



U.S. Department of the Interior
*Science Plan in Support of
Ecosystem Restoration,
Preservation, and Protection in
South Florida*
2005



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EXECUTIVE SUMMARY

The Florida Everglades is a complex ecosystem of diverse, interconnected subtropical habitats. Once comprised of over 4 million acres, today the historic Everglades have been reduced by half. The conflict of human versus natural elements in South Florida began in earnest in the early 1900s, when the control of water and the drainage of wetlands were first considered essential for commerce and human safety. Loss of life due to hurricane-related flooding in the 1920s accelerated drainage projects, culminating in the congressional authorization of the Central and Southern Florida (C&SF) Flood Control Project in 1948.

Over the course of the next 50 years, exponential population growth, urbanization, and agricultural practices significantly altered the South Florida ecosystem. Implementation of the C&SF Project hydrologically fragmented the Everglades, resulting in unnatural quantities and timing of freshwater flows to and through the remaining natural areas. These hydrologic changes resulted in severe ecosystem degradation, evidenced by a 90% decline in wading bird populations, declines in commercial and recreational fisheries, significant decreases in the number of Everglades tree islands, and widespread invasions of exotic plants and animals. Currently 68 species in the Greater Everglades are federally listed as threatened or endangered.

During the past two decades, the Florida Legislature and the U.S. Congress have enacted a series of laws to redress environmental harm to the South Florida ecosystem. Many of these laws provide the authorities under which the state and the federal governments operate and fund programs that collectively comprise the South Florida restoration effort. Most recently, the Congress authorized the implementation of the *Comprehensive Everglades Restoration Plan* (CERP), which will be implemented over the next four decades by the federal and state governments. The CERP will modify the C&SF Project to increase future water supplies for the environmental purpose of restoring the South Florida natural system, while also providing for other water-related needs in the region.

To support ongoing South Florida restoration efforts, the U.S. Department of the Interior and its bureaus, the U.S. Fish and Wildlife Service, the National Park Service, and the U.S. Geological Survey, developed this science plan to identify the science needed to support DOI managers in fulfilling their stewardship responsibilities for natural resources in South Florida. The science plan also supports DOI's efforts as a partner in South Florida restoration, including the implementation of the CERP.

Overall, DOI science will assist in the intergovernmental effort to answer three overarching restoration questions:

What actions will improve the quantity, timing, and distribution of clean fresh water needed to restore the South Florida ecosystem?

What actions will restore, protect, and maintain natural resources on DOI lands in South Florida?

What actions will recover South Florida's threatened and endangered species?

Success in addressing these three overarching questions at ecological scales ranging from individual species and communities, to individual parks and refuges, to the entire South Florida ecosystem will require a well coordinated, collaborative, and integrated effort among participating agencies and stakeholders. None of these questions can be answered independently by any one agency or partner. Science must be synthesized and disseminated among the wide range of agencies and partners involved in this effort. Moreover, each of these questions raises more specific questions about the interrelated variables affecting the condition of the ecosystem, including hydropatterns (the quantity, timing, and distribution of water), water quality, ecological responses of biological communities and species to

changes in water quantity and quality, the role of fire, the effects of invasive exotic species, the effects of adjacent land uses on natural areas, and the effects of public use of parks and refuges. The major unanswered questions associated with particular projects are identified in this report and serve as the focal points for discussing what is known and what additional scientific information is needed to help ensure that each project produces the intended performance within the ecosystem.

This DOI science plan identifies the key projects and information needs for DOI managers as they fulfill their roles as stewards and partners in South Florida restoration efforts. Two DOI bureaus, the U.S. Fish and Wildlife Service (FWS) and the National Park Service (NPS), are responsible for the resource stewardship and public use of extensive public federal lands in the region, including Everglades National Park (the largest national park east of the Rockies), Biscayne and Dry Tortugas National Parks, Big Cypress National Preserve, and the Arthur R. Marshall Loxahatchee, Florida Panther, National Key Deer, and Ten Thousand Islands National Wildlife Refuges. The FWS has responsibilities for threatened and endangered species and other species of concern under such authorities as the Fish and Wildlife Coordination Act, the Endangered Species Act, and the Migratory Bird Treaty Act. The DOI also has a trust responsibility for American Indian reservation communities, including the Seminole and Miccosukee Indian Tribes. DOI's partnership role includes support for the Comprehensive Everglades Restoration Plan (CERP) including interim goals, performance measures, and support for various project components. Furthermore, it identifies a strategy for ensuring that the scientific information needed by managers is available at the appropriate time, when decisions are made. The coordination and prioritization of DOI science needs—based on managers' needs for information to support decision making—lays an important foundation for identifying gaps in scientific information and the management needs that must be addressed to achieve and maintain a restored Everglades.

This plan outlines the importance of developing and effectively synthesizing and communicating the best available science input into the decision making process in managing the DOI lands in South Florida. The USGS, in consultation with NPS and FWS, have developed a process for prioritizing the science needs relevant to the restoration and resource management projects identified in this science plan. This process utilizes a multi-tiered approach to assist in prioritizing critical science information needs. The prioritized list generated from this process will be the foundation for DOI's annual science funding strategy. Incorporated into this tiered approach are a number of factors:

- The relevance of the science effort to improving understanding of the ecological and hydrologic processes affecting DOI lands and resources
- The applicability of the science to multiple DOI restoration objectives or multiple projects
- Synthesis and sequencing to address the most urgent management information needs
- Maximization of cost-share opportunities and science coordination across bureaus or with DOI's CERP partners

The prioritization process outlined above emphasizes program integration and a primary goal of coordinating DOI investment in science to achieve economies of scale by effective integration of science programs from many different jurisdictions, including the private sector. The DOI bureaus are currently using this prioritization process to prioritize next year budget requests for science. In Addition, the NPS, FWS, and USGS will continue to proactively seek out partnerships and improve existing ones to maximize scientific inquiry

This plan strives to ensure that new information resulting from changed or unforeseen circumstances, new scientific or technical information, or information developed through the principles of adaptive management will be incorporated into the prioritization of DOI science efforts and land managers' decision making process. The DOI Science plan clearly identifies questions that managers have for the

restoration process and the underlying scientific questions and information needed to address these questions. The plan also identifies timelines to get the information to managers when they need it. In order to answer these questions in a timely fashion, this plan specifically provides for development and use of improved predictive tools as well as a more comprehensive monitoring effort that will be the basis for new information that will be provided to the Department and partners' ecosystem restoration as adaptive management principles are implemented.

Three specific program areas, each with specific projects, are set forth in greater detail in the following pages. These program areas include (1) projects to improve the quantity, quality, timing and distribution of water; (2) habitat and species recovery projects; and (3) land and resource management projects. Implementation of this science plan will ensure that priority science needs are met for each of the projects identified and that DOI's science programs support the needs of the land-managing agencies involved in the South Florida restoration effort.



1. PLAN BACKGROUND AND PURPOSE

The Greater Everglades Ecosystem

The Natural System

The southern Florida peninsula encompasses a mosaic of subtropical habitats connected and sustained by water. Before European settlement, this region of about 18,000 square miles was dominated by wetlands, which originated in the Kissimmee River drainage basin and flowed southward, through Lake Okeechobee and the Everglades, into highly productive estuaries and nearshore coastal waters, including Biscayne and Florida Bays.

South Florida receives between 40 and 65 inches of rainfall annually, most occurring during the wet season (June through October). The area is characterized by very low topographic relief. The nearly flat topography, proximity of thousands of miles of coastline, and high annual rainfall make much of the area susceptible to flooding.

Historically, water levels and flows in the wetland areas of the Everglades fluctuated seasonally in response to rainfall and runoff. During heavy rains, all but the tree islands were flooded. During the dry season, water levels generally were close to the land surface, but during droughts they often fell substantially below it. Major fires were a natural occurrence during droughts, and they swept over the land, burning vegetation and peat.

The freshwater marshes were characterized by extremely low levels of nutrients, creating the conditions conducive to extensive wetland sawgrass prairies – known as “the river of grass.” These wetlands were punctuated with relatively low “uplands,” which provided forested refuges for migratory species during times of flooding, as well as habitat for a diversity of year-round communities. In and around the estuaries, freshwater mingled with salt to create habitats supporting mangroves and nurseries for wading birds and fish. Beyond, nearshore islands and coral reefs provided shelter for an array of terrestrial and marine life.

The habitat in South Florida originally supported far-ranging animals, like the Florida panther, and super-colonies of wading birds, such as herons, egrets, roseate spoonbills, ibis, and wood storks.

Human Alterations to the Natural System

Some early land developers saw the potential for “improving” the Everglades wetlands through development and agriculture. However, efforts to reclaim the area for development and human habitation evolved slowly, as the marsh and sloughs were largely impenetrable and uninhabitable.

The conflict of human versus natural elements in South Florida began in earnest in the early 1900s, when the control of water and the drainage of wetlands were first considered essential for commerce and human safety. Loss of life due to hurricane-related flooding in the 1920s accelerated flood protection projects, culminating in the congressional authorization in 1948 of the Central and Southern Florida (C&SF) Flood Control Project. Over the course of the next 50 years, population growth, urbanization, and agricultural practices significantly altered the natural system.

