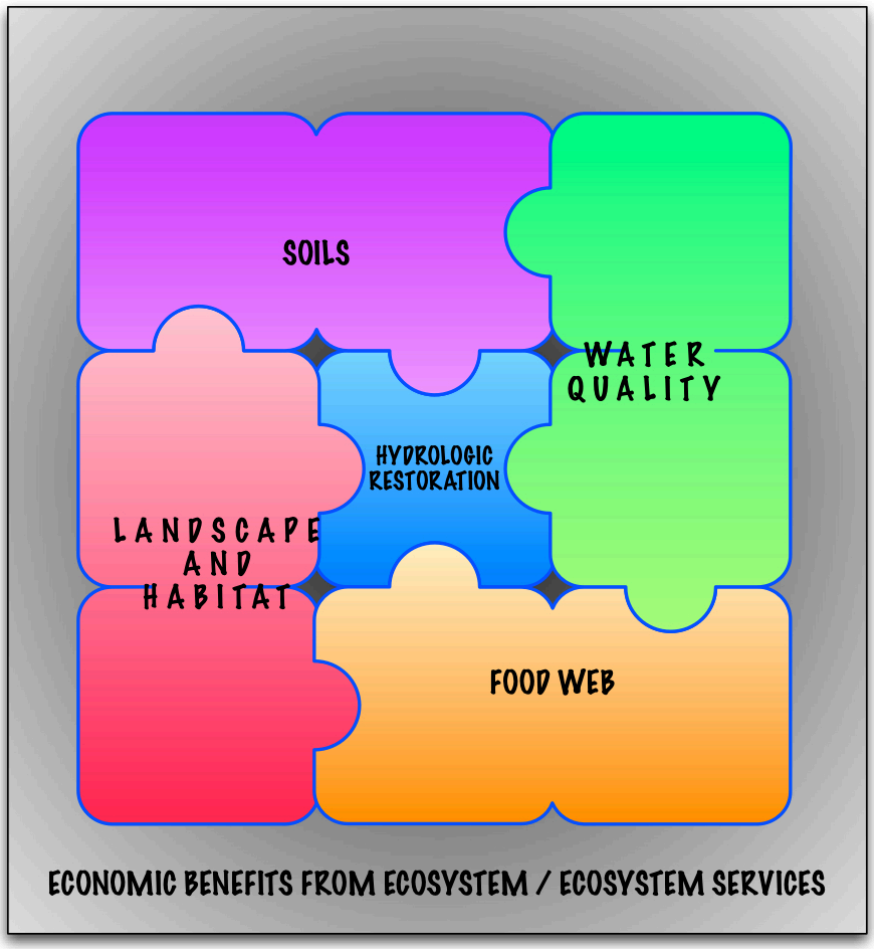
KEY QUESTIONS AT THE INTERFACE OF SCIENCE AND



MANAGEMENT

PRODUCED FOR

THE CRITICAL ECOSYSTEMS STUDIES INITIATIVE

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Introduction

The SERES Project Objective

The SERES (**S**ynthesis of **E**verglades **R**esearch and **E**cosystem **S**ervices) project is a Critical Ecosystems Studies Initiative effort to synthesize freshwater Everglades research. The importance of synthesizing the ever-growing body of scientific information related to the Everglades is routinely recognized in science plans, such as those by the Department of the Interior [1] and the South Florida Ecosystem Restoration Task Force [2], and there are many examples of excellent synthesis efforts [3-6]. These efforts primarily summarize and analyze the available scientific information for other scientists. While they have greatly contributed to cross-disciplinary understanding, the SERES project has a different objective. The objective in SERES is to focus on synthesizing Everglades research for a primarily non-scientific audience.

The scientific research on the Everglades is driven largely by Everglades restoration, the ongoing process to reverse the ecological decline in south Florida. The decision makers charged with implementation of the various restoration efforts require useful scientific information. But science information is merely one of their considerations, as they must also include fiscal, legal, and policy perspectives. The scientific information needs to be accessible, and presented in a way that informs, not constrains, decision-making. The SERES project is intended to help address that need.

This Document

The SERES Project will focus on providing useful information to decision makers and the informed public. Investigations [7] have demonstrated that this is best accomplished when the effort is a collaborative effort between scientists and managers. The SERES project is a scientific endeavor, and these typically begin with a definition of the questions under investigation. This initial phase is when the collaboration between scientists and managers is especially important. By getting a clearer understanding of the issues and information needs facing Everglades restoration from different perspectives, especially those of managers, decision-makers, and key opinion leaders, scientists can focus on providing relevant and credible information.

