An Assessment of Research Program Needs and Priorities



EVERGLADES NATIONAL PARK

AN ASSESSMENT OF RESEARCH PROGRAM NEEDS AND PRIORITIES FOR EVERGLADES NATIONAL PARK

Submitted to the Hon. Nathaniel P. Reed,
Assistant Secretary for Fish and Wildlife and Parks
U. S. Department of Interior
and to Gary Everhardt,
Director, National Park Service,
U. S. Department of the Interior
Washington, D. C.

by

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January, 1976
Gainesville, Florida

January 31, 1976

Hon. Nathaniel P. Reed
Assistant Secretary of the Interior
for Fish, Wildlife and Parks
U. S. Department of the Interior
Washington, D. C. 20240

Dear Secretary Reed:

Following instructions in your December, 1975, memo I have prepared the enclosed report evaluating the Research Program at Everglades National Park as it presently exists and the steps needed to round the program into a model for the Service and to meet the increasingly complex management information needs of the Park. Dr. Ariel Lugo from the University of Florida greatly aided in the effort of researching and preparing this document. He and I visited the Park's Headquarters at Homestead and met with research, management and administrative personnel in the Park. In addition, I had meetings and extensive telephone conversations with many scientists in South Florida including personnel of the U. S. Geological Survey and faculty at the University of Miami. Discussions were also held with representatives of the Chief Scientist's Office of the National Park Service in Washington, D. C.

After discussing the issues facing Everglades National Park with these individuals and reviewing the available literature and pertinent Agency files I feel the Park finds itself today at a crossroad that may determine its future health and survival. Changing land use patterns around the park plus intensifying water management problems affecting the park make the situation particularly critical. Dr. Durbin Tabb, in his 1963 report to the National Park Service concerning research needs for the Park, stated then that: "Everglades National Park is threatened by loss of a part of its most important ecological control factor, the fresh-water runoff from the Everglades and adjacent drainage basins. . . Discussions of the problem revealed that there is inadequate information available to predict with any degree of accuracy the consequences of reduction of surface water on the Park's unique flora and fauna. Fundamental ecological research is clearly needed." Thirteen years later the need is even more pressing than when first stated in 1963. As our report discusses, "change" in the Park's flora and fauna seemed to be the

primary topic of discussion in our meetings with those who know the Park best. What makes this moment in time so important is that we are now in a position to know that the Park is changing but we don't know why or whether the changes are good or bad; natural or artificial.

The 1966 Everglades National Park Natural Sciences Research Plan, in outlining General Research Objectives and Criteria for the Park, recommended that "whenever situations exist which threaten irreversible deterioration of resources unless promptly checked, priority should be given to projects that have a direct and immediate bearing on the survival of the features which the Park was established to preserve." Dr. Lugo and I have made special effort to recommend those programs that will address the management problems of the Park "head on" and resolve these issues. Hopefully the research program we are recommending takes into consideration not only today's issues (which are those easiest to justify) but also the issues of tomorrow. As you know, the longer term issues are the hardest to anticipate and even harder to justify, but keep in mind that they also contain the seeds of the greatest harm and the greatest gain.

This report represents a synthesis of information and views drawn from many sources. Portions of the material relating to program justification statements has been taken from existing articles, reports and agency memos. A bibliography of source documents utilized is contained in the report appendix. We would like to extend special acknowledgement to the Superintendent and Staff of Everglades National Park who provided all possible assistance during the course of this program review.

Dr. Lugo and I thank you and Director Everhardt for the opportunity to participate in deliberations concerning the research needs of Everglades National Park and sincerely hope you find this report useful in your efforts to preserve this truly unique national heritage for future generations.

Sincerely,

George M. Gardner

GMG:mf

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EXECUTIVE SUMMARY

At the request of the Assistant Secretary for Fish and Wildlife and Parks, U. S. Department of the Interior, an evaluation of the Research Program at Everglades National Park has been conducted, examining the program as it presently exists and the steps needed to round the program into a model for the Service and to meet the increasingly complex management information needs of the Park. The review involved meetings with research, management, and administrative personnel in the Park as well as extensive discussions with many Florida scientists, other federal agencies (such as the U. S. Geological Survey) and officials in the Washington office of the National Park Service. An extensive review of agency files and the scientific literature was also made during the evaluation. Thus, this report represents a synthesis of information and views drawn from many sources. As our report discusses, the Park finds itself today at a crossroad that may determine its future health and survival. Changing land use patterns around the Park plus the insidious water management problems facing the Park are causing significant changes in the Park's ecology and threatening many of the species and communities which the Park was created for to exemplify and maintain for

posterity. Examples of these changes are declining and shifting wading bird populations, changing vegetation patterns, exotic plant invasions, and increasing estuarine salinities.

At a time when the Park is under increasing stress as a result of alteration of historic flow patterns of external water flowing into the Park and alteration of lands on Park boundaries which are ecologically linked to the natural ecosystems of the Park, we find the Park's research program unable to counteract these threats to the Park with scientifically accurate, relevant information on which to base programs to defend the Park's interests.

The Research Program at the Park has not been the historic beneficiary of a well planned and programmed approach. Staffing has been added on a piecemeal, crisis basis and at best has provided for sketchy data to meet immediate crisis needs. When research personnel have been added to the program over the years, supporting funds have often been inadequate to cover both the personnel costs of the positions and the expenses of operations. Even given the patchwork efforts which have been employed to support the research effort at Everglades a surprising amount of information is known about the Park's ecological and physical properties. Although this knowledge allows us to intuitively dictate what is good and what is bad for the welfare of the Park we find it breaks down

when detailed questions needed to justify a particularly important management action are asked or when we ask a quantitative question at the macroscopic level designed to justify an equally macroscopic type of managerial action.

The report identifies three issues considered to be the most significant justifications for an expanded research program within the Park:

1. No matter what the Park Service does inside the Park, the health and future of the natural ecosystems within the Park cannot be assured unless outside rates, quantities and schedules of water deliveries to the Park can be managed in greater accord with the requirements of the Park's ecosystems once these requirements are determined.

2. The Park is competing not only for water in south Florida but also for land. At least four "hot spot" land areas adjacent to Park boundaries and ecologically linked to Park ecosystems are singled out in the proposed research program as locations constituting important issues to the Park's survival and for which increased research information is needed. These external areas provide important drainage of water into the Park. If mismanaged, vital sheet flow can be lost (or already has been lost in one case), water quality can decline and the areas can serve as focal points for exotic species expansions into the Park. Examples of these problem areas include the headwaters of Taylor Slough and the Northeast Shark River Slough drainage.

3. Altered environmental conditions within the Park are leading to intensification of management actions within the Park. Important questions concerning the impacts of management programs on the Park's ecosystems exist. How much intervention with the natural processes of the Park is needed, possible or

> even desirable? Research is necessary to answer these pressing questions. The degree to which the Service may be called upon to intervene in the management of a natural wilderness surrounded by lands undergoing intensive development is a problem certain to intensify with time and one for which information to guide our decisions must be obtained through further research.

To address these issues and solve the most pressing resource management problems at Everglades National Park a four-part research program is proposed. Part I of the plan deals with water-related research and includes a water monitoring and evaluation program designed to determine how much water is coming into the Park, where it is going, how much is staying there and how long, and how much is leaving and when so that a complete water balance sheet can be constructed for key areas in the Park. These studies include analysis of those elements, nutrients and pesticides which are known to affect water quality and pose hazards to Park wildlife. Also included is evaluation of the impact on receiving communities of water delivered by canal versus natural sheet flow of water. Water-related studies have been designated as the highest priority studies of those proposed because water is the lifeblood of the Park and all other natural functions relate to this factor.

Part II of the plan concerns the "hot-spot" areas within and without the Park which constitute either present or future management problems for the Park. These areas are:

Northeast Shark River Slough, Headwaters of Taylor Slough, Southeast Dade County Canal C-111, Hole-in-the-Donut and the Big Cypress. These areas involve water-related issues, exotic species problems, land-use impacts and other human use issues. The proposed program is designed to give Park managers an information base with which to address these problems "head on" and resolve them.

Part III of the program deals with studies of community or mosaic ecosystems in the Park that will document the response of Park communities to the changing south Florida environment. Only through these kinds of holistic studies will Park administrators be in a position to formulate managerial actions that are both realistic (dealing with real problems of fire, water and land) and in harmony with the requirements of the Park's ecosystems. This line of research avoids the pitfall of earlier species by species descriptive approaches to most research which historically have provided limited insight into only one or two elements of a very complicated system. Under the mosaic ecosystem category (systems composed of many communities) we include three for research: Shark River Slough (a mosaic of marshes, alligator holes, tree islands and saline systems), Florida Bay and estuaries (a mosaic of saline communities upon which most of the region's fisheries depend at some time in their life cycle) and the Dry Tortugas (a mosaic of coral reefs,

islands and nesting marine sea birds). In the community ecosystem category (study of individual communities) we include the sawgrass community (the dominant vegetative type in the Florida Everglades). These community studies are proposed as the crux of the research program inside the Park and a great many of the management decisions that will be made in the future will depend on findings from these studies.

Part IV of the plan, called "General Studies" contains studies viewed as fundamental to completing the Resources Basic Inventory of the Park and necessary to aid in understanding and evaluating Park problems. Included in this category is a project to map the Park's vegetation, soils and topography, each of which exerts profound influence upon the structure and function of the Park's ecosystems. Also included in this category is an extensive fire ecology program. Fire is one of the major forces which affects every plant community in the Park at one time or another. Two other projects found in this category are a study of the Florida panther and a library search. The latter is proposed to collect in the Park's library all publications dealing with the Park. Particular emphasis must be placed on locating unpublished data currently in the files of many different agencies and investigators who over the years have studied the Park, for analysis and integration into a working hypothesis

of the dynamic functions of the Park's ecosystem and determination of how this system can best be managed for maximum benefit to the environment and the Park visitor.

To aid in the implementation of the plan the report presents several organizational charts and flow diagrams to illustrate suggested approaches to the successful implementation of the program. Included in these schemes are a number of new mechanisms of integration of research and information not currently in use in the Park. These include the formation of an Everglades National Park Scientific Advisory Board, a Park Research and Resource Management Policy Group, an Annual Everglades Science Symposium, an Ecological and Environmental Management Information System, an expanded role for the Park's library, a new Research-Resources Management Center, and a series of Interagency Agreements and Meetings concerning resource monitoring programs in the South Florida Region. Also included are proposed changes in the utilization of personnel to direct the research.

The idea behind these suggestions is that to be successful, a research program must be subjected to constant peer review and the influx of new ideas; have access to first class information; and above all contain mechanisms that arrest intellectual inbreeding and too much specialization.

The issue of space to accomodate the proposed program is addressed in the report. It is recommended that an existing

facility within the Park (containing an estimated 7200 square feet of floor space that is occupied only three to four months of the year) be rehabilitated to serve this higher program priority need within the Park.

In the final section of the report we address the budget and personnel requirements to implement the proposed program. Two budget categories are established (Categories I and II) to reflect our assessment of relative priorities within the proposed plan. Category I constitutes the recommended program and will cost $1,630,000.00. However, if budgetary constraints necessitate a reduction in the proposed plan, we have identified in the Category II group the studies considered to be of lower priority. Deletion of these studies will lower the proposed budget to a "bare-bones" level of $1,338,000.00.

The majority of the research program has been designed for implementation using either Schedule A appointments within the Service or contract to lessen the burden on Service personnel-manpower ceilings. Only three new permanent positions for the Park are proposed: fire ecologist, vegetation ecologist, and an information specialist. The plan also proposes funding an authorized but unfunded research hydrologist position.

Extensive utilization of temporary-position personnel is recommended to support the Park's permanent research staff. Twelve such positions are proposed in the recommended program.

Also strongly recommended in the report is the incorporation of the proposed Category I budget into the Park's base funding to insure the long term continuity of research effort and to create a pool of research monies which can be utilized to sustain the research program with added studies as their need arises.

Specific findings and recommendations in the report which are believed to warrant special consideration in this summary include:

1. The establishment of an Everglades National Park Scientific Board patterned after the Fish and Wildlife and Parks Natural Sciences Advisory Committee and comprised of no more than seven scientists from outside the Service with the purpose of providing Park scientists and administrators with fresh thinking and insights into approaches to resource management actions and research in the Park. This Board should early examine the Park's policy on the control of exotic plants and review on-going research and resource management programs within the Hole-in-the-Donut.

2. Creation of a Park Research and Resources Management Policy Group to steer policies that guide research and resource management in the Park.

3. Establishment of an annual Everglades Science Symposium dealing with research relating to the changing south Florida environment and having as a symposium theme the presentation of papers that add to our understanding of the south Florida ecosystem.

4. Development and implementation of an effective Ecological and Environmental Management Information System to serve the Park. Specifically proposed is the utilization of $30,000.00 from FY 76 Service Reserve Funds to initiate immediate efforts to design and implement the system.

5. Expansion of the current function of the Park's library. This library should contain all Park-related literature and serve as a communication center with the public, the management policy group, researchers and naturalists.

6. Restructuring the present organizational structure within the Park which currently divides resource responsibility among Resource Management, Water Management, and Natural Science with each division reporting to a different supervisor. Specifically it is recommended that water management functions be brought directly under the Research Environmental Coordinator who should retain responsibility for integrating all water management monitoring and research with the rest of the Park's research program. Research activities currently handled by the Resource Management Division should likewise be placed under the direction of the Natural Sciences Division, working in close coordination with resource management personnel.

7. Research needs in the Park are such as to require a combination of a strong in-house program for long term research studies and the utilization of academic institutions and other agencies for studies more amenable to short term contract.

8. It is recommended that the much discussed "Carribbean Science Office" not be created at this time pending further review and justification which would include examination of the potential dilution of the research program within the Park.

9. It is recommended that a new Research-Resources Management Center be established at the Iorni Buildings within the Park which will involve the relocation of the YCC Camp program which employs some 50 youths for two or three months each summer and utilizes that facility. The proposed complex should house the research-resources management operations, a technical library, reference collection, laboratory facilities

and other work and study space. Included in this recommendation is the utilization of all or portions of a $180,000.00 line item appropriation in the Park's FY 76 budget for planning a contemplated new research center for Everglades National Park. It is believed that the Iorni Building can be refurbished for approximately $75,000.00.

10. Given current Service fiscal constraints, it is recommended that the Service not undertake expansion of existing district ranger stations within the Park at Flamingo, Tamiami, Key Largo, and Ft. Jefferson estimated to cost $375,000.00. Consideration should be given to expanding the station at Everglades City due to a lack of facilities along the Park's west side.

11. It is recommended that formal memoranda of agreement be negotiated with the Corps of Engineers and the Central and South Florida Flood Control District for the monthly exchange of water and biological data collected by the involved agencies and that a formal meeting be convened quarterly with appropriate research and resource management personnel in all three agencies for face-to-face discussion concerning on-going agency programs and proposed activities or existing problems concerning the Park.

12. Increased support of the Environmental Coordinator is proposed in the form of supplemental support staff to implement the proposed research program and the development of research study-team leaders to direct research on a day-to-day basis.

13. It is recommended that $4,000.00 be utilized from FY 76 Service Reserve Funds to sponsor two conferences in the Park,

one dealing with the design of a water monitoring and evaluation program and the second dealing with the current research and resource management program for the Hole-in-the-Donut.

14. It is also recommended that the Director, NPS, Regional Director, Chief Scientist, and Park Superintendent meet to resolve the issue of whether the science budget remains under the direct control of the Park or is controlled by the Region.

INTRODUCTION

'The Everglades' is a magic word that brings different images to the minds of different people. These images range from the sublime sight of Roseate Spoonbills feeding in a slough to the majestic poise of the bald eagle perched on its nest and from fires racing through endless expanses of sawgrass to bothersome hours in mosquito-infested mangrove swamps. In the Everglades the temperate zone meets the subtropics, blending the wildlife and vegetation of both. It is interesting and at the same time annoying that the variety of images that make the Everglades such a unique landscape in our country is also the thing that is at the root of many of the problems associated with the management of this piece of wilderness. Nature, by herself, has integrated in a harmonious whole the many conflicting forces that form what we identify as the Everglades. At times this system of paradoxes is completely flooded; at other times consumed by fire. Most of the time temperatures are hot but cold fronts originating at the poles may reach the area causing extensive vegetation kills. Rains are frequently short duration thunderstorms but many also reach hurricane intensities during certain seasons. Some areas of the Everglades

are complete natural monospecific communities of sawgrass or mangroves but other areas are dominated by tropical hammocks, the most diverse forests known in the continental U. S. These conflicting forces, tuned by mysterious natural frequencies, set in motion complicated responses in the plants and animals of the Park. Without an adequate data base may of those responses are difficult to interpret and easily misread by those who are not knowledgeable observers of the Park's intricate ecology.

Many of the problems confronting our Nation's third largest Park arise from the geographical position of the Park with respect to its neighbors. These neighbors actually compete with this wilderness for such life essentials as water, space, nutrients, monetary resources, and attention. Everglades National Park is an important member of the south Florida regional family and as a member of this region contributes both to the function and quality of the south Florida landscape and requires itself certain minimal resources to maintain its ability to function properly in this environment. As a provider the Park is the major contributor to the productivity of the fisheries of the Gulf and south Florida Atlantic coasts of the United States (this includes fish, shell fish, sea-turtles, sports fishing, etc.): it provides recreation to millions of Americans that travel thousands of miles to visit this park; it supports one of the country's

most consumate bird, animal, and plant collections; and the Park services thousands of Floridians with high quality environmental conditions which include clean water, soil and air.

As a consumer, the Park requires precise schedules of water influx. Waters entering the Park should attain certain minimal quality standards determined by the needs of the Park's plant and animal life. The Park also requires a minimal area of land to be able to provide all the organic productivity necessary to maintain the increasing demands for its natural services; and it further requires great sensitivity on the part of its managers in determining when to apply management actions to its systems. There will be times for example, when the best management action may in fact be no action, allowing nature to evolve the proper plant communities that are best adapted to a changing south Florida environment.

Obviously, if Everglades National Park is going to continue to survive as an important member of the south Florida environment, an aggressive program that can both protect and manage the Park at the local level and at the same time serve as a strong voice to defend the Park's rights and promote its value to the other members of the south Florida family is required. This is not an easy task in view of the growing demands of the urban sector in south

Florida and the increasing demands on the Park and on the agriculture in the area. The limited amount of land and water resources particularly aggravate the problem.

Programs to manage the Park need not only to be imaginative and aggressive but must also incorporate novel approaches for the use and synthesis of information. Such programs must include the development of new information that is both scientifically precise and relevant to rapid decision making. The ability to apply the sensitivity of an artist in the implementation of such programs will depend on the ingenuity and common sense of Park personnel in charge of managing the ecosystems of the Park.

As recognized in earlier program reviews, the research program at Everglades National Park has not been the historic beneficiary of a well planned and programmed approach. There is consensus that since the Park's establishment, staffing has been added on a piecemeal, crisis basis and at best has provided for sketchy data to meet immediate critical needs. The Park's professionally competent research staff has been critically hampered in its research efforts by a poorly designed and poorly financed program. Where research personnel have been added to the program over the years, supporting funds have often been inadequate to cover both the personnel costs of the positions and the expenses of operational funding. As various

specific management problems of the Park have been identified, some of the Service's meager research funds have been devoted to the support of a few modest, problem-oriented investigative efforts. In recent years, patchwork efforts using Southeast Region reserve funds to provide support of immediate and critical one-time research needs have been employed to deal with increasingly serious problems. Everglades National Park is in a class by itself with respect to the scope and urgency of its natural sciences research needs. At this Park, at a moment in time when the Everglades' peculiar treasure has been awarded World Biosphere Reserve status, the historic mission of the National Park Service to protect, preserve and perpetuate exemplary natural areas can be reaffirmed most opportunely.

In recognition of the Park's growing resource management problems and the urgent need for an accelerated, well designed and properly financed research program to guide management decisions affecting the long term future of Everglades National Park, Assistant Secretary of the Interior for Fish and Wildlife and Parks, Nathaniel P. Reed, has asked for an evaluation of the research program at the Park as it presently exists and what steps (fiscal, etc.) are needed to round the program into a model for the Service and meet the increasingly complex management information needs of the Park. This report constitutes that evaluation

and represents the first steps in the attempt to make the research program at Everglades a model for the Service. If properly conceived and successful, elements of this program could be extended to other equally unique areas in the United States under the jurisdiction of the National Park Service.

In preparing this report we first identify what we believe are the major problems and issues facing the management of Everglades National Park. Next we lay out a research program that in our opinion will aid in the solution of these problems and issues. Finally, in a third section we identify ways of integrating the knowledge that will emerge from the execution of the research plan. Changes in administrative procedures and improvements in personnel and facilities are then discussed and detailed budgetary costs are presented last.

We firmly believe that the priorities outlined in this report are in accordance with current and future Park needs as visualized by those that know the Park best (Park administrators and scientific researchers both within and without the Park). Further, these priorities and needs are in basic accord with earlier assessments of research priorities in the Park as outlined in Tabb's 1963 report, The 1966 Everglades National Park Natural Sciences Research Plan, and the 1971 report by Lugo et al. on Models for Planning and Research for the South Florida Environmental Study.

THE PROBLEMS AND ISSUES

It is difficult to list and arrange in any order of importance the problems and issues of management of the Park. They all seem important and critical! For the purpose of brevity we highlight three general issues that encompass the gamut of problems facing the Park. These are the issues of external control of water inputs to the Park, "Hot-Spot" areas that are ecologically part of the Park and the issue of the intensity of human management inside the Park.

Hydrologic Issues

Everglades National Park constitutes a unique, highly water-oriented environment not found anywhere else in the National Park System. This 2,020 square mile sub-tropical wilderness at the southern tip of Florida is greatly dependent upon a plentiful supply of high quality water flowing through the region in an overland sheet pattern for up to eight or nine months of the year. Water has been identified as " *** the basis of being of the Everglades National Park ***."

One can state without much question that no matter what the Park's resource managers do inside the Park they alone cannot control the destiny of Everglades National Park. This stems from the fact that a significant amount of the water so vital to the function of the Park's ecosystem does originate outside of the Park and reaches the Park only after the quantity, quality, place, and schedule of delivery has been determined by those allocating South Florida's water supply. Agriculture, the Conservation Areas, and urban systems all use the water before it reaches the Park.

Park Research Scientist, William Robertson, described the present situation well in 1971:

> Water management in the present situation is a job to tax the wisdom of Solomon. It is complicated by variable rainfall, by high evapotranspiration and seepage losses, and by the fact that the Everglades is a smaller and less efficient vessel for water than it used to be. One-third or more of the original floodplain is now developed land that has to be kept dry. There's less place to put water in wet periods and thus, more frequent need to waste water to sea.
>
> Also, loss of peat in the farm area, and on wild lands because of fire, has greatly reduced the system's ability to hold water. The transition from flood to drought can occur within a few months.

As a result of alteration of historic flow patterns of external water flowing into the Park and the construction of dikes, canals and water impoundment areas in the Park's

historic drainage, coupled with the institution of fixed water delivery schedules to the Park, Everglades National Park finds itself today at a crossroad that may determine its future health and survival. Changing land use patterns around the Park plus the insidious water management problems facing the Park are causing significant changes in the Park's ecology. Examples of these changes are declining and shifting wading bird populations, changing vegetation patterns, exotic plant invasions, and increasing estaurine salinities. Thus the issue of the Park's philosophy towards it neighbors becomes one of the major issues that demands priority attention. What needs to be done to protect the rights of the Park as a legitimate use of water?

