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Ecosystem Management and the Florida Everglades: The Role of Social Scientists

J. Walter Milon, Clyde F. Kiker, and Donna J. Lee

ABSTRACT

Recently many state and federal agencies in the U.S. have embraced an ecosystems management approach to environmental protection and regulation. This approach requires a high degree of cooperation between natural and social scientists to translate policy objectives into research hypotheses, models, and evaluation procedures to guide implementation decisions. An adaptive procedure to guide interdisciplinary research is described and illustrated with highlights of recent progress and pitfalls from the restoration initiative for the Everglades/South Florida ecosystem.

Key Words: adaptive management, ecosystem management, Florida Everglades, interdisciplinary research, social science.

The most significant new concept in environmental policy debates during the past few years is ecosystem management. What began as a loose collection of ideas and principles based on biological field studies (Grumbine) has become a central theme for state and federal environmental resource management. The Clinton Administration established an Interagency Ecosystem Management Task Force in 1993 to explore the implications of ecosystem management in 18 federal agencies. Subsequent reports indicate a high level of federal commitment to implementing the ecosystem approach despite many obstacles (e.g., Interagency Ecosystem Management Task Force; U.S. Environmental Protection Agency; U.S. General Accounting Office). A recent survey identified more than 600 ecosystem management projects underway around the U.S. (Yaffee et al.).

One centerpiece of federal and state ecosystem management efforts is the South Florida/Everglades ecosystem restoration initiative. The southern portion of Florida (see figure 1) is a mosaic of interrelated terrestrial, freshwater, and marine systems that includes several national and state parks, preserves, and special management areas. The region encompasses more than 18,000 square miles and accounts for nearly 50% of Florida's 14 million residents and an equal percentage of the more than 40 million annual visitors to the state. Since the late 1800s, and especially after 1948, the natural hydrological conditions of the region have been fundamentally changed to provide flood protection and water supply for domestic, industrial, and agricultural users (Light and Dineen). In 1993, the South Florida Ecosystem Restoration Task Force (and related Working Group) was created through an interagency agreement among six federal agencies; in 1995, membership of the South Florida Task Force was expanded to include

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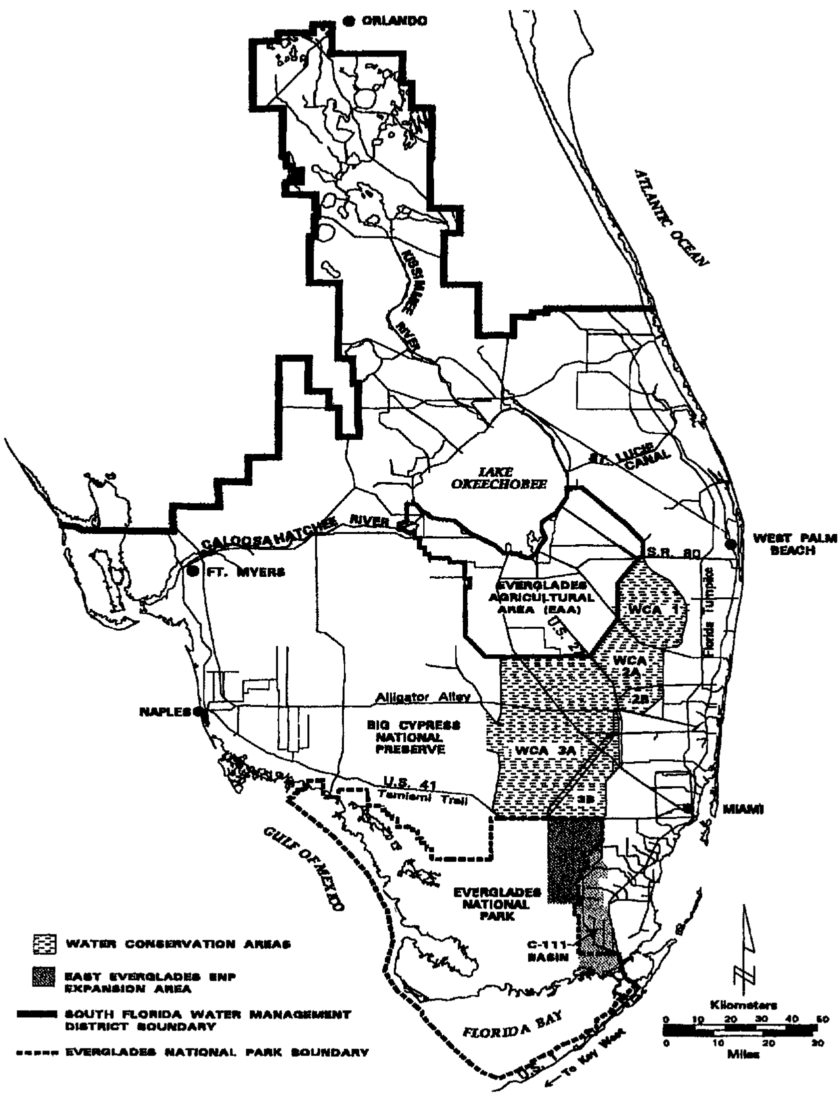