This document summarizes a proposed set of questions that will serve to focus investigations. The questions are an interface between the implementation of Everglades restoration and scientific investigations, a bridge. The scientists on the SERES Project team drafted a set of questions, and then provided these to science managers at the agencies involved in Everglades restoration, including the South Florida Water Management District, the National Park Service, the Florida Department of Environmental Protection, the US Fish and Wildlife Service, among others. This document contains the questions that are the result of those discussions.

The next phase is to get comments from a broader audience, including those upper level managers at agencies working on Everglades restoration, decision makers, and the public. This document captures the conversations to date, and provides some background for further input from decision-makers, agency managers, and opinion leaders.

Science Coordination

A number of other important science integration and science synthesis efforts are underway, and for SERES, as well as the other efforts, to be successful, there must be open and constant communications and coordination. The National Oceanographic and Atmospheric Administration (NOAA) is sponsoring an effort *Marine and Estuarine Goal Setting for South Florida,* named MARES [8]. While MARES focuses on the marine and estuarine systems and SERES focuses on the freshwater Everglades, they share common strategies and tools; the investigators have met and agreed to jointly work on science communication skill development and on valuation of ecosystem services.

RECOVER is has also undertaken *Shared Vision of Everglades Restoration* [9], and as a first step, has produced a draft report on *Knowledge Gained* [10]. This effort has resulted in summaries of research in a variety of topics, along with extensive bibliographies; SERES will not duplicate this effort, and instead will focus on those areas that most affect the questions posed by managers, decision-makers and opinion leaders. SERES has briefed RECOVER on their efforts, have attended the public meetings, will offer comments on the documents, and will continue to engage with RECOVER.

Also, the Science Coordination Group (SCG) of South Florida is charged with integrating science among all the agencies working on Everglades restoration. Their Science Plan [2] spells out not only how science is coordinated at the project-level, but also how important scientific information can be communicated to broad audiences (see Section 6). The SERES project is a focused type of communication. The SERES team has presented to the SCG, and most of the individual members were contacted directly. Moreover, we see coordination with the SCG as a key step in both focusing the science on relevant topics and communicating to key audiences.

Key Questions

In developing a set of questions, we asked managers, decision-makers, science managers, and members of the informed public what information would be of particular interest to them and would aid their decision-making and management of the Everglades. We found that, in general, managers, decision-makers, and the informed public focused on questions of hydrology (related to projects) and economics, while scientists focused on questions of function and relationships

in the Everglades; science managers asked questions in all areas. Additionally, managers asked questions about trade-offs, and questions that will help prioritize decisions.

The questions below are direct questions posed by at least one manager that we believe is representative of the key questions in topical areas identified by scientists as essential to understanding how the Everglades works. These questions are necessarily incomplete, but will serve to focus efforts on the issues of the most concern, and therefore, of the most benefit.

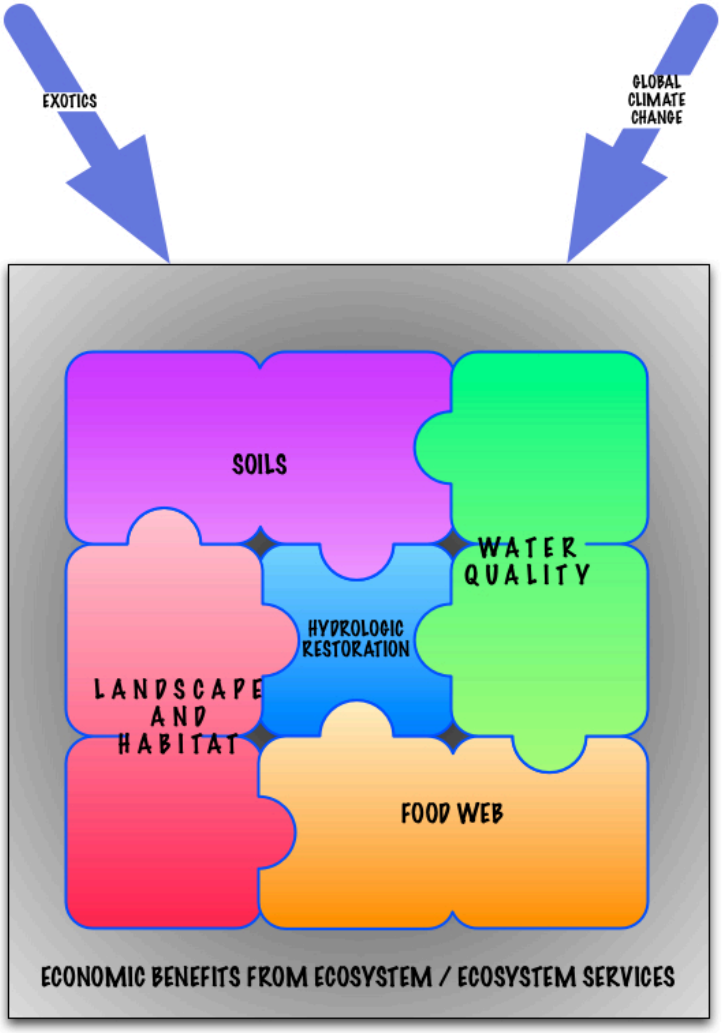
Question # 1:
Hydrologic Restoration
For a range of storage, what are the hydropattern and flow effects?