Today South Florida encompasses significant remnants of the Everglades, including four national parks, thirteen national wildlife refuges, and numerous state parks and conservation areas, along with important urban centers, including Miami, and agricultural areas, including the Everglades Agricultural

Area (EAA). The C&SF Project, which provides for the diverse water-related needs of the region, consists of more than 1,400 miles of primary canals and more than a hundred water-control structures.

Providing for the diverse water-related needs of this area over many decades has resulted in unintended consequences for the Greater Everglades. Less than half the original wetland acreage of South Florida remains. Surface water flow within the Greater Everglades is fragmented and disrupted, changing the quantity and natural timing of water deliveries and negatively affecting the water quality and natural areas. Water flows from the Kissimmee River into Lake Okeechobee, and outflows from the lake, are through manmade canals. In the EAA, water is drained during wet periods and augmented during dry periods. Many wetlands that historically functioned as natural filters and water-retention areas are either severely impacted or entirely lost due to drainage changes or development. Compared to historic flows, canal discharges into Biscayne and Florida Bays are heavier during wet periods and lighter during dry periods, creating greater salinity fluctuations in the bays and affecting habitats along the gulf coast and within the reef tract from Key Biscayne to the Dry Tortugas. Additionally, the two bodies of water between Florida Bay and Biscayne Bay, Card and Barnes Sounds, have been essentially cut off from natural water deliveries.

The drainage system imposed by canals and other drainage features has impacted groundwater storage capacity. Aquifers provide municipal water supplies in the region. By 1990 about 872 million gallons of water per day (94% of it ground water) was being consumed by the nearly 6 million people living in or visiting the South Florida area. Another 2.7 million gallons per day (divided nearly evenly between ground water and surface water) was being used for agriculture.

Water quality is degraded in some areas by high levels of nutrients (such as phosphorus and nitrogen), pesticides, and other contaminants in agricultural and urban runoff. Nutrients and sulfur in major rivers (such as the Kissimmee and Caloosahatchee) and in canals draining the EAA affect Lake Okeechobee, the Everglades wetlands, and estuaries. These changes in water quality affect wetland vegetation. Replacement of the normal diversity of Everglades plants with cattails creates unsuitable habitat for Everglades animals, including fish and wading birds. Scientists have observed that the wetland area dominated by cattail is expanding, and if unchecked, could soon affect major portions of the remaining Everglades.

The evidence that the changes in surface and groundwater flows and water quality have had negative effects on habitats and organisms includes a 90% reduction in wading bird populations, 69 species on the federal endangered or threatened list, widespread invasion by exotic species, declines in commercial and recreational fisheries in Biscayne and Florida Bays, a significant decrease in the number of Everglades tree islands, the invasion of coastal sawgrass prairies by mangroves and compositional and structural changes in habitats throughout the region.

Addressing the Unintended Consequences of Growth

Overview of the Restoration Effort

By the 1970s and 80s the imbalance between natural system functioning and the growth of urban, agricultural, and other human uses had become a focus of decision making in Florida, as well as in Washington D.C. Since that time, a growing body of state, federal, tribal, and local programs and massive appropriations have been directed at restoring and protecting the natural environment of South Florida.

During the past two decades the Florida Legislature and the U.S. Congress have enacted a series of laws to redress environmental harm to the Everglades. Many of these laws provide the authorities under which the state and the federal governments operate and fund programs that collectively comprise the

South Florida restoration effort. In 1992 Congress directed the U.S. Army Corps of Engineers (USACE) to take steps to restore the Kissimmee River floodplain, which was disrupted when the river was channelized during the 1960s. In 1996 Congress established the intergovernmental South Florida Ecosystem Restoration Task Force (the Task Force) to coordinate the restoration efforts among the state, federal, tribal, and local agencies involved in the effort. At that time Congress also directed the USACE to submit a comprehensive review study of the C&SF Project for the purpose of modifying the project to restore, preserve, and protect the South Florida ecosystem. In 2000 Congress authorized the implementation of the \$8 billion *Comprehensive Everglades Restoration Plan (CERP)*, which will be implemented over the next four decades by the federal and state governments. The CERP will modify the C&SF Project to increase future water supplies for the purpose of restoring the Everglades to a more natural state, while also providing for other water-related needs in the region.

As public land managers of much of the Everglades, and with program responsibilities for fish and wildlife and Indian trust responsibilities, DOI plays a key role in the intergovernmental effort to restore and protect the natural resources located within the South Florida ecosystem. This is a collaborative effort, in which coordination among many agencies at all levels of government is critical to the successful restoration of the ecosystem. Within this collaborative work environment, DOI is both a steward, with specific mandates from Congress, and a partner, working with other agencies to achieve their own particular mandates in ways that are most advantageous to the ecosystem as a whole.

The Department of the Interior as Steward and Partner

Two DOI bureaus, the U.S. Fish and Wildlife Service (FWS) and the National Park Service (NPS), are responsible for the resource stewardship and public use of extensive public federal lands in the region, including Everglades National Park (the largest national park east of the Rockies), Biscayne and Dry Tortugas National Parks, Big Cypress National Preserve, and the Arthur R. Marshall Loxahatchee, Florida Panther, National Key Deer, and Ten Thousand Islands National Wildlife Refuges. The FWS has responsibilities for threatened and endangered species and other species of concern under such authorities as the Fish and Wildlife Coordination Act, the Endangered Species Act, and the Migratory Bird Treaty Act. DOI also has a trust responsibility for American Indian communities, including the Seminole and Miccosukee Indian Tribes.

DOI also chairs the Task Force, which provides a forum for sharing information, coordinating research, and facilitating the integration of the work efforts of the many agencies involved in ecosystem restoration. The Task Force has set three overarching goals for South Florida restoration:

1. Get the water right.
2. Restore, preserve, and protect natural habitats and species.
3. Foster compatibility between the built and natural systems.

The CERP is the foundation for Everglades restoration. The overarching goal of the CERP is “the restoration, preservation and protection of the South Florida ecosystem, while providing for other water-related needs of the region, such as flood protection and water supply.” Led by the USACE and the South Florida Water Management District (SFWMD), the CERP is the blueprint for a significant portion of ecosystem restoration activities in South Florida. The CERP focuses on improving the quantity, timing, and deliveries of fresh water feeding the system. It also addresses improvements in water quality. These hydrologic improvements are anticipated to contribute to restoring natural terrestrial, estuarine, and marine habitats, which will promote the restoration of biological functions.

However, these improvements are insufficient, by themselves, to restore and sustain the ecosystem. Restoring habitats and biological function will require additional efforts, such as removing invasive

exotic species and reintroducing and recovering species. Ultimately restoration success will depend on implementing a reasonable balance between human needs and the needs of the ecosystem. South Florida's 'built environment' has experienced unprecedented accelerated growth over the past several years with increasing pressure on natural resources. Much of this developing landscape is sandwiched between Everglades and Biscayne National Parks. Restoration of the Greater Everglades requires sustainable compatibility of the built and natural systems; specifically, flood control, water supply and water quality.

The Role of Science in Ecosystem Restoration

The initiative to restore the South Florida ecosystem is unprecedented in its scope and complexity, and it will require innovative solutions and long-term commitments. The challenges faced by restoration managers are daunting: to understand the effects of nearly a century of wetland drainage and impoundment for water supply, flood protection, and development, and to acquire and utilize the information needed to restore the health of this unique ecosystem.

The Congress has directed that this complex restoration effort be guided by, and continuously adapted to reflect, the best science available. This will require an open and continuous dialog between scientists and managers. Two recent (2003) reviews of science programs – the Critical Ecosystems Study Initiative, conducted by the National Academy of Science (NAS), and the Science Coordination in South Florida report, conducted by the General Accounting Office (GAO) – identified the improvement of science coordination, the synthesis and integration of research data, and the communication of research findings to managers as high priority tasks for Everglades restoration. This strategy will guide how the Department of the Interior meets these priority tasks and will be the basis for integrating DOI science investment into the larger habitat restoration and management efforts.

The USACE has established a multi-agency Restoration Coordination and Verification Team (RECOVER) to support the implementation of the CERP with scientific and technical information. Science is being integrated into management of CERP components through an iterative process of research, modeling to identify targets and goals, project planning, project implementation, monitoring, assessment, and adaptive management. An ever-increasing body of knowledge and understanding of this complex system is providing new approaches to restore and protect the Everglades. DOI is a partner in developing and maintaining this scientific basis in support of RECOVER and the CERP. The science, which must continue to evolve with the information synthesized into tools that can be used by managers to inform their decisions. In addition, DOI pursues science to support many non-CERP components of ecosystem restoration.

Ongoing Interior Science Efforts

In March 2002 the DOI Office of the Secretary, NPS, FWS, and USGS entered into a memorandum of understanding to coordinate all ongoing and future monitoring, research, planning, and interagency coordination activities supporting South Florida restoration. This coordination will facilitate the leveraging of resources and the development and use of the best available research products and monitoring and assessment tools responsive to the needs of NPS and FWS managers.