A related issue concerns the impact of man-diverted waters on receiving ecosystems. The Park's ecosystems are adapted to receiving natural sheet flow water. Historically this flow reached Park ecosystems only after flowing overland through extensive areas covered with natural vegetation. Now, inputs to the Park are channelized and delivered by pumps through an intricate maze of canals, culverts, and other structures constructed by man (Figure 1). It has already been established that these waters are of lower quality than those that travel overland through natural marshes. Is this an important determinant in the

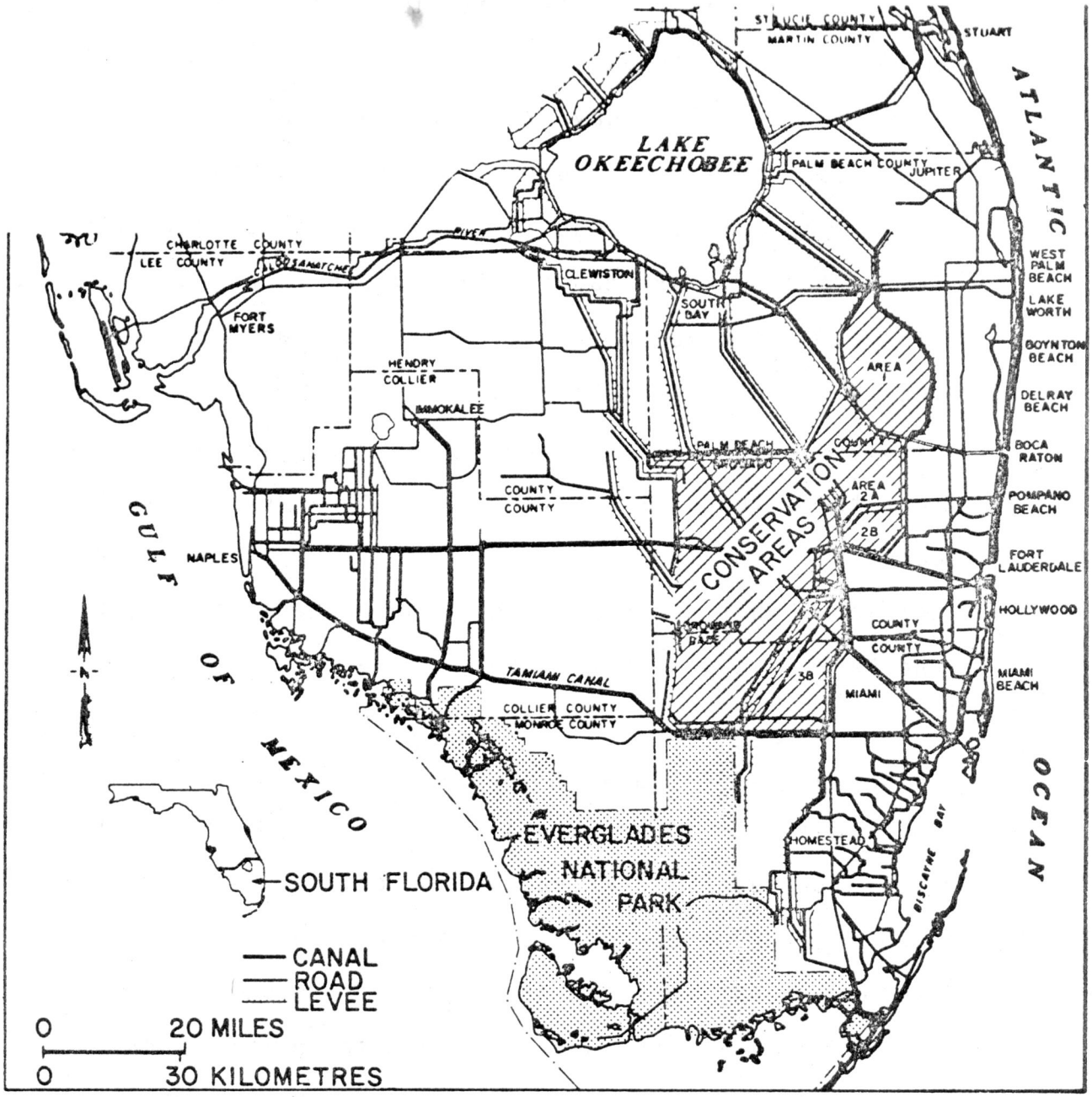


Figure 1

Hundreds of miles of canals and levees are used to control and manage the water resources of south Florida.

Park's health and function? Should the Park's water inputs be filtered by natural ecosystems? Should normal periodicities of flow be restored to the system? Will sheet flow need to be reinstituted to maintain the Park as a viable ecosystem? Indeed, can sheet flow be reinstituted if needed?

Hot-Spot Land-Use Issues

The issues of water are compounded by issues related with land. The Park is surrounded by private lands which are ecologically linked to the natural ecosystems of the Park. These lands are being increasingly subjected to uses which may threaten the Park's ecology.

During the last three decades the population of the seven-county south Florida area increased from less than half a million to about 2 1/2 million.

The Office of Business Economics projects that by the year 2000, south Florida will have more than 4.4 million residents, an increase of more than 80 per cent over 1970. When the increasing stress placed on the hydrologic system of south Florida is considered, the need for establishing the Park's water requirements and to protect lands outside the Park's boundary which ecologically comprise part of the natural ecosystems of the Park becomes obvious. Certain

types of agricultural or urban developments at the Park boundaries are unquestionably incompatible with wilderness concepts and the protection of endangered species, and may threaten loss of vital sheet flow of water to the Park. Specific boundaries of the Park are under more intense pressure than others and thus represent problems of varying magnitudes. Examples of areas of particular concern are: Northeast Shark River Slough, Headwaters of Taylor Slough, areas of the Big Cypress, and Southeast Dade County.

The attitudes and policies the Park Service adopts in dealing with these vital issues will be crucial to the Park. These issues cannot be ignored as they strike at the heart of the Park's long term future.

Internal Resource Management Issues

Observers of the Park have expressed growing concern for the continuing change in the composition of plant and animal communities in the Park. These changes are interpreted by some as problems to which the only alternatives available are either intensification of management actions to return the Park to its original state, or the adoption of a wait and see attitude hoping that nature knows best. The underlying issue in this controversy is one of the most critical issues pertaining to the management philosophy in

the Park. How much intervention is needed? How much human intervention is possible, feasible or even desirable? To what degree should man intervene with the natural processes of the Park? The philosophy of intervention is based on the fact that the natural features of the Park have already been changed by man and thus more human intervention is needed to maintain some kind of a balance or at least to complete management actions that are still unfinished. The conservative view points out that natural ecosystems will adjust to these changes and that only time is required for succession to proceed to new, balanced states. Any intensive interference by man, they say, only retards succession even further, may compound the parks present problems and even cause more problems in the future.

The above discussion of the issues of water and management intensity suggests there are no easy solutions to the Park's problems. Only through a clear understanding of the cause of the problems and of our capacity to implement recommended actions will we be able to maintain this ecosystem which we all agree is a precious possession of mankind. To get underway, we need to know the current state of our knowledge about the system, our capacity to apply this knowledge, and to know if we are ready to implement necessary management actions such as those relating to water delivery.

In dealing with Everglades National Park we are in an enviable position because the Park's own fame coupled with the foresight of government has resulted in many studies dealing with the Park's ecological and physical properties. We have a fairly good idea of the general ecology of the Park. Studies by numerous individuals, many of whom have spent their lifetimes creatively studying the Park, combined with the intensive research conducted during the South Florida Environmental Study have provided a mass of background data that allows us to intuitively dictate what is good and what is bad for the welfare of the Park. Where our knowledge breaks down is when we ask detailed questions needed to justify a particularly important management action or when we ask a quantitative question at the macroscopic level designed to justify an equally macroscopic type of managerial action. For example, we see the sawgrass community yellowing and dying in large patches and don't know why. In trying to narrow this question down, we find that such an apparently basic fact as the flowering rhythm and reproductive process of this dominant plant in the Park is unknown to us. Similarly, observations indicate that many of the Park's birds are moving north and away from the Park and that snake, gar, and crocodile populations are declining or disappearing. When efforts are aimed at doing something about these

situations, one runs into ignorance about where gars breed, where the birds feed and why, and what factors may account for the failure of crocodile reproduction. At the large, macroscopic scale, we know that quantity, quality, and schedule of water delivery are crucial for the functioning of ecosystems in the Park. However, we don't know how much water comes into the Park, we don't know its quality, nor do we know the effects of delivery schedules on the Park's ecosystem function. Similarly, the amounts of water that are lost annually through evapotranspiration have not yet been determined. Yet, it is generally accepted that this latter value may be as high as 80-90 per cent of the total water budget of the Park.

Quite obviously, resource managers will never know all that needs to be known about the Park. Realistically, not even the most meticulous scientist aspires to know that much. But one fact is abundantly clear: we cannot pursue an aggressive management program or even pretend to be managing the Park without a more thorough understanding of exactly what is happening to the system and how its function is affected by and responds to human management. This becomes particularly obvious in this scientific age when science has now the tools and brainpower to obtain almost any piece of information needed from this ecosystem to guide its management.

In the following section we outline a research plan designed to close the gaps of knowledge that now exist between what is known and what needs to be known about the Park to manage its resources. It must be remembered that we are dealing with an environment that is inherently unstable, subject to major perturbations both cyclic and incidental, and often with organisms that have long generation times such as crocodiles, sea turtles, wood storks and sooty terns. Hopefully, the research plan takes these facts into consideration.

THE RESEARCH PLAN

In order to provide a good handle on the information needed to solve the problems and issues facing Park managers we have designed the research program outlined in Table 1. This program responds to all the levels of detail for which information is realistically needed. The plan presented in Table 1 starts with the most general aspects that affect management (the external factors that affect the Park's ecosystems) and ends with general studies that do not fit easily in any one category but which are important for overall interpretation of the Park's dynamic function. A special studies section that addresses specific management issues is incorporated with the belief that specialized documentation work on these problems is needed prior to the adoption of Agency positions concerning these critical land and water management issues of the Park. A section on ancillary facilities that must be provided to make such a program viable and successful is presented.

Table 1

Proposed Program and Associated Budget: FY 77

Water Related Studies:

1.	Monitoring water influx and climate:	
	A. Inhouse staff and support, water records	$146,000
	B. Water monitoring satellite units and computer	90,000
	C. Salinity Gradient monitoring	30,000
2.	Budget Studies:	
	A. Water budgets for Shark Slough, Taylor Slough and SE Dade County including S-12 Structure Study	80,000
	B. Nutrient budget	50,000
	C. Heavy metals and pesticides	48,000
		$444,000

Hot Spot Studies:

1.	Northeast Shark Slough	Covered in above item
2.	Taylor Slough	Covered in above item
3.	Southeast Dade County, C-111	Covered in above item
4.	Hole-in-the-Donut	
	A. Succession Studies	
	(i) Inhouse staff and support	$ 44,000
	(ii) Contract	80,000
5.	Big Cypress	135,000*
		$259,000

Community Studies:

1.	Shark River Slough Mosaic	
	A. Primary productivity and transpiration	130,000
	B. Detrital and grazing food chains	50,000
	C. Fish population, Alligator population, Wading bird feeding distribution	74,000
	D. Wading bird rookery formation dynamics	8,000*
	E. Crayfish autecology	30,000*
	F. Shark Slough vegetation succession	50,000
	G. Sawgrass	30,000
2.	Florida Bay and Estuaries Mosaic	
	A. Florida Bay natural resource survey	47,000*
	B. Florida Bay fisheries studies:	
	(i) Florida Bay fish ecology	42,000
	(ii) Lobster population study	24,000

Table 1 continued

(iii) Stone crab fishery study	$ 24,000
(iv) Fishery catch data analysis	29,000
C. Crocodile population study	30,000*
D. Water fowl survey	20,000*
E. Loggerhead turtle study	15,000*
3. Dry Tortugas Mosaic	
A. Marine resources map and survey	5,000*
B. Sooty Tern study	24,000*
	$632,000

General Studies:

1. Mapping program	
A. Vegetation	50,000
B. Soils	30,000
C. Topography	30,000
2. Fire ecology	39,000
3. Florida panther study	15,000*
4. Library search	20,000*
	$184,000

Resource Management Coordination	72,000
Data Processing and storage	39,000
	$111,000
Total	$1,660,000
Building Renovation	75,000

'76 Fiscal Year Contracts: (1) Data information system study, $30,000; (2) Water Conference, $2,000; (3) Exotic plant conference, $2,000.

Note: Items with asterisk (*) represent priority Category II programs.

Also implicitly recognized throughout the research plan is the Government's responsibilities in the Park concerning rare and endangered species. The Endangered Species Act of 1973 places major responsibility upon all government agencies to protect endangered species. The Act specifically charges all federal agencies with the responsibility of "carrying out programs for the conservation of endangered species and threatened species . . . and, by taking such action necessary to insure that actions authorized, funded, or carried out by them do not jeopardize the continued existence of such endangered and threatened species or result in the destruction or modification of habitat of such species . . ." determined to be critical to the species. Also, the Act of 1947 (specifically establishing the Park) and subsequent Acts which modified the Park boundaries, make it clear that Everglades National Park is intended to exemplify and maintain for posterity (1) the abundant native wildlife, including rare and colorful birds; (2) the extensive fresh-water and salt-water areas, open Everglades prairies, mangrove forests, and all other natural features which make this Park the only large subtropical wilderness remaining in the United States.

A number of the recommended studies within this research program have been specifically designed to meet Service responsibilities concerning these mandates.

Water-Related Studies

It is clear that Everglades National Park must establish itself as a legitimate water user in south Florida. The single most critical need within the Park is a greatly expanded long-term hydrological monitoring and evaluation program that can be utilized to formulate an effective plan for controlling and predicting water levels within the Park and assessing impacts of water management practices on the Park's biota. Unfortunately this capability will not come cheaply. Estimated costs for this portion of the plan amount to $444,000/year. These studies, dealing with external factors responsible for driving or greatly influencing the structure and function of the Park (called forcing functions), and associated budget studies which actually develop balance sheets (telling the manager how much of what is coming into the Park, where it is going, how much is staying there and how long, and how much is leaving and when) have been lumped into a general category of "Water-Related Studies." Included are water influx, quality of incoming waters, and climate.

The main objective of these proposed hydrologic investigations is a detailed fresh-water budget for the Park drainage systems that will reveal accurately how much inflow and outflow by each route occurs over a given period of time and how much water is needed from external sources at critical periods to reestablish and maintain

the original natural conditions of the Park. Major research effort must be directed towards: (1) analysis of the hydrology of the Park to define the historical water situation; (2) evaluation and monitoring of hydrologic changes resulting in the Park from present and proposed water control works; (3) identification of the relations that exist between various conditions of water and the biology of the Park; (4) determining the vegetation changes that have occurred between 1940 and 1974 from analysis of aerial photography and establishing the causes for the changes in relation to changing water influx.

Specific items covered under the "Water-Related Studies" category and which are explained in greater detail below, include the following:

Study	Budget
(1) Monitoring of water influx and climate:	
Inhouse staff and support costs	$146,000
New water-monitoring satellite station equipment and a water data computer terminal	90,000
Salinity gradient study	30,000
(2) Budget studies:	
Water budgets for Shark and Taylor Sloughs and S.E. Dade Co. C-111 Canal	80,000
Nutrient budgets for Shark and Taylor Sloughs	50,000
Heavy metals and pesticides	48,000
	$444,000

(1) Monitoring of Water Influx and Climate Total $146,000

In order to manage the water resources of the Park an expanded long-term hydrological monitoring and evaluation program that can be utilized to formulate an effective plan for controlling and predicting water levels within the Park and assessing impacts of water management practices on the Park's biota must be undertaken. This program, leading to a detailed fresh-water budget for the Park, will necessarily require an expansion of the Park's existing hydrologic investigations. Staff and support costs necessary to accomplish the proposed water resource program are as follows:

Water Records Collections 1/6 time			$24,334	
C-111 Study 1/3 time			48,668	
L-67 Study 1/3 time			48,668	
Salinity Gradient Study 1/6 time			24,334	
60% Personnel costs:	Nix		13/8 Perm	$31,079
	Res. Hydrol.		12/1 Perm	21,325
	Hermance		9/8 Perm	18,288
	Tech		4/1 Temp	8,455
	Tech		4/1 Temp	8,455
				$87,602
40% Support costs:				58,401
				$146,003

Water Monitoring Satellite Station Equipment and Water Data Computer Terminal Total $ 90,000

In order to provide for near-real-time hydrologic data on water levels and rainfall for use in recommending a water-management program for the Park, an expanded program using the LANDSAT-1 satellite

relay and processing system is proposed. There are currently 19 operating LANDSAT-1 data-relay platforms in use in south Florida with 7 operating within the Park in the Shark River Slough. An additional 10 units are currently being installed by the USGS in the western portions of the Big Cypress Swamp.

It is proposed that an additional 10 data-collection platforms (DCP) be installed in the Park at an average cost of $7,500 for installation and annual operation per unit, or a total cost of $75,000. Details of the LANDSAT-1 system are discussed in a recent paper by Wimberly (1975). The DCP's can monitor the following parameters which are important in terms of water quality and quantity budgets:

(1) Water level stage, tide
(2) Integrated precipitation
(3) Temperature (both wet and dry bulb)
(4) Flow velocity
(5) Soil moisture
(6) Dissolved oxygen
(7) Hydrogen ion concentration (pH)
(8) Conductivity
(9) Integrated pyrometer
(10) Integrated wind velocity and direction
(11) Turbidity
(12) Barometric pressure (bottom hole)

Specific applications of the LANDSAT-1 system to Park management are illustrated by the use of data from the existing LANDSAT-1 stations in the Park for fire management. (Swayze, Bancroft, Heiger and Cordes, 1975).

Monitoring sites should be carefully selected to maximize this high cost technology with emphasis on selecting sites which warrant continuous 24-hour per day monitoring. Long-term benchmark sites should be selected that network the whole Park, keeping in mind the data needs of other proposed studies. Consideration should also be given to selecting sites which are remote and not readily accessible by Park hydrologists.

It is intended that the LANDSAT-1 network be supplemented by existing and proposed gauging stations within the Park, utilizing Park personnel to monitor and service these stations as well as take supplementary measurements and samples as needed. A good water budget for the Park will require extensive data concerning water inputs, outputs, and storages.

A water-data computer terminal costing approximately $15,000 (based on estimates provided by the USGS) is proposed for installation in the Park to tie the Service in to the USGS national water data storage and retrieval system and the National Weather Service Data Bank. Details of these systems are discussed in a paper by Heigher, Coker, Cordes and Rogers (1975). Both the Corps of Engineers and the Central and South

Florida Flood Control District are currently tied in to this system and several water budget studies for the conservation areas are already underway, although no comparable budget is being prepared for the Park at the present time.

Salinity Gradient Study Total $30,000

As discussed by Heald (1970), alteration of historic freshwater flows into Everglades National Park has lead to a gradual landward intrusion of salt water, increased salinities in the estuarine bays and lagoons, and a reduction in the capacity of the system to withstand the stresses of "normal" drought periods. Areas of the Park which formerly experienced maximum salinities of about 20 parts per thousand (o/oo) now reach 40 o/oo during the winter dry months, causing marked changes in the flora and fauna of these areas. Development of the watershed area of northeast Florida Bay has resulted in reduced runoff with the consequence that hypersaline conditions now exist for much of the year. Dry season salinities range from 35 to 50 o/oo, with up to 70 o/oo during severe drought periods. These increasing salinities are severely stressing the plant communities of the area, particularly the mangroves and the offshore Thalassia grassbeds. Salinities are also thought to be critically affecting crocodile reproduction and leading to increased predation of juvenile and larval marine organisms.

Proposed salinity gradient studies are divided into the following subcategories:

(1) water quality and quantity monitoring, both surface subsurface

(2) assessment of both aquatic and terrestrial vegetative succession in relation to salinity

(3) resurvey of the 82 stations sampled by Tabb, Thomas and Maynard in their 1967 study of Florida and analysis of changes which have taken place (see Tabb et al 1967) utilizing same parameters studied earlier

(4) assessment of changes, if any, in the frequencies, presence and abundance of vertebrate and invertebrate organisms which utilize the brackish water ecotone during some portion of their life cycle

(5) monitoring of soil salinity and comparing current measurements with earlier data collected in the same areas such as the data of Davis (see Davis, 1940)

(6) resurvey of the stations sampled by McPherson (1970) in his study of the hydrobiological characteristics of the Shark River Estuary and analysis of changes if any that have taken place since the last survey.

The $30,000 allocated above for this study is intended primarily for ecologically related aspects of the study with the water quality and quantity portions of the study being funded under the $24,338 budget

item appearing under the "Monitoring of water influx and climate" category. Thus, the total funding intended to apply to the salinity gradient study is $54,338.

(2) Budget Studies Total $178,000

To effectively manage the Park's water resources, the Park Manager must know how much of what is coming into the Park, where it is going, how much is staying there and how long, and how much is leaving and when. Accordingly, a series of budget studies are proposed to provide this information.

Water Budgets Subtotal $ 80,000

Water is the dominant factor in the Everglades environment. The seasonal changes in the quantity and quality of water have created a distinct, water-dependent biologic community. There currently exists no water budgets for the Park which describe the temporial routing and volumns of water moving through the Park. Ultimately a detailed water budget for the whole Park must be derived utilizing available technology to develop computer simulation models to assess near-real-time results of alternative water management decisions concerning release schedules, etc. At present an arbitrary rule prescribes that a specific volumn of water be released to the Park on an annual basis by means of control structures along the Tamiami Trail. This rule does not take into account what the actual needs within the Park may be at a specific time nor does it

provide for seasonal or optimal requirements within the Park. The rule may actually work hardships (as in the case of Wood Storks) because water may be supplied to the Park when it is not needed there but when it may be vitally needed elsewhere.

It is proposed that water budgets be developed first on a sub-unit basis (i.e. Shark River Slough, Taylor Slough, and South Dade C-111 Canal) with a subsequent development of a water budget for the whole system as funds and priorities permit. Such budgets will necessitate monitoring on a continuing basis to detect and predict changes that might result in further damage to the functioning of the Everglades ecosystem. Analysis of data from monitoring should include the development of predictive models to describe the behavior of the system. The modeling should be composed of two distinct components: one, the generation of stochastic inflow data, and two, a systems analysis of the resulting storages and outflows by means of simulation. These budgets can be prepared either by NPS hydrologists in-house, under contract with university or private consultants, or by the USGS, utilizing professional expertise from the USGS Systems Analysis Group in Reston, Virginia. It is stressed that the end products desired are working computer models which can be used in conjunctionwith near-real-time data to predict water dynamics as a function of variable inflows and outflows.

With the development of these detailed water budgets serious efforts to determine the relationship between various water conditions

and the resulting impact on the Park's biota can commence. When proposed hydrologic monitoring sites are selected by the Service careful review should be made of those sites proposed by the USGS (1969) in their report titled "Proposed Hydrologic and Ecologic Studies of Areas Contributing Water to Everglades National Park" that was prepared for the South Florida Everglades Area Planning Council.

Also included within this category is a study utilizing LANDSAT-1 satellite imagery to determine water stage-volumn relations within the Park and to assess at a microscopic scale the distribution patterns of water entering the Park. For example, recent pilot studies of the water discharges entering the Park through the S-12 structures by the USGS graphically illustrate the differences in distribution of water depending on whether Gate A or Gate D is utilized for the releases. Recent studies by Swayze, Bancroft, Heiger and Cordes (1975) suggest a strong correlation between the discharge patterns observed through analysis of such LANDSAT-1 satellite imagery and the incidence of fires within the Park. Thus $10,000 of the $80,000 indicated for Water Budget Studies is proposed for contract with the USGS to undertake a one-year study of water stage-volumn relations within the Park utilizing this remote sensing imagery.

Nutrient Budgets Subtotal $ 50,000

There exists no comprehensive assessment of nutrient budgets

for the Park at the present time. Most of the data on the quality of surface and ground water in the Kissimmee-Okeechobee-Everglades drainage system are from samples by the USGS, analysis of which are published in its annual reviews of water resources data for Florida. Some stations extend back into the early 1940's. Other agencies such as the Corps of Engineers, the predecessor agencies to the water quality office of the Environmental Protection Agency, agencies of the State of Florida and several universities have also collected water quality data; however, most of this data is currently available in a centralized location from the USGS in Miami.

The USGS water quality program in the Park began in 1959, and some of these data have been discussed in various publications and reports in addition to appearing in the annual state-wide reviews. The Service published a report in 1971, titled "Appraisal of Water Quality Needs and Criteria for ENP" which concluded on the basis of data available at that time, that except for chlorinated hydrocarbons, "There is little indication of large scale deterioration, despite a widening of the range of values in recent years. Upward trends in some constituents are becoming apparent, though the rates of change are low." The report noted that these conclusions were tentative and that longer observations and study may alter them.

