New Science

Everglades National Park
Summary of New Science

POC: Kevin Kotun and David Hallac, Physical and Biological Resources Branch Chiefs 305-224-4229/4239, kevin_kotun@nps.gov david_hallac@nps.gov

The Historical Everglades were Wetter than the Pre-Drainage targets in CERP
Recent refinements to the NSM incorporate additional historical hydrological. ecological and topographic information, indicating that water volumes passing through the central Everglades were approximately 50% higher than those in NSM runs for CERP, and flow across Tamiami Trail was likely double the amount of water provided by the 1999 CERP.

Data Sources:
1. USGS paleo-ecological studies of mollusk communities in Florida and Biscayne Bays indicate that pre-drainage estuarine communities were adapted to more stable freshwater flows and lower salinities than those present today. Statistical salinity models for Shark Slough and Taylor Slough indicate that the quantity of water flowing through the Everglades to Florida and Biscayne Bays would have been 2-4 times higher than current flows to support these communities.
2. USGS paleo-ecological studies of Everglades freshwater marshes showed that by the 1930's, construction of the Hoover Dike and Atlantic Coast canals shortened hydroperiods, reducing slough communities and increasing tree island sizes in the central and southern Everglades.
3. FIU/SFWMD paleo-ecological studies show that central Shark Slough in NESS and WCA 3B was dominated by white water lily (*Nymphaea odorata*) prior to the late 19th and early 20th centuries, indicating greater water depths and flooding durations.

Tree Island Flooding Tolerance in the Everglades
Recent SFWMD/FIU/ENP vegetation surveys on over 70 tree islands in the central and southern Everglades (ENP and WCA-3A/B) were recently evaluated using EDEN water depth data to estimate the flooding tolerances of the 38 dominant tree species occurring on these islands. The results indicate that although the tree islands in NESS and WCA 3B are significantly drier than the islands in WCA 3A, the majority of these tree islands are still dominated by flood-tolerant species. This suggests that water depths in NESS and WCA 3B could be increased while still maintaining these areas within the known flooding tolerances of their dominant species.

Overland Flow is Important to Vegetation Pattern Formation in the Everglades
Overland flow has long been recognized as a formative factor shaping many wetland ecosystems. Since the publication of "The Role of Flow in the Everglades Ridge and Slough Landscape" (SCT, 2003) several studies have reiterated and strengthened the conclusions in this paper regarding the importance of flow to the Everglades.

Data Sources:
1. USGS laboratory and modeling studies indicate that the downstream transport of particulate matter by overland flow is required to generate stable ridge and slough patterning. This conclusion is supported by the results of numerous field studies which demonstrate the relationship between flow and particulate matter transport and the accretion of soil organic matter that helps to maintain the height of ridges above the surrounding sloughs.
2. USGS field studies indicate that the velocities needed for particulate matter transport are rarely achieved in the impounded portions of the Everglades. These studies also show that the density of vegetation (i.e. sawgrass) is an important factor regulating flow velocities and sediment transport. Increased vegetation density is linked to altered water depths and hydroperiods in the impoundments, this causes increased hydraulic resistance, interfering with the processes of ridge and slough formation.
3. UCDavis/NPS tracer studies have documented large-scale flow patterns in the Everglades. These studies show that flow patterns are parallel to the ridge-slough orientation in well-preserved areas of central WCA 3A. In degraded vegetation regions (southern WCA 3A and 3B) the flow direction is determined by regional hydraulic gradients controlled by structure operations and border canals. This results in surface water flow *across* ridges, rather than parallel to them (see Figure 1). These studies indicate that both the flow speed and direction must be restored to support the processes of ridge and slough formation.