Figure 1. The South Florida/Everglades Ecosystem

relevant state agencies and the Miccosukee and Seminole tribes. This group seeks to coordinate state and federal efforts to "restore and maintain the integrity of the South Florida Ecosystem" (U.S. Department of the Interior).

This paper utilizes the South Florida case study to describe the interdisciplinary research necessary for ecosystem management and, in particular, the role of social scientists. We begin with a brief overview of the ecosystem management concept and the merits of the approach relative to conventional management. We then describe a general framework for interdisciplinary research to support ecosystem management, with special emphasis on the interrelationships between natural and social sciences in the development and testing of hypotheses to guide management decisions. We illustrate this framework through analyses of a sample of important research issues in the South Florida restoration process and conclude with some observations on the changing role for scientists in an ecosystem management framework.

Principles of Ecosystem Management

At present, there are several well-recognized principles of ecosystem management, but relatively little agreement on the details of implementation. The most cited definition, put forth by Grumbine, is management that "integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general goal of protecting native ecosystem integrity over the long term" (p. 31). This definition embodies three primary themes: (*a*) ecosystems—interacting biological (including human) and physical components, (*b*) conservation biology—sustainable areas of biodiversity within a native habitat, and (*c*) integrated organization—coordination of social institutions to achieve desired goals. Depending upon the emphasis given to each theme, ecosystem management can be viewed as a preservation-dominated approach to resource management (Sedjo) or as an organizational tool to reconcile diverse, conflicting political interests (Haeuber).

Ambiguity in the focus of ecosystem management is reflected in the differing perspectives on ecosystem management as expressed by various federal agencies. For example, the National Park Service's historical mandate for preservation is reflected in its description of ecosystem management as "a philosophical approach that respects all living things and seeks to sustain natural processes and the dignity of all species and to ensure that common interests flourish" (quoted in Haeuber, p. 25). On the other hand, the Interagency Ecosystem Management Task Force states, "The goal of the ecosystem approach is to restore and sustain the health, productivity, and biological diversity of ecosystems and the overall quality of life through a natural resource management approach that is fully integrated with social and economic goals" (Vol. I, p. 17). This latter interpretation emphasizes the interrelationships between biological and social systems and the need for consistency between ecological and social goals.

Proponents of ecosystem management argue a fundamental advantage is that traditional resource management tends to be myopic and fails to recognize the complexity and uncertainty inherent to ecological and social systems (e.g., Agee and Johnson; Ludwig, Hilborn, and Walters; Holling; Stanley). Therefore, an adaptive management approach is a necessary element of ecosystem management. Adaptive management is based on the premise that information about ecological and social systems is (and will always be) imperfect. Management decisions should be viewed as part of a sequential process designed to provide new information which is then used to assess and modify, if necessary, prior decisions (Walters). New information about ecological and social systems is generated from a process that views each new management decision as an experiment within a series of experiments. Each experiment is based on one or more hypotheses about the behavior of critical ecological and/or social system indicators (endpoints). Thus, adaptive management requires: (*a*) close integration between natural and social scientists and policy makers in the formulation of goals and hypotheses, (*b*) clearly defined response indicators (endpoints),[1] and (*c*) monitoring and evaluation to identify and assess the implications of change in the response indicators relative to goals and objectives. In many respects, adaptive management is Deming's business strategy of "total quality management" (Latzko and Saunders) applied to environmental management. The Interagency Ecosystem Management Task Force contends that without this sequential research process, management "is reduced to little more than a trial-and-error process" (Vol. II, p. 56).