There is currently no nutrient data monitoring underway within the Park. Thus detection of long term changes in nutrient conditions

which may be taking place cannot be identified and assessed at the present time. Recommended are nutrient budget studies for Shark River Slough and Taylor Slough. Even though there are currently no good water quality data for the western portion of the Park at this time, it is recommended that water quality studies in this area be phased in at a later point in time when funds and manpower are available.

The proposed nutrient budget studies should include monitoring inflows, storages and outflows of the standard parameters measured by USGS in monitoring water quality and should include all reportable constituents, nutrients, and physical parameters in water, sediments, and indicator organisms for each trophic level in the food web if possible. Nutrient budget studies can probably best be accomplished through contract supplemented with in-house support.

The objectives of the water quality investigations then should be to determine the effect of water quality on the Park's flora and fauna and the occurence, distribution and source of pollutants in the Park.

Water quality in south Florida depends largely on land use and human activity -- agriculture, urbanization, and water management -- primary factors in assessing future water quality and all subject to continued activity in the years to come. According to the USGS, water control in the Everglades agricultural area will probably most affect

the quality of water in other areas in the future. It is important that the Park's long-term water quality monitoring program not only be resumed, but expanded.

Heavy Metals and Pesticides Subtotal $ 48,000

The toxic effects of heavy metals on the biota of the Park have yet to be evaluated. The toxicity levels for heavy metals must be evaluated to provide recommendations for limits of these constituents. Nutrient budgets and cycles in the aquatic ecosystems must be determined and desirable ranges of trace elements defined. Monitoring for heavy metals must be resumed within the Park as early as possible to allow detection of any changes which may be occurring in heavy metal concentrations entering the system.

Although some sampling for chlorinated hydrocarbons has been done in the Park, the sampling period to date and the intensity of sampling has been inadequate to support firm conclusions on the seasonal or geographic patterns of insecticide pollution within the Park. Data on biological magnification of insecticides in the Everglades ecosystem are sketchy, but these data appear to show a consistent pattern of increases at each trophic level. DDT and its metabolites are the major chlorinated hydrocarbon insecticides present and these are found throughout the Park in concentrations that are

significant biologically at upper trophic levels. PCB's and the chemical toxiphane are of growing concern. Little is known of the extent or effects of PCB's on the Everglades ecosystem.

Proposed for long-term monitoring are ambient levels of pesticide and heavy metals contamination in the Park. The widespread and abundant use of pesticides for agricultural purposes on areas immediately adjacent to the Park raises questions as to whether they are becoming concentrated in Park food chains.

Data collected by the USGS from many areas in South Florida indicate that pesticide concentrations in water are generally low. Pesticide concentrations in canal sediments are considerably higher because most pesticides of the DDT family are relatively insoluble in water. For example, some soil samples underlying marshes in the Everglades had concentrations of the DDT family (DDT, DDD, and DDE) as much as 1,000 times greater than the surface water. The data also showed that concentrations of DDT tend to increase and to accumulate in the higher orders of the Everglades food chains and in omnivorous marsh-dwelling crustaceans. Marsh fish, intermediate in Everglades food chains, concentrated these compounds as much as 10,000 times greater than residues in the water. The highest concentrations of the DDT family were found in the higher carnivores, such as the alligator, eagle, and Everglades kite.

In view of the presence in areas adjacent to the Park of not only chlorinated hydrocarbons such as DDT but also other toxicants (such as PCB's) it is recommended that long-term monitoring be conducted in the Park to evaluate whether pesticide and heavy metals biomagnification is occurring in the Park. In the proposed study, emphasis will be placed on determining the pattern of magnification through the food chain from ditritus and periphyton through top consumers. Three study sites will be located in areas where environmental pressures outside the Park will most likely affect habitats within the Park. Basic analyses of chlorinated hydrocarbons and up to four heavy metals will be conducted on samples taken from representatives of the entire food chain. Samples (total 204) will be taken in wet season, drying season, and dry season in Shark River Slough at Levee 67 (20 samples), Taylor Slough (30 samples), Eastern Florida Bay estuary (18 samples). Samples will be collected by Park personnel, and analyzed under contract by a qualified pesticide laboratory.

Proper design of a water-monitoring program including selection of specific sites for monitoring equipment is fundamental to a successful program. To accelerate the design and implementation of the water monitoring network we recommend that $2,000 be allocated from FY 76 Service Reserve Fund Account to pay for a water conference which should be called as soon as possible to discuss what stations are needed to develop a water budget for the Park. It is suggested that this conference be coordinated by the Office of the Assistant Secretary for Fish and Wildlife and Parks. Representatives from the Service, Corps of Engineers, Central and South Florida Flood Control District, USGS, and those designing the Management Information System for the Park should be invited to attend. It is hoped that this meeting will take place within the next three months as lead time is needed prior to the actual implementation of a water monitoring program.

"Hot-Spot" Studies

In addition to the high priority water studies indicated above, related "Hot-Spot" studies whcih constitute either present or future management problems for the Park have been selected for special study to provide the Service with information on which to base necessary action programs. Five geographical areas located either within or adjacent to the Park's boundaries have been selected for this category. These areas are: (1) Northeast Shark River Slough (Canal L-67, Levee L-29, and the S-12 Structures);

(2) Headwaters of Taylor Slough; (3) Southeast Dade Co. Canal C-111; (4) Hole-in-the-Donut; and (5) Big Cypress. The approximate location of these areas is shown on Figure 2. The areas above, with the exception of the Hole-in-the-Donut and Big Cypress, constitute problems which are primarily water-related; the funding and research plans for these were discussed under the "Water-Related Studies" category above. Funding needs for the Hole-in-the-Donut and Big Cypress include:

Study	Budget
Hole-in-the-Donut:	
(1) Successional studies	
Inhouse staff and support	$ 44,000
Contract	$ 80,000
Big Cypress:	
(1) Natural resource survey	135,000
Subtotal	$259,000

The rationale for studying each of the five geographical areas is discussed below.

Northeast Shark River Slough
(Canal L-67, Levee L-29 and the S-12 Structures)

Historically water flowed to the Park from the Big Cypress, from the Everglades through Shark River Slough, and from the south part of the coastal ridge by way of Taylor Slough. Since 1962, flow into Shark River Slough has been regulated by control structures in the south boundary of Conservation Area 3A as shown in Figure 3.

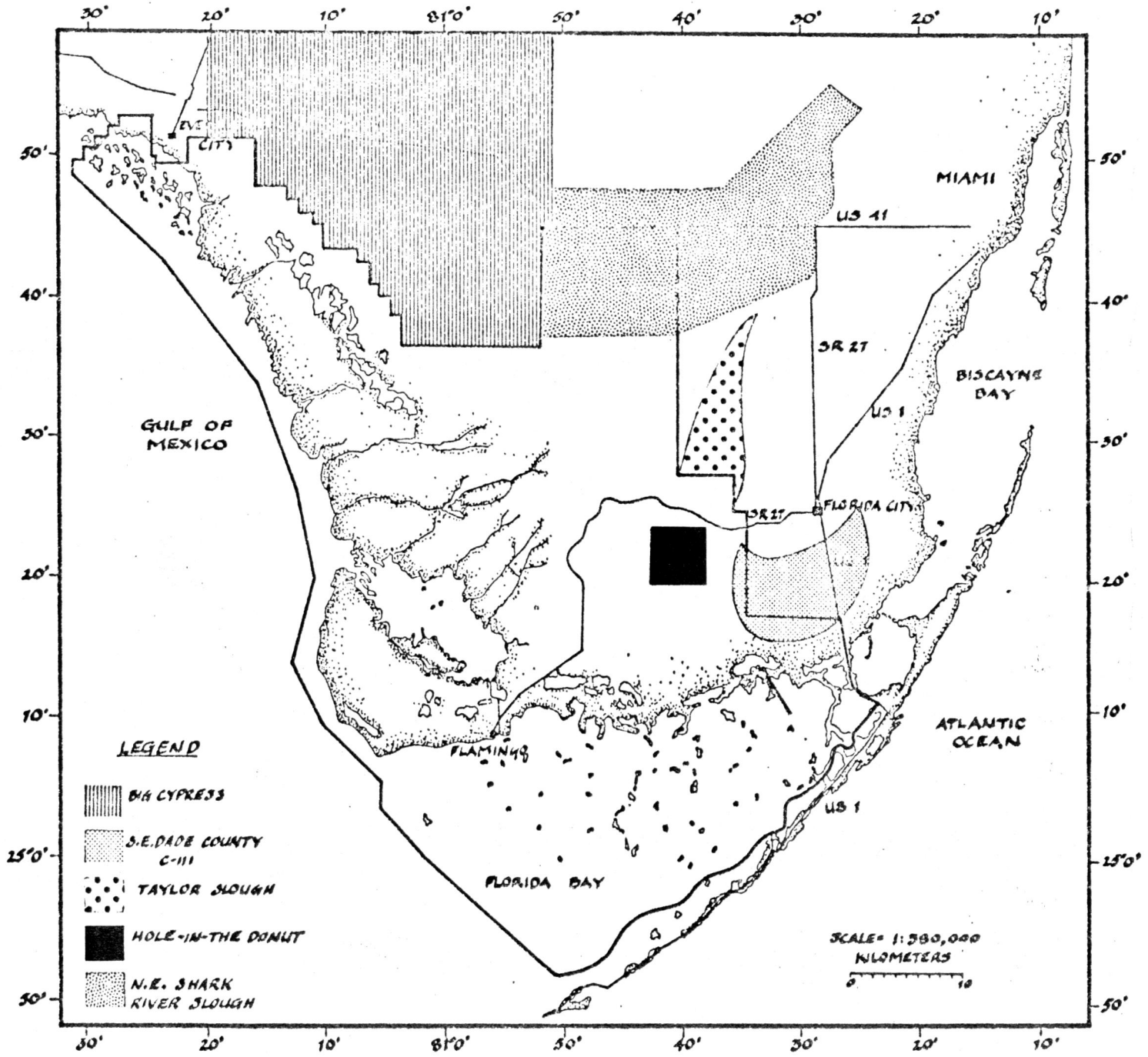


Figure 2 PROPOSED 'HOT SPOTS' SPECIAL STUDY SITES
Everglades National Park

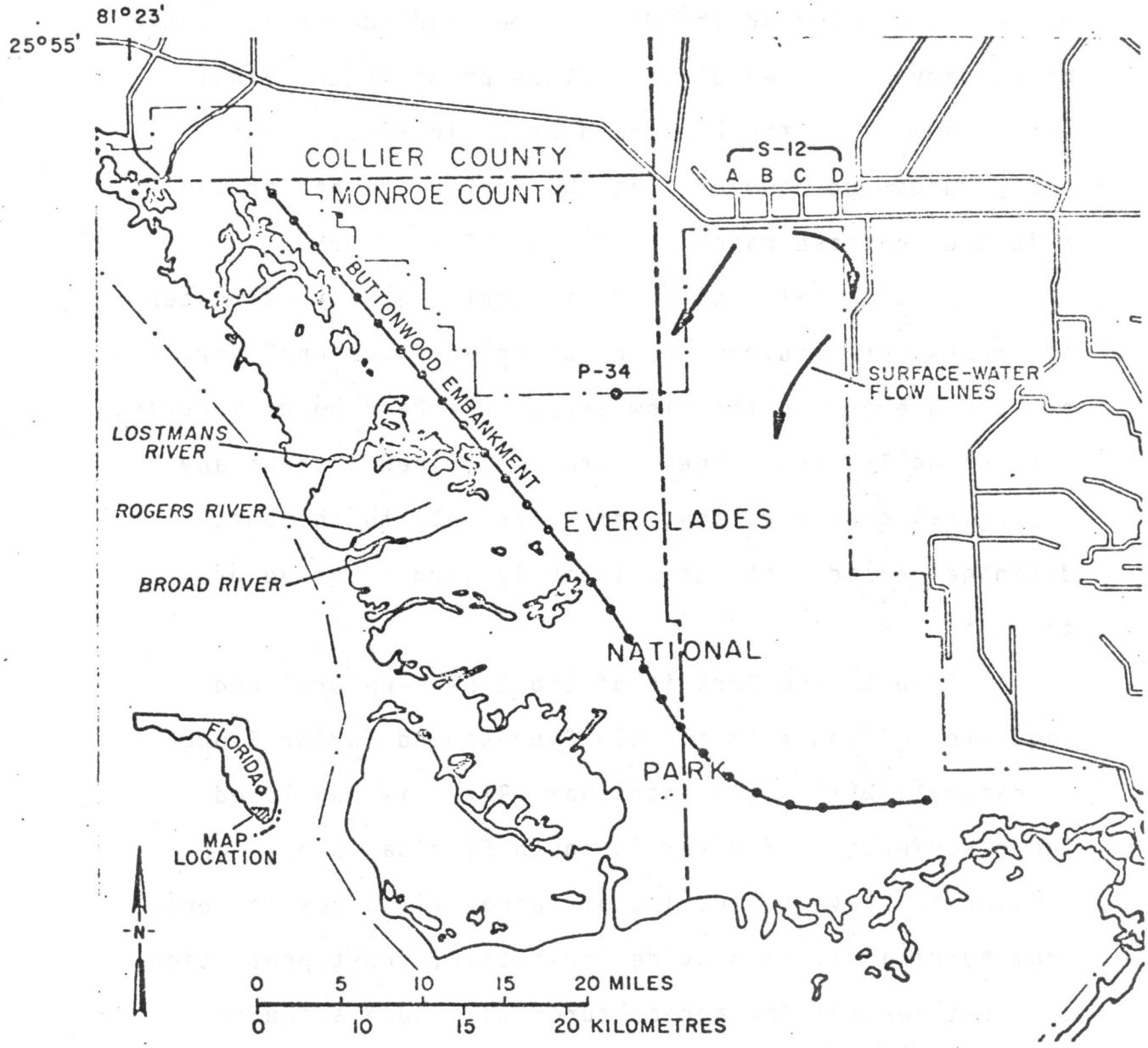


Figure 3 --Approximate locations of the Buttonwood Embankment, stage recorder P-34 and S-12-A, B, C and D control gates.

As Tabb noted in his 1963 Summary of existing information concerning the Everglades Region, pronounced changes in the water level, water supply and water dispersal in and around the Park (unrelated to the completion of Conservation Area 3) took place prior to the final establishment of the Park boundaries in 1947. Tabb's study suggested however that the Park biota had probably adjusted to these major changes by 1947.

Of critical importance is that the only estimates of freshwater requirements of Everglades National Park are those based on the flow across the Park borders during the period 1941-60. These were determined without any ecological consideration, and refer only to the post-drainage period, not the relatively virgin period prior to that.

Flow to the Park is of two types—natural and regulated. Flow from the Big Cypress and Taylor Slough is natural, while flow into Shark River is regulated. The distribution of water in south Florida is now controlled to prevent flooding of metropolitan developments from hurricanes; to provide irrigation, frost protection, and pest control for agriculture; to insure adequate drinking water and sewage dilutent for the metropolitan areas; and to supply the ecosystem of Everglades National Park. Each of these user groups has specific needs as to <u>when</u>, <u>where</u>, and <u>how much</u> water of a certain quality

is required for its use. Historically, in wet years there were few problems in allocating the resource, but during long-term droughts, a specific, objective method for sharing the adversity had to be worked out.

Because of the complexity of the biological system in the Shark River Slough, and the lack of adequate quantitative biological data, the biological water requirements of the Slough could not be (and still have not been) defined. Information necessary to manage the system directly for the goal of maintaining the biotic communities of the Park simply was not available. Historical data for some of the hydrological elements of the system, however, were utilized to calculate minimum historical water flows into the Park and the seasonal timing of those flows under the implied hypothesis that if the natural hydrological system is preserved, the natural biological system will also be preserved. Hence a management plan was developed to recreate, to the extent possible, the historical system, assuming that the biology would take care of itself.

In 1962 the Army Corps of Engineers completed levees and control structures that completely cut off the natural flow of water into the Shark River Slough. For nearly eight years the issue of how to manage the water deliveries to the Park was discussed with several

interim schedules implemented. Finally, in 1970, Congress formalized a water management program in Public Law 91-282 which called for water releases on a monthly schedule, based on the approximate median monthly historical flows. This schedule called for a minimum annual discharge into the Shark River Slough of 260,000 acre feet, with 50 per cent of the water to be delivered during the months of September, October and November.

The establishment of levees and water control structures at the head of Shark River Slough and the implementation of a discharge schedule has resulted in significant changes in the system. This action caused a shift from the overland sheet flow of water into the upper Slough to delivery at nearly a point source. All of the water that once flowed into the Slough across a 15 1/2-mile-wide front is now channeled through several gates on the Slough's western edge, and much of it is delivered to the central Slough by means of a canal.

Estuarine salinities have increased significantly following the completion of levee and control structures in 1962. Prior to 1962, salinities were rarely greater than 25 parts per thousand (0/00), and since 1962 have seldom been below 20 0/00, often exceeding 40 0/00 for a month at a time. Large, mature, shrimp-eating game fish, such as red drum and gray snapper, that were not

often found in the Shark Slough prior to 1962, are now commonly caught there by sport fishermen. It is thought that the abnormally high salinities also drive the juvenile pink shrimp out of the estuary at a smaller size, probably subjecting them to increased predation in the open sea. Data, however, are lacking to substantiate this hypothesis.

Alteration of historic runoff patterns appears to be intensifying the already pronounced hypersaline character of Florida Bay and adjacent estuaries, bays and lagoons and the effect hypersalinity has on marine life. It is generally recognized that salinity twice that of sea-water is harmful to most marine organisms, including the major sea grasses found within the Park's boundaries. Salinity values of slightly less than twice the strength of sea-water prevents hatchlings of eggs of most marine animals. Continued loss of the diluting effect of prolonged fresh-water runoff in large volumes to the entire region influenced by Florida Bay is believed to be leading to almost permanent hypersaline conditions. The effects of increased hypersalinity on the great fisheries of the region, including that for pink shrimp in the Tortugas, remain unknown although a serious possibility exists that permanent hypersalinity in Florida Bay could subject the juvenile stages of most of the fishes and crustaceans (that are largely protected while in the brackish water areas from predation by the adults of species that cannot tolerate low salinity)

to lethal stresses by denying the juvenile stages the required brackish areas for their completion of the growing cycle.

Little research has been done on the fresh and salt water tolerance of the Park's flora and fauna. Knowledge of this tolerance in the brackish zone of the Park is of particular importance if we are to know the quantity of fresh water that is required as well as the seasonality of delivery needed.

Increasing estuarine salinity is not the only problem associated with the construction of canals, levees and water control structures in the Slough.

Past studies of water quality conducted for the Park by the U. S. Geological Survey suggest that water quality has not been extensively affected by land-use changes in the Everglades Basin. However, water quality has changed significantly where water from other areas of the Basin have been routed by canal to the Everglades to alleviate critical water shortages. For example, dissolved solids and chloride have increased from water originating in or passing through the Everglades agricultural area. Water back pumped to the water-conservation areas from urban or agricultural canals has also changed water quality in the Everglades. Water movement from the Everglades agricultural area has increased the average chloride concentration at Station P-33 in Everglades National Park

from 10 to 70 mg/l since 1959. Chloride concentration at Station P-34, about 20 miles west of P-33, has not increased similarly as most of the water flowing by P-34 is from the Big Cypress.

Uncompleted studies in the late sixties of changes in the vegetative communities of the Slough showed that significant changes were taking place in the Slough at that time. Analysis of data examined during that study showed that the most noticeable change in both the upper and lower parts of the Slough from 1940 to 1964 was a decrease in acreage of the wet prairie communities. The decrease was greatest in the upper Slough. Study results suggested that the loss was balanced by an increase in the area of the sawgrass communities with no appreciable change in the tree and shrub communities. In 1940 wet prairie occupied one-third of the upper Slough, but by 1964 they occupied less than one-fifth of this region. The decrease was accompanied by an increase in area of sawgrass marshes from 59 to 72 per cent.

In the lower Slough the change in area of wet prairies was less dramatic, decreasing from 14 to 10 per cent in 24 years, and areas of sawgrass marsh decreased slightly from 69 to 67 per cent. Here the increase was in woody species which went from 17 to 23 per cent of the area. There is no quantified information available on changes in the Slough's vegetation from 1964 to date, however the

overall trend in the Slough is believed to be toward a loss of aquatic associations and an increase in semi-aquatic and tree and shrub associations. True facts of recent changes in the Slough remain unknown however, and the picture is complicated by the fact that the area has been in a long-term drought cycle in recent years and by the variable water releases to the Park between 1962 and 1970 until the Park secured its guaranteed annual water supply.

One of the most dramatic changes observed in the Shark River Slough in recent years has been the precipitous decline in the large wading bird populations in the Slough. The Wood Stork population in the Park for example has fallen from 20,000 breeding birds to fewer than 2,000 in the last 15 years. (The Everglades-Big Cypress nesting population of storks makes up about 70 per cent of the total U. S. population and has declined by approximately 50 per cent since 1960.) The Wood Stork is only one of several wading birds that have not been able to consistently find the conditions necessary to successfully reproduce in the Slough. Wood Storks nested successfully in the Park in seven out of the nine years from 1953 to 1961, but there have only been four successful years in the last 14. Since 1962, birds have tended to delay rookery formation for one to three months. As a consequence, by the time young birds are approaching fledging, spring rains have frequently begun dispersing the concentrations of fish

upon which the storks feed. Under such conditions the adult birds apparently cannot gather enough food to support themselves and their young, so they abandon the rookeries. Park scientists have recently observed a pattern of wading birds nesting north of the Park rather than in their historic sites within the Park, suggesting the existance of increasingly poor feeding conditions in the Park as a probable consequence of alteration of historic water regimes in the Park. These and other studies of the Park indicate significant changes <u>are</u> underway in the Park's biological system: Major alterations of the biology of the Shark Slough system occurred (and continue to occur) coincidental with the establishment of the water control structures at the top of the Slough and the initiation of managed water releases to the Park.

A complete water budget for the Slough as a whole is the most urgent priority in understanding the functioning of the Slough. In addition to a proposed general hydrologic budget for the Slough, critically needed are studies of the Northeast Shark River Slough area, particularly that portion immediately outside the Park boundary that is intersected by Levee L-29, to determine whether or not the water control system in this area must be either reengineered or removed to restore the full Shark River Slough drainage into the Park. These studies must cover several aspects. The first is a hydrologic

analysis that examines the patterns of water flow in the area including discharges through the S-12 water control structures. Thus, in addition to a hydrologic study by Park hydrologists, a special study is recommended of the dynamics of water flow using satellite imagery to depict at a macroscopic level the temporal distribution of water discharges in the Slough. This specific study should be made by the U. S. Geological Survey.

Also needed in this area is a study designed to compare the impact on receiving communities of water delivered by canal versus natural sheet flow water. Park scientists have reason to believe that delivery of water to the Park by canal is having adverse impacts on the biota. This study should be a short term study of 2-3 years duration designed to compare the effects on ecosystems of water inflows with different qualities and quantities. Specifically the study should clarify what, if any, difference it makes to the ecosystem to receive waters from canals vs. water from overland flow. This will require water nutrient data and must be coupled to several other studies mentioned elsewhere in the report: the study on productivity and evapotranspiration and the food chain studies recommended for the Shark River Slough. This study must be a large scale field study comparing

field situations of known water history. Measurements should emphasize the effects on species composition, plant growth, vegetation structure and the impact on food chains. It is recommended that one study site be located North of Levee L-29, one to the South of Levee L-29 in the area to the East of the Park's boundary in the Slough and one site located in the vicinity of the S-12 structures where one finds the closest approximation to sheet flow conditions.