ES (CESI) and the USGS Priority Ecosystem Science (PES) program are DOI's primary science programs supporting South Florida management and restoration efforts. The USGS, the principal science arm of DOI, provides physical and biological sciences information, independent of the other bureaus. This science facilitates understanding of how the ecosystem functioned in the past, and assists in developing management tools, including landscape-scale models, to evaluate the impacts of proposed actions to restore the Everglades natural system. The purpose of the CESI and PES programs is to provide the

scientific information DOI managers need to fulfill their resource management and technical advisory responsibilities and to do a better job of targeting research to meet on-the-ground management needs. These programs have already provided a rich database of information about how the ecosystem functions and how the natural system has been altered. Information from the modeling, planning, and monitoring programs helps DOI managers understand the complex ecological and hydrologic linkages that affect DOI lands and other managed resources, set management priorities, and effectively participate in restoration decision processes.

More specifically, the scientific work accomplished over the past decades through CESI, PES, and other DOI efforts has

- contributed to the development of the Natural System Model, which simulates the predrainage hydrology of the Everglades

- clarified linkages between hydrologic conditions and ecosystem attributes

- produced tools to predict how the current system might respond to restoration of historic hydrologic conditions

- determined the background levels of nutrients needed to keep Everglades vegetation from converting to species tolerant of higher nutrient doses, such as cattail

- contributed to the understanding of the interactions of the Everglades surficial aquifer system and the canals, and of problems of seepage and seawater intrusion

DOI managers have focused early science efforts on restoration projects such as the Everglades Construction Project, the Modified Water Deliveries to Everglades National Park Project, and the C-111 Project, which directly impact DOI lands and are scheduled for completion within the next five years. Information derived from these early projects will inform larger scale restoration decisions and improve the design of future CERP projects.

Purposes of the Department of the Interior Science Plan

To support ongoing restoration efforts, DOI and its bureaus developed this science plan to identify the science needed to support DOI managers in fulfilling their stewardship responsibilities and to support DOI's efforts as a partner in implementing the CERP.

DOI science will assist in the intergovernmental effort to answer three overarching restoration questions:

- What actions will improve the quantity, timing, and distribution of clean fresh water needed to restore the South Florida ecosystem?*

- What actions will restore, protect, and manage natural resources on DOI lands in South Florida?*

- What actions will recover South Florida's threatened and endangered species?*

Success in addressing these three overarching questions at ecological scales ranging from individual species and communities, to individual parks and refuges, to the Greater Everglades requires a well-coordinated, collaborative, and integrated effort among all participating agencies. None of these questions can be answered independently. Furthermore, each of these questions raises more specific questions about all the interrelated variables affecting the condition of the ecosystem, including hydropatterns (the quantity, timing, and distribution of water), water quality, ecological responses of biological communities and species to changes in water quantity and quality, the role of fire, the effects of

invasive exotic species, the effects of adjacent land uses on natural areas, and the effects of public use of parks and refuges.

It is critical that science-based input synthesizing research, modeling, monitoring, and analysis be both timely and relevant to DOI managers' decision-making information needs. This DOI science plan identifies the key projects and information needs of DOI managers as they fulfill their roles as stewards and partners in South Florida. It describes what is known for each project and what science is needed to help ensure that the project results in intended consequences within the ecosystem. Finally, it identifies a strategy for coordinating and prioritizing DOI research or activities based on managers' needs for information to support decision making. By identifying the specific science needed by managers to make adequately informed and timely decisions, and by including the methods and tools needed to make this scientific information readily available to managers, this science plan provides the basis for ensuring that DOI investment in science is effectively integrated into the effort to restore the South Florida ecosystem.

The timetable for the CERP and other restoration projects is an important framework for ecosystem research. However, it will not be possible to resolve all scientific uncertainties before restoration projects are implemented. Managers will rely on an adaptive management approach to ensure that desired results are achieved through a process of monitoring, assessment, and refinement. This will require continuous collection of field data and scientific research to clarify an expanding understanding of the Greater Everglades ecosystem. The external reviews of South Florida ecosystem science coordination conducted by GAO and NAS identify needs for monitoring progress, additional research on ecological processes, model refinement, and improved tools for implementing adaptive management, including mathematical models. This science plan responds to those key findings of the GAO and NAS reviews.

Next Steps – Prioritizing Scientific Research and Synthesizing Results

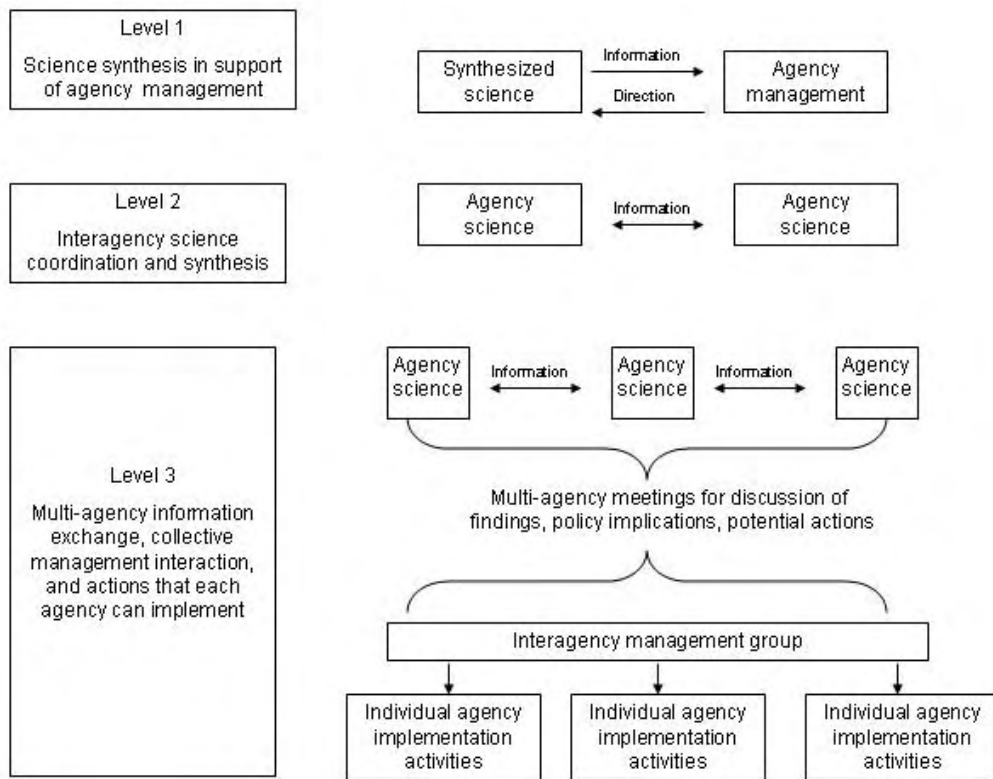
DOI managers will annually prioritize the science needs identified in this plan based on the need to inform land or water management decisions for DOI managed lands and resources, the time period for when scientific input is needed, and/or the extent to which the scientific needs may be unmet by other restoration partners. DOI intends to invest resources to synthesize and disseminate scientific results for managers as part of its responsibilities. The funds supporting the implementation of this science plan will come partly from the available DOI appropriations, such as the CESI (administered by the NPS) and the PES program (administered by the USGS). Other funding sources include DOI's CERP partners, the USACE and the SFWMD. The funding sources will be determined based on the role of each partner in restoration activities and their responsibility for producing the scientific results of interest.

The timetable for the CERP and other restoration projects is an important framework for ecosystem research. However, it will not be possible to resolve all scientific uncertainties before restoration projects are implemented. Managers will rely on an adaptive management approach to ensure that desired results are achieved through a process of monitoring, assessment, and refinement. This will require continuous collection of field data and scientific research to clarify an expanding understanding of the South Florida ecosystem.

Once the data are collected the next step is the synthesis of data into usable information. Currently, the development and utilization of scientific information generated by the Department's bureaus occur at three levels (see figure below). On level one, agency managers identify information needs and pass them to their agency scientists. In return, scientists synthesize the available information to inform the managers' decision-making process. Managers often provide feedback to the scientists during the reporting of the information, allowing for an exchange in information to better inform and accommodate

changing needs. This level one synthesis requires technical staff who are trained and experienced in synthesizing science in ways that best support the managers' needs.

On level two, scientists communicate research findings across agencies. This occurs informally by person-to-person contact or more formally at local and national meetings on a particular discipline or topic. The Department's Science Plan, which synthesizes the science needed to answer the major questions critical to the management of all of the Department's trust resources in South Florida, is an example of this level of synthesis. The plan is being used to gain consensus about the highest priority information gaps across all the Department's bureaus and to eliminate duplicative efforts in filling those gaps. Collaborative research by agencies and universities is another example. The Greater Everglades Ecosystem Restoration (GEER) conference is a regional meeting that strongly encourages this level of synthesis, with the added advantage of providing a forum for multidisciplinary exchanges. Other meetings to synthesize information are being considered for topics including the hydrologic impact on ecology; the role of ecosystem history in assessing/predicting historical, current, and future changes in the landscape; the influence of restoration on contaminants (including sulfur and mercury); and the mining of hydrologic flow and stage data to differentiate the influences of sea level rise, water management, and major climatic events on hydrologic dynamics in freshwater flows and coastal interactions.



Another important aspect of science synthesis is integration of activities that have a common theme. This integration can take many forms, such as periodic meetings among participants in related activities to share information about issues, successes, and failures and to coordinate methods and analyses to advance a collective understanding. A method of information synthesis that is often overlooked by the scientific community is the distillation of complex research findings into condensed, concise, well-

illustrated briefing-style publications. The USGS model for such publications is being adopted by other Department agencies for all new science activities.