Despite the integral role of research in ecosystem management, little has been written about the process of scientists working with managers in an ecosystem setting, and the literature is equally silent on writings addressing interactions between natural and social scientists.[2] This is surprising since a large majority of ongoing ecosystem management projects

[1] Endpoints are quantitative indicators of ecosystem attributes that reflect biological and social relevance, are definable and measurable, and change in response to perturbations (Suter and Barnthouse, pp. 22–27).

[2] Notable exceptions are works by Antle and Wagenet; Harwell et al.; Miller; and the National Research Council.

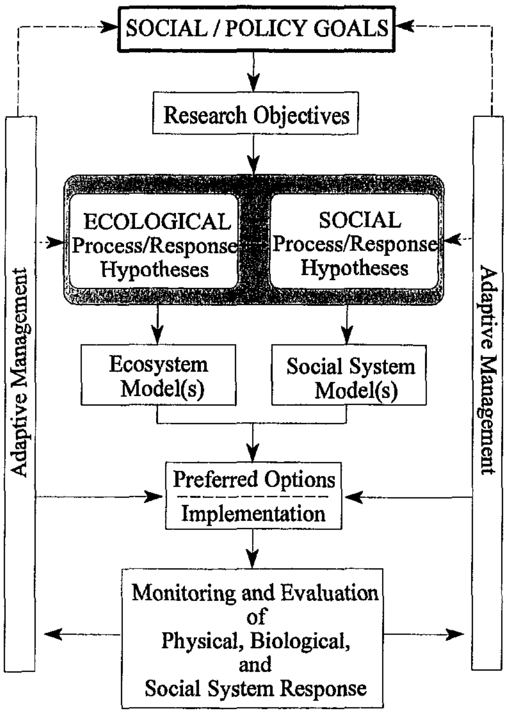

Figure 2. Natural and social science research in an adaptive management framework

around the U.S. cite research as a primary component of the project (Yaffee et al., pp. 17–19). Indeed, the Interagency Ecosystem Management Task Force observes, "The need for scientific information as a foundation for resource management decisions continues to increase dramatically. . . . The interface between social, economic, physical-biological, and ecological models must be improved" (Vol. II, p. 65).

In the following sections, we present a framework for integrating natural and social scientists in adaptive management and describe how this framework could be applied to some critical ecosystem management issues in the South Florida/Everglades setting.

Scientists' Role in Adaptive Management

The contributions of natural and social scientists in an adaptive management framework are illustrated in figure 2. Social goals or priorities for the management of an ecosystem are expressed through various political and governmental entities. These goals reflect the desires of the public at a specific time and are often vague and ambiguous because full knowledge of the ecosystem is lacking and public desires reflect complex cultural beliefs and values that are rarely expressed with precision (Caldwell; Jasanoff). These goals can be expressed as research objectives by scientists and policy makers. The research objectives are conditioned on scientists' understanding of ecological and social relationships and policy makers' interests in achieving these goals. It goes without saying that policy makers' interests may be as complex and dynamic as the ecosystems they manage (Fortman).

Agreement between policy makers and scientists on research objectives leads to a set of ecological and social hypotheses about the performance of the ecosystem that are mutually consistent yet reflect different disciplinary perspectives. Natural scientists address an ecosystem's structure and function (biological, chemical, etc.) and the interactions of populations (including human) within the ecosystem. Social scientists consider the structural and functional features of social systems (economic, political, etc.) and human behavioral interactions with nonhuman components of the ecosystem. The hypotheses form the basis for models of the natural and human systems that can be used to assess the effects of potential and/or actual perturbations to the ecosystem. Each disciplinary perspective may address variables that have substantially different response times and spatial scales.