Question # 2:
Interactions Hydrology- Water Quality
For a range of water quality and flows, what are the consequences of introducing this into the Everglades? What are the consequences of waiting?

Question # 3:
Interactions Hydrology- Landscape Pattern and Heterogeneity
For a range of hydropattern and flow effects, what will happen to tree islands, ridges and sloughs, and wet prairies?

Question # 4:
Interactions Hydrology- Food Webs, Community Dynamics
What range of hydropatterns, flows, and habitats are needed recover the upper trophic levels, such as wading birds and alligators?

Question # 5:
Interactions Hydrology- Soil
What will be the effect of hydrology and water flow on the carbon balance, peat accretion and/or subsidence?



Question # 6:
Economics and Ecosystem Services
What are the economic benefits and improvements to ecosystem services as a result of restoration?

Question #7
Externalities to Everglades Restoration
How will climate change affect Everglades restoration?
How will restoration affect exotic species?

The above questions are related, just as the general topics related to ecosystem function in the Everglades are inter-related. The primary questions, however, are related to those issues that drive public policy decisions. During our interactions with managers, it became clear that articulating benefits and possible future conditions, along with trade-offs, was the most useful scientific input.

These questions will serve as a means of focusing the scientists performing the synthesis on the issues are most pressing to decision-makers, clarifying where scientific synthesis would be most helpful.

Appendix: Questions

During our interactions with managers and scientists, we heard a wide range of questions. The primary motivation was to find questions that, if answered, would be of practical benefit in getting Everglades restoration implemented. Those in **blue were from upper level managers, decision-makers**, and key opinion leaders, those in **red were from the agency science managers**, while those in **black were from agency and academic scientists**. From these questions and interviews, the main synthesis questions were developed.

Hydrology

- How much water is available? How much do we need to store?
- How much land do we need for storage and treatment? Where should it be?
- What is a 'flow-way' and how does it help restoration? Do we need one?
- How much of Tamiami Trail and other dams need to be removed?
- Will ASR work? Are in-ground reservoirs viable?
- How often can we miss the targets (wet years too wet and/or dry years too dry) and still call it 'restoration'? How close do we need to get?
- Explain the basics of restoration. What is it about the water that we need to get right? What if we don't have enough land, water, or Everglades left?

- For a range of storage options, what are the hydropattern and flow effects? How much storage/hydroperiod/flow is needed to support key habitats (tree islands, ridge and slough)?

- How do we provide the flows needed to sustain Florida Bay without drowning out marl prairies?

- How far in time do we have to go back for a reference point of hydrologic conditions in the Everglades?

- In a restored Everglades, how do we differentiate "new" water from "old" water?

- What is the feasibility of ASR? What is the cost of ASR relative to surface storage?

- How much water storage capacity do we currently have in the system (including Lake Okeechobee)?

- How will the Everglades respond to near-term hydrologic restoration and more gradual water quality restoration (as a result of increasing water treatment technologies and source control measures)?

- Can Everglades restoration proceed without constraining water use?

- How much flow/depth is needed to restore the Everglades?

- Will the study focus on hydrology, as the driver of valued ecosystem services in the freshwater system and as the conveyor of inputs to estuarine systems? Is it possible to have a big picture synthesis of hydrology?