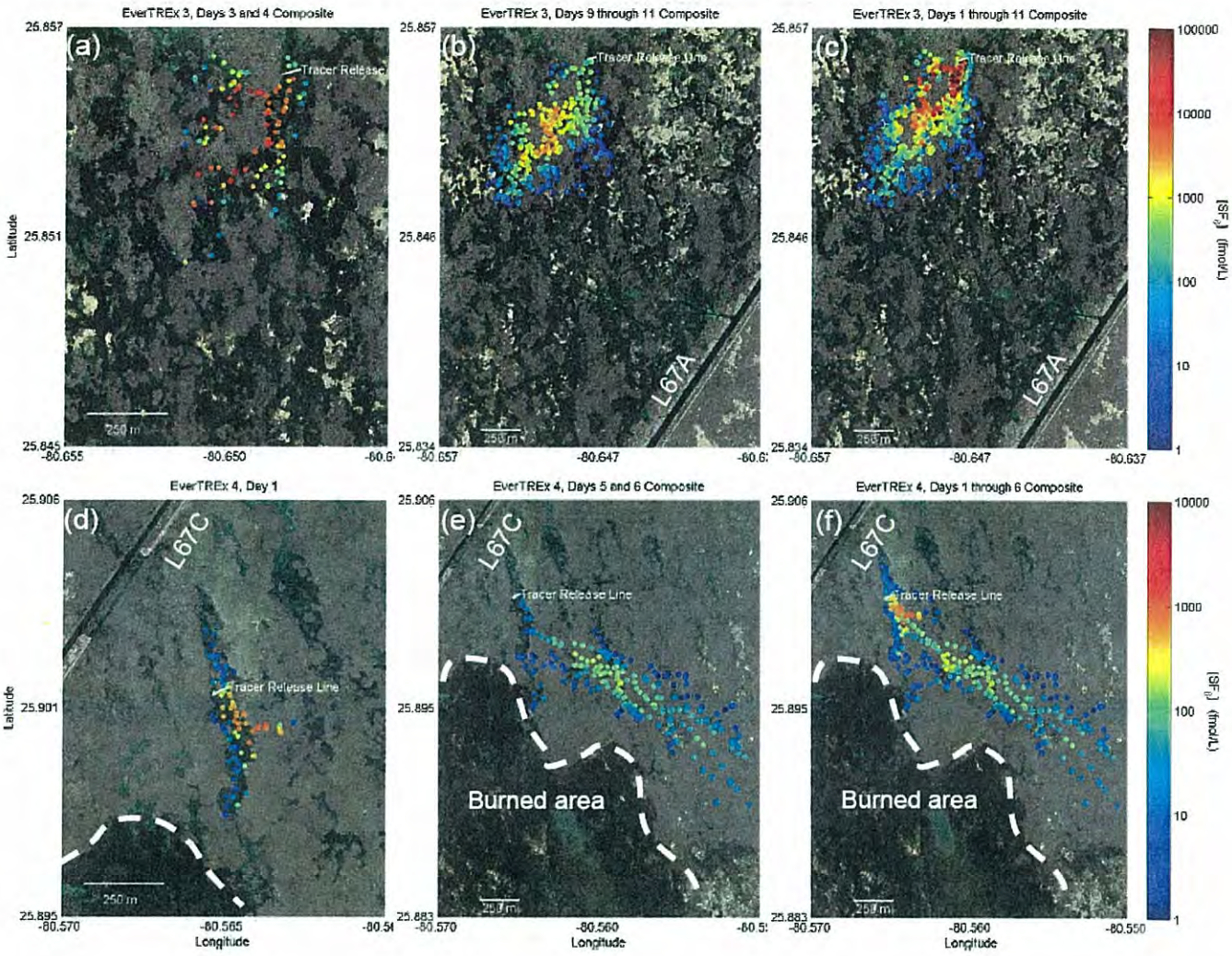


Figure 1 Tracer data in WCA 3A (top panels) and WCA 3B (bottom panels) reveal the current sheetflow patterns do not match the historic ridge and slough orientation, which is approximately north-south. In these images, lighter areas are ridges, and darker areas are sloughs, except the dark area that represents a recently burned area in subplots (d) through (f). Each colored point represents a single tracer measurement. Blue dots are near zero concentration, and thus represent bounds to the plume's extent. Subplots (a) and (d) show a smaller spatial region than the others. Subplots (c) and (f) show composite values collected over the entire measurement period,

The Spread of Invasive Aquatic Animals

POC: David Hallac, Biological Resources Branch Chief
305-224-4239, david_hallac@nps.gov

The canals of south Florida are known to harbor and facilitate the distribution of aquatic invasive species. Changes in water-management operations may inadvertently facilitate the range expansion of aquatic invasive species into natural marshes. Since 2000, seven new fish species have been collected within the marshes of Everglades National Park bringing the total observed to 16 species. All seven were first established in the eastern canals outside the boundaries of the Park. The new introductions generally correspond with the timing and location to recent changes in water management structures and operations or areas with direct canal inflows along the boundary of the park (see Figure 2). In addition to fishes, exotic aquatic invertebrates such as the exotic apple snails are also present in canals along the northern boundary of ENP and are slowly expanding south into marshes through water control structures and culverts.
Thus far, aquatic invasive species have been generally met with a low-level of action primarily limited to maintaining species checklists. Proactive management needs to be in place with an emphasis on prevention. Cooperation among the multiple management agencies involved with Everglades restoration is needed to promote the proactive management required to prevent the spread of additional aquatic invasive species into Everglades marshes.

