lagoon and Caloosahatchee, have caused fisheries impacts and loss of aquatic vegetation. Oyster populations in the St. Lucie estuary have fluctuated widely and recovery is hindered by recurring incidents of excessive discharge and extreme low salinity.

In Florida Bay and the lower Biscayne Bay systems, low freshwater flow, salt intrusion, and rising sea level contribute to high salinity and a loss of diverse estuarine habitats that support wading birds and fisheries resources. The normally low-nutrient southern estuaries are highly sensitive to phosphorus and nitrogen releases, even from sources within the basin. Nutrients released from natural and human-related events have recently contributed to algal blooms of previously unknown scale and duration, and associated loss of seagrass and invertebrates were factors in sustaining the bloom and nutrient levels.

Climate Change: Knowledge of how the Earth's climate is changing has advanced rapidly since 2000, and understanding the implications of climate change for south Florida is critical to restoration efforts. Changing precipitation and temperature



Nutrient releases caused a multi-year algal bloom within Biscayne Bay and northeast Florida Bay (NOAA/AOML).

patterns, ocean acidification, sea level rise, and the possibility of storms of greater frequency and intensity will potentially have effects on all aspects of the system, including the coastal transition zone, invasive species, plant and animal physiology, and drought/flood/fire cycles. Future restoration science must proceed with the acknowledgement of climate change as an explicit aspect of our studies and management decision-making.

Advances in Scientific Tools & Methods

There have been numerous advances in scientific tools and methods since 2000. Through collaboration and scientific peer review, conceptual ecological models have been refined and system-wide ecological indicators have been developed. Both provide a framework for reducing uncertainty and developing restoration targets.

Improved models have enhanced understanding of linkages between hydrology and ecology, as well as our ability to predict responses to system changes. The Natural Systems Model (NSM) has been improved by incorporating additional historical topographic, hydrologic, and ecological information. New hydrologic and mathematical models couple upland landscape to southern estuaries, better defining how flow volumes determine salinity patterns. Other models link surface and groundwater flow and help address smaller scale management issues such as aquifer recharge, salt intrusion, and seepage.

Broad scale, robust monitoring programs have been in place since 2000 (e.g., EMAP and the CERP Monitoring and Assessment Plan) and are providing vital feedback on ecosystem health, contaminants, and management strategies. Integration of new geostatistics, water level recorders, and Google Earth capabilities now produces accurate spatial renderings of Everglades performance and restoration. Monitoring of STAs, in combination with the use of near-real-time data, has allowed for improved decision-making for the optimization of STA operations to balance water flows and phosphorus load reduction. As CERP restoration efforts progress, monitoring and assessment will continue to document environmental conditions and the effectiveness of restoration efforts into the twenty-first century (Doren et al. 2008; RECOVER 2007).

Conclusions

Because the greater Everglades system and species that depend upon it continue to decline, the synthesis of information across scientific disciplines and the implementation of timely ecosystem restoration are vital. While the success of south Florida restoration efforts will ultimately be judged by the ecological responses they produce, the independent review panel on Everglades restoration progress emphasized that "Natural system restoration will best be served by moving the system as quickly as possible toward physical, chemical, and biological conditions that molded and maintained the historical Everglades" (NRC 2007). In addition to refined estimates of the volume of water needed to establish more natural salinity patterns and hydrology in the southern estuaries and marshes, the critical role of sheetflow and flow velocity in the evolution and maintenance of the ridge and slough landscape is understood far better than when the CERP was formulated. Yet, increased flows should be achieved without harmful water levels or impacts to water quality and will be evaluated by policy-makers.

Avian species in the Everglades are highly dependent on natural water level transitions. The Cape Sable seaside sparrow and Everglade snail kite remain highly imperiled, making ecosystem restoration both more urgent and more challenging. Independent expert review has concluded that although careful management will be needed through the transition to a restored system, there are no true conflicts between the needs of these species in the Everglades and that completion of ecosystem-wide restoration will benefit both sparrows and kites (Sustainable Ecosystems Institute 2007).

Monitoring has demonstrated that the State's water quality program has made progress in removing phosphorus, particularly as additional STAs have come on line in recent years; however, additional water quality improvement is needed for water entering Lake Okeechobee and the Everglades Protection Area. The issue of phosphorus in the watershed of Lake Okeechobee will require additional load reduction strategies to reduce the mobility of the phosphorus (SFWMD 2009).

Proactive management of invasive species is crucial, with an emphasis on prevention of new introductions. We must put national-level policies and regulations in place, based on strong risk analysis and screening tools that can scientifically evaluate the threat a species poses for invasion.

Sea level rise, and other consequences of climate change, must be considered in Everglades restoration planning and implementation. It is important to note that climate change only heightens the need to increase the flow of water through the Everglades and into the southern estuarine system in order to maintain the freshwater differential needed to mitigate effects of sea level rise and salt intrusion. Preparing now for a future with climate change will permit adaptation efforts that can reduce risks and increase sustainability for and resilience of both the natural ecosystem and the built environment of south Florida (see Climate Change in South Florida information brief).

Complete information on the references cited in this document can be found at the following location:

http://www.sfrestore.org/new_science.html