Headwaters of Taylor Slough

Flow to Everglades National Park from the 90-square mile Taylor Slough constitutes an important external source of water for the eastern end of the Park. The headwaters of the Slough upstream from the Park are privately owned and currently undergoing critical land use changes from a natural sawgrass community to an agricultural system. In 1970 an amendment to P.L. 91-428 authorized acquiring agricultural inholdings in the Park, including the 6,000 acres of land in the Hole-in-the-Donut previously utilized for agricultural purposes. With the phase-out of this agricultural usage of the Hole-in-the-Donut by June 20, 1975 the growers in south Florida have embarked upon the rapid development of replacement agricultural lands on the periphery of the Park in Taylor Slough. Recent reports indicate agricultural interests intend to have 6,000 to 12,000 acres under cultivation in the Taylor Slough drainage by the end of next year.

Development of this drainage posses several problems of concern for the Park, particularly in terms of water quality and quantity. Specifically, what impact will pumping for agricultural use have on groundwater supplies in the vicinity of the Slough during drought periods? How will sheet flow to the Park through the Slough be affected by farming and rock plowing of the soil? Will routing the Park's water supply through agricultural lands affect the quality of the water entering the Park? Also of importance is the planned construction of the S-332 pump station for withdrawals from Canal L-31 to redistribute the present flows of water flowing along the Park's east boundary. Baseline data are lacking to evaluate the impact of altered flows on the Taylor Slough system. Numerous problems with the seasonal variation of the delivery of the guaranteed 37,000 acre-feet per year of water have already been identified by Park personnel. However, substantially more information about the system is needed before further threats to the Park's eastern boundary can be documented and proper water delivery schedules determined.

Finally, recent studies of the area have shown it to contain an important population of an endangered species, the Cape Sable Sparrow. Loss of the plant community currently undergoing development for agricultural purposes

in this area will seriously reduce the available habitat for this endangered species.

Southeast Dade Co. Canal C-111

The Southeast Dade Co. C-111 "Aerojet Canal" was built in 1964-65 along the southeast boundary of the Park. The canal was originally designed to provide barge access to the Aerojet space missile test center located adjacent to the Park's eastern boundary so that missiles could be transported in and out of the facility by barge. The Canal was also intended to connect with other canals in the area contemplated at that time designed to drain the South Dade area for agriculture and future urban development. Gated culverts were installed at the southern end of the canal during construction to permit sheet flow of water into Barnes Sound but prevent salt water from backing up into Taylor Slough. There is growing evidence that this system is not performing properly and in fact may be contributing to the hypersalinity problems of Florida Bay through alteration of the area's historic flow patterns. Large areas of mangroves in the Bay are beginning to die and show evidence of salinity stress. Crocodile numbers, once estimated to be as high as 2000 individuals continue to decline and now number approximately 200. There is recent research evidence showing an intolerance for salt water by juvenile

crocodiles. This work may be a real breakthrough in understanding these creatures. The concerns of hypersalinity in terms of its impacts on the juvenile stages of most fish and crustaceans utilizing the Bay's brackish water zone has already been discussed.

A detailed hydrologic investigation of the area is needed to assess the effects of C-111 and determine whether the canal system must be either reengineered or removed to restore the original hydrologic regime to the area. This study should be closely coordinated with the proposed study of salinity gradients throughout the Park.

The Big Cypress

The Big Cypress National Fresh Water Reserve is a large and complicated ecosystem important to the Park and adjacent coastal estuaries of Southwest Florida. The Big Cypress not only provides vital water supplies and wildlife refuges for the Park but is a unique wilderness in its own right. Although this regional ecosystem has not been subjected to the long term tradition of study that the Park has enjoyed there exists a number of excellent studies which provide important insight into the properties and dynamics of ecosystems within the Big Cypress Reserve. Included in this group of studies are those done by the Department of the Interior during the height of the Jetport controversy. These studies demonstrated the importance

of the area as a supplier of water to the Park and documented the very high quality of surface waters within the Big Cypress. In addition these studies cursorily documented the diversity of plants, animals and ecosystems within the region. Unfortunately these studies were of short duration and did not deal with the subject of seasonal and year-to-year variation in the communities of the Big Cypress. It has been shown that wet cycles in this area occur at approximately ten-year intervals, hence a thorough portrayal of the natural variation will eventually require extended study.

The most complete study in the area was the award-winning study "Ecosystem Analysis of the Big Cypress Swamp and Estuaries" by the Environmental Protection Agency (EPA) done as part of the South Florida Environmental Study. This study concerned the largest strand in the Big Cypress, the Fakahatchee, which constitutes approximately 10 per cent of the Big Cypress land area. This strand contains most of the communities represented in the Big Cypress. The EPA study was a holistic ecosystems study exemplifying the type of study proposed for the Shark River Slough and other mosaic and community-type ecosystems. The study provides the best available information concerning productivity and function of Big Cypress component ecosystems.

There are extensive resource management problems in the Big Cypress (most of which relate to use provisions

in the enabling legislation) that will require immediate attention and study. Fire is a major factor controlling the distribution of plant communities, but the effects of fire may be different in the Big Cypress than in neighboring ecosystems. Therefore evidence of fire frequency and effects needs to be gathered as well as information on other factors affecting succession, including those of exotic plant invasions.

Since hunting will be allowed in the Reserve, the impact of hunters, their vehicles, and hunting camps upon the wildlife populations and their habitats must be assessed and monitored. Information on the status of endangered species and other important wildlife species must be accumulated for this area. Photopoints, transects, and vegetation plots must be established as soon as possible to ascertain long term changes that may be occurring in the Reserve. Similarly, an extensive hydrologic monitoring program coupling to that proposed for the Park proper must be initiated immediately.

The Big Cypress study should initially concentrate on producing an inventory of the natural resources of the Big Cypress, identifying the major ecosystems of the Big Cypress and outlining a more detailed plan for subsequent study and management of the Reserve. A survey of plant, animal and community types should be the immediate objective. Species or community lists should <u>not</u> be the main

result of this survey. Instead, maps with locations and delimitations of community types accompanied by quantitative descriptions of species composition and community structure should be obtained. Stations for long term monitoring of change and environmental quality should be established on the basis of this general survey. Monitoring should begin as rapidly as possible.

When and if this large area (2450 square miles) is added to the Park, its addition will cause pressure on existing priorities and work loads within the Park. To avoid dilution of effort and the danger of a decline in the quality of research, we propose that contract studies be utilized in the Big Cypress area for initial inventory of plants, animals and resources, and identification of critical areas, ecosystems, and specialized habitats. With this basic information Park scientists will then be in a good position to advise the Service as to future management issues and study priorities in that area.

Hole-in-the-Donut

The succession and possible permanent establishment of exotic species in the area known as the Hole-in-the-Donut is perhaps one of the most visible problems facing the managers of Everglades National Park. It is of the most crucial importance for the Park Service to avoid being caught up in the emotional atmosphere generated

by the issue. Short term thinking by Park purists may precipitate actions that on a long term basis are more harmful to the area than the problems they are trying to solve today. In this area of the Park man has dramatically altered the soil substrate; areas that before were pinnacle rock are now regions with macerated, mixed marl and rock. Rock plowing changed not only the substrate but also the water relations of the area and may have increased the area's capacity to support plant growth. It seems highly unlikely that a re-establishment of the traditional subclimax ecosystem will be possible when conditions have changed so much. We may have to live with a new and more structured type of ecosystem—which may contain exotics—in those areas of the Park. The effects of topography and substrate on the composition and structure of Florida vegetation is one of the better established facts in our ecological tool box and both have changed in the Hole-in-the-Donut area. Regardless of who is right in predicting the future of the Hole-in-the-Donut (those that see it as an exotic-dominated system, those that see different types of climax communities, or those that believe that the glades-pinelands environments will return) the National Park Service must keep its management options open. The Park must pursue several avenues of action in its efforts to cope with this situation. The Service cannot afford to rely completely on

burning, mowing, or plantings. Instead it should take advantage of the size and the variety of historic plots available in the area to experiment with several solutions. Once a pattern emerges that appears to be relatively well understood, the Service can pursue that solution with vigor and determination.

Accordingly, we propose that studies be initiated to: (1) identify and inventory the diversity of successional agricultural plots available within and without the Park; (2) establish successional pathways that correlate with the plot history and substrate; (3) recommend a variety of successional methods and document the relative success of each. These plots should correlate with substrate and water hydroperiod; (4) develop experimental approaches that may enhance the Park's ability to cope with the invasion of exotics into man-disturbed areas; (5) if new ecosystems are inevitable in certain areas, to recommend ways of managing these ecosystems; and (6) determine if exotic species can be utilized as sensitive "thermometers" of ecosystem disturbance in the Park.

In terms of invasion of exotics, two species of Australian pine, Brazilian holly, Melaleuca and Calubrina, are the major exotics of concern while the potential threat of establishment of water hyacinth in the Shark River Slough is of growing concern to the Park.

Park personnel consider the Australian pine to be the greatest problem at this time because it is the most widespread exotic in the Park. It poses a serious problem because of the displacement of native vegetation and interference with Loggerhead Sea turtle and American Crococile nesting areas. Brazilian holly rapidly invades disturbed sites and to some extent pineland and other communities, completely displacing native vegetation. Its monospecific community is believed to be of little value to the area's wildlife. Melaleuca, although not abundant in the Park itself at this time, may be the most serious because of adaptation to fire and ability to grow in wet as well as dry sites. It poses a more serious issue in Big Cypress which is undergoing an aggressive invasion by this species in specific areas. Calubrina, found in the Buttonwood vegetation zone of the Park, has begun dominating large areas of the Park during the last 10 years. Actual acreage covered by this plant in the Park at this time is unknown.

The sudden appearance of water hyacinth in the canal systems of Shark River Slough apparently triggered hasty management control actions by the Park's Resource Management Division personnel based on the concern that the hyacinth could become a successful invader of the Slough if allowed to become established.

Studies of these species both in terms of their individual life histories and the community relationships in which they are found are needed to guide the resource management plan for the Park.

Central to the successful management of these species in the Park is recognition that one must manage not just these intruding species, but the systems to which these species belong. Ecosystem management is based on the concept that species and populations are part of a larger system (ecosystem) which regulates their mineral and energy flow. In order to manage any part of such an integrated system, one must manage the whole system; this requires understanding of the whole community in which the species occurs. Such understanding permits the manager to exert control over the principal energy and matter flows that allow a particular species to become successful during a given time period. The fallacy of single species or single factor management is that it concentrates attention on a single detail which may or may not be important to overall management objectives. Meanwhile, conditions in the region may be leading to an end directly opposite to that which management intended.

Greater emphasis on ecosystem management is needed for successful control of pest species. It may be necessary to accept the presence of new invader species in the Park playing an active role in the functioning of

the Park's ecosystem. Perhaps instead of designing species-oriented eradication programs, we should be attempting to identify this role and concentrating control efforts toward environmental manipulation that would tend to correct or reduce the effect of the man-induced ecosystem simplification that has favored the success of exotic species.

Proposed then are contract studies investigating the ecological amplitude, competitive ability, morphological plasticity and diversity of biotypes and ecological equivalence of species in a community context for Australian pine, Brazilian holly, Melaleuca, Calubrina and water hyacinth.

Also recommended in this section of the report is the convening by the National Park Service of an immediate conference of scientific experts knowledgeable in the area of tropical plant succession and the problems of exotic plant species in south Florida to review the current resource management restoration program for the Hole-in-the-Donut and make recommendations to the Service concerning that program. It is recommended that conference participants include at least the following individuals:

	Name	Affiliation
1.	Dr. Taylor Alexander	University of Miami
2.	Dr. Jack Ewel	University of Florida
3.	Mr. Dale Wade	U.S. Forest Service
4.	Dr. John Popenoe	Fairchild Tropical Gardens

5. Dr. Hugh Popenoe	University of Florida
6. Dr. Robert Knight	U.S.D.A. Plant Introduction Station
7. Dr. George Cornwell	EcoImpact, Inc.

The primary purpose of this conference is to review objectives of the Hole-in-the-Donut restoration plan and associated management activities. It is our impression that the present program underwent a very rapid development (on the order of one to two weeks according to Park personnel) in response to urgent requests for a restoration plan from the regional office, and concern exists that the full implications of the present plan have not yet been explored in terms of the feasibility of the program. The Park Service may well be embarking on a restoration program that will be prohibitively expensive and doomed to failure.

Community Studies

A third category of studies identified as high priority for the Park falls under a general catogory of "Community Studies."

Everglades National Park constitutes a regional ecosystem composed of extensive community and mosaic ecosystems. Some of the ecological communities in the Park are easily recognizable and include such visitor

favorites as hammocks, pinelands, ponds, marshes, and bays. These communities do not operate in a vacuum but are all interconnected by the complex movements of water, animals, and climatic phenomena. Groups of communities sometimes occur in predictable mosaics. An example of a mosaic of ecosystems is a slough such as Taylor or Shark River Slough. The single communities and the extensive mosaics of communities together form the regional system known as the Park. In our conversations with Park personnel we identified at least 15 distinct communities and an equal number of mosaic ecosystems. Preliminary models of these systems were presented in two earlier south Florida Environmental Project Studies: "Models for Planning and Research for the South Florida Environmental Study" by Lugo et al. (1971) and "Carrying Capacity for Man and Nature in South Florida: Energy Models for Recommending Energy, Water and Land Use for Long Range Economic Vitality in South Florida," edited by Odum and Brown (1974).

Although all of the ecosystems are integral parts of the Park, constraints on personnel, funds, and time limit the number that can be intensively studied to answer the most pressing management questions relating to the Park. For this reason, and to meet the most critical management needs of the Park, studies of three

mosaic and one community ecosystems are recommended as the most urgent priorities. The selected systems are the Shark River Slough (a mosaic of marshes, alligator holes, tree islands and saline systems), Florida Bay and estuaries (a mosaic of saline communities upon which most of the region's fisheries depend at some time in their life cycle), the Dry Tortugas (a mosaic of coral reefs, islands and nesting marine sea birds) and the sawgrass community (the dominant vegetative type in the Florida Everglades).

These community studies are proposed as the crux of the research program inside the Park and a great many of the management decisions that will be made in the future will depend on findings from these studies. It is thus crucial to understand what we mean by community studies. A community study implies that the totality of nature's manifestations in one particular area will be studied. This includes the most fundamental descriptions of an area as well as measurements of how it works. For example, each community study should start with detailed measurements of topographic contours at the 6 inch contour, soil surveys, complete inventories of plants and animals, vegetation mapping, and structural description of the community. Long term studies of community succession and periodicities in its biological

clocks as well as the effects on the community of water level, fire, and disturbances should be started immediately.

In addition to the considerations stated above, there are other types of effects to be taken into consideration in the design of community studies. Such things as longitudinal effects of water depth, drought, fire, animal migrations, and man must be evaluated at this level. The relationships between ecosystems are also obligate objectives of the studies of mosaic ecosystems. Only through the thorough examination of these ecosystems will managers ever achieve a management posture of authority and confidence.

Individual plant and animal species are among the most important components of communities and as such their study should not be separated from the community studies. By being an integral part of the community studies, population studies can be conducted more thoroughly and efficiently at less cost. For each species to which special consideration is given, information on growth, reproductive potential, and the factors that control this potential is needed. Life tables should be constructed or, at least, studies should be designed to include life table information. In this way a study done today serves as a base for a study that may be needed tomorrow. Finally, the role of the species in the complexity of the community to which it belongs is another

important consideration to be included in the design of population studies.

Specific items recommended under the "Community Studies" category include the following:

Study	Budget
(1) Shark River Slough Mosaic	
(A) Primary productivity and evapotraspiration	120,000
(B) Detrital-grazing and grazing foodchains	50,000
(C) Fish population, Alligator population, Wading bird feeding distribution	74,000
(D) Wading bird rookery formation dynamics	8,000
(E) Crayfish autecology	30,000
(F) Shark Slough vegetation succession	50,000
(G) Sawgrass	30,000
(2) Florida Bay and Estuaries Mosaic	
(A) Natural Resources Survey	47,000
(B) Florida Bay fisheries studies:	
(i) Florida Bay fish ecology	42,000
(ii) Lobster population study	24,000
(iii) Stone Crab population study	24,000
(iv) Fishery catch data analysis	29,000
(C) Crocodile population study	30,000
(D) Water fowl survey	20,000
(E) Loggerhead turtles study	15,000
(3) Dry Tortugas Mosaic	
(A) Marine Resources Survey	4,000
(B) Sooty Tern Study	24,000
Subtotal	632,000

The general justifications for these studies are presented next.

Shark River Slough Mosaic

The Shark River Slough has been selected for high priority detailed community studies because it constitutes the major drainage of the Park and is the area with the best historic data base. In addition to a complete water budget for the Slough, we are recommending a number of related studies which are needed to understand the structure and function of this most important Park area.

Study of primary productivity and evapotranspiration is recommended to yield information on productivity, evapotranspiration, and the effects of hydroperiod and topographic location on these parameters. Rates of organic productivity are a primary determinant of the abundance of organisms found in the Slough. This study is believed critical to the understanding of the Slough as a whole.

Also recommended as a very high priority study is analysis of the detrital-grazing freshwater food chain in the Slough. Energy flow through most ecosystems takes two pathways: grazing of the live material (usually referred to as grazing food chains), and grazing of dead material (referred to as detritus food chains). Detritus food chains are usually the most important food chains in most ecosystems but

they become obviously important to the naked eye only in the marine and freshwater ecosystems. This is so because in these ecosystems one can easily demonstrate that showy organisms, such as fish, are detritus feeders or depend on detritus feeding organisms. In the Park, Odum and Heald conducted their seminal studies on the potential detrital base of south Florida fisheries and linked the productivity of the fishery to detritus from mangrove forests and salt marshes. The possibility remains that freshwater marshes also contribute detritus to the detritus-based food chains in the Park. Hard data to even demonstrate the importance of fresh water detritus food chains versus grazing food chains in the Park are lacking. Crayfish, for example, may be an important link in these chains. It is of critical priority to the management of the Park's fisheries, marshes, forested wetlands, and even bird life to clarify the relative importance of these pathways.

The water-plant-animal food chain relationship reaches to the heart of the biotic survival problem in Everglades National Park. Until it is known how the living components of the Park respond to various conditions of fresh-water supply, Park managers are not in a position to make sound decisions relative to the measures required to provide these organisms. The major objective of all food chain studies should be to describe and

define the basic biological food web in the fresh and brackish waters in relation to hydroperiod, water depth, salinity and other chemical and physical characteristics of the water. Data from research of this quantitative nature will have particular importance when ultimate control measures and schedules of fresh-water releases into the Park are being determined. This kind of research must be intensified far beyond that now in progress and constitutes a very high priority research item.

An important adjunct to the above generalized food chain study is a recommended intensive study of the freshwater fish populations of the southern Everglades. The freshwater fish populations constitute the critical central links in the food chain leading to the dominant predators, including wading birds and alligators. Nothing is presently known about the nature of these links, especially what the population numbers of these fish are, how much time is needed for fish to become large enough to be consumed by birds, what foods these fish eat, and how their reproduction relates to water conditions.

As a final element of the food chain studies, we are proposing a detailed life-history study of one of the most unobtrusive but at the same time most abundant animals of the Everglades about which little is known—the crayfish. Few accounts of studies on

stomach contents of fish, birds, frogs, snakes and mammals of the Everglades are found that do not list crayfish in the diet. In addition to its value as a food source, the crayfish may play an exceedingly important role in providing burrow microhabitats for estivating animals during drought cycles. The recommended study should define the role of the crayfish in the Shark River Slough Ecosystem in relation to hydroperiod, water depth, salinity and other chemical and physical characteristics of the water as well as biologically.

Also recommended are long term studies on the American Alligator, a species which plays a dominant role in the Shark River Slough Ecosystem. Earlier studies in the Big Cypress demonstrated the importance of alligator holes for both fish and wading bird populations, especially during times of drought. We have almost no information on the size, age, and distribution of the Park's alligator population. The role of the alligator in the Everglades is only superficially understood and the carrying capacity of the Park for this species remains unknown. Also, although earlier research showed that high water levels drowned alligator nests (thus affecting population size), the full impact of water conditions on alligators is not known. The proposed studies are designed to answer these and related questions about this species.

Two studies which relate so closely to the productivity of the Slough so as to be inseparable from the area concern the crown jewels of the Park, the wading birds. Past studies on the avifauna of the Park have documented some of its species diversity and in the examples of eagles, and storks, have gone into considerable detail concerning the population ecology of these species. Taken as a whole, however, we still do not understand very well where most of the Park's birds are feeding and why, the dynamics of rookery production, and factors responsible for the significant changes in population numbers being observed. Basic life history of most of the bird species found in the Park remains unknown. Recent observations suggest a significant shifting of bird popultions towards the north, outside the Park. Yet Park researchers are in a poor position to evaluate the long term importance of this fact without a great deal more study. Hence broad ecological studies on nesting and feeding are in order. Considering that bird populations are one of the main attractions in the Park and that their historic large numbers suggest an important ecological role in the Everglades ecosystem, these studies are of considerable priority.

Another study of considerable importance concerns the sawgrass community. Sawgrass is one of the most abundant plant species in the Park. However, only two

recent studies have been devoted to this important species. Tremendous gaps in our knowledge also exist when it comes to this plant. Rates of sawgrass productivity and its role in the Park remain virtually unknown. Of growing concern are observations that large expanses of the Park's sawgrass are yellowing and dying with no apparent explanation of what is causing the die-off other than the possible absence of fire. Definitive studies on its fire ecology, lifecycle, and responses to hydroperiod are required to elucidate the response of this community to different management programs and to possibly explain its periodic diebacks. The role of sawgrass marshes as feeding areas for wildlife requires considerable investigation. Knowledge about the ecology of this community is obviously mandatory.

The final study proposed for the Shark River Slough Mosaic is, in many respects, one of the most important of all: documentation of historic succession and change in the Slough as related to water, fire, and other associated phenomena. Throughout this report and particularly in the section on issues, "change" has been a dominating concern. Succession is the process that describes change in ecosystems. In an area of constantly changing environments such as south Florida, it is reasonable to expect change in the plants and animals that live there. Of concern is how to interpret the significance of the changes taking place in relation

to the Park. Is the Park changing naturally, in the right direction, or is the change detrimental? These questions can best be analyzed by studies of historic succession as proposed for Shark River Slough. During our program review, Park researchers placed a very high priority on this research item, a priority with which we strongly concur. Recommended is a contract study analyzing changes in the vegetation of the Slough from 1940 to 1974 as determined from analysis of aerial photographs and field studies. These data should be evaluated in relationship to all available information on the Slough.

Florida Bay and Estuaries Mosaic

The second mosaic selected for priority investigation constitutes the marine and brackish water areas of the Park. The economic and ecologic importance of these areas not only to the Park but to the region and the Caribbean cannot be overemphasized, yet little is understood about the functions of these areas. It must be recognized that studies to tell us everything which should be known about these vital areas are prohibitively expensive due to the size of the areas and their biological complexity. The costs of complete studies which are believed justified in terms of what needs to be known

about the system and how it is being changed could quickly double or even triple the proposed budget for Park research. Recognizing this fact and accepting the reality that funds necessary to provide the needed data base to understand the dynamics of Florida Bay and the Estuaries are likely unavailable, we have attempted to augment the minimal research program already underway for this mosaic with studies which will hopefully function as an early warning system for the Park, signalling problem areas which must have further study on a priority basis. Also included are specific studies of current resource management problems in these areas. One of the early responsibilities of the proposed Scientific Advisory Board for the Park should be a review of additional research needs in this mosaic as the studies proposed are those believed to be only the minimal necessary to monitor the system.

The Natural Resources Survey is proposed to monitor the Bay islands and mainland fringe areas with heavy emphasis on bird population dynamics and their interrelationship with other communities in the Park and to initiate a monitoring program to evaluate the impacts of visitor use of the Keys. There is growing evidence to suggest that increasing human visitation to the Keys may be adversely affecting utilization of these areas by birds and reptiles.

Also needed is a comprehensive ecological investigation of Florida Bay fisheries, including their relationship to Park management programs. There have been no previous detailed ecological studies conducted within the Florida Bay portion of Everglades National Park which would relate to sport and commercial fisheries management programs.