- What are the net benefits from various options in terms of quality, quantity, timing, and distribution and when will the benefits be realized, …., ten, twenty, thirty years?

- How much water do we have, how much can we get, how much do we need?

- Water storage options —how much and where will they be located? When should that water be captured? How will surface storage affect the regional ecology?

- What storage is needed to achieve needed flow restoration and what are the scales of success and timescales of responses?

- How to convey the water southward?

- How can water and water quality management be combined to produce the most benefits (e.g., the most amount of food for wading birds)?

- How can different hydrological requirements of different species be managed? If we have to make choices, what is more important? Flow or water quality? Are we at a tipping point, at the verge of losing the system?

- What is the appropriate quantity, quality, timing and distribution for restoration?

- How do you determine water quality versus water quantity impacts? What are the cost benefits of achieving water flow with "dirty" water compared to no or less water flow with "clean" water?

- Does a de-compartmentalized and uncontrolled Everglades require water storage to allow proper ecosystem function in the remaining system? If yes, how will water storage reservoirs be created and managed to accomplish hydrologic restoration without de-compartmentalization?

- Can the Everglades be successfully restored without limiting or reducing human water use?

- How should management actions for the benefit of the Cape Sable seaside sparrow be balanced with other trust species such as the snail kite and important ecosystem characteristics such as the ridge and slough patterns?

- How much latitude do we have to deal with water storage as related to the central bubble of the diagram (hydrologic restoration)?

- How will the needed water storage reservoirs be created and managed to accomplish hydrologic restoration in a manner that permits full decompartmentalization? How specifically will hydroperiod be affected and what will the effects be on wetland ecosystem functions and services? How variable will the effects be during wet years and even more importantly, during dry years?

- Increased flow will potentially allow restoration of higher flow velocities and associated sediment transport that could enhance highly valued ecosystem functions and services? What are the relative effects of adjusting hydroperiod and flow velocity/sediment transport in terms of their positive influences in preserving highly valued ecosystem functions and services?

- Descriptions of the hydrology needed to restore various plant communities and wetland functions. Especially important are descriptions of the possible Everglades ecosystem responses to dry year (drought) scenarios, the Everglades ecosystem responses to wet year (flooding) scenarios. This will help clarify the quantities of water needed by the Everglades during drought years.

Soils

- In the natural system, what role did peat soils play in the control of water depth and recharge over time? Will a built or restored Everglades be able to simulate this?
- How will restoration proceed with other contaminant issues: mainly agricultural chemicals in EAA soils and legacy phosphorus in Lake Okeechobee sediments?
- Will the Everglades serve as a carbon sink or source under climate change (peat building/geomorphological processes)? What will be the function of hydrology and water quality in affecting this? What's the equation for the water inflow functions?
- What hydroperiod is needed to maintain critical soil formation in ridge and slough and tree island habitats?
- What evidence is there that Everglades ecosystem functions and services (e.g., carbon sequestration) are degrading at an increasing rate under management?
- How does rising sea level contribute to peat collapse?
- What are the achievable end-states of a restored Everglades ecosystem in terms of its highly valued ecosystem functions and services? How are those end-states affected by specific components of restoration (e.g., restoration of hydroperiods, flow velocities, reduction in contaminant loads and concentrations, etc.)?
- How will the needed water storage reservoirs be created and managed to accomplish hydrologic restoration in a manner that permits full de-compartmentalization? Specifically, how will hydroperiod be affected and what will the effects be on wetland ecosystem functions and services? How variable will the effects be during wet years and even more importantly, during dry years?

Landscape

- What are the trade-offs between tree-islands and endangered species?
- How often can we miss the targets (wet years too wet and/or dry years too dry) and still call it 'restoration'? How close do we need to get?
- What happens to plants and animals if we can't get back the same ratios of habitats?
- How should management actions for the benefit of the Cape Sable seaside sparrow be balanced with other trust species such as the snail kite and important ecosystem characteristics such as the ridge and slough patterns?

- For a range of storage options, what are the hydropattern and flow effects? How much storage/hydroperiod/flow is needed to support key habitats (tree islands, ridge and slough?)

- How long will it take for tree islands to respond in a positive way to a "restored" Everglades hydrology?

- What are the achievable end states of a restored Everglades ecosystem in terms of its highly valued ecosystem functions and services? How are those end-states affected by specific components of restoration (e.g., restoration of hydroperiods, flow velocities, reduction in contaminant loads and concentrations, etc.)?

