South Florida
Ecosystem Restoration Task Force

Plan for Coordinating Science



December 1, 2004

Table of Contents

Executive Summary

Restoring the South Florida Ecosystem involves a complex combination of initiatives intended to return the degraded ecosystem to a more natural state. The historic ecosystem was an 18,000-square-mile region of subtropical uplands, wetlands, and coastal waters that extended from the Kissimmee Chain of Lakes south of Orlando through Florida Bay and the reefs southwest of the Florida Keys. The restoration effort is a long-term process requiring the resolution of complex environmental, engineering, and management issues. Continual improvements in plans and designs must be made by incorporating new information and lessons learned (referred to as adaptive management). Restoration involves the cooperation and coordination of multiple federal, state, and tribal organizations to address these issues and make the decisions necessary to achieve restoration. The Congress established the South Florida Ecosystem Restoration Task Force (Task Force) to, among other things, coordinate policies and programs and exchange information among the member organizations responsible for the restoration, preservation, and protection of the South Florida Ecosystem. As part of their role, the Task Force has developed this plan to coordinate programmatic (i.e., system-wide) science among the member organizations. Over the past decade, the member organizations have invested hundreds of millions of dollars on restoration-related scientific activities, which has significantly advanced the understanding of the South Florida Ecosystem.

Sound, relevant, and timely scientific information is critical to establishing restoration goals and making the decisions necessary to meet those goals. Restoration science, for the purposes of this Plan, includes research, modeling, monitoring, and science applications. Science applications include the synthesis and communication of science information to facilitate management decisions (e.g., development of restoration performance measures). Coordination by the Task Force is necessary to ensure that the most critical science needs across topics and regions are addressed, and that quality science is produced and shared among all restoration partners. The Task Force established the Science Coordination Group (SCG) to help it coordinate science across all restoration initiatives and to ensure that science is incorporated into decision making as effectively and efficiently as possible.

The Task Force is developing the Plan for Coordinating Science in two phases. Phase I of the plan includes a description of the approach developed to identify programmatic-level science needs and gaps to facilitate management decisions and to coordinate efforts to fill these gaps. It also includes a description of the need to ensure quality science. A science need is defined as a process or phenomenon that must be rigorously understood if ecosystem restoration decisions are to be scientifically based. A gap occurs when there is not a full understanding of the process or phenomenon or an effort is not in place to achieve that understanding in a timely manner. Phase II includes the results of implementing the needs and gaps identification for a subset of science coordination topics. Phase II, scheduled to be completed in 2006, will include the full identification of needs and gaps, additional essential coordination actions, and processes for ensuring quality science. Upon completion of Phase II, the Task Force will charge the SCG to update the plan biennially thereafter.

The SCG used two approaches to identify science needs and gaps. One approach relied upon the current understanding of the cause and effect relationships in the ecosystem to identify research, modeling, and monitoring needs and gaps. The second approach used SCG-member science and management expertise to identify science application needs and gaps. Many of the latter were identified based on the experience of SCG members including their participation in the Restoration,

Coordination and Verification (RECOVER) component of the Comprehensive Everglades Restoration Plan (CERP).

The universe of potential research, modeling, and monitoring needs was narrowed by focusing on the current understanding of the relationships that describe the system's function (e.g., the relationship between upstream water management within the Everglades to the seagrass community in Florida Bay). These relationships are documented in a series of conceptual ecological models (CEMs) that describe how the system currently operates taking into account historical impacts. These CEMs are retrospective in nature because they allow the analysis of the conditions that gave rise to the current system. However, the CEMs cannot be used for prospective evaluations of future conditions. The SCG convened scientific panels to identify those relationships described in the CEMs that are the most critical to restoration success. These critical relationships were brought forward by the SCG as the critical science needs. The panels also identified prospective science needs from the evaluation of potential future impacts that are not described by the relationships in the retrospective CEMs.

The SCG convened panels for the Florida Bay and Total System CEMs. The Florida Bay CEM was used because there is a great degree of scientific consensus on the relationships within this model and because of the breadth of the research program in Florida Bay. The Total System CEM was used because it addresses the broader system-wide needs, which are a primary focus of the Task Force.

The SCG then evaluated current programs and reached consensus on detailed science gaps for Florida Bay and preliminary Total System gaps. The gap analysis consisted of surveys of restoration partner organizations to describe the present and planned programs that addressed the identified needs. A review of this information led to the identification of the science gaps. The Task Force identified initial coordination actions and will continue to identify coordination actions for each gap. The needs, gaps, and associated coordination actions for Phase I are presented in this report.

Research, Modeling, Monitoring. The SCG identified five research, modeling, and monitoring gaps requiring a coordinated response at the Task Force level.

RESEARCH, MODELING, AND MONITORING GAPS
• Fully implementing the critical science elements described in the Florida Bay and Adjacent Marine Systems (FBAMS) Strategic Science Plan
• Initiation and timely completion of the Comprehensive Integrated Water Quality Feasibility Study (CIWQFS)
• Initiation and completion of the Florida Bay and Florida Keys Feasibility Study (FB/FKFS) water quality model in accordance with the Feasibility Study project schedule to provide timely information for upstream CERP projects
• Maintaining the full scope and schedule for the CERP Monitoring and Assessment Plan (MAP), including the elements funded by Task Force members other than the CERP implementing agencies (i.e., U.S. Army Corps of Engineers and South Florida Water Management District)
• Refining the Natural System Model (NSM) to adequately address transitions from wetlands to coastal areas and to include appropriate elevation data to create a more accurate representation of the natural system baseline

The Task Force will review the status of the Comprehensive Integrated Water Quality Feasibility Study (CIWQFS), the Florida Bay and Adjacent Marine Systems (FBAMS) Strategic Science Plan, the Florida Bay and Florida Keys Feasibility Study (FB/FKFS), and the CERP Monitoring and Assessment Plan (MAP) implementation and work with the lead agencies to address improvements to the NSM.

Science Applications. The SCG identified two preliminary science application gaps. These gaps include:

SCIENCE APPLICATION GAPS
• Developing and using Task Force-level system-wide indicators and restoration endpoints to include performance measures, monitoring, the pre-restoration baseline, and assessment protocols to evaluate restoration progress
• Developing and vetting a conceptual ecological model for the Florida Keys by the same processes used in other subregions

The Task Force has tasked the SCG to develop an approach for establishing system-wide indicators and restoration endpoints by December 2004, to develop these indicators and endpoints by December 2005, and to develop a fully-vetted Florida Keys CEM by September 2005.

The vast amounts of diverse data and information generated by research, monitoring, modeling, and science application activities in South Florida must meet the highest scientific standards to ensure that restoration decisions are based on sound science. Furthermore, to be relevant and effective, scientific information must be synthesized and communicated in a timely manner and in a useful format for managers. The Task Force will establish processes for ensuring that quality science is generated and made available to support restoration decisions. Ensuring the preparation, dissemination and use of sound science includes:

- Implementing quality protocols and independent reviews of scientific information generated during the restoration
- Promoting timely sharing of relevant scientific information among organizations participating in the restoration
- Tracking the progress in addressing gaps by the multiple organizations conducting science activities
- Updating this plan for coordinating science so that it remains relevant in supporting restoration efforts

The Task Force has also directed the SCG to develop system-wide protocols for organizational-level quality assurance programs, to establish processes for sharing scientific information, and to institute a procedure of tracking progress in filling gaps and reviewing and updating the needs, the gaps, and the Plan. The SCG will complete these actions as part of Phase II.

1.0 Introduction

Large ecosystem restoration efforts – such as in the South Florida Ecosystem – are comprised of an intricate combination of initiatives intended to return the degraded ecosystem to a more natural state. These restoration efforts will take decades and require resolution of complex environmental, engineering, management, policy, and technical issues. Managers will have to make numerous project-specific and restoration-wide decisions as restoration proceeds. This will include evaluating options and predicting results; selecting, planning, and implementing options; comparing actual results to expectations; and continually improving the strategies, project designs, and operations to incorporate new information and lessons-learned into future decisions. This process is referred to as adaptive management.

An **Ecosystem** is a discrete spatially identified unit that consists of interacting living and non-living parts.

Good management decisions require a sound scientific understanding of the ecosystem. It is vital that sound science be available in a timely fashion to support those management decisions. This understanding is developed through sound, timely, and relevant scientific information that is synthesized, distributed, and applied in a consistent fashion. The adaptive management process ensures good management decisions by continually incorporating new scientific findings into restoration decisions. The successful application of adaptive management relies on continual, coordinated input from relevant scientific activities. Science coordination ensures that the most current scientific information is presented to decision makers in a concise and timely manner. Science coordination includes identifying science needs, assuring that critical gaps are filled, and resolving conflicts or competing priorities. Coordination supports efficient gathering of scientific information and reduces unnecessary or duplicative scientific efforts.

Task Force Goals:

Goal 1: Get The Water Right

Subgoal 1-A: Get the hydrology right

Subgoal 1-B: Get the water quality right

Goal 2: Restore, Preserve, and Protect Natural Habitats and Species

Subgoal 2-A: Restore, preserve, and protect natural habitats

Subgoal 2-B: Control invasive exotic plants

Goal 3: Foster Compatibility of the Built and Natural Systems

Subgoal 3-A: Use and manage land in a manner compatible with ecosystem restoration

Subgoal 3-B: Maintain or improve flood protection in a manner compatible with ecosystem restoration

Subgoal 3-C: Provide sufficient water resources for built and natural systems

Many federal and state agencies, Native American Tribes, and other state and local political representatives are involved in South Florida Ecosystem restoration. Each of these restoration partners has a unique mission and, therefore, a unique role in the restoration process. The Water Resources Development Act (WRDA) of 1996 created the South Florida Ecosystem Restoration Task Force (Task Force) to, among other things, coordinate policies and programs and exchange information among the members for the restoration, preservation, and protection of the South Florida Ecosystem. These duties include coordinating the science supporting restoration. The Task Force membership consists of senior representatives from each restoration partner to support the most efficient coordination. A primary focus of the Task Force is to coordinate the implementation activities of the individual members to support the overarching goals and subgoals of the Task Force.

The Task Force established a Florida-based Working Group to assist in carrying out its responsibilities. The Working Group established a Science Coordination Team (SCT) to help coordinate science activities. To ensure that science is incorporated into decision making as effectively and efficiently as possible, and to address GAO's and Congressional recommendations to improve science coordination, the Task Force created a Science Coordination Group (SCG) in December 2003 to replace the SCT. Members of the Task Force, SCG, and Working Group are identified in Appendices A – C.