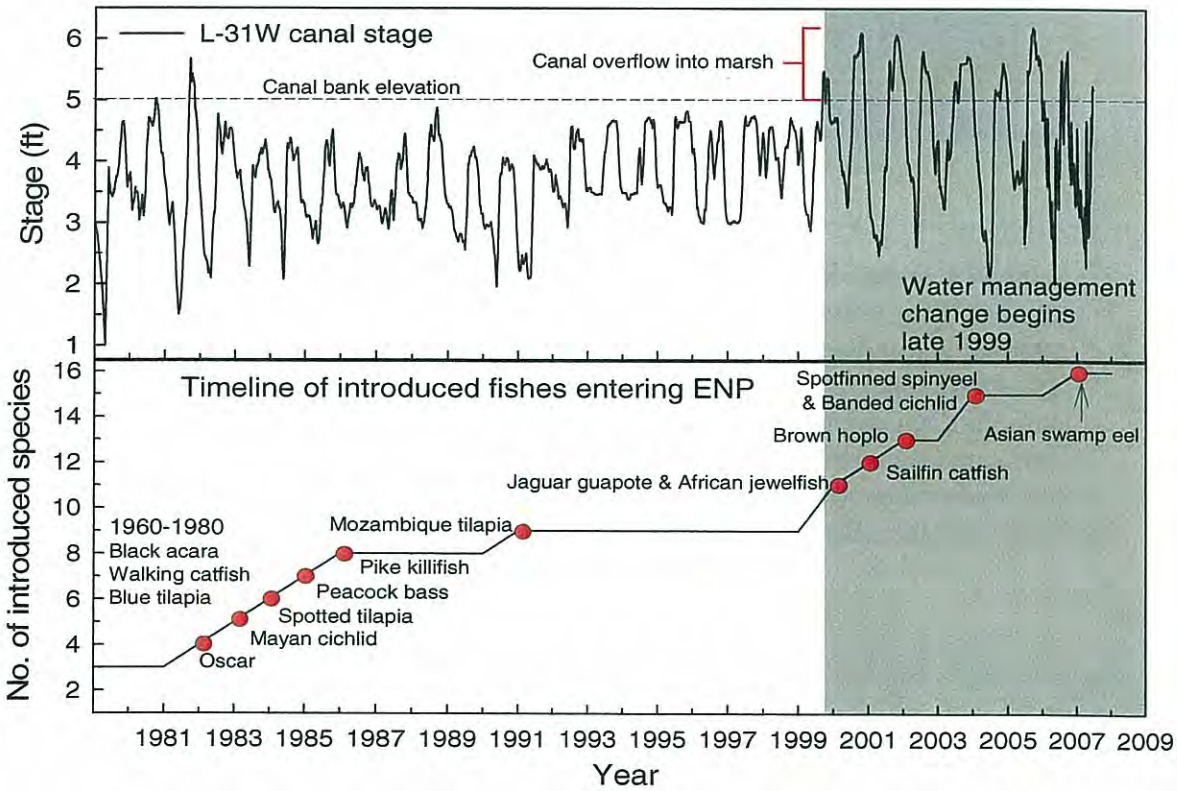


Figure 2 above: Stage in the L-31W canal with the canal bank elevation from 1979-part of 2007. Timeline of introduced fish species. Note the change in water management starting with a test at the end of 1999, the overflow of the canal bank and the corresponding increase in the number of exotic fishes in ENP.

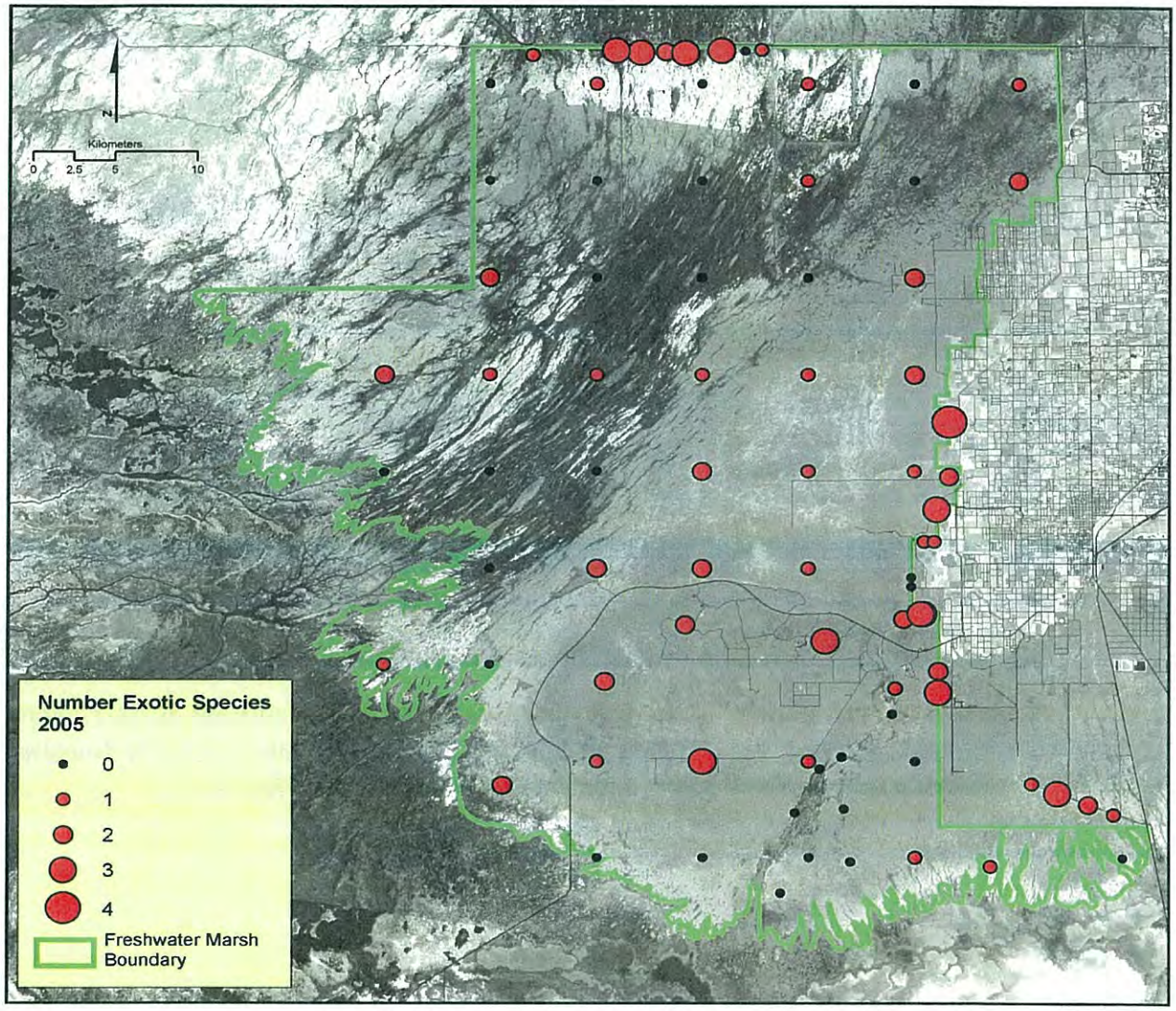


Figure 3: Number of Exotic Fish Species collected at each site in Everglades National Park park-wide sample in 2005. Note, the highest number of exotic fish species generally collected near canals. Also 2005 was a big inflow year because of hurricanes.