- How will the needed water storage reservoirs be created and managed to accomplish hydrologic restoration in a manner that permits full de-compartmentalization? How specifically will hydroperiod be affected and what will the effects be on wetland ecosystem functions and services? How variable will the effects be during wet years and even more importantly, during dry years?

- Increased flow will potentially allow restoration of higher flow velocities and associated sediment transport that could enhance highly valued ecosystem functions and services. What are the relative effects of adjusting hydroperiod and flow velocity/sediment transport in terms of their positive influences in preserving highly valued ecosystem functions and services?

- Fire – a wetter Everglades will burn less than fire-dependent species and ecosystems are adapted to, with adverse effects

- The destruction and loss of tree islands is irreversible within a human time frame, and current hydrologic conditions are not conducive to the establishment of new islands.

Trophic Level Food Web

- What are the trade-offs between tree-islands and endangered species?

- How often can we miss the targets (wet years too wet and/or dry years too dry) and still call it 'restoration'? How close do we need to get?

- What happens to plants and animals if we can't get back the same ratios of habitats?

- What is it that we have to monitor? Is it necessary to spend so much money on so many different metrics?

- What are the key indicators that managers should be looking at and that can guide a management philosophy?

- Can you have a "healthy" ecosystem without 100% recovery? How much environmental lift is needed to be "successful"?
- What is needed to address the bass fishery in L-67A if backfilled? Is backfilling needed?
- Can you construct artificial tree islands on the L-67A/C levees? Is this useful?
- What quantifiable values do different Everglades landscapes (marsh, tree islands, etc.) have to offer wildlife?
- How would the net ecosystem benefits of DECOMP compare to the change in habitat for harvestable organisms (primarily fish and deer) in WCA-3B?
- What plants and animals do we want to have in a restored Everglades?
- How can we meet the needs of the recreational fishing community (i.e., by creating deepwater habitat) and still restore the Everglades?
- How do you balance trade-offs for endangered species (specifically: the snail kite versus the Cape Sable seaside sparrow)?
- What should be the "bridging strategy" between the existing condition and a restored condition to make sure we don't harm habitats and key species?
- How can water and water quality management be combined to produce the most benefits (e.g., the most amount of food for wading birds)?
- How do changes in water quality affect vegetation and habitat?
- How can different hydrological requirements of different species be managed? If we have to make choices, what is more important: flow or water quality? Are we at a tipping point, at the verge of losing the system?
- What evidence is there that Everglades ecosystem functions and services are degrading at an increasing rate under management?
- How should management actions for the benefit of the Cape Sable seaside sparrow be balanced with other trust species such as the snail kite and important ecosystem characteristics such as the ridge and slough patterns?
- What hydrology is needed to restore various plant communities and wetland functions? Especially important are descriptions of the possible Everglades ecosystem responses to dry year (drought) scenarios, the Everglades ecosystem responses to wet year (flooding) scenarios. This will help clarify the quantities of water needed by the Everglades during drought years.

Water Quality

- What are the trade-offs between water quality and water quantity?
- How clean does the water have to be? What is the incremental benefit and cost of water quality cleanup?
- How do we get the most "lift" for the initial investment? Example: we can 'easily' get to 14 ppb, but 12 ppb costs significantly more. Should we spend all at once to get to 12 ppb, spend incrementally and look for alternatives?
- With regard to water quality (i.e., phosphorus levels), at what point should water be rejected from entering Everglades marsh?
- What is the tradeoff between water flows and water quality at the present time?
- What would be the ecosystem impacts of waiting for water treatment technologies (i.e., for phosphorus) to catch up to hydrologic restoration?
- How will the Everglades respond to near-term hydrologic restoration and more gradual water quality restoration (as a result of increasing water treatment technologies and source control measures)?
- How do we fit water quality restrictions into current restoration scenarios?
- How will restoration proceed with other contaminant issues: mainly agricultural chemicals in EAA soils and legacy phosphorus in Lake Okeechobee sediments?
- If we wait to get the water to 10 ppb, will it be too late for the Everglades? Can you take some risk with water quality while moving forward with other restoration efforts?
- How do you clean up the inflows to Lake Okeechobee and how do you remove the legacy phosphorus? Do we have to? Can we restore the Everglades without cleaning up the Lake?
- How do changes in water quality affect vegetation and habitat?
- How can water and water quality management be combined to produce the most benefits (e.g., the most amount of food for wading birds)?
- What is the appropriate quantity, quality, timing and distribution for restoration? How can different hydrological requirements of different species be managed? If we have to make choices, what is more important? Flow or water quality? Are we at a tipping point, at the verge of losing the system?