Most Task Force member organizations have science programs that work individually and collectively to provide technical information to support restoration decisions aligned with Task Force goals. In addition, partnerships, such as the Florida Bay and Adjacent Marine Systems (FBAMS) Science Program, have been established to coordinate scientific activities over a particular ecosystem region or restoration program. Over the past decade, these individual agencies and partnerships have invested hundreds of millions of dollars on restoration-related scientific activities. This federal and state investment in science has improved our understanding of how restoration will occur and led to the development of some of the adaptive management tools needed for restoration. Notably scientists have identified key factors responsible for ecosystem degradation such as altered hydrology. Although much progress has been made, the scope of these individual agency or partnership programs does not include all South Florida Ecosystem restoration activities.

The Florida Bay and Adjacent Marine Systems Science Program coordinates research in and around Florida Bay. It is led by the Program Management Committee, which is charged with providing policy makers reliable scientific information and science-based recommendations relating to areas within and adjacent to Florida Bay.

Coordination by the Task Force at the broadest level is necessary to ensure that the most essential science needs are identified and being addressed across all restoration activities and that information is being shared among all stakeholders. The Task Force has developed this science plan to support its efforts to coordinate programmatic-level science for South Florida Ecosystem restoration. The plan is being developed in two phases. Phase I includes a description of the formal approach developed to identify science needs and gaps, coordinate efforts to fill the gaps, and ensure quality science. Phase I includes the results of implementing a needs and gaps identification for a subset of the science activities under the purview of the Task Force (discussed in Section 3). Phase II will include the evaluation of needs and gaps for the remaining science activities. Phase II will be completed in September 2006. The plan will be updated biennially thereafter.

Science Coordination Goal: Ensure sound, timely, and relevant scientific information is available to support decisions at all points in the restoration process through coordinating efforts, sharing information, and identifying and filling information gaps.

2.0 Scope

WRDA 1996 defined the South Florida Ecosystem as "the area consisting of the lands and waters within the boundary of the South Florida Water Management District, including the Everglades, the Florida Keys, and the contiguous near-shore coastal waters of South Florida." This 18,000 square-mile region historically included subtropical uplands, wetlands, and coastal waters extending from the Kissimmee Chain of Lakes south of Orlando through Florida Bay and the reefs southwest of the Florida Keys. The area is shown in Figure 1.

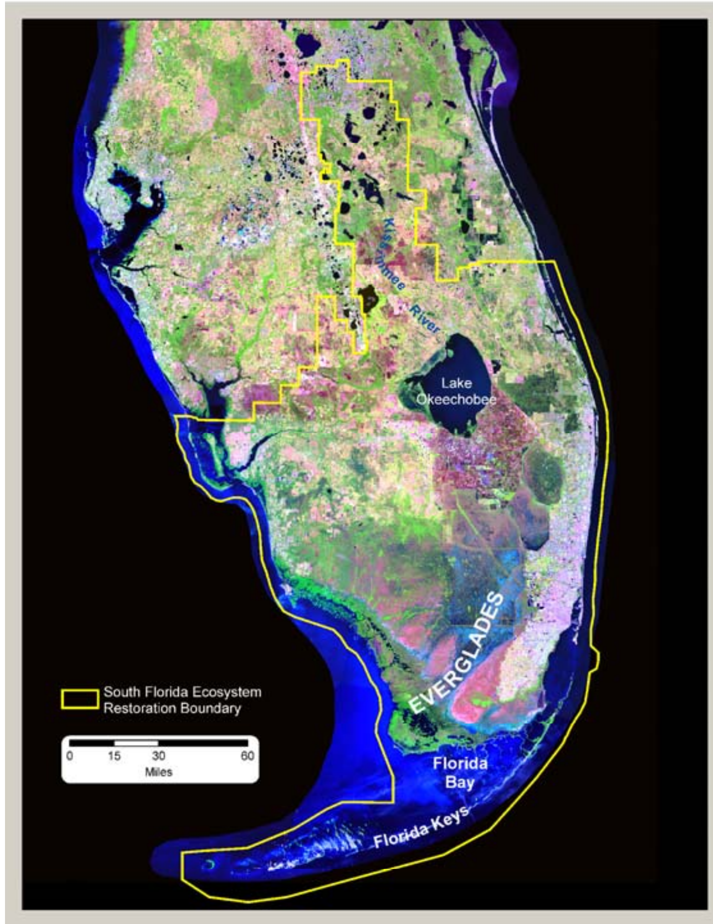


Figure 1. Areas within the yellow boundary line, including Florida Bay and Florida Keys comprise the South Florida Ecosystem.

South Florida Ecosystem restoration includes all restoration programs and projects within this geographic area. Many of the restoration projects are part of the Comprehensive Everglades Restoration Plan (CERP). CERP consists of more than 60 projects intended to restore, protect, and preserve the water resources of the South Florida Ecosystem through changes to the Central & Southern Florida (C&SF) Project. The C&SF Project includes approximately 1,000 miles of canals, 720 miles of levees, and several hundred water control structures designed primarily to provide water supply, flood protection, and water management to South Florida. The C&SF Project has adversely affected the south Florida Ecosystem by disrupting the natural flow of water across the landscape.

Other projects not included in CERP are also significant and equally crucial to South Florida Ecosystem restoration. These include, but are not limited to, the Modified Water Deliveries to Everglades National Park and C-111 Project, the Kissimmee River Restoration

The Modified Water Deliveries to Everglades National Park and C-111 Project will modify water flow to Everglades National Park to restore more natural hydrologic conditions to the Southern Everglades and Florida Bay.

The Kissimmee River Restoration Project is restoring over 40 square miles of river and associated wetlands by revitalizing headwaters of the upper river basin and reestablishing natural flooding patterns in the lower river basin to restore wetland conditions.

The Multi-Species Recovery Plan is designed to recover multiple species through the restoration of ecological communities over a large geographic area.

The Special Report on the Role of Federal Agencies in Invasive Exotic Species Management with Regard to Everglades Restoration will further clarify and identify the overall problem with invasive exotic species and the federal roles, and provide recommended actions and resources for federal agency activities with regard to managing invasive exotic species for Everglades Restoration.

Project, the Multi-Species Recovery Plan, and the Special Report on the Role of Federal Agencies in Invasive Exotic Species Management with Regard to Everglades Restoration. The Task Force's role is to coordinate all South Florida Ecosystem restoration projects – both CERP and non-CERP.

Ecosystem restoration science activities occur at multiple levels as represented in Figure 2. The most fundamental level of coordination is the science managed by individual organizations. The next level of coordination is through a partnership of two or more organizations. This level may be focused on a restoration program, such as the Restoration Coordination and Verification (RECOVER) program that provides system-wide scientific support to CERP, or is focused on a specific geographic region (e.g., Florida Bay and adjacent marine sciences program). The third and broadest level of coordination is across an entire ecosystem, including all relevant geographical areas and restoration programs and projects. The Task Force operates at this highest strategic level by influencing the multiple South Florida Ecosystem partnerships and Task Force member organizations to coordinate their science efforts.

Figure 2. Science activities that support restoration can range from multiple science initiatives at the researcher level to high-level programmatic coordination that occurs at the Task Force level.

Scientific information is generated from a variety of activities. In addition to traditional scientific research, it also includes monitoring; detecting, assessing, or predicting change; and synthesizing information to support management decision making. Restoration science in the context of this plan includes four types of activities:

> **RECOVER** is a multi-organization effort to organize and apply scientific and technical information to support CERP. RECOVER's objectives are to evaluate and assess CERP performance, refine and improve the Plan, and ensure a system-wide perspective is maintained.

- **Research** – To generate new knowledge of and technologies required to better understand specific or collective functions of the ecosystem
- **Modeling** – To predict ecosystem response to changing conditions including the ecological effects that projects or project options may have on the ecosystem (e.g., project alternative evaluations)
- **Monitoring** – To establish pre-restoration baseline conditions and to assess and evaluate the performance of individual projects, the combined effect of multiple projects, and impacts of natural phenomena (e.g., droughts, tropical storms, freezes)
- **Science Application** – To ensure that relevant scientific information is synthesized and conveyed in formats that facilitate management decisions, and that this is done in a timely manner. This type of activity includes the development of metrics, such as indicators of restoration success and associated performance measures.

This plan addresses coordination of all four types of science activities at the programmatic level. Coordination includes processes for identifying needs and gaps, taking coordination actions to fill gaps, and ensuring the quality of the information. At the request of the Task Force, the SCG developed processes for identifying the most essential restoration science needs and for conducting a gap analysis to determine those areas requiring coordination at the Task Force level. A description of the methodology used and initial results from the SCG need identification and gap analysis processes are provided in Section 3. Section 3 also lists the initial coordination actions being taken by the Task Force to fill these gaps and ensure the overall quality of the science supporting restoration.

3.0 Coordinating Strategic-Level Restoration Science to Facilitate Management Decisions

> A **Critical Science Need** is a scientific process or phenomenon that must be rigorously understood if ecosystem restoration decisions and actions are to be scientifically based. Failure to adequately elucidate these scientific understandings could jeopardize restoration success.

Science coordination at the Task Force strategic-level is a complex process because of the number and diversity of restoration partners participating in the effort to collect and analyze scientific information to make decisions. A comprehensive analysis of the breadth of science efforts within each restoration partner organization is time and resource intensive. To address science coordination in an efficient manner the SCG used a risk-based approach to identify the most critical science needs first. This approach ensures that the most critical of all scientific needs are identified, programs are analyzed for gaps in scientific information, corresponding coordination actions are implemented to fill gaps, and quality scientific information is available to support sound management decisions. The approach includes:

- **Identifying Needs** – Distinguishing the scientific knowledge critical to restoration success
- **Identifying Gaps** – Evaluating ongoing science programs to determine if there are gaps in research, modeling, monitoring, or science applications for each identified critical restoration science need
- **Coordinating Actions** – Improving the compatibility among programs, resolving conflicting viewpoints, facilitating integration and synthesis, and providing science information to restoration managers in a timely and useful form
- **Ensuring Quality Restoration Science** – Making sure that restoration science is sound, relates to restoration goals, and is shared among stakeholders.

Section 3.1 describes the process for identifying needs. Section 3.2 describes the process for identifying gaps and actions. Section 3.3 lists the subset of needs, gaps and actions identified in this first phase of the Plan. This section will be completed for the full suite of needs and gaps in the second phase of developing the plan. Section 3.3 also describes the needs for developing and sharing consistent, sound scientific information, and tracking progress in filling gaps. These needs will also be completed in Phase II.

3.1 Needs Identification Process

A major component of this Plan is the implementation and testing of an objective strategy for identifying the science needs critical for restoration success as defined by the Task Force goals and subgoals.

The SCG used two approaches to identify science needs and gaps. One approach relied upon the current understanding of the cause and effect relationships in the ecosystem to identify research, modeling, and monitoring needs and gaps. The second approach used SCG-member science and management expertise to identify science application needs and gaps. Many of the latter were identified based on the experience of SCG members including their participation in RECOVER.