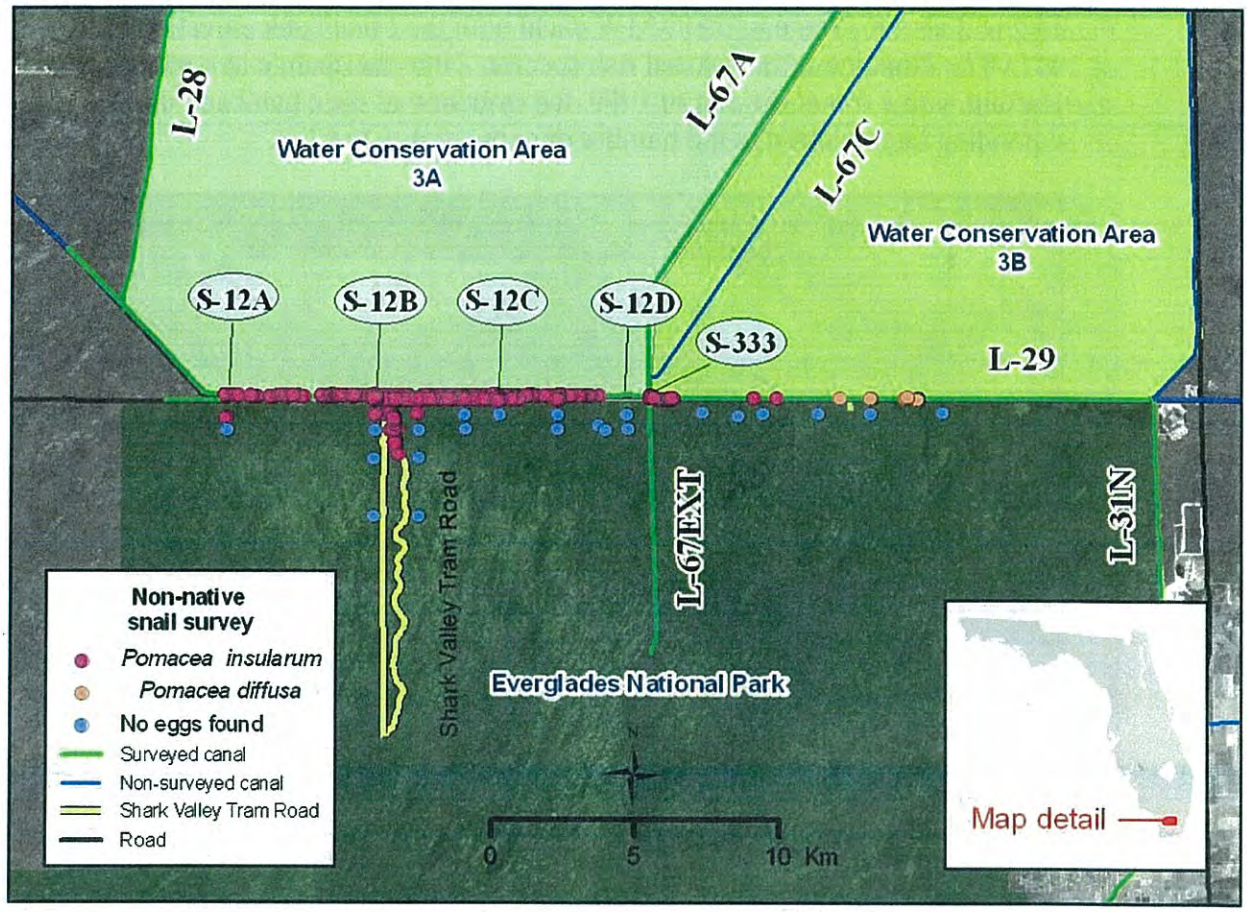


Figure 4: The distribution of Exotic apple snails in and outside of ENP in 2008. 2 species were found, many eggs in the L29 canal, Old Tamiami Canal, and a few found in the marsh south of inflow points and along the Shark Valley Tram Road.

USEPA Everglades Environmental Monitoring and Assessment Program (EMAP)

Contacts: Peter Kalla, Program Leader Kalla.peter@epa.gov 706-355-8778
Daniel Scheidt, Associate Program Leader Scheidt.dan@epa.gov 706-355-8724

Initiated in the 1990s in response to concerns about pollution, this Program is an iterative, comprehensive evaluation of the ecosystem's ecological condition. The Program provides quantitative information on about 100 biogeochemical parameters in surface water, pore water, floc, soil, periphyton and fish. Over 1000 stations have been sampled to date (left), resulting in more than 100,000 data values. The Program also assesses soil subsidence, aquatic food webs, periphyton communities, and vegetation communities. The Program features USEPA's random survey statistical design, which allows scientists to give managers quantitative statements, with known confidence limits, about the magnitude and extent of environmental problems.