In addition to the technical capabilities required at level one, level two synthesis requires protocols and communication processes to improve the quality of collaboration and information exchange among scientists.

The third level of synthesis occurs when information collected by various agency and university scientists is jointly presented with the goal of information exchange and informing a collective group of managers. The managers discuss the findings, examine management or policy implications, and set a course of action to incorporate the key insights derived from the scientific information exchange. The Task Force's plan to coordinate science and its Avian Ecology Workshops are examples of the third level of synthesis. In its plan to coordinate science, the Task Force has reviewed strategic science program areas and identified key gaps for further collaborative action. In the avian workshops, the Task Force assembled a panel of scientists who developed a synthesis report from numerous scientific presentations for consideration by the Task Force Working Group. The FWS is directing a substantial new research effort to fill the information gaps identified by the panel.

In addition to the technical capabilities, protocols, and processes required by levels one and two, level three synthesis requires collaborative policies and managers skilled in interagency cooperation and coordinated management.

A key component of the Department's synthesis activities is the effort to integrate its science into the CERP. In the authorization for the CERP (WRDA 2000), Congress asked the Corps to develop programmatic regulations that, among other things, "ensure that new information resulting from changed or unforeseen circumstances, new scientific or technical information or information that is developed through the principles of adaptive management contained in the CERP, or future authorized changes to the CERP are integrated into the Plan." Effective and informed adaptive management requires the synthesis of experimental research (understanding how the ecosystem operates), ecosystem monitoring (observing change), and forecast modeling (predicting change). Much of the earlier research on the South Florida ecosystem focused on establishing a basic understanding of ecosystem structure, processes, and functions. In addition, previous and current research on development of ecological, hydrologic, and chemical models provides a mechanism for synthesizing the data and information into a better understanding of integrative processes within the ecosystem. Although additional experimental/empirical research and model development are still needed, with the recent development of the CERP-related MAP, the opportunity is emerging for greatly improving the synthesis of experimental, monitoring, and modeling studies to effectively inform restoration planners and decision makers.

The Department's management bureaus identified the need for including ecological models in the evaluation of CERP project alternatives and the critical role that the Department needs to play in the IMC. Therefore, PES managers are increasing funding for ecological modeling studies and initiating a new study to implement ecological modeling at the IMC. They also are continuing to evaluate the Department's role at the IMC and will likely be stationing additional NPS personnel at the IMC in the near future.

2. PRIORITIZATION OF SCIENCE RESOURCE ALLOCATIONS

Prioritizing science needs for ongoing South Florida restoration is integral to the DOI mission as steward and partner with other federal and state agencies. With the enactment of the CERP it is important not only that appropriated funds be targeted at the highest priority research, planning, and interagency coordination needs of the restoration effort, but also that this prioritization be coordinated both within DOI and with state, federal, and other partners. This coordination leverages resources, maximizes the value of federal funds, and results in the best available research products and monitoring and assessment tools responsive to the needs of the NPS, the FWS, and DOI's CERP partners.

Prioritizing the science needed to support South Florida restoration begins by focusing on three key program areas benefiting DOI's resources and mission in South Florida:

1. Activities to improve the quantity, timing, and distribution of clean fresh water needed to restore the South Florida ecosystem
2. Activities to restore, protect, and manage natural resources on DOI lands in South Florida
3. Activities to recover South Florida's threatened and endangered species

The following chapters briefly describe key projects that support these program areas and summarize the remaining science needed to plan and adaptively manage these projects. Taken together, the restoration and resource management projects represent the high priority DOI science information needs critical for supporting restoration and management of the South Florida ecosystem.

The USGS, in consultation with the NPS and the FWS, is developing a process for prioritizing the science needs relevant to the restoration and resource management projects identified in this science plan. This process utilizes a multi-tiered approach to assist in prioritizing critical science information needs. The prioritized list generated from this process will be the foundation for DOI's annual science funding strategy. This tiered approach looks at a number of factors:

- The relevance of the science effort to improving understanding of the ecological and hydrologic processes affecting DOI lands and resources
- The applicability of the science to multiple DOI restoration objectives or multiple projects
- The applicability of the science to the development and refinement of performance measures and targets used to evaluate and assess restoration success
- Synthesis and sequencing to address the most urgent management information needs
- Maximization of cost-share opportunities and science coordination across bureaus or with DOI's CERP partners

Using this process, managers and scientists from the NPS, FWS, and USGS will annually review the benefits of DOI-funded science towards supporting DOI managed lands and resources, and the sequencing and timing requirements for that science. The NPS/FWS/USGS team will then recommend

an annual funding strategy and propose how available funds from the NPS CESI and USGS PES programs should be used to target scientific efforts yielding the greatest benefit related to DOI's responsibilities in South Florida. This strategy will take into account the ongoing research funded by other partners and stakeholders to avoid duplication and to maximize the use of other scientific efforts.

The prioritization process outlined above emphasizes a primary goal of achieving economies of scale by effectively integrating science programs from many different jurisdictions, including the private sector. The NPS, FWS, and USGS will continue to proactively seek out partnerships and improve existing ones to maximize scientific inquiry.

Finally, the prioritization process will emphasize coordination in developing annual funding proposals to implement DOI research, monitoring, and assessment programs supporting South Florida restoration activities



3. PROJECTS TO IMPROVE THE QUANTITY, QUALITY, TIMING, AND DISTRIBUTION OF WATER

Introduction

This chapter addresses DOI interests in individual water projects and the corresponding needs for scientific and technical information to help ensure that the projects achieve their intended purposes consistent with the legal mandates assigned to DOI agencies.

Overview of Water Management Activities and Authorities

Projects to increase environmental water supplies and restore more natural surface and groundwater flows are the core of the South Florida restoration initiative. The changes in the regional hydrology created by the C&SF Project have resulted in a sharp decline in the natural abundance and diversity of organisms in the Greater Everglades. Without corrective actions to restore the predrainage hydrology, natural ecosystem functions cannot be recovered.

Because half of the historical original Everglades has been drained and developed, it will be impossible to restore the entire ecosystem to predrainage conditions. However, managers and scientists believe that for the remaining Everglades it will be possible to achieve a healthy and functioning ecosystem that once again exhibits the essential characteristics of the predrainage system. These characteristics include more natural hydropatterns, including wet and dry season cycles, natural recession rates, natural surface water depths and patterns, and in coastal areas, natural salinity and mixing patterns. These characteristics are a precursor to achieving anticipated ecological benefits, which include improving native flora and fauna, restoring the presence of key species in historic habitats, and promoting natural patterns of plant communities ranging from aquatic communities to uplands.

The water engineering projects required for this initiative are coordinated primarily by the USACE and the SFWMD through the CERP and other project authorities. The water project managers are ultimately responsible for ensuring that the projects under their jurisdiction are producing the desired ecological improvements in the Greater Everglades. As a partner with specific authorities for the protection of fish, wildlife, and parks, DOI works cooperatively with the USACE, the SFWMD, and the Florida DEP to ensure that the improvements planned to restore a more natural hydrology to South Florida adequately consider the intended, anticipated, and actual responses within the ecological communities based on the best possible scientific information and analysis.

Restoring more natural surface and groundwater flows must address four interrelated factors: the quantity, quality, timing, and distribution of water. More water is not always better. Alternating periods of flooding and drying were vital to the historical functioning of the Everglades ecosystem. In general, the CERP and other water management projects include five kinds of engineering components for capturing and redirecting water to simulate a more natural system:

surface water storage reservoirs and water control structures

aquifer storage and recovery systems

projects to remove barriers to sheetflow

seepage management projects

operational changes in water delivery schedules

Together these components are planned to recapture much of the 1.7 billion gallons per day of water currently being discharged via canals into Biscayne and Florida Bays, the Straits of Florida, and the Gulf of Mexico. This water will be used to restore natural system functioning and to supplement urban and agricultural water supplies.

A major focus of DOI participation in the water engineering projects is on ensuring that the timing and distribution of water flows to wetlands, especially in the national parks and federal wildlife refuges, mimic natural flow patterns and preserve natural wetland functioning. Natural flows are driven by the seasonal rainfall patterns in the region, and the restoration project components must be designed and operated to mimic this natural variability. For example, the FWS is assisting the Corps and the South Florida Water Management District in revising the regulation schedule for Lake Okeechobee. Regulation of Lake Okeechobee is central to water management in the rest of the C&SF system. This provides an opportunity to not only improve habitat conditions within the littoral zone of Lake Okeechobee, but also influences conditions in connected areas, including the St. Lucie and Caloosahatchee estuaries and the Water Conservation Areas.

Another DOI concern is that the quality of the water used to rehydrate the landscape must be suitable for natural system functioning. The desired responses by plant and animal communities to the right amounts of water being available in the right places and at the right times will not occur unless the quality of the water meets the appropriate water quality standards. The CERP includes a number of construction projects, primarily reservoirs and stormwater treatment areas, specifically designed to ensure that water delivered into the Everglades meets appropriate standards. Because phosphorus enrichment was one of the earliest and most serious water quality issues identified in the Everglades, many of these projects



concentrate on controlling phosphorus in runoff from urban and agricultural lands. Recognizing the critical importance of water quality to ecosystem restoration objectives, the CERP calls for a Comprehensive Integrated Water Quality Feasibility Study (CIWQFS), which will outline water quality issues, and a plan for linking water quality targets to hydrologic targets.