The first approach relies upon a consensus understanding of cause and effect relationships within the system to identify critical science needs in research, monitoring, and modeling. To organize understanding, RECOVER incorporated these cause and effect relationships into a series of conceptual ecological models (CEMs). CEMs were developed both for the Total System and for individual subregions within the South Florida Ecosystem. The South Florida CEMs illustrate the links among societal actions, environmental stressors, and ecological responses to explain how and why natural systems in South Florida have changed. CEMs are intended to be used as planning tools to guide and focus scientific activities in support of South Florida Ecosystem restoration. SCG and other scientists reviewed the CEMs and used them as a filter to identify those science needs required to successfully attain the restoration goals of the Task Force.

South Florida Conceptual Models

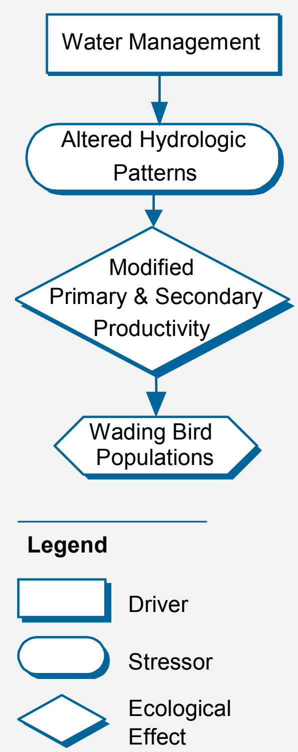
1. Total System
2. Big Cypress Regional Ecosystem
3. Biscayne Bay
4. Caloosahatchee Estuary
5. Everglades Mangrove Estuaries
6. Everglades Ridge and Slough
7. Florida Bay
8. Lake Okeechobee
9. Lake Worth Lagoon
10. Loxahatchee Watershed
11. Southern Marl Prairies
12. St. Lucie Estuary and Indian River Lagoon

The CEM approach for determining which scientific needs are most critical to restoration success is based on the U.S. Environmental Protection Agency's (EPA's) ecological risk assessment framework, which provides a method to evaluate the risks/impacts to the environment from a driving force. The first phase of the EPA method, problem formulation, focuses on the development of CEMs that explicitly describe the relationships between drivers, the resulting environmental stressor, and their impacts on ecosystem structure and function.

These models represent a consensus understanding of the major pathways linking stressors (e.g., altered hydrologic patterns) and specific ecosystem attributes (e.g., wading birds populations). The models consist of a graphic representation and narrative that describe the dynamics of the region. The model components include:

- Drivers – The major external driving forces that have large-scale influences on natural systems. Drivers can be natural forces (e.g., hurricanes) or anthropogenic (e.g., regional land use programs)
- Stressors – The physical, chemical, or biological changes that occur within natural systems that are brought about by the drivers, causing significant changes in the biological components, patterns, and relationships in natural systems
- Ecological effects – The biological responses caused by the stressors
- Attributes – Subset of the biological components of a natural system that are representative of the overall ecological condition of a system that can be used to represent the known or hypothesized ecological effects of the stressors (e.g., wading bird

Example of a Path within the Total System Conceptual Ecological Model



population in a particular area) and the elements of the system that have important human value (e.g., endangered species). Attributes are also known as endpoints

A brief description of the twelve South Florida Ecosystem CEMs is provided in Appendix D (See the 2004 CERP Monitoring and Assessment Plan for a detailed description of the models).

Because of the complexity of the ecosystem and the number of CEMs, the SCG tested this approach by initially applying it to two CEMs, the Florida Bay and the Total System CEMs (Appendices E and F, respectively). The Florida Bay CEM was chosen for analysis since there is substantial scientific consensus regarding the relationships within this specific, regional CEM as a result of its long-standing successful science program. Therefore, a greater specificity (and narrower scope) resulted from the needs and gaps identification for Florida Bay. In contrast, the Total System CEM was used because it addresses the broadest relationships across the South Florida Ecosystem. As a result, the analysis of this CEM allowed the Task Force to begin to focus on some of the higher order science needs and gaps for the entire ecosystem. It is important to understand that the CEMs reflect the processes that resulted in the present system condition (i.e., a retrospective analysis). Additional science needs were identified by SCG members in recognition of what aspects of the ecosystem were not captured in the CEMS but were likely in the future to affect the ecosystem as restoration is implemented (i.e., a prospective analysis).

3.2 Gaps and Coordination Actions Identification Process

3.2.1 Gaps Identification Process

A central component of restoration science coordination is the evaluation of whether ongoing science efforts are addressing the science needs in scope and timeliness to support ecosystem-wide restoration goals. A gap is identified when information is insufficient, incomplete, or not timely to address the management needs, or where no effective mechanism exists to exchange information and ensure the highest quality science is available to support restoration decisions. There are also technical science application gaps, such as integration of multiple sources of data and synthesis of data across different spatial and temporal scales.

The gap analysis consisted of interviews and surveys of partnership and organization-specific program representatives to evaluate their science initiatives with respect to each science need. The gap analysis considered the unique aspects of each type of science. Generally, for research, modeling, and monitoring, the following criteria were evaluated to determine whether gaps existed for each need.

- Alignment of science activity goals and objectives to need
- Adequacy of technical depth to address need
- Adequacy of spatial or temporal cover and resolution to address need
- Procedures followed to ensure the soundness of the science activity

The following criteria were evaluated to determine whether science application gaps existed for each need.

- Process used to share the results with restoration managers
- Effort to synthesize data necessary to address a need
- Alignment with performance measures or other measures of restoration success
- Required coordination processes for multi-agency efforts
- Alignment of science information generation to restoration management timeline

3.2.2 Coordination Actions Identification Process

The Task Force coordinates actions through its member organizations. The Task Force has a broad suite of coordination actions available to address each gap. The action(s) selected depends on the type of gap identified and the most effective way to address the gap. In some cases, existing partnerships can address gaps. For example, as part of the implementation of CERP, the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (SFWMD) established RECOVER to assess, monitor, and evaluate progress in implementing CERP with the overall goal of ensuring that the goals and purposes of CERP are achieved. Program managers from USACE and SFWMD in conjunction with members from the U.S. Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (FWS), U.S. Geological Survey (USGS), Everglades National Park (ENP), Miccosukee Tribe of Indians of Florida, Seminole Tribe of Florida, Florida Department of Agriculture and Consumer Services (FDACS), the Florida Department of Environmental Protection (FDEP), and the Florida Fish and Wildlife Conservation Commission (FWC) comprise the RECOVER Leadership Group, which provides management and coordination for RECOVER activities. Information produced by RECOVER has aided Task Force efforts to address science issues for South Florida Ecosystem restoration. The Task Force developed actions for addressing each gap identified during Phase I of this plan. Additional actions will be developed as new gaps are identified in the future and will be incorporated into subsequent updates of the plan.

Coordination Action Options

- Clarifying roles and responsibilities
- Aligning or realigning programs to milestones
- Convening panels or work groups to evaluate options for addressing technical issues and propose solutions to the Task Force
- Developing or modifying partnerships
- Improving communication mechanisms
- Sponsoring science conferences and workshops to facilitate information sharing and clarify technical issues

3.3 Needs, Gaps, and Actions

The SCG identified science needs and gaps for South Florida Ecosystem restoration. The Task Force reviewed and approved the needs and gaps and identified appropriate actions for each of the gaps. This section is divided into subsections that address the different types of needs, gaps, and actions. Section 3.3.1 describes needs, gaps, and actions for restoration science, and Section 3.3.2 describes needs, gaps, and actions to ensure quality science. All actions are summarized in a single table in Section 3.3.3.

3.3.1 Restoration Science

Restoration science needs, gaps, and actions were identified for research, modeling, monitoring, and science applications. Research, modeling, and monitoring science needs, gaps, and actions were identified primarily through the use of the Florida Bay and Total System CEMs. Science application needs, gaps, and actions were identified through the use of SCG member experience and expertise.

3.3.1.1 Research, Modeling, and Monitoring

This section describes Florida Bay and Total System characteristics, focusing on the critical relationships that are the basis for the needs. Subsequent discussion describes ongoing activities relative to the needs and the associated gaps. Finally, Task Force actions are identified for addressing the gaps.

Florida Bay Science Needs, Gaps, and Actions

Background

Florida Bay is a shallow, triangular bay with an average depth of three feet and an area of 850 square miles. The bay is bordered on the north by the Everglades, on the east by the Florida Keys, and on the west by the Gulf of Mexico. The bay is a spatially complex system characterized by a diverse array of shallow basins, banks, and islands that provide habitat to multiple endangered and protected species and migratory birds. Florida Bay also supports important commercial and recreational fisheries resources.

Critical science needs were identified for Florida Bay using the Florida Bay CEM. This model was developed as a simplified representation of the existing Florida Bay ecosystem through the examination of extensive historical data and current understanding of ecological processes that gave rise to the current conditions of the bay. Studies of Florida Bay over the past decade, in particular those conducted since 1994 by the FBAMS Science Program, have provided a wealth of baseline data on the status and trends of the Bay and insight into the driver-stressor-effects.

The Florida Bay CEM (Appendix E) shows the central importance of salinity and water quality for sustaining the health of the Florida Bay ecosystem. Of particular importance within the Florida Bay ecosystem are critical benthic habitats (e.g., seagrass beds, and hard bottoms) that support key upper trophic level species. A main hypothesis of the Florida Bay CEM is that decreases in the volume and disruption of the timing and distribution of water coming from the landscape have caused systematic increases in average salinity and reduced salinity variability in some areas of Florida Bay. These salinity alterations resulted in a seagrass population less resistant to stress. The loss of seagrass habitat has altered the species composition and diversity of upper trophic levels of Florida Bay. Progressive nutrient loading may have exacerbated the seagrass problems and changes in nutrient availability may also be related to the occurrence of blue-green algal blooms in the central basins and diatom blooms along the western margin. These blooms may affect the habitat quality and diversity of upper trophic levels of Florida Bay.

Salinity

The salinity of Florida Bay is affected by freshwater inflows from the Everglades, local rainfall and evaporation rates, and the circulation of water within the bay as well as the exchange of water with the Gulf of Mexico and Atlantic Ocean. During the last century, water management practices decreased the volume and disrupted the timing and distribution of freshwater inflow into the bay. Structures built to support an overseas road and railroad through the Florida Keys reduced the circulation between Florida Bay and the Atlantic. Understanding the effects of upstream water management projects and Keys structures on the temporal and spatial scales of salinity distributions within Florida Bay is essential to making restoration decisions that will support critical benthic habitats and key indicator species.