In an ideal world, the research hypotheses reflect direct interaction and exchange between natural and social scientists so that critical determinants of an ecosystem's performance and the most important endpoints are simultaneously considered. Nevertheless, it is important to recognize that many determinants will be imperfectly understood, so that the process of developing and testing "working hypotheses" in an adaptive management framework only seeks to reduce the ambiguity inherent to natural and social systems (Caglioti). Within this scientifically informed adaptive management process, the research hypotheses form the basis for an array of possible options and actions from which policy makers (ecosystem managers) select an initial preferred course of action. Following implementation, monitoring and evaluation of the physical, biological, and social systems responses must be conducted to assess the initial working hypotheses, to reduce scientific uncertainty, to inform the public, and, if necessary, to develop alternative hypotheses and action plans. This is the critical "feedback" element of adaptive management that requires interdisciplinary scientific dialogue and interaction with policy makers and the public. At this stage, prior investments in the development of compatible natural and social science hypotheses will be most apparent. A lack of acceptable indicators of ecosystem performance will greatly complicate decisions about the effects of prior actions and will jeopardize public trust in the management process.

Interdisciplinary Science for Adaptive Management of the Everglades/South Florida Ecosystem

The ecosystem management approach can be illustrated by restoration initiatives for the Everglades/South Florida ecosystem. In addition to the South Florida Ecosystem Task Force, other governmental entities have helped to define restoration goals for the ecosystem. In 1994, the U.S. Army Corps of Engineers, a member of the Task Force, published a three-volume report series designed to identify problems and opportunities, solicit public input, formulate conceptual restoration plans, and recommend further detailed studies for the Central and Southern Florida Project (CSFP).[3] In 1995, following its establishment by Governor Lawton Chiles, the Governor's Commission for a Sustainable South Florida published its "Initial Report" that offered 110 recommendations for the future of the region. These recommendations address hydrologic, ecologic, and socioeconomic attributes of the region. Foremost among these recommendations is that the existing water management infrastructure should be redesigned to "restore a sustainable South Florida ecosystem that preserves the valued properties of South Florida's natural systems and supports productive agriculture, fishery, and tourist-based economies and a high quality of life" (p. 18).

Congress and the Clinton Administration stipulated in the Water Resources Development Act of 1996 that a feasibility evaluation and recommended plan for restoration of the Everglades must be developed by July 1, 1999. The Army Corps of Engineers which, as the lead federal agency for the CSFP, has primary responsibility for developing and implementing the plan, has noted: "The approach that is necessary to begin restoration immediately with minimum risk is adaptive management" (U.S. Army Corps of Engineers 1996, p. 2).

Redesign of the CSFP will raise many questions that will require integrated research by natural and social scientists. In the following, we consider two components of this redesign and discuss some of the research issues that scientists should address in an interdisciplinary setting.

Agricultural Land Use, Water Quality, and Terrestrial Habitat

The CSFP made it possible to develop a large area on the former southern shore of Lake Okeechobee into agricultural land. This area, called the Everglades Agricultural Area (EAA) (figure 1), is a major producer of sugarcane, vegetables, and turfgrass. It also has been a source of nutrient loadings in surface water runoff to other areas of the ecosystem—notably the downstream Water Conservation Areas (WCAs), and has altered groundwater

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[3] Since the Flood Control Act of 1948, federal activities to build a water control infrastructure throughout the Everglades/South Florida region have been referred to as the Central and Southern Florida Project. This "plumbing system" is considered one of the largest water management projects in the world. It is interesting to note the following statement from the initial authorizing legislation: "The basic problem of this area is, therefore, to *restore the natural balance between soil and water* [emphasis added] in this area insofar as possible by establishing protective works, controls, and procedures for conservation and use of water and land" (U.S. Army Corps of Engineers 1994, Vol. 1, p. 31).

tables and subsidence levels due to drying of the muck soils.