This Program has provided monitoring and assessment data for determining ecosystem health and the effectiveness of Everglades restoration activities from the 1990s into the twenty-first century. As CERP restoration efforts and Everglades phosphorus and mercury control efforts progress, this probability-based sampling can be repeated to document the condition of the Everglades and the effectiveness of these actions. Everglades EMAP data have been requested by over 30 organizations, Federal and state agencies, Indian tribes, research universities, and corporations.

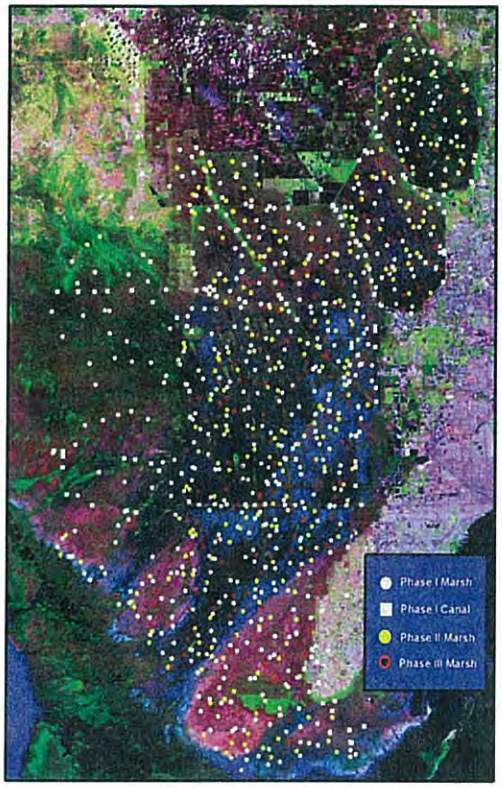
Findings for 2005:

About 57% of the Everglades marsh had a surface water sulfate concentration exceeding 1.0 part per million, CERP's restoration goal. Sulfur has been implicated in mercury methylation and bioaccumulation.

Soil phosphorus exceeded 500 milligrams per kilogram (mg/kg), Florida's definition of "impacted", in 24% of the Everglades, and it exceeded 400 mg/kg, CERP's restoration goal, in 49% of the Everglades. These proportions are statistically higher than the 16% and 34% observed in 1995-1996.

The mercury concentration in mosquitofish, a key prey fish for Everglades gamefish and wading birds, dropped markedly from 1995 to 2005. However, 65% of the marsh exceeded 77 parts per billion, a concentration deemed to be protective of top predators such as birds and mammals. Bioaccumulation factors vary by a factor of 1000 across the Everglades.

USEPA Everglades Environmental Monitoring and Assessment Program (EMAP)



Initiated in the 1990s in response to concerns about pollution, this Program is an iterative, comprehensive evaluation of the ecosystem's ecological condition. The Program provides quantitative information on about 100 biogeochemical parameters in surface water, pore water, floc, soil, periphyton and fish. Over 1000 stations have been sampled to date (left), resulting in more than 100,000 data values. The Program also assesses soil subsidence, aquatic food webs, periphyton communities, and vegetation communities.

The Program features USEPA's random survey statistical design. This EMAP sampling design allows scientists to give managers quantitative statements, *with known confidence limits*, about the *magnitude and extent* of environmental problems.

This Program has provided monitoring and assessment data for determining ecosystem health and the effectiveness of Everglades restoration activities from the 1990s into the twenty-first century. As CERP restoration efforts and Everglades phosphorus and mercury control efforts progress, this probability-based sampling can be repeated to document the condition of the Everglades and the effectiveness of these actions.

Everglades EMAP data have been requested by over 30 organizations, Federal and state agencies, Indian tribes, research universities, and corporations.

Program Contacts

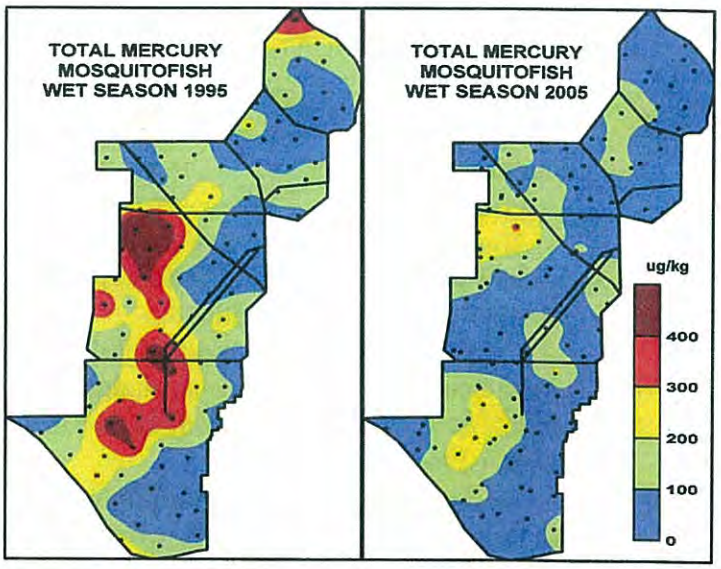
Peter Kalla, Program Leader
Kalla.peter@epa.gov 706-355-8778
Daniel Scheidt, Associate Program Leader
Scheidt.dan@epa.gov 706-355-8724