Determining the effects of upstream water management projects, as well as the effects of the potential restoration of Keys' tidal passes, requires coupled hydrodynamic and hydrological models. These models need to be capable of accurately estimating salinity and flow fields over a domain encompassing the lower southwest Florida Shelf, Florida Bay, and the Florida Keys (including the Florida Keys National Marine Sanctuary). These tools are necessary to rigorously evaluate restoration project alternatives and to manage the region's coastal ecosystems. Progress has been made with the development of coupled hydrodynamic and hydrological models, which are expected to be operational within the next year as part of the Florida Bay and Florida Keys Feasibility Study (FB/FKFS). An instrumental factor in this progress has been the science coordination efforts of the Florida Bay Program Management Committee (PMC) working since its inception in close conjunction with the FB/FKFS.

Water Quality

Florida Bay and adjacent waters are highly oligotrophic and therefore sensitive to changes in water quality (e.g., water clarity and nutrient availability). Increases in nutrient loading as a result of upstream restoration projects can have deleterious ecological effects (e.g., promoting the development of phytoplankton blooms that can reduce water transparency and thereby diminish the light that seagrass and coral reef communities need for photosynthesis). Nutrient increases can also cause macro-algal overgrowth of coral reefs. Of particular relevance is the uncertainty associated with the bioavailability of organic nutrients, dissolved organic nitrogen (DON), and the degree to which upstream restoration will affect the input of readily available inorganic nutrients like soluble reactive phosphate. Such ecological effects would degrade the quality of the ecosystem. Understanding the impacts of upstream restoration projects on water transparency and nutrients is critical to protecting seagrass habitats and coral reefs. Another important factor required to understand water quality dynamics in Florida Bay are the biogeochemical nutrient dynamics occurring at its northern boundary. The mangrove transition zone serves as the northern boundary to Florida Bay, and it almost certainly plays a critical role affecting the nutrient loads and chemical species resulting from restoration activities. Water quality modeling in Florida Bay has not advanced as rapidly as hydrodynamic and hydrological modeling.

> **Oligotrophic ecosystems** are systems that have evolved to function with low inputs and concentrations of nutrients. These ecosystems are susceptible to eutrophication problems.

Ecological Effects

To understand and predict the responses of seagrass communities, nurseries, and higher trophic function (e.g., forage base for fish-eating birds) in Florida Bay to restoration activities requires the development of ecological models. There are two general types of ecological models: mechanistic and statistical. Mechanistic models simulate various, interrelated mechanisms affecting an ecological system. Such models are necessary to make rigorous predictions (and explain anomalous outcomes) in non-linear dynamic systems like Florida Bay. However, mechanistic models are very complex and difficult to build, particularly when multiple driving forces indirectly affect the systems. Changes in upland water-flow regimes may influence Florida Bay communities through multiple stressors, not just salinity but also water clarity, nutrients, and contaminants. Statistical models correlate a change in some environmental parameter with a single ecological response or attribute. They are based on observed trends in system structure and function and are easier to create. Statistical models have been developed for pink shrimp and a few other species in Florida Bay. In the interim, until mechanistic models are available, these statistical models will be used to make the predictions required by the FB/FKFS.

- **Florida Bay Needs.** Based on the review of the Florida Bay CEM, the following overarching critical science needs were identified:

FLORIDA BAY NEEDS

- To understand and predict the effects of water management, restoration of Keys' tidal passes (i.e., Flagler's Railway [Keys' Fill]), local development, and agricultural practices on Florida Bay's:
  1. Salinity
  2. Water Quality (e.g., light, nutrient availability)
  3. Seagrass communities, associated nurseries (e.g., pink shrimp), and higher trophic functions (e.g., forage base for fish-eating birds)

The three major ongoing science efforts addressing Florida Bay critical science needs are the FBAMS Science Program, the Southern Estuary Module of the CERP Monitoring and Assessment Plan (MAP) (Part 1), and the FB/FKFS. For the last 10 years, the FBAMS Science Program has been leading and coordinating the research, modeling, and monitoring efforts for Florida Bay. In 1994, the Florida Bay Program Management Committee developed the first interagency science plan for the bay. This was markedly revised in 1997 into a Strategic Science Plan. That plan was updated recently into the *2004 Strategic Science Plan for Florida Bay*. The new plan focuses on five science areas linked to ongoing or planned modeling efforts: physical processes, water quality, benthic habitats, higher trophic levels, and mangrove-estuarine transition processes. In addition, and because of the underlying sensitivity to hydrodynamic models of shallow systems to local bathymetry, information is needed on the dynamics of Florida Bay's mudbanks stability or change, including the response to local sea level rise.

The CERP MAP is intended to regularly assess the performance of CERP by providing the sustained physical, hydrological, and biological observations required to calibrate and validate models, conduct adequate ecological assessments, and support adaptive management. The implementation of the MAP will generate scientific and technical information to evaluate CERP performance and system responses and to produce assessment reports describing and interpreting the responses. MAP describes monitoring aspects and supporting research, and briefly describes the assessment process. The Southern Estuary Module of the MAP focuses on Florida Bay, Biscayne Bay, and the Southwest Florida coast. The MAP assumes that existing monitoring will continue with existing funding sources and that partnering agencies will contribute funding and/or will participate in implementation of the MAP.

The FB/FKFS purpose is to determine what modifications are required to successfully restore the water quality and ecological conditions of the bay, while maintaining or improving conditions in the Florida Keys. The FB/FKFS relies on the development of hydrodynamic, water quality, and ecological models that integrate existing data. The FB/FKFS is a joint effort lead by the USACE and the SFWMD that is scheduled to be completed by late 2005.

- **Florida Bay Gaps.** The review of the above critical science needs, associated uncertainties, and ongoing science efforts identified three major gaps for Florida Bay.

FLORIDA BAY GAPS

- Fully implementing critical elements within the FBAMS Science Plan and its evaluation of current restoration plans and alternative plans (e.g., DON availability, mudbank evolution, and improved bathymetry)

- Fully implementing and sustaining the CERP MAP for the Southern Estuaries. Less than 50% of the funds required to do this are in the CERP/RECOVER budget. Task Force coordination and agency actions are required to fully implement and sustain RECOVER/MAP.

FLORIDA BAY GAPS
• Sustaining critical elements within the FBAMS Science Program and completion of the FB/FKFS water quality model in accordance with the Feasibility Study Project Schedule to provide timely recommendations to upstream CERP projects

The FBAMS science plan and the FB/FKFS are focusing efforts on the development of models, and the key information needed so that they can be used to guide restoration planning and implementation. Without appropriate models, proactive evaluations of restoration alternatives cannot be conducted.

- **Florida Bay Actions.** To address the three gaps identified for Florida Bay, the SCG recommends the Task Force:

FLORIDA BAY ACTIONS	LEAD	MILESTONE
• Review FB/FKFS model progress, implementation of the CERP MAP for the Southern Estuaries, and the FBAMS Strategic Science Plan	Task Force	12/04

Total System Science Needs, Gaps, and Actions

Background

The Total System addresses the entire area under the purview of the Task Force and includes the lands and waters that extend from the Kissimmee Chain of Lakes through Florida Bay and the reefs southwest of the Florida Keys, as outlined in the Scope in this Plan. The SCG used the CEM for the Total System (Appendix F) to identify four major topical areas: water management, land use management/development, nutrients, and spatial extent. The SCG further identified exotic and invasive species and contaminants, from a prospective analysis of critical Total System needs that are not fully represented in the Total System CEM but pose a threat to restoration success.

Water Management

Water management operations and the current structural system of levees, canals, and roads have substantially altered hydro-patterns in South Florida freshwater wetlands. Alterations include changes in the total volume of water available to natural wetlands, changes in the natural temporal and spatial patterns of water depth, distribution, and timing of flows, and a shift from slow-moving sheet flows to point source releases. For example, alterations have resulted in unnaturally abrupt changes in salinity levels in the estuaries and adjacent wetlands. The overall effect of water management activities has modified stressors such as natural fire patterns, nutrient cycling, and productivity/decomposition dynamics. These modifications have caused drastic changes in the shape and quality of habitats. Understanding the relationship of water management activities to salinity regimes, nutrient dynamics, sediments, detritus, and ecological attributes of wetland systems is essential to making restoration decisions.

> **Detritus** consists of fragments and particles of decomposing organic matter, which can be very important for the support of aquatic food webs and in the formation of sediments. Plants are a major source of detritus in wetland ecosystems.

Land Use Management/Development

Land use management/development has altered landscape patterns and processes. Changes in land use and new land development can alter hydrologic and fire patterns. Runoff from development or from agricultural lands can cause increased inputs of nutrients, pesticides, and other contaminants to the system. The combined effects of restoration projects and continued development in South Florida will continue to create challenges to restoration success. Understanding and predicting the effects of land use management/development on landscape and hydrological patterns and processes is critical to ensuring restoration success.

Nutrients

Elevated levels of phosphorus and nitrogen introduced by human activities (i.e., anthropogenic sources) and transported through the South Florida Ecosystem have substantially altered community structure and composition, and natural system patterns of productivity in freshwater and estuarine ecosystems. Adverse responses include changes in species dominance from sawgrass to cattails, shifts in species composition in periphyton mats from green algae/diatom communities to calcitic blue-green algae communities, and an increased frequency of extensive algal blooms in Lake Okeechobee and in estuaries. These changes have resulted in structural degradation of wading bird foraging habitat, changes in rates of biological processes, altered food webs, and reductions in secondary productivity. Understanding the system-wide transport, transformation, and effect of nutrients is critical to adequately addressing anthropogenic inputs and their impacts and differentiating between anthropogenic and natural effects.

> **Anthropogenic eutrophication** is over stimulation of primary production caused by excess nutrients introduced to a water body by human activity. The excess nutrients may cause undesirable shifts in the composition of the plant community, or promote hyper production of plants, which accelerates organic decomposition thereby reducing dissolved oxygen concentration in the water body. Both decrease the quality of aquatic habitats.

Spatial Extent

The large spatial extent of South Florida natural areas was essential for supporting genetically and ecologically viable populations of species with narrow habitat requirements (e.g., Cape Sable seaside sparrow) or large feeding ranges (e.g., Florida Panther). Extensive space, in combination with regional differences in topography and physical geography patterns, created the range of habitat options that supported levels of primary and secondary productivity necessary to sustain highly mobile animals during variations in seasonal, annual, and multi-year rainfall and surface water conditions. Reduction in spatial extent of natural wetlands and system fragmentation (i.e., creation of unnatural boundaries such as the eastern protective levee) has drastically reduced the system-wide capacity for water storage, altered natural patterns of flow direction and volume, and impacted water supply, flooding, and drainage options. These alterations in hydropatterns have resulted in shortened hydroperiods and overdrained wetlands, especially in higher elevation marl and cypress prairies. These alterations have also reduced total system levels of primary and secondary aquatic production, habitat options for animals with large foraging ranges, regional carrying capacity for animals with specialized or limited habitats, system-wide biodiversity, habitat diversity, and connectivity at regional levels. Understanding the impacts of changes in spatial extent and fragmentation to primary and secondary productivity, population dynamics, and biodiversity is essential to making restoration decisions that protect upper trophic species.