- How do you determine water quality versus water quantity impacts? What are the cost benefits of achieving water flow with "dirty" water compared to no or less water flow with "clean" water?

- Does the existing or historic Everglades provide greater or better water purification than a transformed Everglades?

- How specifically will restoration influence patterns of loading and transport of water-quality contaminants such as phosphorus, sulfur, etc. and what will be the effects on wetland ecosystem functions and services?

- What are Everglades ecosystem responses to a range of hydraulic (flow) and associated nutrient loading scenarios? This will help determine the type and amount of treatment needed.

- What are the "downstream" nutrient balance effects on estuaries? What is good for the (freshwater) Everglades may be damaging to the estuaries and vice versa.

- What are the potential effects of mercury mobilized through methyl-mercury formation and of endocrine disruptors that would be introduced if domestic wastewater were directed into the Everglades?

Climate

- How will climate change affect the Everglades?

- Is the restoration effort futile in regards to sea level rise? If not, how should the restoration effort be modified?

- How does rising sea levels contribute to peat collapse?

- Will the Everglades serve as a carbon sink or source under climate change (peat building/geomorphological processes)? What will be the function of hydrology and water quality in affecting this? What's the equation for the water inflow functions?

- Climate community will be probabilistic?

Exotics

- How will restoration affect exotics? Make them easier to control or harder?

- With regard to exotics, should we consider control strategies rather than the elimination approach? What about bio-controls?

- Should agencies without major land-management responsibilities get involved in exotics control? If so, how?

- Will exotic species issues overshadow restoration successes?

Economics

- What is the economic benefit of Everglades restoration? What economic benefits accrue to the country, the state?
- To what extent does the economy of south Florida depend on the Everglades?
- How many jobs are created by Everglades restoration?
- How clean does the water have to be? What is the incremental benefit and cost of water quality cleanup?
- What are the priority projects for Everglades restoration? What projects need to come first, and how much benefit does each project give?
- Given limited funds, how do we get the most "bang for the buck", .i.e., get a large increment of restoration for the least amount of money?
- Should we spend all of our money in one area to "solve" to the problem, and let everything else go, or do we incrementally move all the pieces along?
- How will we quantify benefits and changes in ecosystem services as a result of Everglades restoration?
- How will DECOMP affect deer and fishing?
- What is the benefit of a healthy restored southern freshwater Everglades?
- What quantifiable values do different Everglades landscapes (marsh, tree islands, etc.) have to offer wildlife?
- How can we meet the needs of the recreational fishing community (i.e., by creating deepwater habitat) and still restore the Everglades?
- How do we justify the expense of restoration when benefits are difficult to quantify or have not been quantified?
- How do we balance the restoration needs of the ecosystem with recreational uses (e.g., bass fishing and deer hunting)?
- Just what is the strategy for Everglades restoration? Are some projects a higher priority than others?

- Ecosystem Services- What about questions related to growth and development, sustainability of ecosystem services? What is the social dimension part of this? Are humans a part of the boundary? And if so, who is representing that? Have you left out a lawyer, an accountant? Are ecosystem services needed?
- What can science tell us about the trade-offs?
- What are the units of benefits?
- What are the risks/benefits of acting/not acting now?
- How much info is enough to move forward? What constitutes baseline information?
- Financial issues - A lot of the questions that managers are answering these days are financial.
- How confident do managers need to be?
- How are we going to define uncertainty?
- What are the units to be used for ecosystem services/benefits?
- Can the Everglades be successfully restored without limiting or reducing human water use?
- Identify the elements of large-scale ecosystem restoration programs through an evaluation of other restoration efforts with similar political/economic challenges.
- Can recreational fishing and air-boating co-exist with de-compartmentalization in the freshwater Everglades?
- What evidence is there that Everglades ecosystem functions and services are degrading at an increasing rate under management?

Other Manager Questions/Comments

- What will a restored Everglades look like?
- How do we protect Native American archeological sites while building the projects we need to restore the greater Everglades ecosystem?
- What do we do about Lake Okeechobee? Scientists seem to be all over the map on this.

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