DOI is particularly concerned about the potential harm to fish and wildlife from contaminants that might be released as a result of CERP projects. The rehydration of lands previously used for agriculture, water stored in underground aquifers, or water diverted or reclaimed from urban areas may reintroduce contaminants from the soils. This issue is not addressed as part of the water quality targets for

CERP projects but must be addressed as part of the stewardship responsibilities of DOI.

DOI is also interested in improving fish and wildlife habitat and recreational potential of water storage reservoirs and other constructed features in ways consistent with the water management functions of the project features.

DOI collaborates with the USACE and SFWMD on three primary activities:

Ensure that hydrologic performance targets accurately reflect the natural predrainage hydrology and ecology. The CERP and other restoration projects focus on hydrologic restoration in natural areas, with the assumption that ecologic restoration will follow. The SFWMD Natural System Model simulates predrainage Everglades hydrology as a basis for identifying hydrologic

targets. Ecological responses are inferred based upon conditions observed in the current ecosystem. As new information is gathered and modeling techniques are improved, understanding of the predrainage Everglades will increase, and targets and plans will be refined. Because natural flows are critical to DOI responsibilities in South Florida, participation in the development, refinement, and calibration of hydrologic models of the predrainage Everglades is an important component of DOI science plan.

Ensure that hydrologic performance targets protect threatened and endangered species and promote fish, wildlife, and park values. The CERP is a conceptual plan that is expected to be refined as science is applied to critical restoration questions and as details of the ecosystem are better understood. Modeling tools are continuously developed, improved, and used to create more detailed plans and to predict their impacts.

Each CERP project has or will have a project management plan that describes the general scope of the project. Based on these scoping plans, more detailed implementation plans, called *Project Implementation Reports* (PIRs), are prepared and submitted to Congress for approval. These reports require compliance with the National Environmental Policy Act (NEPA) and include consultations required under the Endangered Species Act and the Fish and Wildlife Coordination Act. As part of each PIR, the USACE identifies the appropriate quantity, timing, and distribution of water to be dedicated and managed for the natural system. The state will reserve that water for the natural system under the provisions of state water law.

As PIRs are formulated for individual projects, local models and other techniques are used to forecast and evaluate possible impacts of the projects and to formulate interim goals. Data from DOI field studies on the hydrologic requirements of individual species, communities, and ecosystems are essential to improving the models used to predict the impacts of project alternatives.

Assess the responses of ecological communities and species as a basis for adaptive management. Once projects are underway, DOI monitoring will focus on the responses of ecological communities and species to changes in hydrology and water quality. Such information will provide the basis for adaptive assessment and management to ensure that water management projects result in the desired ecological effects. For projects that are not meeting interim goals, managers can make science-based adaptations and better plan for achieving the longer term goals.

Overview of Science Support for DOI Managers

South Florida has one of the most extensive hydrologic and ecological data collection and analysis efforts in the country, with contributions from numerous federal and state agencies, including DOI. The collected field data support modeling efforts that convert large amounts of technical information into planning and evaluation tools. These tools directly support project design and adaptive management. In order to meet the modeling challenges of the CERP, DOI should be an active and important participant in the Interagency Modeling Center (IMC), which was established to provide an environment to conduct work in an open and collaborative technical environment.

Hydrologic Research and Modeling

Regional “landscape-scale” hydrologic models are guiding the early CERP projects. Landscape-scale modeling helps managers understand and plan for how multiple projects will interrelate across broad geographic areas under multiple jurisdictions. The Natural System Model (NSM) is the most widely applied quantitative hydrologic model to date. It provides regional scale estimates of South Florida’s predrainage hydrology.

While the NSM provides a picture of the historic, predrainage Everglades, the South Florida Water Management Model (2 x 2 Model) provides a picture of how the regional water management system works. At a scale of 2 square miles, this landscape-scale model simulates regional predictions of the hydrologic conditions that would occur given changes in water management in South Florida. The 2 x 2 Model has been used for nearly two decades to evaluate the consequences of modifications to the C&SF Project. The acquisition of the basic data needed to support the model (evaporation, rainfall, geology, vegetation, water levels, topography, etc.) has been a priority for many years, and the model is “complete,” although it is continuously updated. Groundwater flows have been added to improve some simulations of hydrologic conditions, but all the subsurface simulations end at the mainland shoreline rather than extending to the continental margin. The NSM Model is derived from the 2 x 2 Model and is continuously updated with that model to ensure that the inputs to each are the same.

A next generation hydrologic model that uses higher resolution in key areas, known as the South Florida Regional Simulation Model (RSM), is being developed by the SFWMD. Two higher resolution (500 x 500 meters) hydrologic models, known as the TIME and SICS, are available for the southern Everglades and are being used to predict salinity in the coastal wetlands. Additional models, particularly at local levels, and linkages among models are needed for the detailed design and adaptive management of individual projects.

Changes in the hydrology of the South Florida ecosystem will ultimately cause changes in downstream estuaries and embayments. Because hydrologic models used to design the CERP do not accurately represent groundwater and surface water flow without uncertainties, surface water and groundwater inputs into coastal estuaries such as Florida and Biscayne Bays, many questions remain regarding the link between changes in water management and the salinity and water quality in these estuaries. The Florida Bay Interagency Science Program is integrating the research, modeling, and monitoring projects needed to understand how the bay currently functions and how it will function in the future as part of the South Florida ecosystem. DOI interests in projects affecting Florida Bay and Biscayne Bay are addressed for each individual project.

Ecological Research and Modeling

The natural vegetation of the Everglades is a mosaic of dozens of different community types, each with its own hydrologic and nutrient requirements, many of which fluctuate widely over the course of a year. And just as vegetation patterns can be influenced by the presence or absence of water, vegetation patterns can also influence hydropatterns, thus affecting water flow and/or the transport of nutrients.

Computer models are used to project and evaluate how vegetation and wildlife in the South Florida ecosystem will respond to changes in hydrology and land use. These models combine detailed spatial information about elevation and current vegetation patterns with landscape-scale models of hydrology and include assumptions about ecological processes, such as nutrient transport and vegetative succession. It is important that the scale of models applied for ecological restoration match the scale of the problem being addressed.

During the development of the CERP, a set of ecological models were used to predict ecological responses to various water management scenarios in the Everglades ecosystem. These models were driven by the 2 x 2 Model and the higher resolution hydrologic models developed for the southern Everglades. New models are being developed that will output hydrologic data in different forms, which will enhance the compatibility between the hydrologic and the ecological models. While not yet as mature as the hydrologic models, the ecological models are useful for projecting the effects of hydrologic change on biotic communities and certain endangered species.

Three general kinds of ecological models are used to predict the ecological effects of the various CERP projects: Models of vegetative production, habitat suitability index (HSI) models, and faunal demographic models. HSI models produce maps indicating the spatial pattern of habitat suitability for particular species. Demographic models project how population size may change through time as a function of the changing environment. Such models are essential for performing population viability analyses to determine the risk of extinction.

As individual projects are designed and implemented, they will be based on the most up-to-date scientific knowledge currently available. As models are improved and additional models are developed, projects will be adaptively managed to increase the potential for restoration success.

Water Quality Research and Modeling

Degradation of water quality is pervasive throughout the Greater Everglades, particularly in agricultural and urban coastal areas. The past 20 years have seen extensive field and laboratory investigations used to determine the phosphorus standard that would protect the natural ecological conditions within the Everglades. These investigations are summarized in the SFWMD *Consolidated Reports*. The Environmental Protection Agency (EPA) and the USGS have worked on many other aspects of contaminants in the Everglades, and the EPA has summarized the available knowledge about water quality parameters such as mercury, nitrogen, and pesticides. In addition to the water quality study included in the CERP, which focuses on restoration targets for nutrients and bacteria, DOI is pursuing a science program to support the assessment and management of contaminants that could be introduced into the system as an indirect effect of water engineering projects.

Monitoring and Adaptive Management

WRDA 2000 authorizes the USACE to adaptively manage the ongoing CERP program to continuously incorporate new scientific and technical information into projects. This adaptive assessment and monitoring program will be used to refine and improve the design and operation of CERP projects and to determine whether the CERP is achieving its overarching objective of recovering healthy and sustainable ecosystems in South Florida. The adaptive management program is being carried out by "RECOVER," which is an interagency team of scientists and technical staff being led jointly by the USACE and the SFWMD. DOI scientists and technical staff serve on the RECOVER leadership group and co-chair some of the RECOVER subteams.



A RECOVER Adaptive Assessment Team (AAT) has developed a systemwide *Monitoring and Assessment Plan* (MAP), which establishes a framework for (1) measuring and understanding systemwide responses to CERP projects, (2) determining how well the CERP is meeting its goals and objectives, and (3) identifying opportunities for improving the performance of the CERP where needed. The MAP will provide a single, integrated plan for participating agencies, including DOI, to measure systemwide responses and the performance of the CERP.

Two key assumptions have been made that will be critical to the success of MAP implementation: (1) Existing monitoring will continue with existing funding sources (i.e., the MAP does not replace other agency efforts). (2) Partnering agencies will contribute funding and/or will participate in implementation of the MAP.