The few survey fishery studies conducted within the Park include two checklists of flora and fauna collected in northern Florida Bay between 1957 and 1968 and central Florida Bay in 1964-1966. Information is needed to describe the communities of fish and macroinvertebrates inhabiting particular areas and derive a basic understanding of their spatial distributions; to determine how sport and commercial fishery populations change, and quantify the numbers and weights of the individuals per unit area; and to examine the life history and trophic relationships of the biota within the study area. Baseline studies required include quantification of habitat types and investigations of indices necessary to enumerate and monitor population abundance and changes. Characterization and mapping of Florida Bay benthic features and their biological communities are a part of this study as is a water quality analysis of the Bay.

There is a very limited amount of published water quality data on Florida Bay. In recent years the Park has

established approximately 38 water quality stations throughout the Bay to provide critically needed information concerning the long term status of water quality in the Bay. Hydrographic measurements and observations are also needed to supplement and complement previous work in Florida Bay as well as to correlate physical and biological parameters of the fishery ecology program. Included under this Community Mosaic are detailed investigations of the population status of stone crab and lobster within Park waters. Stone crab fishing is one of the principal fisheries of Everglades National Park. There are indications that the stone crab population has been over-fished and needs protective regulation within the Park boundaries. Removal of stone crabs from the Bay's ecosystem could profoundly upset the population balance of other marine species. Furthermore the resultant damage to the Bay bottom by pot fishing (both stone crab and lobster) needs serious study.

To manage the stone crab fishery effectively we need to know what the specific biological criteria are in order to determine a sustained yield basis for the fishery. We need to understand the growth rate, migration and feeding habits, and general ecology of the stone crab to develop a basic foundation for a sound resource management program.

Due to recent strong public support by local and out of state consumers to expand the existing stone crab market, park managers have been subjected to pressure to relax stone crab fishery regulations. Thus, without essential information on population dynamics, life history, and adult and juvenile habitat requirements, this important fishery resource may suffer irreparable damage in the loss of the entire fishery.

Florida Bay is believed to contain within the Park a large but generally unfished population of lobsters. Moreover, the Park, Ft. Jefferson National Monument, and Biscayne National Monument are probably the principal nursery grounds which provide the majority of stock for the off-shore fishery. Recent closing of the Bahamian fishing grounds to U. S. fisherman has noticeably increased lobster fishing in those Park areas open to fishing and is causing pressure to open closed areas for additional exploitation.

The southern Florida Bay portion of Everglades National Park is also the scene of an intensive sport fishing harvest of the commercially important spiny lobster. Consequently, there is a need to measure the impact of human harvest on the quasi-protected population of spiny lobster in eastern and central Florida Bay, especially since very little information is available on their early life history. Information on habitat preferences and nursery requirements,

feeding and migratory habits and distribution patterns of the spiny lobster are vital to formulate and regulate effective lobster resource management programs. There have been no specific spiny lobster research programs established for Everglades National Park. A spiny lobster research program is currently concluding at Ft. Jefferson National Monument. Current biological studies in northwest and central Florida Bay should reveal general baseline information on a monthly basis as an indication of lobster location, size range and seasonality supplemented by estimates of relative and absolute abundance. However, current tropical research suggests that reef dwelling lobsters, unlike other major commercial species, may not be randomly distributed within their habitat, thus indicating a need for more selective and intensive methods of sampling such as in situ examinations through diver tagging and capture-recapture trap surveys.

Concerning assessment of the commercial fishery harvest, catch data have been collected since 1964 in Everglades National Park. In 1972, an effort was made for the first time to also collect measures of fishing effort. Thus, catch rate estimates reflecting fish population levels are now possible, and can be used to evaluate management programs and related fisheries' resources to environmental conditions. Reports of total catch indicate a general decline in the spotted sea trout population during

the past six years and an increase in the striped and silver mullet population. However, catch per unit of effort rates since 1972 indicate that the trout and mullet fisheries apparently fluctuate seasonally and the total catch alone does not necessarily represent overall decreases in the population levels of spotted sea trout and mullet. On the other hand, the stone crab fishery shows signs of weakness as catch rates fell sharply through the 1972 season suggesting a significant reduction in stone crab abundance. An automatic data processing, storage, and retrieval system has been developed and implemented. Its utilization must be expanded to assess the impacts of harvesting on the marine community.

National Park Service policy regarding fishing in the Park is to manage the fisheries to provide a sustained yield. In order to assure perpetuation of the fisheries, the harvest by sport and commercial fishermen must be accurately estimated and continuously monitored. Information on the status of these populations is thus needed to guide management policies regulating harvest of lobsters and stone crabs in the Park. Also recommended for funding is expansion of the current program assessing sport and commercial fishing within the Park. Marine and estuarine fish stocks of the Park are being subjected to rapidly increasing fishing pressure by sport fishermen (a two and one-half-fold increase from 1959 to 1969). The harvest

from National Park Service areas by sport fishermen needs to be accurately estimated and continuously monitored to assure perpetuation of the fisheries on a sustained yield basis and provide a foundation for sound management.

Three other studies dealing with crocodiles, waterfowl and Loggerhead Sea turtles are also recommended for this community mosaic. The only place in the United States where the crocodile is found is in and around the Park's environs. Recent hatching failures, a declining population, and increasing environmental stress related to the hypersalinity problems of Florida Bay indicate that continued study for the Park's population is needed with particular emphasis on the collection of population data for this species.

Waterfowl are believed to depend heavily on the Park for food and resting areas during migration. The Cape Sable prairie is reported to support waterfowl numbers in excess of 100,000 birds at a time during migratory periods for waterfowl in transit either to or from the Caribbean. Migratory waterfowl use of this area is believed to consist principally of teal, with a few scattered baldpate, gadwall, and pintail. Wintering waterfowl consist largely of both scaup species, a few redheads and canvasback, and coot. The proposed study of the Florida Bay and estuaries system should include an analysis of its support function for the Atlantic Flyway

as the current importance of this area for waterfowl is unquantified.

A significant nesting colony of Loggerhead Sea turtles exists on Cape Sable. Stressed throughout its world-wide range, populations of Loggerheads have declined to the point that the species is now considered endangered. Its Caribbean range has been dramatically reduced; Mediterranean colonies are being exploited; many of its nesting beaches in the southeastern United States have been destroyed by development and as the world's leading expert on sea turtles, Dr. Archie Carr, has said, "the long-term trend is not heartening." A few protected beaches on the coast of Florida and the barrier islands of the Carolinas and Georgia may be all that remain to perpetuate the species in North America. The Cape Sable beaches in Everglades National Park form one of the least damaged of the remaining U. S. rookeries. Continued study of this rookery is believed highly important for future management of this resource.

Dry Tortugas Mosaic

The third mosaic selected for specific study, the Dry Tortugas, is located at the Fort Jefferson National Monument. Two specific activities are recommended in this study plan: further study of the Sooty Tern and Brown Noddie Colonies and a marine resources survey.

The Dry Tortugas study of the Sooty Tern and Brown Noddie colonies has produced one of the best-tagged colonies of migratory marine birds in the world. The presence of large numbers of individuals of known age in the population, established by earlier intensive banding, affords a study base upon which to expand our knowledge and understanding of the only significant breeding population of these tropical, pelagic birds in the conterminous United States.

The second study, although of lower priority, is also believed warranted. During the course of a recent lobster study at Ft. Jefferson National Monument, Park Service personnel noted extensive fisheries exploitation of the Dry Tortugas atoll with several cases of severe damage to coral structures within the Monument. No survey exists for the Monument's marine resources at present that can serve as a basis for legally determining damage or deterioration as a guide to management policies. However a very fine series of studies was done at the old Carnegie Laboratory on Loggerhead Key which could serve for comparison to new investigations. The proposed project would survey one shoal area every year during an intensive two-week period at the Fort. The National Park Service would provide logistic support and continuity while much of the expertise would be solicited outside the service on a voluntary basis. The U. S. Geological Survey, the State of Florida, the National Museum, the University of Miami,

and the University of Michigan have already notified the Park that they wish to be considered as participants in such a volunteer project. For a small investment, the Park Service can attract considerable outside professional help.

General Studies

The fourth major category of studies, called "General Studies," contains associated studies viewed as fundamental to completing the Resources and Basic Inventory of the Park and necessary to aid in understanding and evaluating Park problems.

Included in this category are the following:

Study	Budget
(1) Mapping Program	
A. Vegetation	50,000
B. Soils	30,000
C. Topography	30,000
(2) Fire Ecology	39,000
(3) Florida Panther Study	15,000
(4) Library Search	20,000
	184,000

Mapping Programs

The Resources Basic Inventory of the Park is significantly deficient in its information concerning mapping of vegetation, soils and topography. Proposed in this research program are efforts to correct this deficiency. We envision the vegetation mapping being

accomplished through a joint in-house-contract effort. The soils and topographic mapping should be accomplished in such a manner as to result in a single map product but may also entail a joint in-house-contract effort. Details on these specific items are provided below.

Vegetation mapping

An accurate, up-to-date and detailed large-scale vegetation map of the Park is needed to provide a means of determining total changes which occur in the plant communities of the Park by establishing a baseline against which future vegetation changes may be measured. Area coverages of the various vegetation communities will also be needed to aid in the calculation of evapotranspiration estimates for the Park's water budget.

There has never been a vegetation map made for Everglades National Park even though it is generally recognized that vegetation maps provide one of the most useful "blueprints" for intelligent management of Park and wilderness resources. The proposed map of the Park will provide a basic beginning for the long-overdue inventory of plant resources and their distribution within the Park. Moreover, the map will serve as an excellent basis for the presentation and orientation of information about the Park to both the public and National Park Service personnel. In addition, the information collected for and presented

on the map will be especially helpful in management decisions, such as what areas to clear with prescribed burns, where to best direct surface water, what areas need resource investigation and where to best place educational and recreational facilities.

Soils and topographic mapping

Soils throughout much of the Park have not been classified other than in very broad categories. There is reason to suspect that deposits of organic soil in the interior of the Park have been reduced considerably by fire since the last available soil survey in the 1940's. Correlation of certain botanical conditions is suspected but has not been verified in the Park, and certainly, is not understood. A systematic description of the Park's soils is needed to aid in the understanding of the impacts of fire, water and soil itself on the vegetation of the Park. Development of an accurate soils map for the Park is an expensive and time-consuming undertaking and involves the type of undertaking most likely to suffer the earliest mortality when budget cuts are made to bring proposed studies into line with available research dollars. At the same time, the information obtained from such a soils map is of sufficient importance that we can no longer afford not to begin accumulation of this most basic information about the Park. Hence a modest budget is proposed

to initiate soil science work in the Park, recognizing that such a soils map will take a number of years to complete if funding remains at the proposed level. It is recommended that priority emphasis be placed on mapping the soils of the Shark River Slough Mosaic since that community will receive the most intensive level of investigation in the proposed research plan.

Another important piece of baseline information about the Park which is missing is an accurate topographic map with contours delineating ground elevations within one-half foot. Such a map is needed to make possible a much needed revision of the drainage pattern maps of the Park, facilitate quantitative determinations in the other proposed studies, and to aid in understanding hydrologic relationships in the Park. Changes in elevation of 6 to 18 inches can be particularly critical in terms of the influences of terrain on the surrounding area. Like the proposed soil maps, accurate contour mapping is time-consuming and expensive. We are proposing a modest budget to initiate this mapping and propose that efforts be initially concentrated in the Shark River Slough Community Mosaic.

Fire ecology

Fire is one of the major natural forces which has shaped the vegetative communities of the Park. At one

time or another, fire has affected every community of southern Florida, either creating or promoting that community or deterring or erasing its development. Natural lightning-caused fires in the Park have historically been a wet-season phenomenon and constituted surface fires that burned only a small area because of the fire deterring conditions which were usually present. However, as a consequence of drainage and changing land-use patterns in south Florida, the timing and role of fire in the area has changed considerably. Destructive dry-season fires are having an increasingly pronounced effect on sawgrass, hammock and pineland communities in the Park. Fire suppression in certain areas has caused shifts from subclimax communities to climax hardwood hammocks.

In 1974, the Park experienced the second most severe fire season in its history. During that year, 28 wildfires burned 65,812 acres of the Park. Man-caused fires accounted for 95 per cent of the acres burned.

A complete understanding of fire effects on the biotic communities of the Park is a prerequisite to wise fire management practices that will aid in preserving the integrity of the Park. Long term attention must be given to the study of fire effects on all vegetation types where fire plays a role, with emphasis on stand density, composition, and interaction of fire with water and exotic plants. Management-related information, such as the

effects of different levels of fire exclusion (suppression) prescription upon the evolving flora and fauna of the Park, is also needed.

Florida Panther

Though formerly one of the most widely distributed mammals in North America, the panther is now restricted to Florida—its only documented home east of the Mississippi. Current estimates of the population of the panther in Florida vary widely, ranging from about 50 to 300. These estimates were obtained from questionnaires or relatively brief and superficial surveys of particular regions.

Information currently available suggests that the majority of panthers believed to exist in south Florida are thought to reside in either the Park or the Big Cypress. Although considered to be endangered, almost nothing is known about this cat in terms of its ecological requirements concerning food and habitat preferences, home range requirements or its predation impacts on prey species. An opportunity exists for the Park to release a pregnant captive female cat into the Park and to track her with the use of radio-telemetry to determine more about this rare species and its role in Park ecosystems.

Library Search

Library facilities are perhaps one of the best indicators of a quality research organization. The ease

with which an investigator can obtain literature material from his colleagues is an important facet of a successful research program. The library should have in its collection all publications dealing with the Park and should be a member of an interlibrary loan service. A full time information specialist-librarian should assist researchers in obtaining any relevant publications they may need for their work. This individual should also maintain a complete up-to-date bibliography of Park literature.

Not having all that has been written about the Park in a centralized library complicates synthesis of what is known about the Park. The risk and monetary cost of duplicating work, plus the cost of ignorance, is too high not to support an effort to update an annotated bibliography on the Park, compile all of that material, and interpret the literature critically. The 1966 Natural Sciences Research Plan recognized the need for concerted efforts to assure that all published and unpublished literature which may have a bearing on the natural sciences problems in the Park be reviewed and analyzed. Unfortunately, the sources of existent natural science information relative to the Park and its resources have not even been collected in one place, much less scrutinized systematically for clues that will help establish a more complete understanding of the early state of the Park's resources and environmental influences. A determined library search effort can, and will, correct this sad situation.

IMPLEMENTING THE PLAN

Central to the success of this research program is a carefully thought out approach to organizing the personnel involved and the establishment of mechanisms to achieve meaningful integration of knowledge. In this section of the report we propose a number of concepts which we believe can contribute to the ultimate success of this program. We begin with a generalized approach to resolving resource management problems affecting the Park, followed by a short discussion of historical approaches in science to integrating knowledge. Next, recommended integration mechanisms are proposed and a conceptual organization plan designed to improve and strengthen resource management and research is presented. A number of new activities and programs are proposed under this conceptual organization plan. They have been designed in such a way that implementation of individual aspects of the program can proceed independently of adoption of the conceptual organizational plan. It is urged that if a decision is made <u>not</u> to implement the conceptual organization plan itself that the individual components of the plan approved by the Service be implemented as rapidly as possible.

Finally, this section concludes with a discussion of budgetary aspects of the proposed program.

A Generalized Approach

Below we present a simple flow diagram (Figure 4) showing the logical steps that one would follow in trying to resolve management problems that arise at a park like Everglades National Park. Initially the resource manager perceives problems to which he can formulate alternatives for solution. A truly creative resource manager will generate as many alternative solutions as possible since choice is the source of creativity. From a series of alternatives many issues of philosophy and of fact will certainly emerge. These are the crux of a successful program and will require strong selection and scrutiny before any action is taken. At this point the resource manager will require additional inputs from scientists, peers and outsiders. He or they will have to assess existing knowledge and will in some instances probably recommend new research before the creative process may continue. After the research, the integration of knowledge (new and old) becomes the key factor in the management process. Depending on the care taken in this step, plans of varying quality will emerge. To be of acceptable quality, the plan should be rigorous and

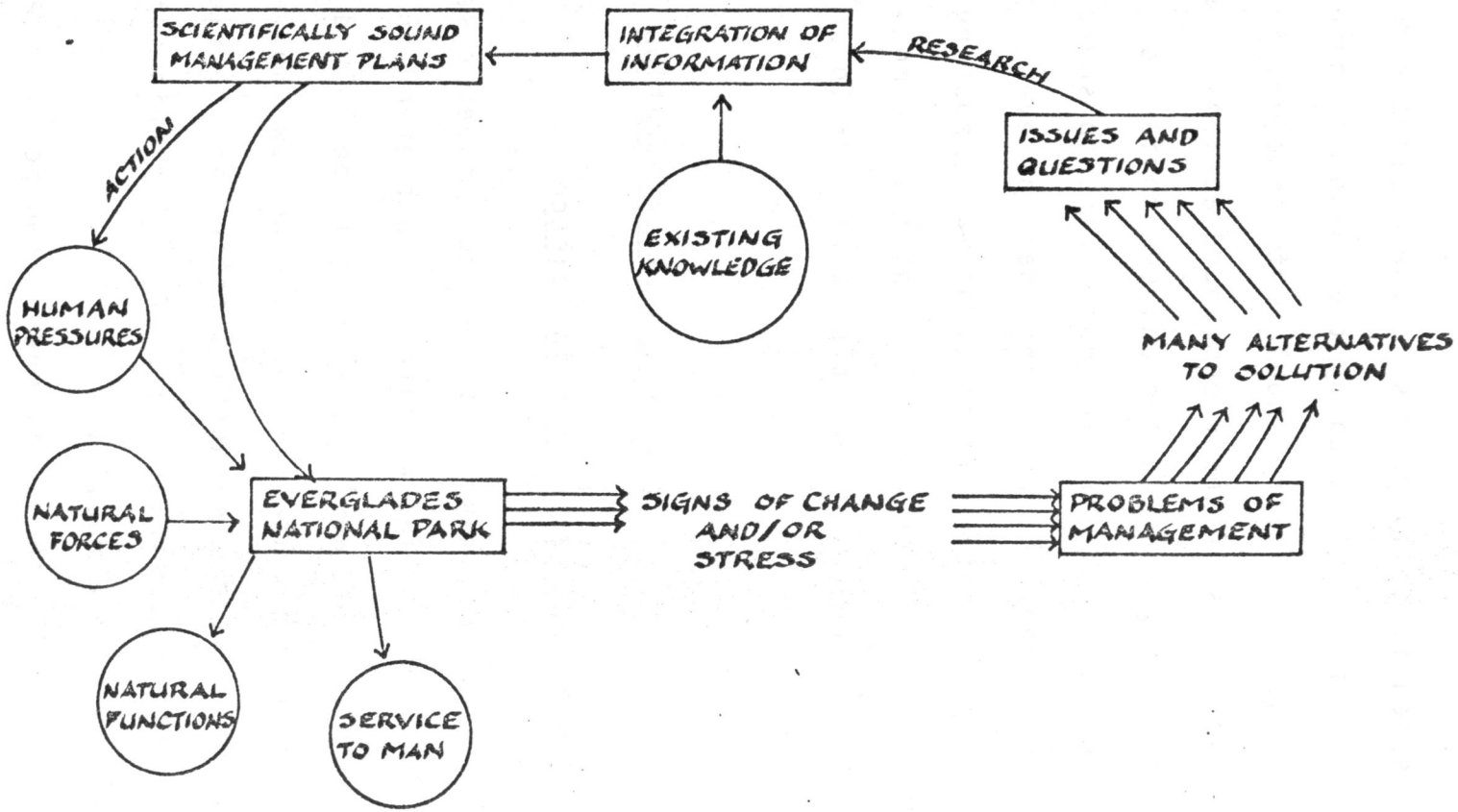


FIGURE 1 A GENERALIZED APPROACH

scientifically precise. The actions recommended in the plan may be limited by technology or monetary resources. These limitations should not, however, invalidate the usefulness of the recommended actions. In the preparation of a mangement plan, compromises of any sort are weak and undesirable substitutes to sound scientific knowledge. Later in the chain of events technological and/or monetary limitations may impose restrictions on the ideal plan necessitating that common sense and the sensitivity of the artist take over to accomplish the mission.

Mechanisms of Integration

Historical Approaches in Science

Assuming that the recommended research plan is implemented and executed to completion in its entirety, one problem would still have to be solved. That would be to integrate all the old and new knowledge into hard and effective managerial action in the field. In this section we explore ways of making this integration of knowledge a reality.

In the past, one or two people were the dominant figures in an organization and it was they, with their vast knowledge of natural history, who made the managerial recommendations. A weakness of this way of doing things

was that one or two people could not amass the breadth of knowledge necessary to manage nature. A swing to specialists-consultants occurred next. A specialist in the field could get to the point of fully understanding one relationship and advising managers what to do. Specialists flourished, but soon this approach also collapsed due to narrow thinking which ignored the complexity of nature. The specialist was replaced by the interdisciplinary team. These teams often failed to make much progress because they never really communicated. Specialization was so strong that interdisciplinary teams were mere collections of specialists working in the same area but with different tools and languages.

Systems modeling was next viewed as the solution to the problem of integration because models could relate the knowledge of specialists, help organize information, identify data groups, aid in data analysis, and reduce all information to one language. The South Florida Environmental Study had a strong modeling component. Two apparent weaknesses of modeling were the gap between the modeler and those gathering data and the degree of sophistication needed in the gathering of information. In addition, the data needed to simulate complicated models are not currently available. The research plan proposed in this report should provide good data which eventually will be amenable to modeling. We recommend

that modeling remain as a strong tool of data analysis and integration. However, we do not visualize modeling as the major thrust at this time in the integration of these proposed studies.

We do recommend that considerable thought be given by the Service to funding an energy systems modeling project to aid in the integration of future research information concerning the Shark River Slough Mosaic. Funds for such a contract have not been included in this proposal. Nevertheless, we believe such a study possesses considerable merit.

Recommended Integration Mechanisms

To achieve meaningful integration of knowledge we recommend a combination of the above historic approaches to science. We believe that specialists are needed to study certain details just as generalists are needed to work on broader subject matters. Our plan has been arranged to recognize these groupings and we recommend that they work in teams in suggested communities and mosaic communities. To further integrate the group research the program has to provide a series of activities in which all investigators participate and discuss issues and research problems. These activities may be in the form of seminars, symposiums, or discussions and should be held frequently. In this way the group will slowly

develop a common language and strong group objectives. In making final decisions of policy or management it needs to be clear to all that the natural ecosystem has the last word over that of our ever-present technology.

One problem of integrating efforts in the past was that technological gadgetry became too important and overruled the common sense of the naturalist. We need that common sense back in science. The difference is that now the naturalist has computers, satellites, and other technological electronic gadgetry at his service to aid in the process of applying his common sense.