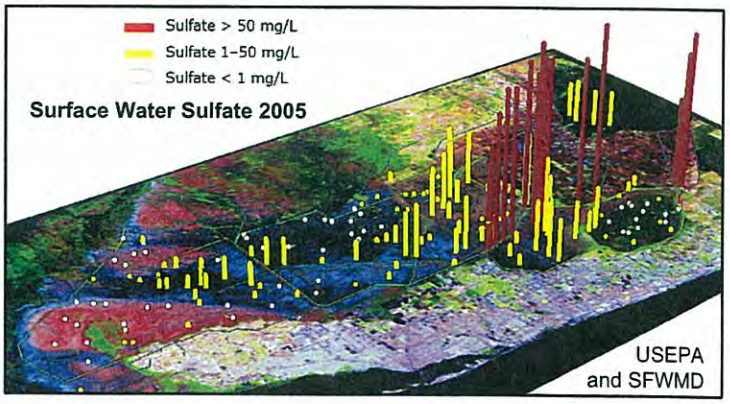
MAJOR FINDINGS 2005

About 57% of the Everglades marsh had a surface water sulfate concentration exceeding 1.0 part per million, CERP's restoration goal. Sulfur has been implicated in mercury methylation and bioaccumulation.

Soil phosphorus exceeded 500 milligrams per kilogram (mg/kg), Florida's definition of "impacted", in 24% of the Everglades, and it exceeded 400 mg/kg, CERP's restoration goal, in 49% of the Everglades. These proportions are statistically higher than the 16% and 34% observed in 1995-1996.

The mercury concentration in mosquitofish, a key prey fish for Everglades gamefish and wading birds, dropped markedly from 1995 to 2005. However, 65% of the marsh exceeded 77 parts per billion, a concentration deemed to be protective of top predators such as birds and mammals. Bioaccumulation factors vary by a factor of 1000 across the Everglades.





ARM Loxahatchee National Wildlife Refuge

POC Matt Harwell
Office: (772) 562-3909 x255
Cell: (561) 755-3819
FAX: (772) 562-4288
E-mail: matthew_harwell@fws.gov

Summary of New Science: provide a plain language summary of the new scientific concepts that have evolved since the Comprehensive Everglades Restoration Plan (CERP) was authorized in 2000.

Contributions specific to Lox since 2000
-- we have developed a better appreciation of the multi-disciplinary examination of invasive exotic vegetation in the Refuge, and started to develop an appreciation of the effects of sustained, extensive exotics treatment efforts
-- we have developed an understanding of the effects of the change in Water Regulation Schedule in 1995 (Brandt's report)
-- we have developed a better understanding of water movement in the Refuge, the Refuge's "water needs", and how canal water intrusion occurs and influences the water quality and ecology of the Refuge interior
-- with the design, building, and operation of STAs, we have developed an understanding that additional STA treatment acreage and better BMPs are needed to help us reach our water quality goals (and the legal requirements)
-- we have developed a far better understanding of the effects of water hardness on the soft-water marsh interior, including how that science influences management decisions
-- we have developed/participated in the DOI Everglades Program Team, bringing WQ/wetland/ecology/hydrology expertise to bear on issues related to Lox, ENP, and the Everglades as a whole (e.g., advanced treatment technology issues with "marsh readiness"; hydropattern restoration with dirty water)
-- fire effects: better understood; more interaction with exotic vegetation work; learning from other systems

Here is the list of what I offered up at their last meeting from their draft meeting notes - note that at that meeting, they were not being discussed from an "agency-involvement" perspective:

Key Insights/New Points: *(What is different from previous thinking?)*

- Ecological 1: Ecological models not used as primary component in Yellow Book. There is an intermediate scale of models that can be used for ecology and planning – they are neither too simple, nor too complex.

- Ecological 2: Indicator concept tells you "what" is going on. We (RECOVER) are also exploring the "why" it is going on, including ties to intermediate-scale ecological models, ability to manage adaptive management decisions, etc.
- Ecological 3: Shifting baselines/soft targets. Concept of ecosystem resilience should be explored and more attention likely to be paid to it over next few years.
- Hydrologic 1: It is more than just storage; dynamic storage is now a key concept. E.g., TS Fay raised Lake Okeechobee extensively, but last week's 1" rainfall bought only 3-4 days of reduced wildland fire threat.
- Hydrologic 2: There is some flexibility within the water regulation schedules- not just lines on paper but with the narrative rules in the schedules.
- Big Picture 1: Preserve and protect parts of system not actively trying to restore is an important point. Don't forget the fringe areas.
- Big Picture 2: Translation of info from scientists to managers. No longer putting science report on CD and FedEx-ing to manager. New development - greater interaction in the translation of science.
- Big Picture 3: Stakeholder engagement and its role in ecosystem restoration. How to focus on stakeholder issues to minimize unnecessary litigation. AM process identify four different tiers of engagement, so is not all or none.

Clarifying Questions for Understanding and Discussion Points:

Do intermediate-scale ecological models exist? Yes, but not formally used in the process at the same level of relevance as hydro (2x2). Still some in development. In the effort to streamline the planning process as part of the revisions to the Pro Regs, need to be careful not to lose the ecological components (perhaps this is brought forward with Interim Goals?). Example of most complicated- Everglades Landscape Model. Simplest- water-only based Habitat Suitability Index model.