> **Primary productivity** is the rate at which organic material is produced by plants and algae through the process of photosynthesis.
> **Secondary productivity** is the rate at which organic material is produced by animals from ingested food.

Exotic and Invasive Species

> **Carrying capacity** is the maximum number of individuals of a determined species a given environment can sustain without detrimental effects.

Non-native species can severely affect the health and sustainability of an ecosystem. Non-native species can become invasive when introduced to a new ecosystem. The reasons some species become invasive and others do not is not well understood by science, and there are several theories to explain the possible biological and ecological underpinnings of invasion. Invasive species have been documented to displace native species often by competing with them for space, light, and nutrients. In severe invasions, they may eliminate local populations of native species and in some cases have caused species extinctions. They often alter the structure and function of the ecosystems they invade. These effects can change the physiographic character of the ecosystem by affecting parameters such as soil composition and chemistry, sedimentation and erosion rates, fire regimes, water quality, and hydrology. Examples of plant species considered major invaders of the South Florida Ecosystem include *Melaleuca* (*Melaleuca quinquenervia*, (Cav.) Blake), Brazilian pepper (*Schinus terebinthifolius*, Raddi), and Old World climbing fern (*Lygodium microphyllum* (Cav.) R. Br.). Some of these species affect the ecosystem in unique ways. For example, dense forests of *Melaleuca* are known to alter local hydrology by producing large amounts of organic debris, which can increase soil depth and alter soil composition. *Melaleuca* leaves also contain highly volatile oils that can support fast moving crown fires. When invaded by *Melaleuca*, native forests that do not normally burn can become susceptible to fire due to its presence.

Approximately 33 percent of all plant species in Florida are non-native and approximately 26 percent of all mammals, birds, reptiles, amphibians, and fish resident in South Florida are not native to the region, giving Florida and its ecosystems one of the largest populations of non-indigenous species in the world. Understanding the interactions between invasive species and the ecosystems and habitats they invade and the properties of an ecosystem that affect the ability of the invasive species to establish and spread is critical to predicting which species may become invasive and for developing effective restoration activities that will help control existing exotic and invasive species and prevent new introductions.

Contaminants

Contaminants are introduced to the South Florida Ecosystem from land use practices and atmospheric inputs. Contaminants include but are not limited to pesticides, herbicides, and heavy metals, such as mercury. Sources of mercury include atmospheric deposition from industrial and waste incinerators, while runoff from agricultural and urban activities can carry pesticides off site. Mercury contamination and bioaccumulation (e.g., from methyl mercury) are pervasive in sediments and aquatic food chains throughout most of South Florida's ecosystem, and pose a risk of chronic toxicity to humans and top predators that consume fish. These contaminants have been shown to impact the health of animals and plants throughout South Florida. Certain unregulated chemicals, such as antibiotics and hormones, are becoming a serious concern because of their widespread use, their biological effects in low concentrations, and their potential impacts on animal populations. These contaminants are referred to as emerging pollutants of concern (EPOCs). Restoration-induced changes in delivery patterns or use of alternative water sources (e.g., reclaimed wastewater) may pose a risk to restoration by introducing contaminants. Understanding the impacts of sub-lethal levels of contaminants and biogeochemical processes that determine the fate and transport of these contaminants is essential to protect the biological communities of the South Florida Ecosystem.

- **Total System Needs.** Based on the review of the Total System CEM and a prospective review of other factors that may influence ecosystem restoration, the SCG identified the following system-wide needs:

TOTAL SYSTEM NEEDS
• To understand and predict the effects of water management activities on salinity regimes, nutrient flows, sediments, detritus, and the ecological attributes of wetland systems (e.g., habitat diversity, submerged aquatic vegetation, wading birds, soil accretion)
• To understand and predict the effects of land use management/development on landscape patterns and processes (e.g., hydrological patterns, nutrient dynamics, fire patterns, wetland edge patterns, and community structure and function)
• To understand and predict the effect of restoration activities on the transport, transformation, and effects of nutrients (i.e., nitrogen, phosphorus) across the South Florida Ecosystem
• To understand and predict the effects of altered spatial extent on the production and availability of food for upper trophic-level species
• To understand and predict the effects of habitat fragmentation on plant and animal population dynamics including but not limited to gaining a better understanding of the impact of fragmentation on populations of species requiring expansive contiguous habitats (e.g., Florida Panther, alligators, Cape Sable seaside sparrow, etc.)
• To understand and predict the effects of loss of spatial extent on carrying capacity and biodiversity
• To understand and predict the effects of loss of spatial extent on water storage capability
• To understand the interactions between invasive species (current and future invaders) and the ecosystem and habitats they invade, and develop a means to predict which species may become invasive and threaten ecosystem structure or function
• To understand the properties of the ecosystem and habitats that affect the ability of invasive species to establish and spread and which habitats are more vulnerable to invasion
• To understand and predict the effects of regional scale population growth and development activities (e.g., land and water use, changes in demographic patterns, changes in agricultural practices) on restoration and ecosystem sustainability
• To understand and predict the effect of restoration activities on the fate, transport, and effect of contaminants (e.g., pesticides, metals, and EPOCs)

- **Preliminary Total System Gaps.** The review of the above critical science needs and ongoing science efforts resulted in identifying three preliminary Total System science gaps – water quality, monitoring, and hydrological model improvements. The SCG will conduct a full gap analysis of the Total System needs in Phase II of the development of this Plan.

  CERP recognized the importance of having an integrated water quality plan that identifies water quality targets and management measures to ensure water quality is linked with hydrologic restoration. The planning activity that will lead to the water quality plan is the Comprehensive Integrated Water Quality Feasibility Study (CIWQFS). The CIWQFS will evaluate all ongoing plans, programs, and projects throughout the South Florida Ecosystem that address water quality, including permitting programs and State, regional, and local planning efforts. Completion of the CIWQFS will be critical to ensuring a coordinated approach to addressing water quality in CERP and can be leveraged by the Task Force for broader coordination across all South Florida Ecosystem restoration activities.

RECOVER has developed a MAP for CERP. The purpose of the CERP MAP is to provide the data required to regularly assess the performance of CERP. The MAP describes monitoring requirements and implementation of the MAP will generate scientific and technical information to evaluate CERP performance and system responses and to produce assessment reports describing and interpreting the responses. The MAP was designed and is being implemented with the assumption that existing monitoring will continue with existing funding sources and that partnering agencies will contribute funding and/or will participate in implementation of the MAP.

Several tools have been developed to describe the current understanding of pre-C&SF hydrology, the most significant of which is the Natural System Model (NSM). The NSM was developed using the hydrologic model developed by the SFWMD to predict hydrologic changes in the Everglades based on operational and structural changes in the C&SF Project. The model was modified based on the best available data to reflect the conditions in South Florida prior to the implementation of the C&SF Project. The NSM estimates the pre-drainage hydrologic responses of the Everglades. The NSM is valuable in designing features to achieve restoration, and its use allows for meaningful comparisons between the responses of the natural, pre-drained system to that of the managed system. For part of its domain, improved topography is being incorporated into the NSM. It is not yet clear whether this is sufficient. Moreover, there remains a concern that the NSM does not yet adequately address the hydrologic transition from the wetlands to the coastal areas. This is essential to accurately predict the inflow of freshwater to Florida Bay.

TOTAL SYSTEM GAPS
• Completing the CIWQFS (for both contaminants and nutrients) in the South Florida Ecosystem
• Maintaining the current scope and schedule for the RECOVER MAP, including the monitoring not funded by CERP but by the other Task Force member organizations
• Refining the NSM to adequately address transition from wetlands to coastal areas and to include appropriate elevation data to create a more accurate representation of the natural system baseline

The CIWQFS and the CERP MAP focus on two topics of importance to the Task Force. The Task Force will review the CIWQFS at their December 2004 meeting to evaluate its status and whether additional coordination actions are necessary to complete the study. The SCG recommends a similar review of the CERP MAP.

- **Initial Total System Actions.** The Task Force identified the following two initial actions:

TOTAL SYSTEM ACTIONS	LEAD	MILESTONE
• Review current status of the CIWQFS and implementation of the CERP MAP	Task Force	12/04
• Work with implementing organizations to address necessary improvements in the NSM	SCG	9/05

3.3.1.2 Science Applications

Methods are needed to synthesize and communicate scientific information to make management decisions and evaluate restoration progress. This includes indicators of restoration success, performance measures, restoration endpoints, ecosystem baselines, protocols for assessing the overall success of restoration based on monitoring indicators, and comparing them to restoration endpoints. Indicators are needed to evaluate the following:

- Effects of stressors on the natural system – typically physical attributes (e.g., salinity in water bodies)
- Alterations in ecological conditions – typically biological attributes (e.g., robust microbiological colonies sufficient to support increasingly complex life forms in the food chain)
- Changes in water supply to meet urban and agricultural needs (e.g., frequency of water supply restrictions in urban and agricultural areas)

Indicators must have associated restoration endpoints, a plan for monitoring the indicators to detect change, and a means to assess multiple indicators and integrate the results to evaluate overall restoration success. Baseline conditions must be measured in terms of indicators in order to use indicators to determine change. Indicators to measure both short-term and long-term change are needed.

- **Science Applications Needs.** The SCG identified the following two initial science application needs:

SCIENCE APPLICATIONS NEEDS
• To enable evaluation of overall South Florida Ecosystem restoration progress by developing system-wide indicators and restoration endpoints
• To develop conceptual ecological models for all South Florida subregions

An initial set of indicators was selected for inclusion in the 2002 Task Force Strategy Document and in the 2000-2002 Biennial Report to Congress, the Florida Legislature, and the councils of the Miccosukee and Seminole Tribes. Most of these indicators were based on a RECOVER baseline report prepared in 1999 and revised in 2001. They were selected for inclusion in the 2002 Task Force Strategy Document and Biennial Report because they were thought to be indicative of natural system functioning throughout the region as a whole and understandable. These initial indicators were expected to be refined as more information became available.

Since 2002, new information has become available that will be used to improve the initial set of indicators and to identify other measures of restoration success. The ongoing discussion about indicators includes (1) how best to use them, (2) which ecological attributes are most appropriate and useful as indicators (especially the degree to which their future status may be predicted by reliable models), and (3) how to analyze and report the data in the most effective way for restoration management purposes.