Conceptual Organization Plan

In addition to the Generalized Approach discussed in the preceding section of the report a conceptual organizational plan is presented for consideration (Figure 5 and 6). Included in the plan are the following components, each of which will be discussed in the material that follows:

(1) Everglades Scientific Advisory Board

(2) Park Research and Resource Management Policy Group

(3) Annual Everglades Science Symposium

(4) Ecological and Environmental Management Information System

(5) The Park's Library

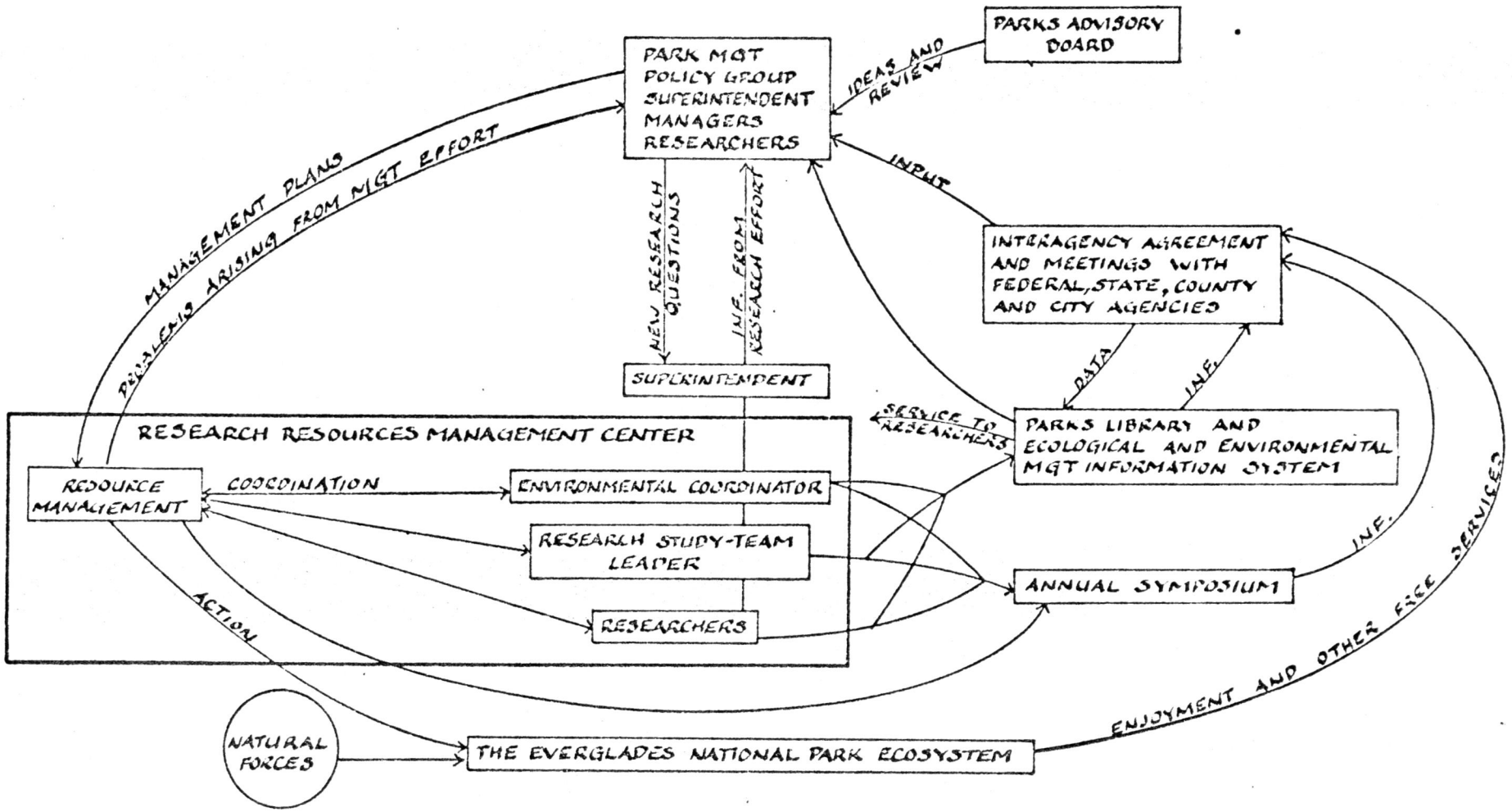


FIGURE 5 CONCEPTUAL ORGANIZATIONAL PLAN

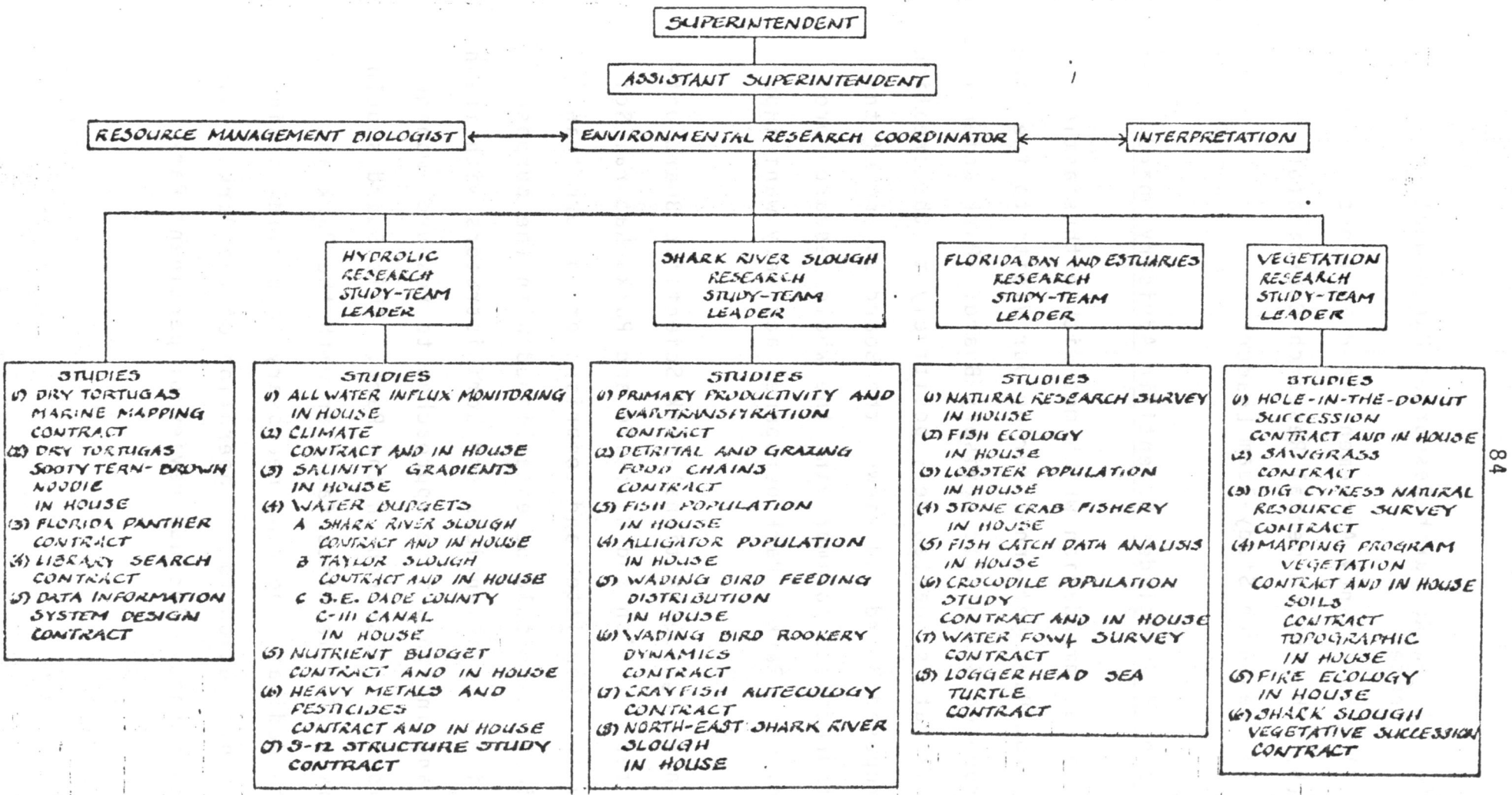


FIGURE 6 PROPOSED CHAIN OF COMMAND AND STUDY ORGANIZATION FOR EVERGLADES NATIONAL PARK RESEARCH PROGRAM

(6) A New Research-Resources Management Center

(7) Interagency Agreements and Meetings

(8) The Environmental Research Coordinator

(9) Research Study-Team Leaders

Proposed Everglades Scientific Advisory Board

One recommendation which met with enthusiastic response from Park personnel during our visits to the Park is the proposed Scientific Advisory Board. Park scientists and administrators reacted very positively to the creation of the proposed Board and viewed the Board as one of the pivotal ingredients to improving the whole research program within the Park. Park personnel actively want input from such a Board.

An Everglades National Park Scientific Board patterned after the Fish and Wildlife and Parks Natural Sciences Advisory Committee and comprised of no more than seven scientists should be established with the purpose of providing Park scientists and administrators with fresh thinking and insights into approaches to resource management actions and research in the Park. This Board should be comprised of scientists familiar with the Park and willing to dedicate the time necessary to provide a significant contribution to the operation of the Park. This contribution should include review of pertinent Park

documents, critique of proposed and ongoing research activities in the Park, suggestion of meaningful research and/or management objectives, expert advice in their area of specialty, on-site review of research in progress, etc. This Board should be utilized to guide the Park's research and resource-management programs as well as Park policies affecting the resource.

Such a Board will need to be firmly structured rather than casually, at least in its on-paper arrangements. It is recommended that the Board meet semiannually the first year of its existence and thereafter once a year in October. Board meetings should consist of a three-day activity during which the Board visits research sites within the Park, interviews Park personnel and identified areas of concern for the Board. It is recommended that Board members not be paid beyond their expenses and that two members of the Board be retired and replaced every three years. A chairman should be appointed to run the Board. National Park employees should not serve on the Board but should be available to serve the Board as it executes its responsibilities. It is recommended that an annual report of the findings and recommendations of the Board be prepared within 30 days following the annual October meeting and submitted to the Fish and Wildlife and Parks Natural Sciences Advisory Committee, the NPS Directorate, the Chief Scientist,

NPS, and the Park Superintendent. Submission of the report to the Fish and Wildlife and Parks Natural Sciences Advisory Committee will help that body carry out its responsibilities relating to natural sciences in the parks and provide an important feedback to them concerning research activities within the National Park System.

The advantages of creating such a Board are numerous. Infusion of new ideas into the Park concerning research and resource management programs is perhaps the greatest spin-off. Another is that opportunities for research on the Park's resource problems will receive wider circulation and interest with the possible further benefit of added research being undertaken in the Park by researchers funded by institutions or other outside sources. A third important advantage is that an interdisciplinary Board can help direct Park thinking towards whole-systems synthesis of research efforts.

There exists no shortage of capable scientists who would qualify for membership to the Board. Important will be that the Board represent a broad interdisciplinary group and be fairly balanced in terms of the points of view represented and the functions to be performed. Also important will be the establishment of appropriate provisions to assure that the advice and recommendations of the Board will not be inappropriately influenced by the appointing

authority or by any special interest, but instead will represent the Board's independent judgment. It is strongly suggested that not more than three members of the Board should be conducting contract research in the Park during their tenure on the Board.

A preliminary listing of candidate Board members compiled from nominations by Park scientists and others in the academic community knowledgeable in the subject follows:

Scientist	General Area of Specialization	Affiliation
Dr. Taylor Alexander	Everglades Veg.	University of Miami
Dr. Archie Carr	Natural History & Zoology	University of Florida
Dr. Frank Craighead	Botany	Park Collabrator
Dr. George Cornwell	Wildlife Ecology	EcoImpact, Inc.
Dr. Jack Ewel	Tropical Ecology	University of Florida
Dr. Bob Ginsburg	Geology	Rosentiel Laboratory University of Miami
Dr. Bob Harriss	Oceanography	Florida State University
Dr. Jim Layne	Mammals	Archbold Research Station
Dr. Roy MacDiarmid	Mammals	University of South Florida
Dr. O. T. Owire	Ornithology	University of Miami
Dr. Dick Robins	Coastal Marine Fisheries	Rosentiel Laboratory University of Miami
Dr. Joe Simon	Marine Invertebrates	University of South Florida

Scientist	General Area of Specialization	Affiliation
Mr. Dale Wade	Fire Ecology	Research Forester U.S.F.S.
Dr. Glen Woolfenden	Ornithology	University of South Florida

A high priority issue for this Board, when constituted, concerns the Park's policy for the control of exotic plants. National Park Service policy for exotic plants according to the NPS Administrative Policy for Natural areas states, "Non-native species may not be introduced into natural areas. Where they have become established or threaten invasion of a natural area, an appropriate management plan should be developed to control them, where feasible." Park personnel recognize that because of the tremendous abundance of exotic plants within the Park, it will be impossible to completely control the major exotic plants within the Park. Current management goals within the Park are directed at maintaining a holding action against invasion at as many areas as possible. Serious questions concerning the appropriateness of this goal exist, particularly in terms of the dollar costs of fighting a "holding action." Scientistsknowledgeable in the exotic plant problems of south Florida can provide valuable guidance to Park management personnel concerning this issue. As suggested under the

section of the report dealing with Invasion of Exotics, changes in our attitudes towards exotic plant species in the changing south Florida ecosystem may be in order. Of particular importance for this group is a review of on-going research and resource management programs within the Hole-in-the-Donut. As discussed elsewhere in this report, the invasion of exotics into the abandoned farmlands that comprise the Hole-in-the-Donut constitutes a serious issue affecting the recovery program for the area.

Should a decision be made not to appoint a permanent advisory board for the Park, an alternative which is suggested is the constitution of a peer review panel by the Regional Scientist to overview proposed research prior to actual award of contracts or initiation of research. Such peer review is considered primary to the success of the proposed plan.

Proposed Park Research and Resource Management Policy Group

To aid the Superintendent in the development of Park resource policies, we suggest the creation of a Park Research and Resource Management Policy Group. It is suggested that the group be composed of the Park superintendent and representatives from resource management and research. This group should be utilized to steer the policy that guides research and resource management in the Park. Sources of information

to the group are: the Park's Scientific Advisory Board, the public, information stored in the Park's library or that which is generated from the research effort, and information from regional and Washington level offices. This group should, in turn, advise the Region and Washington concerning recommended Park policy, and establish plans and priorities for research and management programs in the Park.

Annual Everglades Science Symposium

A recommendation we believe contains strong merit is the establishment of an annual Everglades Science Symposium. Such a symposium should be of great value to Park scientists and the public. Once a year researchers should have an opportunity to share their knowledge and research progress with the public and other scientists who, in return, should benefit from the experience while contributing with their points of view and questions. The symposium should not impose a budgetary cost other than the announcements. A registration fee should cover costs of printing symposium proceedings. People interested in the Park will come at their own expense. The symposium should deal with research related to the environment of south Florida and should have as a theme the presentation of papers that add to our understanding of the south Florida ecosystem. It is emphasized that proceedings should be published annually to facilitate the dissemination of knowledge about south Florida to all interested parties.

Ecological and Environmental Management Information System

One of the truly high priority items necessary to improve the research and resource management programs of the Park is an effective Ecological and Environmental Management Information System to serve the Park. We cannot overstress the urgent need for this sytem. Extensive accumulations of hydrological, meteorological, fire ecology, fisheries, and animal populations data remain untabulated and decentralized. These data are in many cases in jeopardy of being lost or unevaluated upon the retirement or transfer of those who collected the data. Considerable monies and time were spent and will be spent upon data collections for the purposes of understanding and managing the natural resources of the Park. All of these data must be centralized in a computer data retrieval system, so that the complete and rapid retrieval of pertinent information about the Park is available to those that need that information now and in the future. Moreover, only when the environmental data have been centralized can important integration and analysis proceed to form a truly workable hypothesis of the dynamic functions of the Park's ecosystem and how that system can best be managed for maximum benefit to the environment and the Park visitor.

Specific types of data which exist in the Park and are believed suitable for inclusion in the information system include:

(1) hydrologic data for south Florida
(2) fire history data
(3) fisheries data
(4) library data
(5) climatological data
(6) vegetation data
(7) geological data
(8) bird population data

A recent study of the top priority information needs of the Park, made by the Office of Computing Activities of the University of Georgia for the National Park Service, revealed the following:

1. Hydrologic data - there are some 30 stations in and near the Park for which records possibly exist as far back as 1940. The data are of three types - water level, water discharge, and water quality. Most of the data is collected by the USGS and then published in yearly reports. Park researchers have, in the past, attempted to extract what they needed from the USGS publications. However there is difficulty in obtaining data in machine-readable form from the USGS because of costs, software

problems in the USGS system and administrative "red tape."

If the Park Service is unable to obtain the required hydrologic information in machine-readable form and desires to prepare the data in such a form, it is estimated that a maximum of 1365 hours would be required merely to enter the data. This figure was arrived at by assuming the full set of data exists for the past 35 years. Approximately 1 hour would be required to enter water level and water discharge data for each of the 30 stations for a single year. Thus, some 30 hours would be utilized for entering these data for each year and as there are 35 years, this results in about 1050 hours. Add to this an estimated 315 hours for entering water quality data (determined by assuming 9 hours for entering data for one year and using records for 35 years) and one gets a total of 1365 hours. Again, this figure is a maximum as it assumes a full set of data. A more detailed assessment of data available would result in a more accurate, and perhaps somewhat smaller, figure.

2. Fire History Data - Some work had been done towards formulating fire history data for entry into a machine-readable form. There are over 30 different pages of reports and records used in connection with

fire history data. The data go back to 1947 and cover some 300 fires. It is not clear at this time how much of the 30 different forms should be placed in machine-readable form. It is estimated that about 4 to 8 hours would be required for data entry of materials concerning one fire. Thus, it is estimated that some 1200 to 2400 hours would be required for complete data entry of fire history data.

3. Fisheries - the past commercial and sports fisheries data are in machine-readable form and need no further data entry effort. New data for species diversity, etc., would require data entry, but the sample sizes are not large (about 12/month for 2 years) and would require relatively little time.

Data entry is only one aspect of an information system. Other equally important and necessary tasks include system planning and management, programming, output processing, and preparation of system aids (e.g., thesaui and procedure manuals). No detailed estimates of costs of an information system can be made until appropriate decision have been made concerning the design and scope of the system and detailed specifications have been made.

The predominant role of a resources management information system for the Park would be to fill a very sizeable gap in available information, rather than to displace existing (manual) processes. Thus, one can reasonably expect the new capabilities to require appropriate levels

of resource support. One way to keep this support to a minimum, however, would be to take advantage of existing systems and capabilities where possible, such as the computerized water data system of the USGS.

The University of Georgia concluded that an information specialist, a systems analyst, a statistician, a programmer, a keypunch operator, and appropriate subject matter specialist(s) would be needed as a minimum to develop an environmental management information system. This task is believed accomplishable by contract.

We are recommending that an immediate contract be let from this year's Reserve Fund Account to conduct a detailed analysis of the specific type of system that should be developed for the Park so that implementation of the system can proceed during the next fiscal year. This contract is estimated to cost $30,000. In addition, the proposed FY 77 budget for research contains positions and funds for a data analyst and a keypunch technician.

Before leaving the subject of the proposed Ecological and Environmental Management Information System, we feel compelled to voice our strong feelings that the ultimate system implemented must be directly utilizable by the lowest common denominators within the Park. We do <u>not</u> envision an advanced ADP system that only a specialist can operate and extract information from. The system must

be directly usable by all. Also, we suggest that entering backlogged data into the system be done according to its priority and need by Park researchers and managers.

The Library

We propose a greater role for the Park's library. The present library contains the following holdings:

- -4,500 to 5,000 books
- -approximately 75 periodical titles
- -documents and pamphlets (10,000 est.)
- -approximately 6,500 35mm slides (subject catalogued)
- -photofile (pending cataloging)
- -study (specimen) collection

Library of Congress classification is utilized in a Union Catalog for the book holdings with local descriptors used for documents and slides. This library should contain all Park-related literature and serve as a communication center with the public, the management policy group, researchers and naturalists. All pertinent documents should flow into this library and it in return should be prompt to serve its users.

Recommended elsewhere in this report are such things as a library search contract to aid in locating important documents and publications relating to the Park and to pay for obtaining copies of those documents for the Park library. Particular emphasis must be placed on locating unpublished data currently in the files of many different agencies and investigators who over the years have studied the Park. If possible a Park Archives should be established for such important works as the recently completed studies of Dr. Taylor Alexander. Also suggested elsewhere in this report is that a data-information specialist be employed as a permanent position to direct the Ecological and Environmental Management Information System. It is here suggested that the data-information specialist have a library science background as well, if possible, and be responsible for maintaining the Library.

In relation to our recommendations discussed next concerning moving the library and all research and resource management personnel to the proposed new center at the Iorni Buildings, thought should be given to keeping a minimal "popular library" of general interest books at Park headquarters to serve the public and Park personnel in need of general information.

A New Research-Resources Management Center for the Park

In reviewing the pertinent files on the Everglades Science Program a number of issues relating to organizational structure and new facilities were identified which in our judgement warrant discussion. They include:

(1) possible duplication of effort by four distinct functional divisions in the Park (water resources, natural science, interpretation, and resource management) and the extent to which such an organization leads to inefficiency and is counterproductive. Is reorganization needed, and if so, how?

(2) whether the science program at Everglades should be an in-house program employing all of the scientific expertise one needs to analyze the scientific aspects of specific management problems or whether the Service's scientific input should come primarily from academic institutions, through the cooperative Park study units (CPSU). Directorate administrators have suggested that Park Service Policy should be to use the CPSU approach. Policy aside, is an in-house program justified and needed or is some other combination desirable?

(3) proposals to create a "Caribbean Science Office" in south Florida by construction of a new Life Sciences Center in Everglades National Park projected to cost between $250,000 and $1.5 million depending on whose figures one uses. Also mentioned have been satellite stations at Biscayne National Monument and expansion of District Ranger Stations within the Park to accommodate research personnel. Questions posed in this regard are: should the science program at Everglades National Park remain under the direction of the superintendent and be retained within the Park or should it be centralized and report to either the Chief Scientist, WASO, or to the Regional Director?