The MAP addresses only responses expected from implementation of CERP projects and does not include all of the components necessary to achieve long-term restoration of the South Florida ecosystem.

Examples of ongoing monitoring activities that are independent of the MAP include weather and water stage monitoring stations (USGS), salinity monitoring networks in Everglades and Biscayne Bay National Parks (NPS), and the American alligator survey network (CESI).

Organization of Water Projects

The remainder of this chapter discusses 21 projects designed to improve the quantity, quality, timing, and distribution of water flows in the region. The project-specific science needs are identified for each project. The projects are organized into the following six subdivisions:

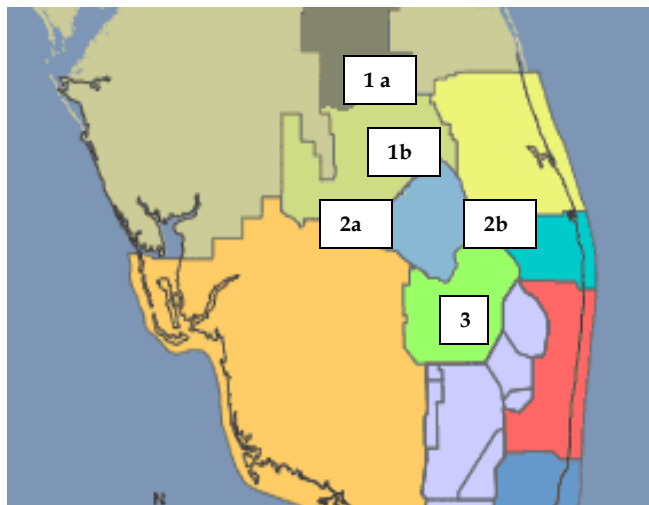
- Kissimmee-Okeechobee Watershed and the Everglades Agricultural Area
- Upper East Coast
- Loxahatchee
- Water Preserve Areas and Seepage Management along the Marsh/Urban Interface
- Lower West Coast
- Everglades National Park, Biscayne Bay, and Florida Bay and Keys

In addition, a summary of the “Landscape-Scale Science Needed to Support Multiple CERP Projects” is provided at the end of this chapter. This science includes

- Landscape-Scale Modeling
- Comprehensive Integrated Water Quality Feasibility Study
- Studies to Support Fish and Wildlife Friendly Siting and Operation of Reservoirs, STAs, and ASR Structures
- Risks to Fish and Wildlife from Contaminants
- Landscape-Scale Monitoring and Assessment

Kissimmee-Okeechobee Watershed and the Everglades Agricultural Area

PROJECTS



1. Kissimmee-Okeechobee Watershed Projects: Kissimmee River Restoration and Lake Okeechobee Watershed
2. Aquifer Storage and Recovery
3. Everglades Agricultural Area Reservoirs

Overview

Historically, Lake Okeechobee served as the primary regulator of flows into the Everglades. Rainwater from the Kissimmee Valley flowed south to Lake Okeechobee. The lake would periodically overflow its banks, and water would continue its slow journey southward through a 60-mile-wide shallow river flowing over the flat and level grasslands of the Everglades.

The Kissimmee-Okeechobee watershed projects (#1 on the map) are proposed to restore natural flows and storage in the Kissimmee basin and to improve riverine and wetland habitats throughout the region. The CERP water storage projects around Lake Okeechobee (#2 and #3) are intended to provide the water management capability to restore a more natural hydrology to Lake Okeechobee and to release water in more natural patterns into the downstream Everglades.

The major DOI interests in these projects fall into three broad categories: the effects on habitats and species within the Kissimmee-Okeechobee watershed, the quality of the water captured for release into the downstream Everglades, and the timing of releases of stored water into the downstream Everglades.

The Kissimmee-Okeechobee watershed supports a great number of federally protected species, including many wide-ranging species such as the Florida panther, wood stork, bald eagle, and West Indian manatee. DOI is concerned about the loss of habitat that will result from the construction and operation of the large reservoirs (four included in the Lake Okeechobee Watershed Project, three in the Aquifer Storage and Recovery Pilot Project, and three in the Everglades Agricultural Area Reservoirs Project). Many of the project areas have important fish and wildlife habitats, including increasingly rare upland forest and prairie habitats and natural wetlands. In an effort to minimize impacts to these lands while planning for and constructing these facilities, the FWS has developed a GIS-based tool to incorporate data on rare habitats, biodiversity, and threatened and endangered species for the Lake Okeechobee Watershed Project. This GIS tool will be refined and used to consider fish and wildlife values when selecting sites for all the large storage reservoirs.

Additional studies of population distributions and abundance will fill gaps in the databases for federally protected species, along with research and monitoring to anticipate and track species' responses to habitat changes. Landscape-scale restoration in the Lake Okeechobee watershed will require decisions that balance the needs of one species or trophic level with another or that maximize biodiversity within the system. For example, the restoration of wetland habitat, while expected to benefit many communities and species, must be achieved in a way that minimizes the risk to threatened and endangered species, including Audubon's crested caracara and the Florida grasshopper sparrow, that have adapted to the drier conditions created by the C&SF Project drainage canals.

The timing and distribution of water deliveries from these water storage projects into the natural areas in the Kissimmee-Okeechobee watershed and also into the downstream Everglades is critical to the recovery of habitats and species. DOI needs to assist the USACE in developing rainfall-driven operating protocols that will mimic the natural timing and distribution of water to natural areas throughout the ecosystem.

The quality of the water captured in these storage projects could be affected by contaminated soils, in areas where former agricultural lands will be flooded to create reservoirs, and by unnatural levels of metals and other contaminants leached from geologic formations, where in-ground wells will be used to store water.

DOI managers can most effectively participate in CERP projects during three project stages: (1) NEPA scoping in the early stages of project design, to help ensure that hydrologic targets accurately reflect the natural pre-drainage conditions, (2) review of project alternatives, to ensure that fish and wildlife and parks are adequately considered in compliance with DOI mandates, and (3) monitoring and assessment of project results, to support project modification if needed to ensure that the intended conditions are achieved. The major questions that DOI managers need to answer at each stage to effectively fulfill their responsibilities as partner and steward are summarized below, along with the highest priority science needs for answering those questions. This information is discussed in greater detail for each individual project following this summary.



SUMMARY OF DOI RESPONSIBILITIES AND SCIENCE NEEDS RELATED TO WATER PROJECTS IN THE KISSIMMEE-OKEECHOBEE WATERSHED AND THE EVERGLADES AGRICULTURAL AREA

| Major DOI Responsibilities and Interests | Major Unanswered Questions | Needed Science | Timeline | |
|---|--|---|---|--|
| Lake Okeechobee, Lake Okeechobee Watershed and Kissimmee River Restoration | | | | |
| Help ensure that hydrologic performance targets accurately reflect the natural predrainage hydrology and ecology (DOI CERP partnership responsibility) | What operating protocols for these projects will mimic the natural predrainage hydrology in the Kissimmee-Okeechobee Watershed? | Research and possible model refinement to establish operating protocols | NEPA Scoping Lake Okeechobee Watershed Completed Kissimmee River Restoration | |
| | Aquifer Storage and Recovery | | | |
| | Will recovered ASR waters be of adequate quality to discharge into natural areas? | Water quality studies | NEPA Scoping ASR Pilot Projects Completed Pilot Project Design Report (PPDR) Complete ASR Projects Currently scheduled to start directly following completion of the pilots in November 2009 | |
| EAA Reservoirs | | | | |
| Help ensure that hydrologic performance targets protect threatened and endangered species and promote fish, wildlife, and park values (consultations on project design related to DOI stewardship responsibilities) | What hydrologic targets will mimic historic flows (including water depths, timing, and distribution) and water quality in the water conservation areas and Everglades National Park? | Research and modeling to refine hydrologic targets, including targets for water quality | NEPA Scoping Phase 1: 2001 Phase 2 TBD | |
| | What operating protocols for releases of reservoir waters will mimic the natural predrainage hydrology in the Everglades? | Research and possible model refinement to establish operating protocols | | |
| | What water quality hazards are associated with storing water on former agricultural lands, and how can they be avoided? | Environmental risk assessments of water quality contaminants | | |
| Lake Okeechobee , Lake Okeechobee Watershed and Kissimmee River | | | | |
| Help ensure that hydrologic performance targets protect threatened and endangered species and promote fish, wildlife, and park values (consultations on project design related to DOI stewardship responsibilities) | Where should treatment wetlands and reservoirs be sited to minimize negative impacts on flora and fauna in the basin and where possible to provide additional habitat benefits? | Studies of threatened/endangered species population distributions and abundance. GIS mapping of habitat | EIS Review, Section 7 Consultation, and CAR Lake Okeechobee Watershed Draft CAR: Feb 2006 Draft PIR/EIS May 2006 Final CAR: Jan 2007 Final PIR/EIS: April 2007 Kissimmee River Restoration Final CAR: 1992 | |
| | What are the potential benefits and adverse effects of the water treatment facilities and aboveground water storage reservoirs on watershed resources? | Research to evaluate effects on dry prairie species Research and modeling to evaluate effects on Everglade snail kites | | |
| | Aquifer Storage and Recovery | | | |
| Help ensure that hydrologic performance targets protect threatened and endangered species and promote fish, wildlife, and park values (consultations on project design related to DOI stewardship responsibilities) | What factors contribute to fish mortality at intake structures? What intake configurations will best reduce the potential for impacting aquatic organisms? | Studies of the effects of intake pumps and control structures | EIS Review, Section 7 Consultation, and CAR ASR Pilot Projects Draft: June 2004 Final: November 2004 ASR Projects Currently scheduled to start directly following completion of the pilots in November 2009 | |
| | What are the tolerances of plants and animals to the ranges of water quality likely to result from ASR? | Research to understand the tolerance of plants and animals to changes in water quality | | |