RECOVER is identifying indicators to be used to assess restoration progress attributable to CERP and to adaptively manage CERP. The *Programmatic Regulations for the Comprehensive Everglades Restoration Plan* contains indicators for interim *goals* (defined in the regulations as a means of measuring restoration success) and interim *targets* (defined as a means of measuring progress in providing for other water-related needs). These indicators are now under review. This is a scientific and public review of the indicators to ensure their comprehensiveness and appropriateness for determining restoration success. A scientific review panel will be charged with assessing the validity of the indicators and providing comment on the presentation of these indicators to the public. To further assess the utility of the indicators, the RECOVER scientific teams will use five-year incremental model runs to "observe" trends in the indicators over the life of the CERP. Once interim goals have been established by the Secretary of the Army, the Governor of Florida, and the Secretary of the Interior and interim targets have been established by the Secretary of the Army and the Governor of Florida, these indicators will be used for system-wide assessment of CERP projects to support planning and adaptive management.

While the SCG and the Task Force may use or adapt some of the indicators developed for CERP by RECOVER, additional indicators not covered by CERP are needed to address the three strategic goals in the Task Force Strategy. For example, indicators will be needed to help evaluate the success of the Multi-Species Recovery Plan.

CEMs have been developed and reviewed for the majority of subregions in the South Florida Ecosystem. The Florida Keys is the only subregion that does not yet have a CEM. The CEMs are essential tools for identifying science needs and gaps.

- **Science Applications Gaps.** The review of the above critical science needs and ongoing science efforts identified two initial science application gaps:

SCIENCE APPLICATIONS GAPS
• Developing and using Task Force-level system-wide indicators and restoration endpoints to include performance measures, monitoring, pre-restoration baseline, and assessment protocols to evaluate restoration progress.
• Developing a conceptual ecological model (CEM) for the Florida Keys and using it to identify science needs and gaps.

The Task Force recognizes that restoration must be based on the best science available and that this will require use of adaptive management principles to continually incorporate new knowledge as it becomes available. In August 2004, the Task Force assigned the SCG with the task of reviewing new information and providing recommendations for revising the Task Force system-wide indicators reported in the 2002 Strategic Document and Biennial Report. These system-wide indicators will be included in the 2006 Strategic Document. The SCG was tasked with designing an open process that will provide ample opportunity for peer review and public input in the recommendation of a comprehensive set of system-wide indicators. After this has been done, the SCG will coordinate the development of restoration end points and timelines that will be used to measure success. The SCG is required to address the following:

- Convert the approved indicators to performance measures by adding desired restoration targets or endpoints to each, and setting a timeline for achieving the restoration end points
- Design a system-wide monitoring plan, or build on existing monitoring plans, to measure responses by the selected indicators throughout the implementation of restoration programs
- Concurrently with designing a monitoring plan, or as additional monitoring information becomes available, characterize the pre-restoration condition (baseline) for each of the approved indicators. This baseline will define the condition of the indicator prior to the initiation of restoration efforts, as a basis for determining whether changes that are

measured are due to the natural variability of the indicator or due to real change that may be linked to restoration or other changes in the environment.

- Design an assessment protocol that can be used to interpret and integrate the results from measurements of indicators for multiple projects, in order to provide an overall assessment of system-wide performance
- Produce periodic (annual/biennial) assessment reports using these protocols. Because of the nature and importance of these conclusions, this document will require a period of public input and peer review.

- **Science Applications Actions.** To address the two science applications gaps, the Task Force has directed the SCG to develop system-wide indicators and restoration endpoints by December 2005, and to develop a fully vetted Florida Keys CEM by September 2005.

SCIENCE APPLICATIONS ACTIONS	LEAD	MILESTONE
• Design an approach for developing system-wide indicators and restoration endpoints	SCG	12/04
• Implement approach to develop system-wide indicators and restoration endpoints	SCG	12/05
• Develop a CEM for the Florida Keys	SCG	09/05

3.3.2 Ensuring Quality Science

The quality of restoration decisions is directly dependent on the quality of the supporting scientific information. Task Force member organizations generally use standard quality assurance/quality control procedures for collecting and analyzing samples and managing data. Agencies generally also use traditional peer reviews to assure the quality of research proposals and publications. Peer review is an independent evaluation of scientific work by other qualified scientists to assess the validity of the scientific activity (e.g., research project).

Science activities that support South Florida restoration generate vast amounts of diverse data and information. Coordination of this information at the Task Force level depends upon agencies using these standard quality assurance/quality control procedures. There are no generally established standards for independent scientific reviews and synthesizing and communicating information among agencies. Quality science also encompasses the timely sharing of information. A protocol is also needed to track progress in addressing science gaps.

3.3.2.1 Quality Protocols and Independent Reviews

Ecosystem restoration requires more complex scientific activities that are focused on decision making. It requires the synthesis of information from many different scientific studies, from different organizations (with potentially different QA processes), and across differing scientific disciplines to make regional and ecosystem-wide decisions. These activities are not routine and require additional approaches to ensure quality in science information. It may also include a means to resolve differing scientific interpretations.

> **Sound science** requires that data, facts, or conclusions to support decision are the results of studies that have:
> - Readily testable hypothesis
> - Systematic and well-documented experimental, monitoring, or analytical methods
> - Appropriate data analysis tools (e.g., models);
> - Results that support the conclusions
> - Results that can be used to evaluate the hypotheses

- **Quality Protocols and Independent Reviews Needs.** Based on the assessment of the current procedures for quality assurance and independent review, the following critical science needs were identified:

QUALITY PROTOCOLS & INDEPENDENT REVIEWS NEEDS
• Develop coordinated processes to ensure that restoration science conducted at the organizational (e.g., federal, state, or local government) level is sound because it has been subjected to appropriate quality assurance protocols, and that there is a process in place for resolving conflicting opinions and information
• Establish a process for independent technical review of restoration science products and the convening of independent panels to provide advice on specific technical subjects

The Task Force identified a need to have quality science to make management decisions. Thus, the Task Force has directed the SCG to identify a means to ensure that programmatic science issues receive independent scientific review. In addition, where differences in scientific interpretation occur, the SCG is to also develop a means to resolve conflicts in the interpretations and make irresolvable conflicting information obvious.

The Task Force has the ability to organize independent reviews. The Task Force has used this ability in the past to convene the National Research Council Committee on the Restoration of the Greater Everglades Ecosystem (CROGEE) and topic specific workshops, such as the avian workshops held in 2003. The Task Force will continue to exercise this ability, as needed, to support quality assurance in order to guarantee that high quality information is used in restoration decision making.

- **Quality Protocols and Independent Reviews Gaps.** The review of quality protocols and independent reviews needs have identified one major gap:

QUALITY PROTOCOLS & INDEPENDENT REVIEWS GAPS
• Developing system-wide organizational level protocols for assuring quality science programs

The major gap is cross-agency protocols for quality assurance of science products. In developing these protocols, the SCG must not only determine the best procedures to ensure quality science but also examine what options exist for promoting the consistent application of these procedures on a system-wide basis.

- **Quality Protocols and Independent Reviews Actions.** To address the gap for quality protocols, the following action was identified:

QUALITY PROTOCOLS & INDEPENDENT REVIEWS ACTIONS	LEAD	MILESTONE
• Develop system-wide protocols for organizational level quality programs	SCG	Complete in Phase II of the Plan

3.3.2.2 Information Sharing

A second way to ensure quality science is to develop a system to support the efficient and timely sharing of relevant scientific information among organizations participating in restoration activities. Sharing of research, modeling, monitoring, and science applications information in a timely manner is invaluable for making sound management decisions. It allows decision makers to consider the newest and best scientific information to evaluate restoration progress and make adjustments if necessary. Sharing relevant information as it becomes available also minimizes the potential for unnecessary or duplicative scientific efforts among the organizations involved in ecosystem restoration.

A variety of methods exist that can be used for the timely and efficient sharing of information from South Florida Ecosystem restoration projects. Such methods include sharing of provisional pre-publication data through methods like regional workshops and meetings, regional newsletters, or internet-available data, abstracts, and reports outlining results of South Florida restoration projects. One obstacle to overcome in this procedure, however, is developing ways to reconcile the concerns of researchers in sharing data sets and other study information that has not gone through the full peer review and publication. Other effective methods that foster early access and sharing of scientific information include holding conferences and symposia on South Florida restoration efforts, which would provide a valuable opportunity to share results, perspectives, and ideas with experts working on similar projects or from other disciplines. In addition to providing opportunities for information exchange, these conferences and symposia create awareness of important tools such as restoration databases, web-based forums, Internet newsgroups, and models that are available, which can facilitate project development and data review.

Scientists should provide technical, research results and conclusions in formats helpful not only to the scientific researchers but also to decision makers who must actively apply that science to their ecosystem management decisions. Managers should also share information on changes in restoration priorities with scientists and provide feedback on study results in ways that will assist scientific research.

- **Information Sharing Needs.** Based on the review of the current procedures for information sharing, the following critical science needs were identified:

INFORMATION SHARING NEEDS
• Processes to vet system-wide results of research, modeling, monitoring, and science applications, and to share information and identify additional science-related needs and gaps relevant to the Task Force's coordination role
• Processes to ensure relevant scientific information from individual restoration organizations or partnerships or environmental initiatives (e.g., TMDL development) is made available to all restoration organizations for use in decision making

INFORMATION SHARING NEEDS
• Sharing of information before publication

Task Force recognizes the critical need for sharing the results of research, modeling, monitoring, and science applications among the agencies, and other groups contributing to South Florida Ecosystem restoration. Adequate and timely communication of important science project results as they are obtained (i.e., prior to publication) will be essential for ensuring that restoration benefits from the best available knowledge and most recent lessons learned.

- **Information Sharing Gaps.** The review of the above information sharing needs, associated uncertainties, and current information sharing efforts identified one major gap:

INFORMATION SHARING GAPS
• No current mechanism exists to assure timely sharing of provisional data or pre-publication scientific findings

The SCG can draw upon a variety of current methods for communicating research findings to enhance the amount of information shared and the timeframe in which sharing occurs. Methods for rapid information sharing could include developing new printed and electronic resources in which scientists and managers can quickly make results available (e.g., regional or topic-specific newsletters; Internet-available project data, abstracts, and reports). Enhancement might also involve establishing more effective links between available but widely dispersed electronic resources (e.g., a central Internet portal providing access to individual project and agency Web sites). In addition, direct information sharing between scientists and managers could be enhanced through the development of regional meetings and workshops or scientific conferences, where parties can meet face-to-face to share results and perspectives. Web-based surrogates to such meetings (e.g., Internet forums, newsgroups) might also be developed to further facilitate this type of information sharing between colleagues.