Proposed (and in some cases partially implemented) strategies to deal with these problems include new water conveyance and storage structures to: (*a*) retain water used in the EAA, (*b*) raise groundwater tables, and (*c*) purify runoff waters entering other areas of the ecosystem. Also, alternative cropping patterns, best management practices (BMPs), and alternative crops are being considered to reduce nutrient inputs and retain more water in the area.

Cooperative work between natural and social scientists is necessary to develop research hypotheses, models, and preferred options from these strategies. Important questions to be addressed concerning natural system issues include the following. How does the selection of water delivery/storage strategies and BMPs influence yields for existing and alternative crops? How effective are alternative nutrient reduction/treatment strategies in limiting nutrient deliveries to other areas? What are the effects of nutrient delivery levels to areas outside the EAA on water quality, native vegetation, and fish and wildlife? What is the expected timing for ecosystem responses outside the EAA given a selected set of strategies within the EAA?

Closely related social science issues beg equally important questions. Given expected changes in yields for alternative nutrient reduction/treatment strategies, what are the corresponding changes in farm-level and regional profitability and incomes? How are related businesses, such as refined sugar production in the EAA, affected by crop and yield changes? Aside from yield changes, what are the direct and indirect costs or benefits associated with alternative water delivery/storage strategies, especially for communities surrounding the EAA? What is the timing and distribution of costs and benefits across private interests within the EAA and the public?

Hydroperiods, Terrestrial and Marine Habitats, and Wildlife

The highly variable cycle of rainfall in South Florida "results in a spatially varying annual hydropattern that influences the floristic and faunal communities across the Everglades" (DeAngelis, p. 314). The CSFP fundamentally altered the naturally occurring sheet flow from Lake Okeechobee to Florida Bay (figure 1) through the creation of drainage canals, water storage areas, and pump stations throughout the region. The modified hydroperiod has greatly reduced wading bird populations in the region, reduced available habitat for many other species, and increased salinity levels in Florida Bay (The Watercourse, pp. 121–48). The task of identifying changes in wildlife populations is complicated by the sheer magnitude of regional biodiversity. There are more than 350 bird species (three of which are endangered), 50 reptile species (one is endangered), 35 mammal species (two are endangered), more than 500 fish species, and 100 coral species. Due to the tropical and subtropical climate of the region, there are plants, invertebrates, and other organisms that exist nowhere else in the continental U.S. (Lodge). Across the entire ecosystem, there are 48 endangered species, 14 threatened species, and 62 candidate species (U.S. Army Corps of Engineers 1994, Vol. 2, Appendix C).

Proposals to reestablish more natural hydroperiods in some parts of the region would provide greater continuity across water storage areas and among different subregions within the ecosystem. These proposals would also reduce dependence on the water storage areas for municipal water supplies and flood protection.

These proposed changes in the hydrologic system raise a number of important natural science issues. How, and to what extent, does reestablishing historic flows in the remaining parts of the original Everglades impact the spatial extent and heterogeneity of existing terrestrial habitats and wildlife populations? What impacts would occur for salinity levels, marine habitats, and fish populations in Florida Bay and other coastal estuaries? What are the temporal periods for various biological system responses to modified hydroperiods? How does redesign of the water storage areas affect water supplies and flood protection for urban areas—especially during extreme drought and rainfall events? What effects will modified hydroperiods have on the spatial distribution, frequency, and intensity of wildfires?

Correspondingly, there are important social science concerns associated with the hydrologic system modifications. How will existing human activities within the ecosystem change in response to modified hydropatterns—especially changes in the probability of flooding or severe water shortages? Do various user and nonuser groups prefer changes in specific habitat types (e.g., wet prairies and open sloughs versus sawgrass)? What population levels for specific species do various user and nonuser groups prefer, and do preferences for species with one set of habitat needs dominate other species with different habitat needs (e.g., wading birds versus passerines)? What economic (and noneconomic) values do individuals living in South Florida and those living in other areas have for changes in the Everglades/South Florida ecosystem? How long do these different groups expect it will take before desired changes occur in the ecosystem? How will future economic and population growth influence, and be influenced by, alternative restoration plans?

Can Adaptive Management of the Everglades Succeed?