Ecosystem resilience- if hydrology put back, most will be all right? Degraded ecosystems have lower resilience. Restoration builds back up the resilience. May be able to achieve/enhance ecosystem resilience while still not total restoration (or still in progress).

Summary of New Science
Miami-Dade County

Integrated Model of Surface and Groundwater Flow for Evaluating Effects of Competing Water Demands in Miami-Dade County (USGS in partnership with Miami-Dade)

Miami-Dade County has entered into a cooperative agreement with the USGS to develop a model of the Biscayne Aquifer in Miami-Dade County that represents flow through the canal network, interaction of surface and groundwater, and surface waters of Biscayne Bay and coastal wetlands. The model will include appropriate resolution to address water management issues related to wellfield protection, effects of water use withdrawals or application of reclaimed water, canal management practices, lake excavations, saltwater intrusion, and sea level rise. USGS initiated work in 2008, building upon existing hydrologic and physical models, and plans to complete the project by 2011. Model development includes calibration and technical peer review. The final model product will be in the public domain, capable of being run on a desktop computer, modular and flexible so facilitate incorporation or linkage with other features, and able to meet the needs of other stakeholder agencies.

Contact Information:

Miami-Dade Water and Sewer Department
Virginia Walsh, P.G.
786 552-8266
walshv@miamidade.gov

South Florida Water Management District
Point of Contact: Tom Teets/Joni Warner
Phone: (561) 682-6993/(561) 682-6537
Email: tteets@sfwmd.gov/jwarner@sfwmd.gov

Summary of New Science: provide a plain language summary of the new scientific concepts that have evolved since the Comprehensive Everglades Restoration Plan (CERP) was authorized in 2000.

Project Paragraph: The majority of the new science that has evolved since the CERP was authorized in 2000 focuses on the relationship between topography, hydrology and ecology. For Lake Okeechobee, a clear relationship has been developed between annual lake stages and lake ascension and recession rates as well as the maintenance of a healthy lake. Similarly, in the Northern Estuaries, marked advances in quantifying the relationship between ecosystem health and the timing and volume of freshwater inflow have occurred. In the Greater Everglades, a better understanding of the importance of sheet flow to maintaining and restoring the natural system is developing. Much has been learned about the influence of recession rates, volume and depth on wading bird recovery, the ridge and slough system, tree islands and other defining characteristics of the historic everglades. In the Southern Estuaries, a clearer understanding has been gained of the historic role and current need for additional fresh water to sustain diverse seagrass habitat and the ecosystem's productivity.

USDA-NRCS
Bill Reck

New Science

NRCS has ongoing program of development of plant material for use in coastal shoreline stabilization. We evaluate and propagate based on survivability and erosion control. Additionally, NRCS is developing plant materials for use cover crop biomass intended to increase carbon sequestration and as biofuels intended as fossil fuel replacement.

Ongoing: Mimi Williams, Plant Materials Specialist, NRCS, (352) 338-9544, MJ.Williams@fl.usda.gov

NRCS believes that the voluntary, incentive-based approach is the most effective method of achieving sound resource management and conservation on private lands. Use of market based approaches is one method of providing agricultural producers with incentives to install conservation practices. NRCS intends to help provide the information necessary for markets to function by increasing our investment in the technology and research needed to evaluate and measure benefits and costs of conservation treatment. Consistent and reliable measurements of conservation benefits will encourage private investment. NRCS has provided a Conservation Innovation Grant to the World Wildlife Fund to evaluate compensating owners of private ranchlands for storage and management of runoff water on isolated wetlands with their property. This can potentially provide improved water quality and water storage at a cheaper rate than large municipal projects.

Ongoing: Sarah Lynch, Director, Agriculture, World Wildlife Fund, (202)495-4781, sarah.lynch@wwfus.org

New USGS Scientific Investigations in the Everglades

USGS / FISC 2008-2009 Research Overview

POC: Barry Rosen
Phone: 407-803-5508
Cell Phone: 407-738-0669
brosen@usgs.gov

USGS Florida Integrated Science Center (FISC) research includes improved water depth estimation capabilities, research on emerging water quality issues, groundwater-surface water modeling, integrated hydrology-manatee modeling, and coral reef ecology. **Water depth estimation capabilities:** The Everglades Depth Estimation Network (EDEN) is a primary product of the RECOVER monitoring and assessment plan, offering continuous water level data for the Everglades that is critical for large-scale field operations, research, and assessments in the Everglades. **Emerging water quality issues:** New research investigates occurrence of organic wastewater compounds (antibiotics, hormones, and pharmaceuticals) in water treatment facility effluent. Research on the microbial ecology of the upper Floridan aquifer looks at geochemical parameters of public health interest in native versus blended waters. Work on land-based pollution from coastal submarine groundwater discharge sites looks at the suspected link between macro algae and the Broward county shelf and the relationship between algal blooms and native benthic ecology. **Coupled surface water-groundwater models:** FISC is current in discussions with the Army Corps of Engineers in Jacksonville, the FWS in Vero Beach over tentative plans to build a web interface to access and display Everglades coupled ground water and surface water models that could be used to assess the impact of sea level rise and salt water intrusion on water management, habitat stability, and vulnerability to coastal storms. **Hydrology-manatee modeling:** FISC is expanding on its integrated TIME-Manatee model by further integrating it with the Cape Sable offshore tidal boundary, incorporating vegetative data, and improving hindcasting. The expanded model will be used to test for the effects of multiple sea level rise and CERP restoration scenarios on vegetation change, including mangrove-marsh ecotones, mapping hotspots of ecotone change, and determine spatially-explicit habitat suitability for species of interest. **Coral reef ecology:** New research on coral reef ecosystems is looking at the impacts of changing climate conditions, ocean pH, and sea level coral disease, benthic habitats, and coral calcification (growth) rates.