- **Information Sharing Actions.** To address the gap identified for information sharing, the SCG recommends the Task Force direct them to:

INFORMATION SHARING ACTIONS	LEAD	MILESTONE
• Develop information sharing processes acceptable to the participating agencies and institutions	SCG	Complete in Phase II of the Plan

3.3.2.3 Tracking Progress and Updating the Plan

The Task Force requires a tracking and updating procedure including an assessment of the success and relevance of its own coordination efforts. Actions that must occur in this area include a periodic evaluation of the processes used to identify needs, gaps, and actions; tracking of the progress being made towards filling the gaps identified; and the periodic update of the overall Plan for Coordinating Science.

Tracking Progress

A critical component of a coordination plan is the ability of the Task Force to track the progress made in addressing gaps by the many organizations conducting science in support of South Florida

Ecosystem restoration. To ensure restoration success, gaps must be addressed in a timely manner. This requires the tracking of gaps from the point of identification to the point of resolution. In addition, lessons learned and methods used in addressing gaps must be available to decision makers to facilitate resolution of future issues. The Task Force directed the SCG to track progress made in addressing gaps and report this progress to the Task Force.

The SCG will establish a process for tracking progress on a continuing basis. The tracking process will reflect the results of the full gap analysis. To ensure that the Task Force is abreast of issues affecting science coordination, the SCG will brief the Task Force once a year on the progress made in addressing gaps. The SCG briefing to the Task Force will consist of a concise summary of the progress of programmatic science activities and the outcomes of completed activities. The annual briefing will include the expected progress on addressing gaps to be achieved in the upcoming annual review period. On a biennial basis, the SCG will conduct an analysis similar in scope to the analysis described in this Plan. The results of the biennial review will be documented in an update of the Plan. Future tracking sections of this Plan will include a detailed assessment of the progress achieved and challenges encountered in addressing each previously identified gap. Because each gap will have its own unique technical and programmatic challenges, the assessment will be gap specific. At a minimum each gap assessment will include:

- Expected schedule for fulfilling the gap and how this schedule supports timely management decisions
- Opportunities that expedited or challenges that slowed progress in addressing the gap
- All interim and final measures taken to address the gap
- Lessons learned that could be applied to better track and expedite addressing other gaps

To facilitate the annual tracking review, the SCG will appoint subgroups based on their expertise as it relates to each conceptual model. These subgroups will be responsible for tracking progress on addressing the identified gaps, including reviewing and compiling gathered information from different organizations and suggesting possible solutions. This information, including progress towards resolving identified gaps and any recommendations, will be made available to the Task Force before each relevant meeting and be compiled and presented as part of the biennial review of the Plan discussed below. The Task Force will review the provided information, offer suggestions on resolutions, and act, as appropriate, to modify or approve actions to address all gaps in the program.

Reviewing the Plan

The restoration of the South Florida Ecosystem will require sustained efforts that span multiple decades. Therefore, for the science activities that support restoration to be effective they require periodic realignment with the priorities that emerge as the ecosystem is restored. The Task Force, in coordination with the SCG, will ensure that the Plan for Coordinating Science is updated on a biennial basis. The biennial review will consider at least the following:

- A review of the needs and gaps previously identified by the Task Force to determine what gaps have been filled
- A review of the activities of the Task Force and each individual organization to determine whether each is meeting the goals and responsibilities outlined in the Plan for Coordinating Science

- A review of the impact of the coordination plan to assess whether Task Force actions are being implemented appropriately and in a timely manner and whether the actions taken are in agreement with the stated goals of the Task Force and Plan
- A review of the needs and gaps identification process to determine if changes are necessary to make the process more effective and efficient
- An identification of new science needs that have emerged as a result of the restoration process
- An identification and evaluation of new gaps and the actions required to address them
- A review of quality science protocols, information sharing, and tracking procedures to determine whether changes are necessary and to describe the lessons learned in applying these processes

- **Tracking Progress and Updating the Plan Needs.** Based on the review of the current procedures for tracking progress and updating the plan, the following critical needs were identified:

TRACKING PROGRESS AND UPDATING THE PLAN NEEDS
• Track progress to ensure that gaps are being addressed in a timely manner and status is being reported to the Task Force
• Review the approach for identifying and filling science needs and gaps to identify improvements in the approach and to update the Plan for Coordinating Science to incorporate lessons learned and progress on filling gaps

General criteria and timelines have been outlined to meet the needs for tracking progress and updating the plan. To meet the tracking need, the SCG will establish systematic processes for tracking progress. The Task Force will review the information presented, provide suggestions on resolutions, and act, as appropriate, to modify or approve actions to address gaps.

The Task Force, in coordination with the SCG, will update the Plan for Coordinating Science biennially and use the Plan to coordinate science. The Task Force will publish updates to the Plan and share it with all interested stakeholders.

- **Tracking Progress and Updating the Plan Gaps.** The review of the above needs for tracking progress and updating the plan, as well as current information tracking and plan review efforts, identified one major gap:

TRACKING PROGRESS AND UPDATING THE PLAN GAPS
• Developing processes for tracking progress for filling gaps and periodically reviewing and incorporating improvements, as needed, to the approach for identifying needs and gaps and updating the Plan.

■ Tracking Progress and Updating the Plan Actions.

TRACKING PROGRESS AND UPDATING THE PLAN ACTIONS	LEAD	MILESTONE
• Develop processes for tracking progress for filling gaps and periodically reviewing and incorporating improvements, as needed, to the approach for identifying needs and gaps and updating the Plan	SCG	Complete in Phase II of the Plan

3.3.3 Coordination Actions Summary

The following SCG-recommended initial coordination actions were developed to address science gaps in South Florida Ecosystem restoration activities. These actions will enhance compatibility and consistency among programs as well as promote timely integration and synthesis of science information for restoration managers. Future actions will be developed as new gaps are identified for the remaining conceptual models and when periodic updates of the plan occur.

ACTIONS	LEAD	MILESTONE
General		
• Complete Phase II of the Plan for Coordinating Science	SCG	9/06
Florida Bay		
• Review the FB/FKFS, implementation of the CERP MAP for the Southern Estuaries, and the FBAMS Strategic Science Plan	Task Force	12/04
Total System		
• Review current status of the Comprehensive Integrated Water Quality Feasibility Study and implementation of the CERP MAP	Task Force	12/04
• Work with implementing organizations to address necessary improvements in the NSM	SCG	9/05
Science Applications		
• Design an approach for developing system-wide indicators and endpoints	SCG	12/04
• Implement approach, develop indicators and endpoints, sufficient to evaluate overall restoration progress	SCG	12/05
• Develop a fully-vetted conceptual ecological model for the Florida Keys	SCG	9/05

Glossary

Adaptive management — A process that includes making decisions, evaluating the results, comparing the results to predetermined performance measures, and modifying future decisions to incorporate lessons learned.

Anthropogenic eutrophication — Over stimulation of primary production caused by excess nutrients introduced to a water body by human activity. The excess nutrients may cause undesirable shifts in the composition of the plant community, or promote hyper production of plants, which accelerates organic decomposition thereby reducing dissolved oxygen concentration in the water body. Both decrease the quality of aquatic habitats.

Attributes — Subset of the biological components of a natural system that are representative of the overall ecological condition of a system that can be used to represent the known or hypothesized ecological effects of the stressors (e.g., fish population in a particular area) and the elements of the system that have important human value (e.g., endangered species). Attributes are also known as endpoints.

Bioaccumulation — The process by which chemicals are taken up by a plant or animal, either directly from exposure to a contaminated medium (soil, sediment, water) or by eating food containing the chemical, and stored in the tissues at concentrations well above those prevailing in the environment.

Biodiversity — All aspects of biological diversity including species richness, ecosystem complexity and genetic variation.

Biogeochemical cycling — Relating to the path by which elements cycle between the non-living environment and living organisms.

Bioavailability — Describes the accessibility of a substance to be absorbed or metabolized by living organisms.

Carrying capacity — Maximum number of individuals of a determined species a given environment can sustain without detrimental effects

Conceptual Ecological Models (CEMs) — Models that reflect the current scientific understanding of external drivers and anthropogenic stressors upon natural systems. CEMs illustrate the links among societal actions, environmental stressors, and ecological responses and provide the basis for selecting and testing the set of relationships that best explain why the natural systems have been altered.

Contaminant — Any physical, chemical, or biological substance that has a potential harmful effect on living organisms or the ecological value of air, water, or soil.

Critical science need A process or phenomenon that must be rigorously understood if ecosystem restoration decisions and actions are to be scientifically based. Failure to adequately elucidate these scientific understandings could jeopardize restoration success.

Detritus Fragments and particles of decomposing organic matter, which can be very important for the support of aquatic food webs and in the formation of sediments. Plants are a major source of detritus in wetland ecosystems.

Driver The major external driving forces that have large-scale influences on natural systems. Drivers can be natural forces (e.g., sea level rise) or anthropogenic (e.g., regional land use programs).

Ecological effects The biological responses caused by stressors.

Ecosystem A discrete spatially defined unit that consists of interacting living and non-living parts.

Emerging Pollutants of Concern (EPOCs) Unregulated or emerging chemical contaminants, including pharmaceuticals and personal-care products (e.g., hormones and antibiotics) and fuel and solvent additives, which may cause chronic biological or human health effects. EPOCs are associated with sewage and wastewater effluent, animal feedlots, and certain industrial processes, but advances in analytical techniques have detected the presence of these compounds in ground and surface water.

Fate and transport The movement, transformation, and resultant products of chemicals introduced into ecosystems.

Fragmentation The breaking up of large and continuous ecosystems, communities, and habitats into smaller discontinuous areas that are surrounded by altered or disturbed lands or aquatic features.

Gap identification Evaluating all ongoing science programs relative to previously identified critical science needs to determine if there are gaps in research, modeling, monitoring, or science applications.

Hydrology The study of the properties, distribution, movement and effects of water on the land surface and in soil, underlying substrate, and the atmosphere.

Hydro-pattern The depth, duration of flooding, and timing and distribution of freshwater.

Hydroperiod The amount of time that the ground or soil is saturated with water or flooded, as well as the spatial distribution of this water. Hydroperiod is often expressed as a number of days or a percentage of time flooded or saturated over an annual period.