With regard to possible duplication of effort of four distinct functional divisions in the Park and the extent to which such an organization leads to inefficiency and is counterproductive, we spent a great deal of time during our program review at the Park discussing this problem with Park personnel. In the context of on-going activities in the Park by these divisions there does not appear to be significant duplication of effort. However, it is our opinion that the present management structure as depicted in Figure 7

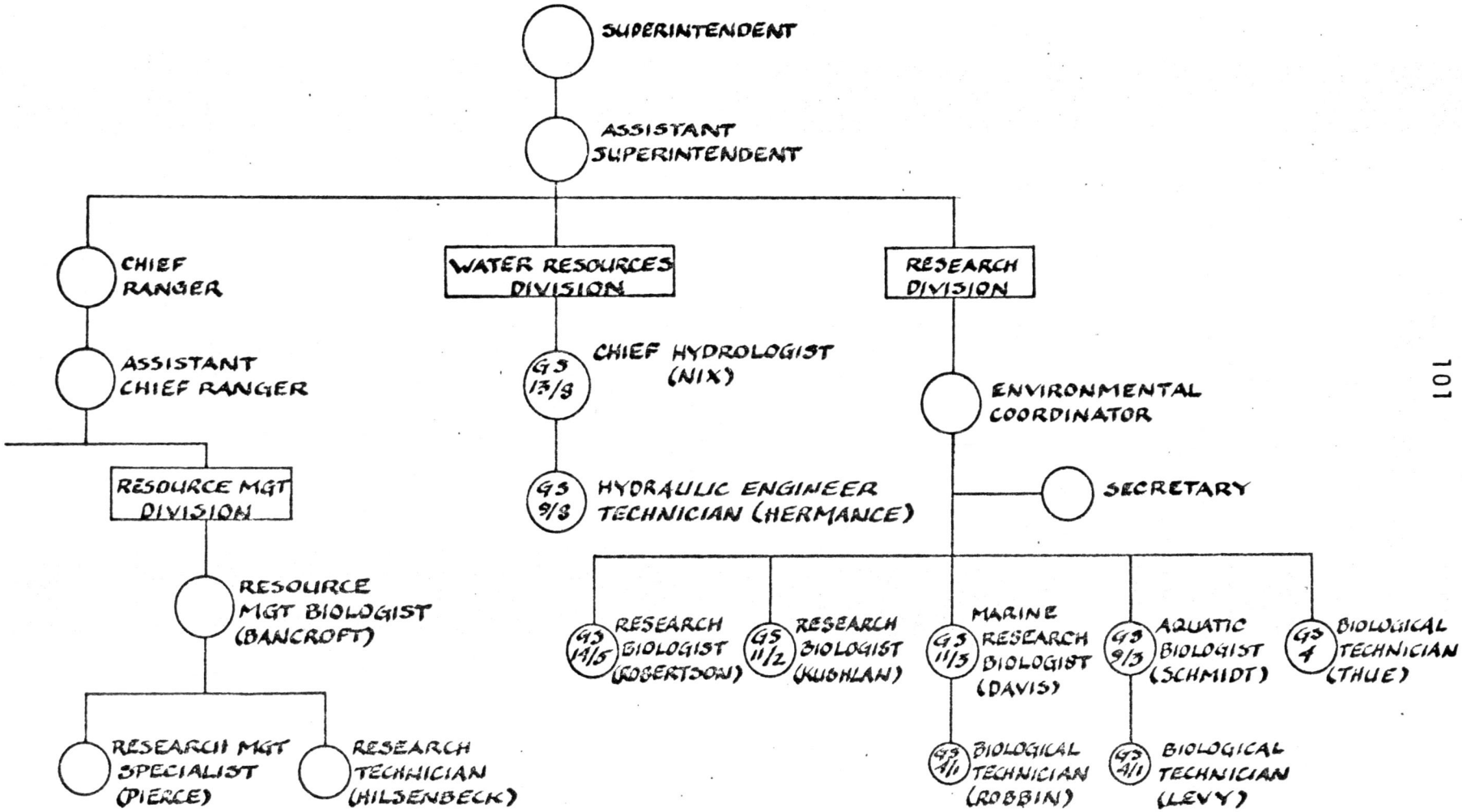
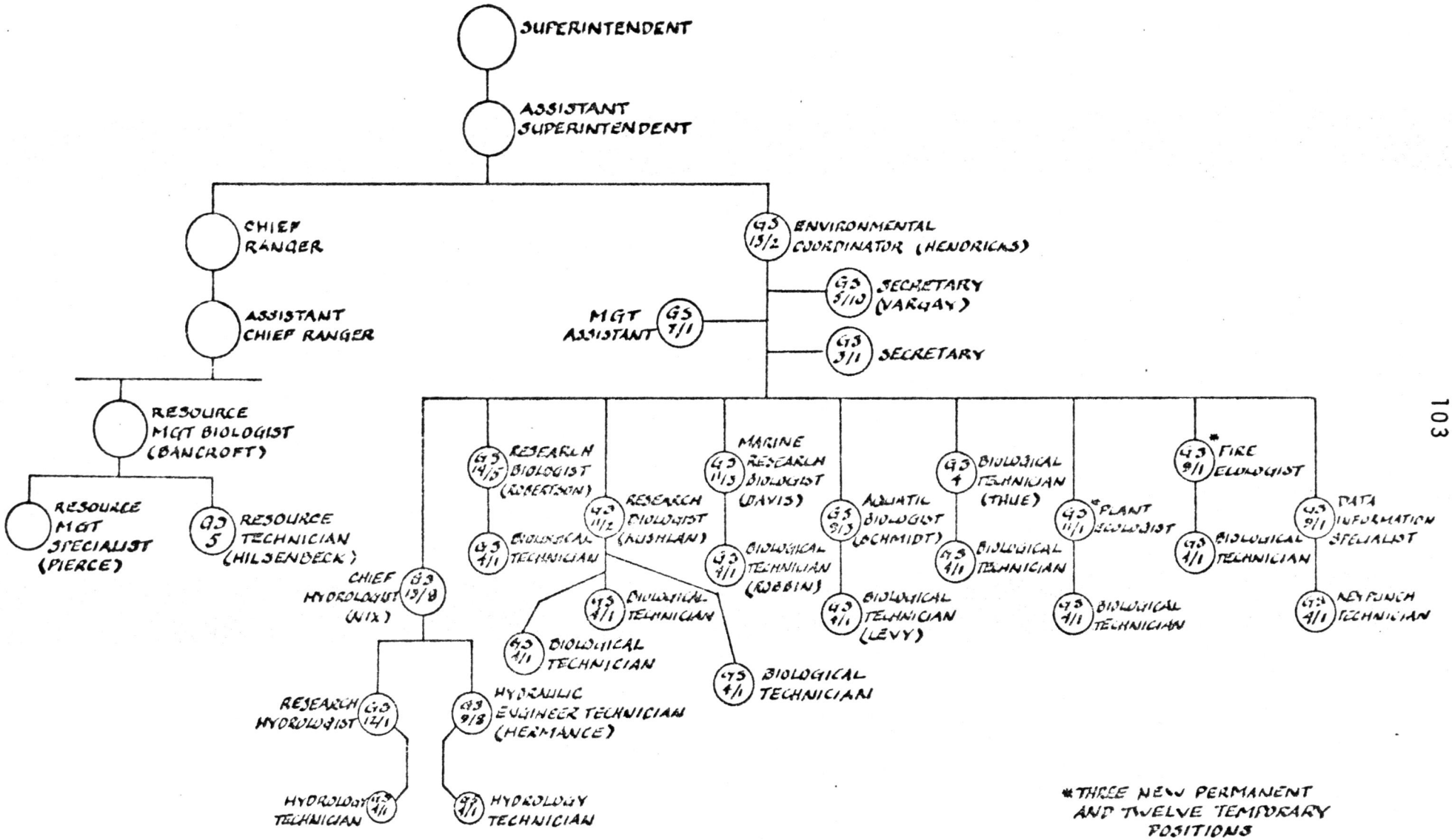


FIGURE 7 EXISTING MANAGEMENT STRUCTURE EVERGLADES NATIONAL PARK

is inefficient and counterproductive. We are particularly critical of the present structure which separates hydrologic programs from the research program. Little or no hydrologic research is currently underway in the Park. Major reliance is placed on water data summaries received monthly under contract from other agencies. Personnel in the Water Resources Division are not being effectively utilized in support of the Research and Resource Management Divisions. Expansion and improvement of water resources investigations with more time being spent in the field gathering data on the dynamics of water within the Park is considered to be a top priority requiring immediate attention. It is our recommendation that the present management structure which divides resource responsibility among resource management, water management, and natural science with each division reporting through various channels as depicted in Figure 7 be revised to create a more logical and efficient operation along the lines suggested by Figure 8. Under this new table of organization the water management functions would be brought directly under the research environmental coordinator who would retain the responsibility for integrating all water management monitoring and water research activities with the rest of the long term research



*THREE NEW PERMANENT AND TWELVE TEMPORARY POSITIONS

FIGURE 8

PROPOSED NEW MANAGEMENT STRUCTURE FOR EVERGLADES NATIONAL PARK

activities in the Park. Such a realignment will insure that the activities of the water management group interface more directly with the needs and priorities of the rest of the research group.

Close examination was made of the relationship between Resource Management and Research and the need for possible reorganization in this area. It was immediately apparent during the program review that the Resource Management Division is well organized and directed. The fire ecology program is exceptionally well organized. Data collected during the burning program will be invaluable in assessing the long term impacts of the Park's fire management program. Unfortunately under the current work load and personnel restrictions, analysis of burn data to determine long term impact is not being made and cannot feasibly be made without adding another position to the staff whose responsibility it is to make such evaluations. In our opinion responsibility for the day to day operation of the controlled burning program should be retained in the Resource Management Division. Consideration should be given to further centralization of the prescribed burning program under Resource Management, As currently operated, the final decision to burn on a given day is the responsibility of the district ranger in the Park and

if that ranger has a higher work priority on a given day, the burning may not get done. As far as the collection of pre- and immediately post-fire data is concerned, these functions should remain with Resource Management. However, it is recommended that responsibility for the evaluation of fire impacts on Park biota be the responsibility of the Research Division, working in close coordination with Resource Management personnel. Because of the importance of fire in shaping and determining succession and change in the Park it is felt that this function will require a new position on the Research staff. This view was concurred in by both research and resource management staffs.

With regard to retaining the science program at Everglades National Park as an in-house program versus obtaining scientific input from academic institutions through Cooperative Park Study Units (CPSU), the research needs at Everglades are such as to require a combination of both a strong in-house program for long term research studies and the utilization of academic institutions and other agencies for studies more amenable to short term contract (1-3 years). Academic institutions can play an important supporting role in fulfilling the research needs of the Park; however, the complexity of the Park's ecosystem, the nature of changes affecting that ecosystem, and the need for energetic

in-house long term assessment of what is happening to the Park all strongly argue for an augmented in-house research effort at the Park. Outsiders should be contracted by the Park to reinforce their own programs where obvious gaps develop. This view was concurred in by Everglades Park personnel interviewed during our program review.

An innovative approach to augmenting in-house scientific expertise has been proposed by the Chief Scientist and is believed to have considerable merit and a place in the research program at Everglades. This is the concept of utilizing university scientists in the Park under Schedule A appointments within the National Park Service. There is a real opportunity to reduce research overhead costs normally assessed by universities by utilizing this approach. We recommend that this approach be fully explored in the implementation of the proposed research program.

Finally, with regard to whether the science program at Everglades should remain under the direction of the Superintendent and be retained within the Park or be centralized and report to the Regional Director, it became apparent early in our program review that this subject constituted a veritable minefield of conflicting opinions which go to the heart of National Park Service policy concerning the organization and administration of research.

As it now stands, Everglades National Park is the only park in the Southeast Region which retains control of its own science-research budget. The Regional Office manages the research budget for all other parks within the Region. We do not propose to attempt to navigate a path through this minefield except to note that in our view day-to-day operational support of the research effort must come from other divisions within Everglades National Park. This is especially true in relation to Resource Management functions. The Superintendent is the individual best suited to insure such operational support is available to researchers when needed. It is also apparent that research recommendations relating to Park management can best be integrated at the Park level with all divisions operating as a team under the leadership of the Superintendent. Settlement of this issue must be achieved soon if the proposed program is to succeed. We therefore recommend that the Director, Regional Director, Chief Scientist and Superintendent confer and resolve this matter as rapidly as possible.

Concerning the issue of creating a "Caribbean Science Office," located either at the Park or in the Miami area, we seriously question whether this constitutes the highest funding priority in relation to the research program at the Park. All personnel interviewed in the

Park concurred with the critical need for a centrally Park-located life sciences complex to house the research-resources management operations, a technical library, reference collection, laboratory facilities, other work and study space and equipment storage areas. It was felt at all management levels within the Park, however, that if such a facility was to be obtained it should be developed within the Park rather than outside the Park. Serious concern was expressed by all Park personnel interviewed that location of the facility elsewhere (such as the University of Miami or elsewhere outside the Park) would result in a further dilution of the Park's research program and lead to increased problems of coordination and integration of effort, a viewpoint with which we concur.

While there may be a justifiable need of extending research coverage to other south Florida National Park Service areas such as Biscayne National Monument (as well as to other areas such as Virgin Island National Park, Buck Island Reef National Park, Canaveral National Seashore, and San Juan National Historic Site) such justification has not been forthcoming at this time in our program view. The office of the Chief Scientist, for example, concedes that no detailed analysis of the research needs and priorities of these other areas has

yet been made that would justify such a consolidation. This is not to say that these areas do not in fact have real research needs but rather is to say that the case has yet to have been made.

It is recommended that the "Caribbean Science Office" not be created at this time pending further review and justification, including examination of the potential dilution of the research program within the Park. We do, however, strongly support the need for additional research-resources management space at the Park, particularly if the research staff is augmented as proposed elsewhere in this report.

Park personnel were unanimous in the view that additional space was secondary in priority to obtaining the minimal funds and personnel necessary to physically conduct the needed research.

Implementation of the proposed research plan will aggravate already crowded conditions at the Park headquarters through the addition of personnel to the research staff and increased interaction with proposed contract researchers. During our program review several alternatives to provided needed space were examined including: (1) construction of a new life sciences building at the Park; (2) leasing space from the University of Miami on the campus; and (3) better utilization of existing space within the Park. In our view existing

space within the Park that can be made suitable for the research-resource management space needs is available and constitutes the preferred option when viewed in the context of Park Service fiscal constraints. It is recommended that the YCC Camp program which employs some 50 youths for two to three months each summer at the Park and utilizes the Iorni Buildings within the Park be relocated to a different location (such as tent camps near the Boy Scout facility) and that the Iorni Buildings be refurbished at a cost not to exceed $75,000 to house the research and resources management programs and the library. The buildings are currently idle the remaining 9 months of the year. Containing an estimated 7,240 square feet, more than ample space exists in the main building to house research and resource management personnel, library, conference room, laboratory reference collection, study space and equipment storage areas (Figure 9). Minimal laboratory sinks and tables are already present in the building, left over from earlier utilization of the facility by the University of Miami. The building already has such things as wall unit air conditioners, a new roof, and partitioned areas in one wing which could readily be converted into offices. The adjacent storage building needs a new roof. The existing building has no telephone lines and it will be necessary to arrange for telephone service. The

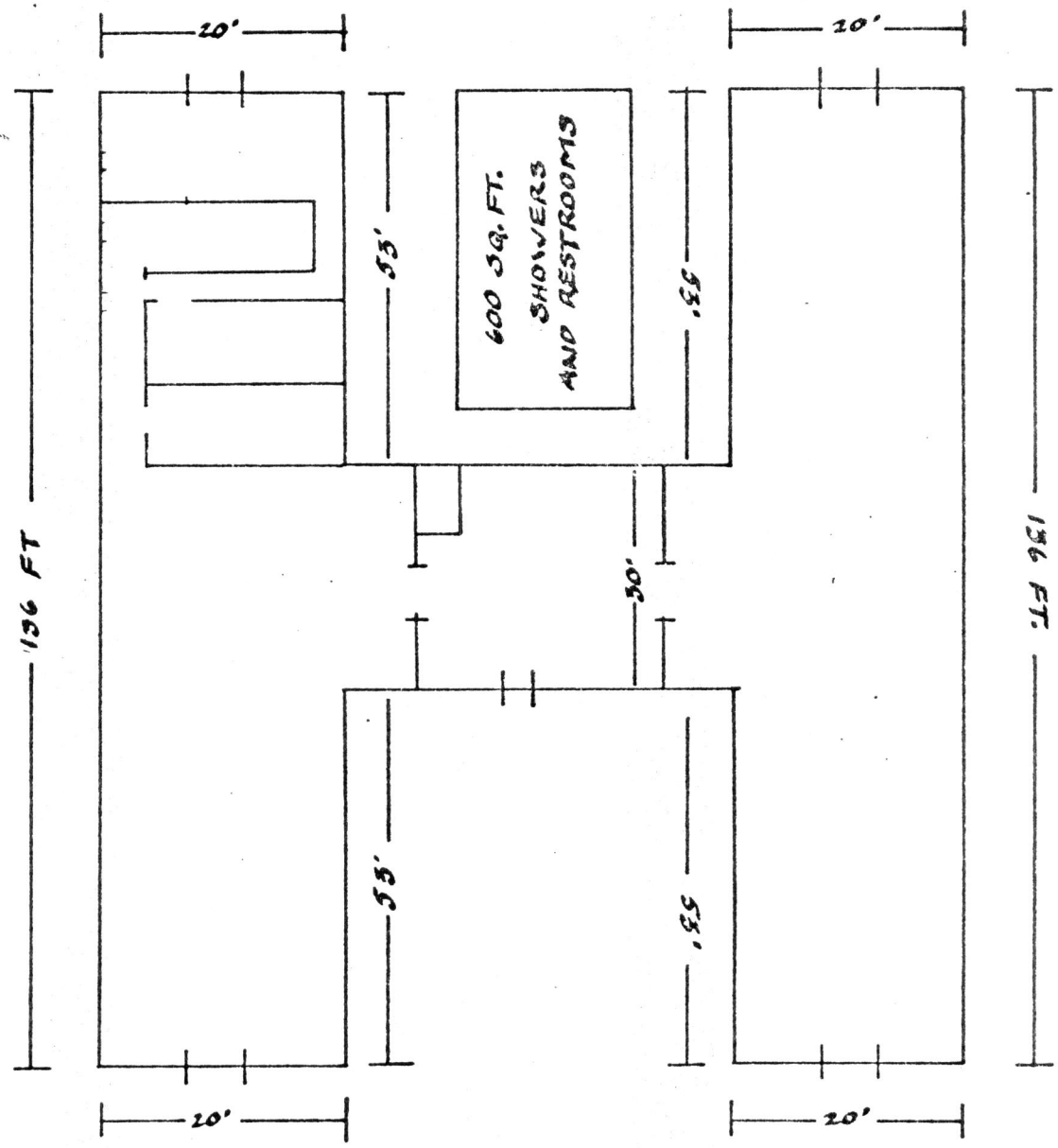


FIGURE 9 GENERALIZED FLOOR PLAN MAIN IORNI BUILDING
EVERGLADES NATIONAL PARK

availability of trunk lines servicing the nearby missile base facilities should be investigated. If none are available, there will be an added expense of providing at least three lines to the facility (an expense which may cost up to $15,000). Also, although the building presently contains air conditioning, the existing service may be inadequate for the buidling size, hence, the need for augmented air conditioning facilities requires further investigation. Provision for routine maintenance and clean-up must be made. It has also been noted that in low areas adjacent to the Iorni Buildings, water tends to stand during the wet season, hence possibly necessitating a limited amount of fill in the vicinity of the building to provide suitable parking facilities, etc.

It is our understanding that the FY 76 Service budget just approved by the Congress contains a $180,000 line item for planning the proposed new research center for Everglades National Park. It is our recommendation that this money be reprogrammed to cover the costs of rehabilitating and furnishing the Iorni Building. With prompt attention the building could be ready for occupancy by mid summer.

The single, strongest criticism against using the Iorni Buildings is that personnel will be physically isolated from Park headquarters as the buildings are approximately 4 miles from headquarters. However this problem is of less concern when viewed in the larger context of space needs and potential program integration achieved by housing research and resource-management personnel together in a central building. Isolation from Park headquarters can be overcome by better utilization of telephones and scheduled meetings as necessary.

In terms of long term thinking, the Missile Base facilities which are near the Iorni Buildings will likely become surplus and available to the Park to house Park personnel. There is general agreement that the missile facilities at the Park will be militarily obsolescent within 10 years if not already so and the military can reasonably be expected to vacate the facility if requested to do so by the Park Service.

A completely new building, while attractive, is not justified when considered in the context of total research needs and priorities. In terms of costs the new building would be prohibitively expensive. The concept of leasing space at the University of Miami is not recommended due to our strong belief that the research program

needs to physically remain in the Park to provide the maximum contribution in meeting the Park's research-related needs.

Given fiscal constraints in the Service at the present time, it is not recommended that the Service undertake expansion of existing district ranger stations at Flamingo, Tamiami, Key Largo, and Ft. Jefferson at an approximate cost of $375,000. However, due to lack of facilities along the Park's west side, considerable thought should be given to expanding the station at Everglades City.

Cooperative Interagency Agreements and Meetings

A major problem which exists in the Park at this time is that no formal mechanisms of communication exist between the Park and two agencies which have an important impact on what happens to the Park: the Central and South Florida Flood Control District and the Jacksonville District of the Corps of Engineers. Meetings between Park researchers and representatives of these agencies are occasional at best and no exchange of research information collected by the three agencies takes place with the exception of limited hydrological data. This is a situation which must be corrected immediately. The fate of the Park rests, to a large extent, in the hands of those two

agencies and improved communication is considered a must. It is therefore recommended that formal memoranda of agreement be negotiated with both agencies for exchange with the Service of water and biological data on a monthly basis and that a formal meeting be convened quarterly with appropriate research and resource management personnel in all three agencies for face-to-face discussion concerning on-going agency programs, proposed activities and mutual problems. This quarterly meeting should be tightly adhered to and not allowed to lapse due to lack of interest or the press of other business.

It is believed that many inroads to the Park's problems can be achieved through frank and open interaction with these agencies as they become more aware of Park needs and problems. Active participation in the hot-spot studies by these agencies should be solicited by the Service to share the research burden and improve understanding of our concerns about these areas.

Environmental Research Coordinator

With the implementation of the proposed research plan the responsibilities and work load of the Environmental Research Coordinator will increase significantly, doubling or tripling his current workload. Since a considerable portion of the proposed studies is designed as

contract studies with outside agencies, institutions and individuals it will be extremely important that the Environmental Research Coordinator be adequately supported with personnel and an organizational structure that will allow proper supervision of contract research. Particular care must be exercised in the early stages of contract preparation to insure that research objectives, methods, and responsibilities are properly spelled out so that contractors know what is expected from them in the execution of their contracts. Under our proposed plan, the Environmental Research Coordinator would remain as the supervisor of all research activities in the Park. Hopefully, his input under this arrangement to various programs will be more effective than might otherwise be the case when his workload increases. Thus, two mechanims to support the Environmental Coordinator are proposed: (1) supplemental support staff; and (2) development of research study-team leaders to direct on a day-to-day basis important segments of the overall research program. To assist the Environmental Research Coordinator, funds to employ, under temporary personnel ceiling categories, a research-coordinator management assistant and a secretary-typist to assist the Coordinator and provide for the typing needs of the overall program have been included in the budget. The second approach, designation of research study-team

leaders to direct day-to-day research is discussed next.

Research Study-Team Leaders

The use of staff scientists as Research Study-team leaders and principle investigators for major portions of the proposed research is recommended. This should result in better research coordination and ensure that research objectives are fulfilled. Four such team leaders are visualized as shown in Figure 6: one to direct all water-related studies, another to oversee the Shark River Slough Mosaic Studies, a third to supervise the Florida Bay and Estuaries Mosaic Studies and the fourth to direct the Hole-in-the-Donut, Big Cypress, Mapping, Sawgrass, and Fire Ecology studies. These team leaders are visualized as day-to-day participants in the research projects they supervise. Suggested groupings of related studies for each team leader to supervise are indicated in Figure 6.

BUDGETS

Existing Programs

The Everglades research staff, including the water resources division consists of nine full-time permanent and two temporary part-time support positions. A research hydrologist was recently added to the organization table, but this position remains unfunded and vacant.

Research

Position	Incumbent	Grade	Permanent or Temporary
Research Biologist	Robertson	GS 14	Permanent
Research Biologist (Coordinator)	Hendrix	Gs 13	Permanent
Research Biologist	Kushlam	GS 11	Permanent
Aquatic Biologist	Schmidt	GS 09	Permanent
Marine Research Biologist	Davis	GS 11	Permanent
Research Hydrologist	Vacant	GS 12/13	Permanent
Clerk-DMT	Vargay	GS 05	Permanent
Biological Technician (Fisheries)	Thue	GS 04	Career Cond. Temp.
Biological Technician	Levy	GS 04	Temporary
Biological Aid	Robbin	GS 04	Temporary
Hydraulic Engineer (Water Resources)	Nix	GS 13	Permanent
Hydraulic Engineer Technician (Water Resources)	Hermance	GS 09	Permanent

The base research budget is $165,000 of which $144,000 is for personnel services, including amortization and miscellaneous costs, leaving a total of approximately $18,000 for operational support of all ongoing research projects.

Water Resources

There are two water resource positions on the superintendent's immediate staff, one is occupied by a Hydraulic Engineer and the other by an engineer technician. In the past their efforts have been described as paralleling and supporting those of the Research-Resources Management units. Funds in the amount of $104,000; approximately $46,900 personnel costs, $3,200 support costs and $54,000 for Contractual monitoring to the USGS, are provided through water resources for acquisition of basic hydrologic data.

Resources Management

The Resources Management team, organizationally located in the Ranger Division, is composed of two full-time permanent positions (one recently acquired), and seven career Seasonal Supporting Staff who perform some of the research data gathering functions independent of the science staff. In the past, the resource management team has had the responsibility of monitoring the short and long-term

effects of their programs (e.g. controlled burning and Hole-In-the-Donut reclamation activities), hence they have, in theory, been performing their own independent research functions.

The information concerning the present (FY 76) and proposed (FY 77) budgets was prepared at our request by the Park. Table 2 summarizes the present budget while Tables 3 and 4 indicate the proposed budget for FY 77 and the list of studies recommended to be conducted in-house. Figure 6 shows all proposed studies in this research plan and total budget costs for the plan are shown in Table 1.