Ecosystem management of the Everglades/South Florida restoration and the adaptive management process offer a unique opportunity for coordinated federal and state administration and for collaborative research between natural and social scientists. To date, there have been many positive developments. The South Florida Ecosystem Restoration Working Group has published annual reports defining priorities and tasks to facilitate restoration efforts and identifying lead agencies to accomplish the tasks. A coordinated budget was developed in 1996 for new monies available from the Water Resources Development Act of 1996. The Army Corps of Engineers was also authorized by the act to complete a final plan for the restoration by July 1, 1999. In addition, the Governor's Commission for a Sustainable South Florida developed a "Conceptual Plan" in 1996 which included planning objectives and preferred options to be evaluated as part of the Corps' study.

These actions created a framework for adaptive management, but substantive evidence of collaborative efforts between natural and social scientists have been limited. An April 1996 workshop for natural and social scientists was convened by the U.S. Army Corps of Engineers, the Everglades Partnership,[4] and the University of Miami to evaluate success indicators (endpoints) for the restoration effort that had been previously developed by the Science Subgroup[5] of the Interagency Working Group. The workshop succeeded in bringing the most important science issues before a broad cross-section of the science community, but the ensuing recommendations stressed that: (*a*) the role of science in the restoration process had not been clearly defined, (*b*) specific hypotheses linking ecological and social interactions had not been developed, and (*c*) social preferences for endpoints had not been considered (Gentile, p. viii). Since the 1996 workshop, the Interagency Working Group has created a Social Science Steering Committee to convene a symposium on social sciences and ecosystem management in 1997.

Some integrative work between natural and social scientists is occurring somewhat independently of the Interagency Working Group, through the Washington office of the Economic Research Service with cooperation from the U.S. Fish and Wildlife Service. This latter group is implementing a work plan to link farm-level production models for the EAA with an environmental indicators model and an environmental valuation analysis (Feather). How these efforts will integrate with the ac-

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[4] The Everglades Partnership is a newly established, not-for-profit consortium of public and private institutions involved in Everglades restoration activities. It is intended to serve as an information resource for the South Florida Ecosystem Restoration Task Force and the Governor's Commission for a Sustainable South Florida.

[5] The Science Subgroup is composed of natural scientists from the agencies represented in the Interagency Working Group.

tivities of the Interagency Working Group remains to be determined.

The lack of substantive interaction between natural and social scientists in the Everglades/ South Florida ecosystem management project is not surprising. The usual factors that hinder interactions—such as differing disciplinary perspectives, limited social science staffing in natural resource management agencies, and a lack of tangible personal incentives for non-agency scientists (National Research Council, pp. 42–45)—are all present in this setting, as they have been throughout much of the history of water planning in the U.S. (Reuss). But even the Army Corps of Engineers, which has a unique mixture of natural and social scientists and has an important stake in the success of adaptive management (Shabman), has not defined a plan or protocol to implement an adaptive management process.[6]

The appeal of ecosystem management and the adaptive management process is that it provides a rational basis for scientists to help managers cope with the inherent lack of knowledge and uncertainty in natural resource management. Some would argue that adaptive management is an inevitable transition. The scientific management principles that have dominated environmental policy and management in the U.S. "lack the cross-disciplinary integration and informed speculation needed to be useful to a policy maker" (Tarlock, p. 1133). Indeed, for the South Florida ecosystem, the U.S. Army Corps of Engineers has recognized that "the future Kissimmee River, Lake Okeechobee, Everglades, Big Cypress, and Florida Bay ecosystems can be', to some extent, what we want them to be, based on our value systems, and our decisions about what conditions and components constitute a restored ecosystem" (1994, Vol. 1, p. 109). As this experiment in ecosystem management unfolds, the extent to which the South Florida Ecosystem Restoration Task Force successfully integrates natural and social scientists into the decision-making and evaluation process will help to determine whether adaptive management is truly a systematic, anticipatory approach or simply another name for trial-and-error.

[6] Previous reports from the Corps indicate that details of an adaptive management strategy would not be developed until the feasibility phase when specific restoration plans are evaluated (U.S. Army Corps of Engineers 1994, Vol. 1, pp. B10–B12).

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