Invasive species	Species not native to an area that establish self-sustaining, reproducing, and expanding populations. In natural areas, they are capable of altering ecosystem structure and function.
Modeling	Applying representations of the organization or operation of a system to evaluate the relative importance of different processes, assess scenarios from changes in organization or operation, and predict the effects caused by changes to inputs in the system.
Monitoring	The organized acquisition and analysis of field measurements and observations to elucidate temporal and spatial patterns.
Needs identification	Describing the critical scientific understanding required to ensure restoration success.
Oligotrophic ecosystem	A system that has evolved to function with low inputs and concentrations of nutrients. Such ecosystems are susceptible to anthropogenic eutrophication problems.
Peer review	Independent review of scientific work by other qualified scientists to evaluate the validity of methods employed, results obtained, the analysis performed, or the inference made based on those analyses.
Performance measure	The specific feature(s) of each attribute to be monitored to determine how well that attribute is responding to projects designed to correct the adverse effects of the stressors (i.e., to determine the success of the project).
Primary productivity	The rate at which organic material is produced by plants and algae through the process of photosynthesis.
Project	A sequence of tasks with a beginning and an end that uses time and resources to produce specific results. Each project has a specific, desired outcome, a deadline or target completion date, and a budget that limits the amount of resources that can be used to complete the project.
Quality science	Ensuring science is sound, relevant, and communicated in a form useful for decision making.
Research	A systematic study directed toward obtaining a fuller scientific knowledge or understanding of the subject studied.
Restoration	The recovery of a natural system's vitality and biological and hydrological integrity to the extent that the health and ecological functions are self-sustaining over time.

Science The application of the scientific method to uncover information and knowledge regarding the function or operation of general laws or theories. In the context of this plan, science includes research, modeling, monitoring, and science application.

Secondary productivity The rate at which organic material is produced by animals from ingested food.

Sound science Studies that have readily testable hypotheses, systematic and well-documented experimental, monitoring, or analytical methods, appropriate data analysis tools (e.g., models), and yield results that support the conclusions and that can be used to evaluate the hypotheses.

South Florida Ecosystem An area consisting of the lands and waters within the boundaries of the South Florida Water Management District, and the contiguous nearshore coastal waters of South Florida, including the Florida Keys National Marine Sanctuary.

Stressors The physical or chemical changes that occur within natural systems that are brought about by the drivers, causing significant changes in the biological components, patterns, and relationships in natural systems.

Sustainability The state of having met the needs of the present without endangering the ability of future generations to be able to meet their own needs.

Target A measurable desired level of achievement during or following implementation of projects described in a strategy.

Upper trophic species Fish, wildlife, and other animals that depend on plants or organisms at the base of the food web.

Wetlands Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of plants or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction.

Acronyms

C&SF	Central and Southern Florida Project
CEM	Conceptual Ecological Model
CERP	Comprehensive Everglades Restoration Plan
CIWQFS	Comprehensive Integrated Water Quality Feasibility Study
CROGEE	National Research Council Committee on the Restoration of the Greater Everglades Ecosystem
DON	Dissolved Organic Nitrogen
EPA	U.S. Environmental Protection Agency
ENP	Everglades National Park
FBAMS	Florida Bay and Adjacent Marine Systems
FB/FKFS	Florida Bay and Florida Keys Feasibility Study
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FWC	Florida Fish and Wildlife Conservation Commission
FKNMS	Florida Keys National Marine Sanctuary
FKWQIP	Florida Keys Water Quality Improvements Program
FWS	U.S. Fish and Wildlife Service
MAP	Monitoring and Assessment Plan
NOAA	National Oceanic and Atmospheric Administration
QA	Quality Assurance
RECOVER	Restoration Coordination and Verification Team
SCG	Science Coordination Group
SCT	Science Coordination Team
SFWMD	South Florida Water Management District
Task Force	South Florida Ecosystem Restoration Task Force

USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WRDA	Water Resources Development Act

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Appendix D – Conceptual Ecological Models of the South Florida Ecosystem

Total System

This model is designed to represent the ecological linkages among the working hypotheses and cause-and-effect relationships that explain the important consequence of system-wide stressors on the Greater Everglades ecosystem. The model integrates major, system-wide working hypotheses that are common to several or all of the regional conceptual models.

Big Cypress Regional Ecosystem

This model covers the Big Cypress region, which includes the freshwater portions of the area extending from the southern edge of the Caloosahatchee River watershed boundary and west of the Everglades. The water table throughout this region is defined as being at the top of the superficial aquifer, which would be above ground over much of the area during the wet season and below ground over most of these same areas during the dry season.

Biscayne Bay

Biscayne Bay is a naturally clear-water bay with tropically-enriched flora and fauna. Because of the Bay's shallow depths and clear waters, its productivity is largely benthic-based. The two principal drivers of this model are watershed development and water management.

Caloosahatchee Estuary

The Caloosahatchee Estuary is located on the lower west coast of Florida, extending 105 kilometers from Lake Okeechobee to San Carlos Bay. Major changes in the hydrology of the Caloosahatchee watershed are the result of significant modifications in land and canal development and watershed management policy.

Everglades Mangrove Estuaries

This model covers the 24-kilometer-wide brackish water ecotone of coastal bays and lakes, mangrove and buttonwood forests, salt marshes, tidal creeks, and upland hammocks. This region separates Florida Bay from the freshwater Everglades. Because of its location at the lower end of the Everglades drainage basin, the Everglades mangrove estuaries are potentially affected by upstream water management practices that alter the freshwater heads and flows that drive salinity gradients.

Everglades Ridge and Slough

This model covers the portion of the Everglades basin where there are Loxahatchee or Everglades Peat soils. The ridge and slough system makes up the deeper central portion of the total Everglades basin.

Florida Bay

Florida Bay is a triangularly shaped estuary, with an area of about 850 square miles, between the southern tip of Florida mainland and the Florida Keys. A defining feature of the bay is its shallow depth. Florida Bay is a complex array of basins, banks, and islands that differ across a set of regions.

Lake Okeechobee

Lake Okeechobee is a large (1,730 square kilometers) freshwater lake located at the center of the interconnected South Florida aquatic ecosystem. The lake is comprised of three distinct components that have dramatically different structure and function: littoral marsh, near-shore region, and open water (pelagic) region.

Lake Worth Lagoon

This model covers the principal estuarine water body in Palm Beach County. Historically, this lake was a freshwater lake with drainage from swamps along its western edge, but today, it is connected to the Atlantic Ocean by two permanent inlets. While the cumulative impact of anthropogenic activities has significantly altered Lake Worth Lagoon, significant regionally important resources remain.

Loxahatchee Watershed

The Loxahatchee watershed includes upland, freshwater wetland, riverine, and downstream estuary components. The basin historically included and drained more than 350 square miles of inland sloughs and wetlands, but today approximately 270 square miles of the original watershed drain to Jupiter Inlet.

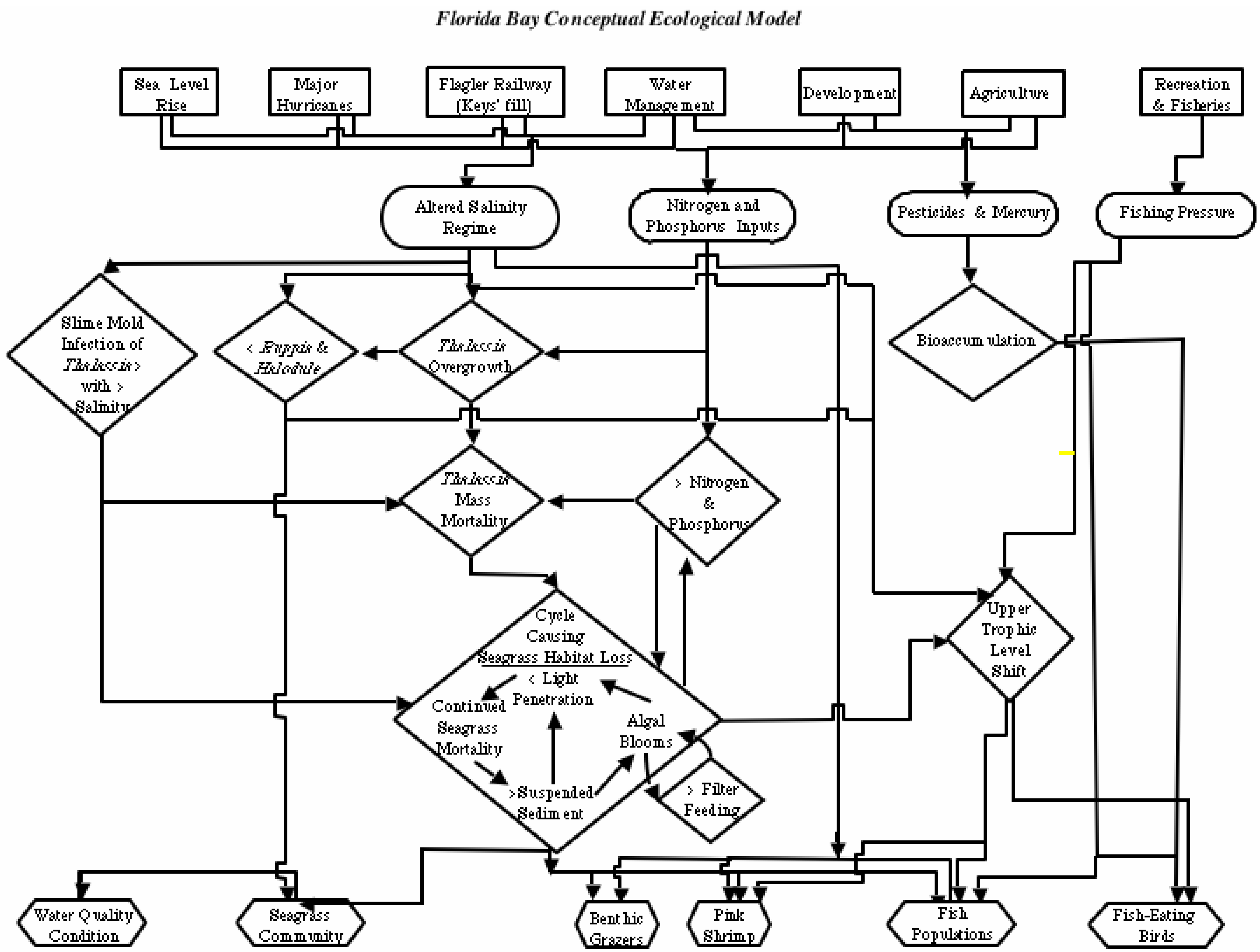
Southern Marl Prairies

This model covers about 190,000 hectares of higher-elevation, freshwater marshes found on either side of Shark River Slough, where water levels typically drop below the ground surface each year. The ephemeral hydrologic characteristics of the southern marl prairies pose stresses to the wetland animal communities regarding survival through the dry season when standing water is usually absent.

St. Lucie Estuary and Indian River Lagoon

This model extends south from Jupiter Inlet, north to the St. Lucie County line, west to the open channel headwaters of the North and South Fork of the St. Lucie Estuary up to the coastal canal structures, and eastward in the Atlantic Ocean out three miles to include the near-shore reef tract. The major anthropogenic changes in this region are significant alterations in the timing, distribution, quality, and volume of freshwater entering the estuary, lagoon, and ocean.

Appendix E – Florida Bay Conceptual Ecological Model



Appendix F – Total System Conceptual Ecological Model

Total System Conceptual Ecological Model
December 1, 2004