Proposed Budget

The proposed research program has been segregated into two budget categories (I and II) to reflect our assessment of relative priorities within the proposed plan. Category I constitutes the recommended program. However, if budgetary constraints necessitate reduction in the proposed program we have identified in the Category II group, the studies considered be of lower priority. Category I studies and associated budgets are shown in Table I. Category II studies are shown in the same table by the placement of an asterisk to the right of the budget column. The Category I proposed budget is an expensive one in relation to current research expenditures in the Park, calling for

Table 2

Present Research Budget: FY 76

Items:				
Rents, amortization, shop, and aircraft deducted before base is alloted.				
Base ($\bar{c}$ 5% Pay Increase as of October) = $159,300 + 5,900				= $165,200
Resource Management Coordination:				
94% Personnel costs	GS 13/1	Hendrix Perm	$24,960	
	GS 5/10	Vargay Perm	12,985	
			37,945	
6% Support costs			2,639	sub total $40,584
Sooty Tern Studies $11,574				
Southern Bald Eagle Studies 11,573				
Great White Heron Studies 11,573				
96% Personnel Costs	GS 14/5	Robertson Perm	$33,415	
4% Support costs			1,305	
				$ 34,720
Visitor Impacts on Coral Reefs $ 4,050				
Spiny Lobsters Ecology @ FOJE 12,150				
Lobster Population and Fisheries Study 9,950				
Stone Crab Fisheries Study 9,950				
76% Personnel costs	GS 11/3	Davis Perm	18,898	
	GS 4/1	Robbin Temp	8,500	
			27,398	
24% Support costs			8,702	
				$ 36,100

Table 2 continued

Shark Slough Alligator Study	$14,333		
Wading Bird Feeding Distribution	7,167		
86% Personnel costs	GS 11/2 Kushlan Per	18,385	
14% Support costs		3,115	
			$ 21,500
Florida Bay Benthic Map	$1,615		
Water Quality Analysis of Florida Bay	4,844		
Florida Bay Fisheries Research Project	16,148		
Sport Fisheries and Commercial Fishery Study	9,689		
94% Personnel costs	GS 9/3 Schmidt Perm	$16,237	
	GS 4/1 Thue Temp (career cond.)	8,781	
	GS 4/1 Levy Temp	5,305	
		30,323	
6% Support costs		1,973	
			$ 32,296
	TOTAL		$165,200

Personnel Costs:

These figures are computed from salary tables plus 10% for permanent positions and 6% for temporary positions. Such items as hazardous duty pay, Sunday differential, uniform allowance, and overtime have not been included in the figure, but are considered as part of support costs.

Budget Changes:

During the year there have been several budgetary changes affecting both the base budget and current support funds. Early

Table 2 continued

in the year, $600 was deducted from the base budget as part of a Park-wide assessment to region. This assessment brought the base to the level of $159,300. In October (pay period 9) the 5% increase went into effect. Although the money has not arrived, the division was directed to add $5,900 to its base in anticipation of its arrival. That brings the division base to its present level of $165,200. In January, the division received $15,000 in regional reserves that is good only for the next six months and cannot be considered as added to the base. The $15,000 will be spent for two technicians, their support in the field, and a small amount of support for each current project (8,500 personnel services, 5,600 support, 900 for distribution). One technician and his support will help Dr. Roberson pull together material for two final reports on Eagles and the Great White Heron. The other technician will assist Dr. Kushlan in his Alligator and Wading Bird projects. Since the arrival of the $15,000, the division has been assessed an additional $1,200 for the shop account which may or may not be deducted from next fiscal year's base.

an annual outlay of $1,630,000. Programs carrying the Category II designation constitute $302,000 of the proposed $1,630,000 budget. Hence the "bare-bones" program will cost $1,338,000.

The majority of the proposed research has been designed for either contract or Schedule A study to lessen the burden on Service personnel-manpower ceilings. As indicated, only three new permanent positions are proposed: fire ecologist, vegetation ecologist and information specialist. The plan also proposes funding of an authorized but unfunded research hydrologist position.

Extensive utilization of temporary-position personnel is recommended to support the Park's permanent research staff. Twelve new temporary positions are proposed. Anyone familiar with the Park and the remoteness of many of the research sites within the Park, and the nature of the research itself, will quickly recognize the futility of one man trying to pull a fish seine, or carry all the required gear into the field or wrestle an alligator in order to place a study tag! It is imperative that each principal investigator conducting research in the Park have at least one assistant to help carry out the research. The proposed budget makes such an allowance.

As was indicated early in this report, poor research program design and inadequate funding has critically

hampered the research effort in the Park. In the past, the practice of tapping Southeast Region reserve funds to provide support of immediate, and what were called "one-time," research needs has been employed to bank the festering coals of growing environmental problems within the Park. A more permanent solution must be found that provides for long term, sustained programatic research on this most complicated of National Park Ecosystems. It is recommended in the strongest possible terms that the proposed budget be incorporated into the Park's base funding to insure that adequate support continues to exist for what will surely be a long and difficult research endeavor. As the proposed individual studies are brought to completion, the Park must retain a reserve fund of research dollars which can be reprogrammed to meet other research needs relating to the recommended research program.

Table 3

Proposed FY 77 In-House (NPS) Budget Including Projects and New Positions

Research Administration and Management				
80% Personnel costs:	Hendrix	13/2	Perm	$25,967
	Vargay	5/10	Perm	12,768
	Mgmt. Asst.	7/1	Temp	11,708
	Sec. Asst.	3/1	Temp	7,528
				$57,971
20% Support costs:				14,493
				$72,464
Dry Tortugas Marine Resources Survey Support Costs				$ 5,000
Florida Bay Natural Resources Survey 2/3 time		$46,600		
Sooty Tern Study 1/3 time		23,300		
60% Personnel costs:	Robertson	14/5	Perm	$33,485
	Tech	4/1	Temp	8,455
				$41,940
40% Support costs:				27,960
				$69,900
Shark Slough Alligator Study 1/3 time		$24,665		
Shark Slough Wading Bird Feeding Study 1/6 time		12,398		
Shark Slough Fish Population Study 1/2 time		37,000		
60% Personnel costs:	Kushlan	11/3	Perm	$19,073
	Tech	4/1	Temp	8,455
	Tech	4/1	Temp	8,455
	Tech	4/1	Temp	8,455
				$44,438
40% Support costs:				29,625
				$74,063

Table 3 continued

Lobster Population Study 1/2 time			$23,437	
Stone Crab Fishery Study 1/2 time			23,436	
60% Personnel costs:	Davis	11/4 Perm		$19,669
	Tech	4/1 Temp		8,455
				$28,124
40% Support costs:				18,749
				$46,873
Florida Bay Fish Distribution & Biology			$41,278	
60% Personnel costs:	Schmidt	9/4 Perm		$16,312
	Tech	4/1 Temp		8,455
				$24,767
40% Support costs:				16,511
				$41,278
Fish Catch Data Analysis				
60% Personnel costs:	Thue	5/1 Career-Cond		$ 9,818
	Tech	3/1 Temp		7,528
				$17,346
40% Support Costs:				11,564
				$28,910
Water Records Collections 1/6 time			$24,334	
C-111 Study 1/3 time			48,668	
L-67 Study 1/3 time			48,668	
Salinity Gradient Study 1/6 time			24,334	
60% Personnel costs:	Nix	13/8 Perm		$31,079
	Res. Hydrol.	12/1 Perm		21,325
	Hermance	9/8 Perm		18,288
	Tech	4/1 Temp		8,455
	Tech	4/1 Temp		8,455
				$87,602
40% Support costs:				58,401
				$146,003

Table 3 continued

Vegetation Succession Study Coord. 1/4 time		$10,976		
Hole-in-the-Donut Succession Studies 3/4 time		32,932		
60% Personnel costs:	Veg. Ecologist	11/1 Perm	$17,880	
	Tech	4/1 Temp	8,455	
			26,335	
40% Support costs:			17,570	
				$43,905
Fire Ecology Studies				
60% Personnel costs:	Fire Ecologist	9/1 Perm	$14,830	
	Tech	4/1 Temp	8,455	
			23,285	
40% Support costs:			15,523	
				$38,808
Data Processing and Analysis				
60% Personnel costs:	Data analysis	9/1 Perm	$14,830	
	Key Punch Tech	4/1 Temp	8,455	
			23,285	
40% Support costs:			15,523	
				$38,808

Note: Three new positions are requested.

There are several ways of estimating budgets for research, but the method used here has been to determine the number of personnel required to do the project and then figure support costs as a percentage of the personnel costs. Since the costs of field or laboratory research can involve considerable equipment and its maintenance, it is usual to project support costs as 40% of personnel costs. During the initial year of a research or resource management project, the ratio may be as high as 40% for personnel services and 60% for support costs. It is felt that each principal research member requires as a minimum one technician (GS-4/1). The addition of projects to the researcher's responsibility requires the addition of technicians and also the upgrading of the level of these technicians to people capable of handling projects independently.

Table 4

Proposed In-House (NPS) Projects for FY 77

1.	Research Administration and Management	$ 72,464
2.	Dry Tortugas Marine Resources Survey	5,000
3.	Sooty Tern Study	23,300
4.	Florida Bay Natural Resources Survey	46,600
5.	Lobster Population Study	23,437
6.	Stone Crab Fishery Study	23,436
7.	Florida Bay Fish Distribution and Biology	41,278
8.	Fish Catch Data Analysis	28,910
9.	Shark Slough Alligator Population Study	24,665
10.	Shark Slough Fish Population Study	37,000
11.	Shark Slough Wading Bird Feeding Distribution Study	12,398
12.	Northeast Shark Slough and L-67 Ext. Hydrological Study	46,668
13.	Southeast Dade Co. and C-111 Hydrological Study	46,668
14.	Salinity Gradient Study	24,334
15.	Water Records Collections and Analysis	24,334
16.	Vegetation Succession Studies	10,976
17.	Hole-in-the-Donut Succession Studies	32,923
18.	Fire Ecology Studies	38,808
19.	Environmental Data Storage, Processing and Analysis	38,808
		$602,016

SUMMARY

This research plan constitutes the third general research plan proposed for Everglades National Park in the last thirteen years. Neither of the preceding two plans was carried to completion although they clearly served to guide and orient much of the research that has been done on the nation's third largest park. Much of the proposed research outlined in our plan reiterates research proposed in the earlier two plans. This is because the earlier plans were unusually well thought out and dealt with foresight concerning vital issues affecting the Park. However, the approach, philosophy and organization of our plan is considered new and unique. This "newness" is not a reflection of any particular talent of the authors, but rather a reflection of the times and the growing pressures on the Park.

At the risk of sounding repetitive or even alarmist, we must again emphasize the crossroads at which the Park finds itself today. The sensitivity of the Park to outside forces acting upon it was recognized by early students of the Park. Today, the issue of the Park's dependence on external factors for its survival remain.

But time has passed, options have been lost, and new deadlines are upon us. Most of the changes occurring in south Florida are self-accelerating and irreversible with respect to the Park. Water and land are finite. Both are being consumed at tremendous rates by other members of the south Florida family. The Park remains with unchanged needs, but needs which are harder and harder to fulfill with each passing year. In this competitive world of ours only those that are prepared and strong with their arguments succeed in the competition. The other users of south Florida's dwindling resources are continuing their pressures for a bigger and bigger share of those resources. The Park must have the tools and the will to press for its fair share in the years to come if it is to survive.

We are sobered by the magnitude of the responsibility facing those who must make the decisions concerning the long term preservation of this ecosystem and funding of the proposed research program. We can only urge that those with the responsibility of allocating Park budgets take the time to investigate a rapidly deteriorating south Florida environment and ponder the future of this great National Park in the heart of Florida's Everglades. Aldo Leopold must have known how the scientists associated with this Park feel when he wrote:

> One of the penalties of an ecological education is that one lives alone in a world of wounds. Much of the damage inflicted on the land is quite invisible to the

layman. An ecologist must either harden his shell and make believe that the consequences of science are none of his business, or he must be the doctor who sees the marks of death in a community that believes itself well and does not want to be told otherwise.

BIBLIOGRAPHY

Alexander, T. R. and A. G. Cook. 1974. Recent Vegetational Changes in South Florida. In: Environments of Southern Florida: Present and Past. Memoir 2. Miami Geological Society. ed. P. J. Gleason. Miaimi Geological Society, 4600 Rickenbacker Causeway, Miami, Florida. pp. 61-73.

Bancroft, L. 1973. Exotic Plant Control Plan 1974-1979. Everglades National Park. Homestead, Florida.

Benson, M. A. 1975. Development of Predictive Methods for Water Levels in Everglades National Park. USGS Water Resources Division Research Proposal. Miami, Florida. 2 pp.

Carr, A. 1973. The Everglades. Time-Life Books. 184 pp.

Carter, M. R. et al. 1973. Ecosystem Analysis of the Big Cypress Swamp and Estuaries. U. S. Environmental Protection Agency. Region IV. Atlanta, Georgia. 30309.

Cornwell, G. W. and K. Atkins. 1975. The Impact of Evicting Farmers from Everglades National Park's Hole-in-the-Donut. A Report for the South Florida Tomato and Vegetable Growers Inc. EcoImpact, Incorporated, 6615. Southwest Thirteenth Street, Gainesville, Florida. 184 pp.

Craighead, F. C. Sr. 1971. The Trees of South Florida: The National Environments and Their Succession. Vol. I. University of Miami Press. Coral Gables, Florida. 212 pp.

Craighead, F. C. Sr. 1974. Hammocks of South Florida. In: Environments of Southern Florida: Present and Past. Memoir 2. Miami Geological Society. ed. P. J. Gleason. Miami Geological Society, 4600 Rickenbacker Causeway, Miami Florida. pp. 53-61

Davis, G. E. and C. E. Hilsenbeck. 1974. The Effects of Watershed Management on the Shark Slough—Whitewater Bay Estuary of Everglades National Park, Florida. Draft Report. Everglades National Park, P. O. Box 279, Homestead, Florida. 16 pp.

Davis, G. E. and J. A. Kushlan. 1975. Hydrobiological Management in Everglades National Park. Draft Report. Everglades National Park, P. O. Box 279, Homestead, Florida. 11 pp.

Davis, G. E. and M. C. Whiting. 1975. The Cape Sable Loggerhead Sea Turtle Rookery 1964-1973. Everglades National Park. Draft Report. Everglades National Park, Homestead, Florida. 15 pp.

Dineen, J. Walter. 1974. The Fishes of the Everglades. In: Environments of Southern Florida: Present and Past. Memoir 2. Miami Geological Society. ed. P. J. Gleason. Miami Geological Society. 4600 Rickenbacker Causeway, Miami, Florida. pp. 375-385.

Earle, J. E. and J. H. Hartwell. 1973. Hydrologic Data for Taylor Slough. U. S. Department of the Interior, Geological Survey. Open File Report No. 73012. Tallahassee, Florida. 28 pp.

Everglades-Jetport Advisory Board. 1971. Big Cypress Watershed—A Report to the Secretary of the Interior, U. S. Department of the Interior, Washington, D. C. 52 pp.

Fogarty, M. J. 1974. The Ecology of the Everglades Alligator. In: Environments of Southern Florida: Present and Past. Memoir 2. Miami Geological Society. ed. P. J. Gleason. Miami Geological Society, 4600 Rickenbacker Causeway, Mimai, Florida. pp. 367-374.

Gardner, G. 1975. The Water Hyacinth, Eichornia Crassipes (Mart.) Solms: An Invader of Florida's Aquatic Ecosystems. Unpublished Manuscript.

Hartwell, J. H. 1973. Water: Implications of the 1971 Drought Upon Dade County's Water Resources and Management Policies. Report to the Izaak Walton League of America. Miami, Florida. 28 pp.

Heald, E. J. 1970. The Production of Organic Detritus in a South Florida Estuary. University of Miami, Ph.D. Dissertation. 110 pp.

Heald, E. J. and W. E. Odum. 1970. The Contribution of Mangrove Swamps to Florida Fisheries. Proc. Gulf and Carib. Fish. Inst., 22:130-135.

Heald, E. J., W. E. Odum and D. C. Tabb. 1974. Mangroves in the Estuarine Food Chain. In: Environments of Southern Florida: Present and Past. Memoir 2. Miami Geological Society. ed. P. J. Gleason. Miami Geological Society, 4600 Rickenbacker Causeway. Miami, Florida. pp. 182-190.

Higer, A. L., A. E. Coker, E. H. Cordes, and R. H. Rogers. 1975. Water Management Models in Florida from ERTS-1 Data. U. S. Department of the Interior Water Resources Division, Geological Survey, Miami, Florida. 42pp.

Higer, A. L. and M. C. Kolipiuski. 1970. Sources of Pesticides in Florida Waters. U. S. Department of the Interior, Geological Survey, Miami, Florida, in cooperation with Nat. Park Serv. and U. S. Fish and Wildl. Serv., Open-Fire Report No. 70005. 20 pp. (mimeo)

Hofstetter, R. H. 1974. The Effect of Five on the Pineland and Sawgrass Communities of Southern Florida. In: Environments of South Florida: Present and Past. Memoir 2. Miami Geological Society. ed. P. J. Gleason. Miami Geological Society, 4600 Rickenbacker Causeway, Miami, Florida. pp. 213-219.

Hofstetter, R. H. and F. Parson. 1975. Effects of Fire in the Ecosystem: An Ecological Study of the Effects of Fire on the Wet Prairie, Sawgrass Glades, and Pineland Communities of South Florida. Part II. Final Report, June 1975. EVER-N-48.

Klein, H., J. R. Armbruster, B. F. McPherson, and H. J. Freiberger. 1975. Water and the South Florida Environment. United States Geological Survey Water-Resources Investigation 24-75. NTIS Acquisition Number PB-236-951. 165 pp.

Klein, H., W. J. Schneider, B. F. McPherson, and T. J. Buchanan. 1970. Save Hydrologic and Biologic Aspects of the Big Cypress Swamp Drainage Area, Southern Florida. U. S. Department of the Interior, Geological Survey, Miami, Florida. Open File Report. No. 70003, 94 pp.

Klukas, R. W. 1967. Factors Affecting Nesting Success of Loggerhead Turtles at Cape Sable, Everglades National Park. U. S. Department of the Interior. Nat. Park Serv., Everglades Nat. Park, Report on Modified Phase of Everglades Nat. Park Resource Study Proposal, No. 7. 58 pp.

Kolipinski, M. C. and A. L. Heiger. 1969. Some Aspects of the Effects on the Quantity and Quality of Water on Biological Communities in Everglades National Park. U. S. Department of the Interior, Geological Survey, Miami, Florida, in cooperation with Nat. Park Serv., Open File Report No. 69007. 97 pp. (mimeo)

Little, J. A., R. F. Schneider and B. J. Carroll. 1970. A Synoptic Survey of Limnological Characteristics of the Big Cypress Swamp, Florida. U. S. Department of the Interior, Fed. Water Qual. Admin., Southeast Water Lab., Tech. Serv. Program, Athens, Ga. 212 pp.

Layne, James N. 1974. The Land Mammals of South Florida. In: Environments of Southern Florida: Present and Past. Memoir 2. Miami Geological Society. ed. P. J. Gleason. Miami Geological Society, 4600 Rickenbacker Causeway, Miami, Florida. pp. 386-413.

Leopold, L. B. 1969. Environmental Impact of the Big Cypress Swamp Jetport. U. S. Department of the Interior, Geological Survey, Washington, D. C., Spec. Rep. 155 pp.

Lugo, A. E., S. Snedaker, S. Bayley and H. T. Odum. 1971. Models for Planning and Research for the South Florida Environmental Study. Final Report on Contract No. 14-10-9-900-363 to the National Park Service. Center for Aquatic Sciences, University of Florida. 123 pp.

Lugo, A. E., S. Jones, K. Dugger and T. Morris. 1975. Ecological Approaches to the Control of Aquatic Plants. (In Press) Department of Botany. University of Florida, Gainesville, Florida.

McPherson, B. F. 1973. Vegetation in Relation to Water Depth in Conservation Area 3, Florida. U. S. Geological Survey in Cooperation with the Central and Southern Florida Flood Control District. Open File Report No. 73025. Tallahassee, Florida. 62 pp.

Miller, R. A. and M. A. Benson. Undated. Systems Analysis of Water Management in Central and Southern Florida. USGS Project Proposal. Miami, Florida. 9 pp.

Morris, T. L. 1974. Water Hyacinth Eichhornia crassipes (mart.) Solms: Its Ability to Invade Aquatic Ecosystems of Payne's Prairie Preserve, Master of Science Thesis. University of Florida. 134 pp.

Myers, R. L. 1975. The Relationship of Site Conditions to the Invading Capability of Melaleuea Quinquenervia in Southwest Florida. Master of Science Thesis. University of Florida, Gainesville, Florida. 151 pp.

NPS. 1975. Fire Management Plan, Everglades National Park. Homestead, Florida.

Odum, H. T. and M. T. Brown. 1975. Changing Capacity for Man and Nature in South Florida: Energy Models for Recommending Energy, Water and Land Use for Long Range Economic Vitality in South Florida. Final Report on Contract No. CX 000130057 to the National Park Service. Center for Wetlands, University of Florida, Gainesville, Florida.

Odum, W. E. 1971. Pathways of Energy Flow in a South Florida Estuary. University of Miami, Ph.D. Dissertation. 162 pp.

Ogden, J. C., J. Kushlan and J. Tilmont. 1974. The Food Habits and Nesting Success of Wood Storks in Everglades National Park in 1974. U. S. National Park Service, Everglades National Park, Homestead, Florida 33030. 95 pp.

Robertson, W. B. Jr. 1953. Survey of the Effects of Fire in Everglades National Park. U. S. Department of the Interior, Nat. Park Serv., Everglades National Park. 169 pp. (mimeo)

Robertson, W. B. Jr. 1955. An Analysis of the Breeding Bird Populations of Tropical Florida in Relation to the Vegetation. University of Illinois. Ph.D. Dissertation.

Robertson, W. B. Jr. 1959. Everglades—The Park Story. University of Miami Press. Coral Gables, Florida. 99 pp.

Robertson, W. B. Jr. 1964. The Terns of the Dry Tortugas. Bull. Fla. State Museum. Bull. Fla. State Museum. Bio. Sci., 8(1)1-94.

Robertson, W. B. Jr. 1971. A Quick Look at Natural History, Biogeography and Biopolitics in South Florida. Talk Given at the Symposium, "Past, Present and Future of the Everglades," Second National Biological Congress (American Insitute of Biological Sciences) Miami Beach, Florida. 25 October 1971. 16 pp.

Robertson, W. B. Jr., G. Sprugel Jr., and Lowell Sumner. 1966. Everglades National Park National Sciences Research Plan. U. S. Department of the Interior, National Park Services, Washington, D. C. 157 pp.

Robertson, W. and J. Kushlan. 1974. The South Florida Avifauna. In: Environments of Southern Florida: Present and Past. Memoir 2. Miami Geological Society. ed. P. J. Gleason. Miami Geological Society, 4600 Rickenbacker Causeway, Miami, Florida. pp. 414-452.

Swayze, L. J., W. L. Bancroft, A. L. Heiger and E. H. Cordes. 1975. The Application of Landsat Data from Collection Platforms and Landsat Imagery for Fire Managment, Everglades National Park, Florida. 15 pp.

Tabb, D. C. 1963. A Summary of Existing Information on the Fresh-water Brackish-water and Marine Ecology of the Florida Everglades Region in Relation to Fresh-water Needs of Everglades National Park. University of Miami, Coral Gables, Florida. 143 pp.

Tabb, D. C. and E. S. Iversen. 1971. A Survey of the Literature Relating to the South Florida Ecosystem (with Pertinent References from Outside the Geographic Boundaries of the Subject Area). Final Report to the U. S. Department of the Interior, National Park Service. Contract No. 14-10-6-990-043. Rosensteil School of Marine and Atmospheric Science, University of Miami, Rickenbacker Causeway, Miami, Florida. 205 pp.

USDI. 1973. A Vegetation Map of Everglades National Park. Memo from Resource Ecologist to the Environmental Coordinator, Everglades National Park. December 11, 1973. 4 pp.

USDI. 1974. Biological Research Needs Big Cypress. Memo from Resources Management Coordinator, EVER-BISC-FOJE to Chief Scientist, WASO. June 20, 1974. National Park Service, Everglades National Park. Homestead, Florida. 18 pp.

USDI. 1975. Hole-In-the-Donut Farmland Restoration—Research Programs, FY '76. Memo from Larry Bancroft, Management Biologist to Supt., Everglades National Park. October 8, 1975. 18 pp.

USDI. 1975. Hole-In-the-Donut Farmland Reclamation Program, FY 1976. Memo from Larry Bancroft, Management Assistant to Chief Ranger, Everglades National Park, July 2, 1975. 15 pp.

Wimberly, E. T. 1975. Satellite Relay and Processing of Hydrologic Data in South Florida. United States Geological Survey Water-Resources Investigations 12-75, Tallahassee, Florida. 19 pp.