U.S. Fish and Wildlife Service

Contact: Todd Hopkins
Phone: 772-562-3909
Email: Todd_Hopkins@fws.gov

Since the authorization in 2000 of the Comprehensive Everglades Restoration Plan, the US Fish and Wildlife Service (Service) has supported research, monitoring, and modeling aimed at improving our understanding of the conservation needs of threatened and endangered species affected by South Florida ecosystem restoration. The following lists the most pertinent areas of recent and ongoing science.

1. Cape Sable seaside sparrow: The Service has provided funding for research on conservation, population dynamics and habitat management for sparrows, including development of an emergency action plan for sparrows, and studies on the effects of fire season, conspecific attraction and predator exclusion.
2. Everglade snail kite: The Service has funded monitoring and research on the hydrologic and habitat requirements for snail kites and their prey, apple snails, with emphasis on hydrology and habitat in the Greater Everglades ridge and slough ecosystem of Water Conservation Area 3A, and the Kissimmee Chain of Lakes.
3. Florida panther: The Service has funded population modeling and population viability analysis, a panther habitat estimator model, evaluation of potential habitat, dispersal zones and reintroduction sites in south-central Florida, and public awareness and attitudes about panthers.
4. Multi-species Avian Ecology Workshops: In 2003 and 2007 the Service, in coordination with the South Florida Ecosystem Restoration Task Force, conducted independent expert workshops to synthesize science related to the hydrologic and habitat needs of four avian species affected by south Florida ecosystem restoration, the Everglade snail kite, Cape Sable seaside sparrow, wood stork and roseate spoonbill.

Organizations: NOAA/AOML and NOAA/SEFSC
Point of contact: Elizabeth Johns, NOAA/AOML Physical Oceanography Division
Phone number: (305) 361-4360
Email: libby.johns@noaa.gov

A number of new scientific concepts and programs have been developed within NOAA since the Comprehensive Everglades Restoration Plan (CERP) was authorized in 2000, as described below.

NOAA's National Marine Fisheries Service (NMFS) is responsible for the Fisheries and the Environment (FATE) program, whose mission is *"to provide the information necessary to effectively adapt management to mitigate the ecological, social and economic impacts of major shifts in the productivity of living marine resources"*. The FATE program announces opportunities for competitive research on an annual basis, and encourages collaborative proposals between fisheries oceanographers and scientists responsible for stock assessments or ecosystem assessments. The FATE annual science meetings have evolved into a NOAA/NMFS national forum for the discussion of Fisheries Oceanography.

NOAA has also been supporting a multi-year study of ecosystem connectivity between south Florida and the upstream waters of the Gulf of Mexico and Caribbean Sea. This project is a collaboration between Fisheries biologists from NOAA's Southeast Fisheries Science Center (SEFSC) and physical oceanographers from NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML). The goal of this study is to understand how the oceanographic environment (currents, water properties, etc.) affects the diversity, abundance and distribution of larval reef fish within NOAA's Florida Keys National Marine Sanctuary (FKNMS) and its upstream source waters.

Finally, within South Florida's coastal marine ecosystem there are major geographical domains with distinct environmental threats and inherent tradeoffs that, for a variety of reasons, have received insufficient attention within the Comprehensive Everglades Restoration Plan (CERP) and South Florida Ecosystem Restoration (SFER). NOAA has created a new program specifically designed for the unique questions and problems related to south Florida's marine ecosystems. This new program is called MARine and EStuarine goal setting for south Florida (MARES). The mission of the MARES program is *"to reach a much needed consensus with respect to quantitative goals for a sustainable and healthy regional marine ecosystem"*. Towards this end, NOAA will be sponsoring a series of workshops over the next several years to bring together a broad range of interested individuals, agencies and institutions. The tasks of the workshops will be to produce Conceptual Ecological Models (CEMs) with explicit qualitative goals, and to develop Quantitative Ecosystem Indicators (QEIs). The workshop results will be disseminated and additional input acquired by conducting targeted briefings for resource managers and planners as well as facilitated workshops specifically for stakeholder groups.

RECOVER/RLG

Kelly Keefe (Kelly.j.keefe@usace.army.mil)

RECOVER is preparing a paper currently titled "Inventory of Ecological Knowledge Gained since the Yellow Book" that will provide a plain language summary of new science related to CERP and Everglades restoration. At this time we have defined "new science" as science information that was not available for consideration when the YB was written, but that may contribute to discussions of how to best implement Everglades restoration. The paper consists of 1-2 page summaries (with detailed references) of multiple topics under the themes of hydrology, ecology, and applied technology. The summaries are backed by extensive documentation, and will be open for review and amendment based on additional peer reviewed science, to ensure that all interested parties have opportunities to check the reported information and contribute. The final paper will be short, accessible, and in plain language for any policy maker or interested person to use as a reference. The intent of the paper is to provide an unbiased inventory of the new scientific information available to date regarding restoration in south Florida pertinent to Everglades restoration for policy makers and interested stakeholders. This paper is currently in (very) rough draft form.