SUMMARY OF DOI RESPONSIBILITIES AND SCIENCE NEEDS RELATED TO WATER PROJECTS IN THE
KISSIMMEE-OKEECHOBEE WATERSHED AND THE EVERGLADES AGRICULTURAL AREA

| Major DOI Responsibilities and Interests | Major Unanswered Questions | Needed Science | Timeline | |
|---|--|---|---|--|
| EAA Reservoirs | | | | |
| | Are there design and operational improvements that could enhance the ecological value of the reservoirs without reducing the intended purpose? | Research to support design and operational rules to enhance fish and wildlife resources | EIS Review, Section 7 Consultation, and CAR Phase 1 Draft: October 2005 Final: December 2005 Phase 2: TBD | |
| Lake Okeechobee, Lake Okeechobee Watershed and Kissimmee River Restoration | | | | |
| Assess the responses of ecological communities and species as a basis for adaptive management (continuation of DOI responsibilities outlined above) | What are the project effects on Audubon's crested caracara, Florida grasshopper sparrow, and Everglade snail kite? (Lake Okeechobee Regulation Schedule review is included with CERP and other C&SF Projects.) | Monitoring and assessment to determine species responses to habitat changes: <ul style="list-style-type: none"> • Audubon's crested caracara • Florida grasshopper sparrow • Everglade snail kite (and its prey, Florida apple snail) • | Post-implementation monitoring and assessment For proposed revision to Lake Okeechobee Regulation Schedule, monitoring of apple snail abundance in the lake's littoral zone must start in FY 06 and continue indefinitely. | |
| | Aquifer Storage and Recovery | | | |
| | What are the project effects on fish and wildlife in target ASR locations? | Baseline studies and monitoring at ASR locations | Post-implementation monitoring and assessment | |
| | What are the effects of water recovered from ASR projects on fish and wildlife in downstream wetlands and estuaries? | Baseline studies and monitoring in downstream wetlands | | |
| Does the Upper Floridan contribute to subsurface flows into Biscayne and Florida Bays? | Geological description of the Floridan aquifer under peninsular Florida, the continental margin, and Biscayne and Florida Bays. | | | |
| How will the Implementation of ASR in CERP affect the water quality, geohydrology and/or ecology in Biscayne or Florida Bay? | Research and modeling to determine the effects to the ecology of Biscayne or Florida Bay. | | | |
| EAA Reservoirs | | | | |
| | What are the effects of the reservoirs on fish and wildlife values? | Monitoring and assessment to determine the effects of the reservoirs on the natural system | Post-implementation monitoring and assessment Part 1, Phase 1 Completion: Dec 2009 Part 1, phase 2 Complete 2015 Part 2 Completion: 2020 | |
| | What are the effects of water recovered from EAA reservoirs on fish and wildlife in downstream wetlands and estuaries? | | | |

Kissimmee-Okeechobee Watershed Projects



Project Purpose and Major DOI Interest

The Kissimmee-Okeechobee watershed originates in the Kissimmee Chain of Lakes near Orlando and terminates where the Kissimmee River enters Lake Okeechobee. The watershed provides both upland and wetland habitats for more than 30 federally listed species.

Two restoration projects, with separate authorizations, within this watershed are of particular interest to DOI: the Kissimmee River Restoration Project, which predates the CERP, and the CERP Lake Okeechobee Watershed Project.

The purpose of the Kissimmee River Restoration Project is to restore 40 square miles of native river and floodplain habitat. Seven miles of the river have been restored, and this project has a priority to be completed as soon as possible.

The CERP Lake Okeechobee Watershed Project includes four separable elements¹ that were combined to address the interdependencies and tradeoffs between the different components. The purposes of this project are to improve the water quality of Lake Okeechobee, provide for better management of lake water levels, and reduce damaging releases to the estuaries. Water from the watershed and the lake will be captured during wet periods for later use during dry periods. Aboveground reservoirs will increase the storage capacity and reduce the duration and frequency of both high and low water levels in the lake (which are stressful to its littoral zone ecosystems) and reduce large discharges from the lake (which are damaging to the downstream estuarine ecosystems). Water from upstream tributaries will be diverted to STAs to reduce nutrient loading into the lake. In addition, the project will restore the hydrology of isolated wetlands by plugging the connections to drainage ditches and diverting canal flows to adjacent wetlands.

The Kissimmee River Restoration and the Lake Okeechobee Watershed Projects have the potential to significantly affect threatened and endangered species habitat in the Kissimmee-Okeechobee watershed. Dry prairie is one of the characteristic communities in the Kissimmee-Okeechobee watershed that supports the endangered Florida grasshopper sparrow and the threatened Audubon’s crested caracara. It is also one of Florida’s most endangered upland ecological communities. DOI is concerned about the timing and distribution of water deliveries and how they will affect habitats and species. DOI is also concerned that the construction of the Lake Okeechobee Watershed Project will convert 54 square miles of mostly upland agricultural lands that support Audubon’s crested caracaras and Florida grasshopper sparrows into water treatment facilities and aboveground water storage reservoirs. Large reservoirs and treatment wetlands will effectively eliminate the fish and wildlife habitat values of the sites selected for these facilities. They need to be sited in locations that avoid harm to federally protected species and designed to potentially provide additional habitat benefits wherever possible.

¹ These four projects are the North of Lake Okeechobee Storage Reservoir, the Taylor Creek/Nubbin Slough Storage and Treatment Area, the Lake Okeechobee Watershed Water Quality Treatment Facilities, and Lake Okeechobee Tributary Sediment Dredging.

Also, the Kissimmee Chain of Lakes is one of the main wetlands supporting the endangered Everglade snail kite, particularly during times of drought in South Florida. The Kissimmee Chain of Lakes has been plagued by human-caused nutrient enrichment, proliferation of exotic and nuisance aquatic plants, and static lake levels under the present water management system. Current management techniques to maintain shoreline habitat include extreme lake drawdowns, aggressive herbicide programs, and muck removal. Extreme drawdowns have been shown to severely reduce the amount of prey (apple snails) available for snail kites. Extreme drawdowns, coupled with post-drawdown herbicide treatments, create shoreline vegetation communities that are less likely to support snail kite nesting and foraging.

What Is Known

Only 16% of remaining dry prairie habitat in Florida is in conservation lands. The majority of loss of dry prairie habitat in this watershed has resulted from conversion to agricultural lands. According to the Central Florida Planning Council, counties within the watershed are likely to experience population growth rates above the South Florida average, making additional impacts on dry prairie habitats likely. If appropriately managed, existing agricultural lands, such as improved pasture, unimproved pasture, and rangeland may provide suitable habitat for Florida grasshopper sparrows and Audubon's crested caracaras.

The heart of the Audubon's crested caracara species distribution falls within the Kissimmee-Okeechobee watershed; however knowledge of the current distribution of Audubon's crested caracaras in this area is incomplete.

Six populations of Florida grasshopper sparrows are found on four tracts of land, one of which is in private ownership, all within the Kissimmee-Okeechobee watershed. Maintenance of the hydrologic and ecologic regime of dry prairies is required for Florida grasshopper sparrow feeding and breeding. With appropriate management, existing protected dry prairie lands can support existing populations of endangered Florida grasshopper sparrows. Recovery of the species will require restoring additional habitat to allow the species to occupy its historic range and increase its population size.

What Is Needed

Studies of threatened/endangered species population distributions and abundance. DOI needs better information on the distributions and abundance of Audubon's crested caracara, Florida grasshopper sparrow, and Everglade snail kite in the Kissimmee-Okeechobee watershed to make recommendations to the USACE regarding site selections and designs for the Lake Okeechobee Watershed Project. Once current distribution and habitat use have been characterized, restoration alternatives can be evaluated to minimize their impacts on these species' habitats and to maximize the enhancement of potential future habitats.

GIS mapping of habitat. In an effort to minimize impacts to the existing habitat where large reservoirs and treatment wetlands, that are part of the CERP, are being constructed, the FWS is refining a GIS-based tool to incorporate data on rare habitats, biodiversity, and threatened and endangered species for the Lake Okeechobee Watershed Project. This project will provide the data needed to maximize potential habitat improvements and minimize the negative impacts in the planning and construction of these management features.

Research and possible model refinement to establish operating protocols. DOI needs to provide recommendations to the USACE regarding the design and operation of water storage and treatment facilities to ensure that they do not have impacts on existing fish and wildlife and to maximize potential habitat benefits for species in the area. These recommendations need to be developed on a timeline that will allow input into alternative selection for each component of the project based on the most current knowledge available to support protection of fish and wildlife values.

Research to evaluate effects on dry prairie species. Research into the effects of alternative water management scenarios is necessary to define the best management for dry prairie species.

Research and modeling to evaluate effects on Everglade snail kites. Additional research and information is needed to support development of water regulation schedules in the Kissimmee Chain of Lakes and Lake Okeechobee that maintain and improve Everglade snail kite prey availability, nesting habitat, and foraging habitat in these regions (see "Avian Species Recovery," page). Detailed information about the effects of various drawdown scenarios on apple snail abundance, distribution, and recovery will allow the development of operating protocols to foster healthy apple snail populations, which are critical to Everglade snail kite recovery. Research will evaluate the effects of extreme drawdowns on snail kite foraging efficiency. A model will be developed to evaluate the cumulative effects on kite habitat due to lake drawdowns in the Kissimmee Chain of Lakes and other CERP projects. This information will also be applicable to an evaluation of potential effects on the population on a wider regional scale.

Monitoring and assessment to determine species responses to habitat changes. Information about the impacts of habitat changes on Audubon's crested caracara, Florida grasshopper sparrows, and Everglade snail kites will assist DOI in providing input into the adaptive management phases of these projects.

[Aquifer Storage and Recovery Pilots and Regional Study](#)

Project Purpose and Major DOI Interest

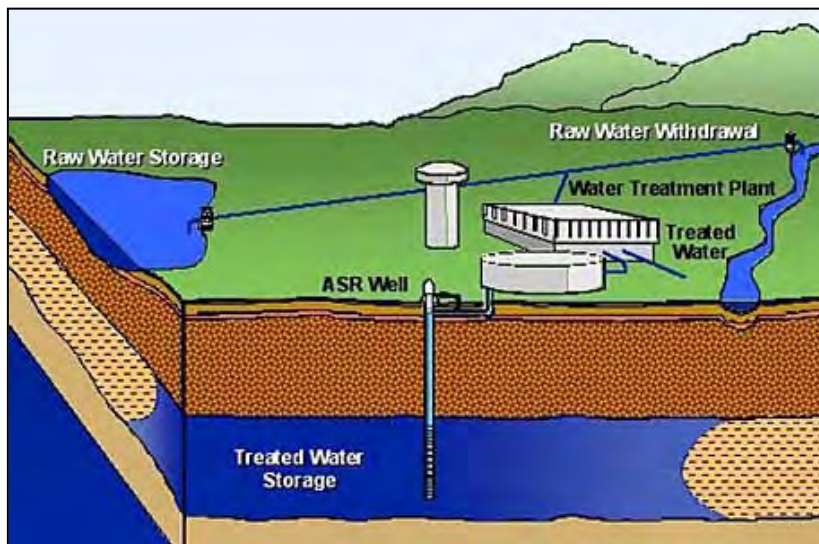
Aquifer storage and recovery (ASR) involves the construction of underground storage wells, often as companions to reservoirs or other surface water bodies, to provide additional water storage capability. Water is stored in a suitable aquifer during times when water is available and recovered from the well during times when it is needed. The CERP proposes to use ASR at an unprecedented scale to temporarily store up to 1.6 billion gallons of treated freshwater per day in the underlying brackish Floridan aquifer system. The storage from regional ASR implementation is expected to help reduce the degree and frequency of damaging high and low water stages on Lake Okeechobee and high and low water flow events in downstream estuaries and wetlands. ASR is also expected to support agricultural and other consumptive water supply needs. The advantages of ASR wells over traditional surface water storage systems include less need to remove land from current uses (such as agriculture), reduced land acquisition costs, reduced evaporation losses, the possibility of locating ASR wells in areas of greatest need (thereby reducing water distribution costs), and the potential to recover large volumes of water during severe droughts. About 330 ASR wells have been proposed, each with an assumed capacity of 5 million gallons per day during recharge or recovery. These wells will store water approximately 1,000 feet underground in a brackish aquifer.

Three ASR pilot projects will be located near Lake Okeechobee, adjacent to the Hillsboro Canal, and near the Caloosahatchee River. These projects will identify the most suitable sites for ASR wells in the vicinities of these surface water bodies and the optimum configurations of those wells. The pilot projects will provide information regarding the characteristics of the aquifer system within the proposed basins, including the hydrogeological and geotechnical characteristics of the aquifer. By addressing technical uncertainties about many aspects of well construction and operation, the pilot projects will provide the information needed to properly design the rest of these facilities.

An *ASR Regional Study* will address regional issues that are beyond the scope of the ASR Pilot Projects, including potential effects of the full-scale CERP ASR Program on the environment and on economically disadvantaged communities and existing users of the Floridan aquifer system.

The results from the ASR Pilot Projects and the *ASR Regional Study* will be utilized to determine the feasibility of large-scale ASR and its potential effects on water levels, water quality within the aquifer, surface water quality, biota, and ecosystem processes.

ASR has the potential to affect ecosystem processes and fish and both positively and negatively wildlife habitats, largely depending on the quality of the recovered water. Another concern is the effect of intake



structures on aquatic organisms at the intake sites. High numbers of operating ASR wells will pump significant volumes of water, which may contain concentrations of aquatic organisms including larval, juvenile, and adult fish. Fish mortality caused by ASR intakes may reduce recreational stocks.

A successful ASR program will benefit fish and wildlife resources by providing a significant part of the additional water supply needed to achieve CERP restoration goals and other

benefits. DOI is particularly concerned that careful attention to the lessons learned in the pilots and regional ASR studies be applied to minimize the potential for direct, indirect and/or cumulative effects on managed resources through habitat modifications and/or contaminant introduction.

The ultimate success of the ASR program will require understanding which geological environments are capable of serving as storage zones while minimizing the potential for adversely affecting the physical and chemical properties (temperature, pH, metals, and radionuclides) of the stored water. The efficacy of ASR at the scale proposed needs to be verified. If the initial assumptions concerning the application of ASR prove to be inaccurate, understanding the relationships between the geological, chemical, and biological processes will be critical to understanding the potential tradeoffs among benefits or impacts to the natural system, and/or to determining the extent to which ASR will be used and what, if any, other water storage contingencies will be necessary. Much information will be garnered from the proposed pilot studies, although individual well characteristics may be highly site specific.

Given the current uncertainty of the projected 70% recovery rates from 330 proposed wells, storage contingency planning is being undertaken by the federal and state partners to evaluate alternatives to replace any realized deficits in storage capacities that are essential to the success of the CERP.

What Is Known

Of the three major aquifer systems underlying the Everglades area (the *surficial*, *intermediate*, and *Floridan* systems), the upper 250 feet of the surficial aquifer system, which includes the highly permeable Biscayne aquifer, is the principal source of freshwater for the more than 6 million people in southeastern Florida.

The intermediate aquifer system, which underlies the shallow surficial aquifer, is a source of freshwater mostly along the gulf coast. The Floridan aquifer, which is the principal source of fresh ground water in many parts of Florida, is the deepest aquifer in the region; however, south of Lake Okeechobee, water in the Floridan aquifer is too mineralized for most uses. Subtle changes in land elevation or slight rises in

sea level can increase the potential for coastal flooding and also can reverse the hydraulic head and allow saltwater intrusion into aquifers.

The physiography and hydrology of the intermediate aquifer system (upper Floridan) and its confining units are partially described for the area under the Florida mainland. However, as this formation extends out under the continental margin, the physiographic and hydrologic descriptions decrease dramatically. The area of discharge for this aquifer, if there is one, is poorly understood but presumed to be located in the deeper regions of the western Straits of Florida, or possibly further east.

ASR water storage technology has been used by drinking water suppliers in the United States since 1969. A recent USGS report indicates that 22 active ASR wells utilize the targeted Upper Floridan aquifer in the CERP study area. The aquifer is brackish to saline in southern Florida, which can greatly affect the recovery of stored freshwater. The success of storage and recovery depends on maintenance of a “freshwater bubble” in this saline environment. Many site-specific factors may affect the integrity of this bubble, including ambient salinity and structural features that may allow the freshwater to migrate.



While most of the few large-capacity, large-diameter (greater than 20-inch) ASR wells in southern Florida are operated at rates of 1 to 2 million gallons per day (mg/d), the CERP-proposed 5 mg/d recharge and production rates per well remain unverified. CERP assumes a recovery efficiency of 70% of the injected volume. The USGS reports highly varying rates of recovery ranging from as low as 2% to as high as 84%, with ten sites achieving a recovery efficiency above 30% during at least one cycle. Recovery rates of 4 to 5 mg/d achieved during recent ASR cycle testing at the Miami-Dade West Well Field, however, offer evidence that the desired recharge rates are possible.

What Is Needed

Water quality studies. The areas of study related to ASR include the specific water quality characteristics of waters to be injected, the water quality characteristics of water recovered, and the water quality characteristics of water within the receiving surface and ground waters.

Hydrogeologic studies. Knowledge of the hydrologic framework and hydrology of the intermediate aquifer system (upper Floridan) and its confining units needs to be improved with further geotechnical and hydrologic studies in areas underlying the Florida mainland and especially between the internal greater Everglades, Biscayne Bay and Florida Bay. In addition, descriptions of the physiography and hydrology of the Floridan aquifer needs to be developed for areas that extend out under the continental margin and into the Biscayne Bay. If any discharge areas are identified additional research and modeling will be needed to determine effects on the ecology in Biscayne or Florida Bay as ASR is implemented.

