dade county
wetlands demonstration project

Volume III
ECONOMIC DECISION MAKING IN ENVIRONMENTALLY SENSITIVE AREAS - OPPORTUNITY COST ANALYSIS

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ECONOMIC DECISION MAKING IN ENVIRONMENTALLY SENSITIVE AREAS---OPPORTUNITY-COST ANALYSIS

Volume III
Dade County Wetlands Demonstration Project

Dade County Planning Department

In Conjunction with the Bureau of
Coastal Zone Management, Florida
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INTRODUCTION

The Dade County Wetlands Demonstration Project was a cooperative County, state and federal government study commencing in July, 1976, and terminating the following June. The goal was to demonstrate techniques for resolving conflicting demands for various land use and economic activities in the environmentally sensitive areas of the western wetlands and Biscayne Bay in Dade County.

For the most part, land use allocation in the U.S. economic system is performed by the market mechanism, whereby a particular site will be put to the use determined by the highest bidder. The willingness to bid (pay) for a site is a function of the returns to be derived from it in the form of production, accessibility and/or amenity value. The aggregate of these bids constitute the demand for land which, when coupled with the available supply, determines actual prices. These prices then, are set by a series of individual, private decisions which reflect private costs and returns. Under certain conditions these private decisions will lead to a socially optimal result. One of the conditions is that prices must reflect all costs and all benefits arising from a particular transaction. Unfortunately it is the case generally with land, and especially with estuarine, beachfront, and marshland, that decisions regarding its use impose substantial external costs on parties who are not directly involved in the transaction basically, the general public. These costs are not being reflected in the prices which guide the actions of those who are altering or even destroying coastal zone and/or wetland resources.

Land prices in the areas under study in this demonstration understate, perhaps seriously, the true value of the resources involved. The values foregone in the form of fish and wildlife production, recreation, outdoor amenities, provision of water supply and other useful services are not accounted for in the typical market transaction. The situation is one in which the allocation of these lands proceeds on the basis of underpricing, thus encouraging excessive use of the resource, improper development techniques, and a failure to consider alternatives. The last point is particularly crucial since there are reasonable alternatives for the urban uses to which these wetland areas are put. Conversely there are few, if any, real alternatives for the services performed by the wetlands. The pressures for urban development of these areas will continue in the same manner as before as long as the total cost of their actions are not explicitly taken into account by those who intend to utilize the land. A broader, public perspective is required if optimal decisions regarding the use of these resources are to be made.

Two independent studies were produced from this effort. This report focuses on the techniques for decision-making and demonstrates an approach that has general applicability. The other report focuses on the

physical characteristics and management problems in the two study areas. The next section which briefly describes the physical setting of the areas and the environmental problems associated with them is taken largely from the latter report.

Dr. Daniel Bromley, Department of Agricultural Economics, University of Wisconsin, served as economic consultant for this study and contributed significantly to it in a variety of ways. The discussions of economic issues involved in an environmental setting and the economic concepts which apply were written primarily by Dr. Bromley as was the section evaluating the basic methodological approaches available. Of the several possible techniques, he suggested opportunity-cost analysis as being the most feasible and applicable to the local problems. The last section provides illustrations of this technique in two hypothetical cases.

DESCRIPTION OF THE AREAS AND THE PROBLEM SETTING

East Everglades

The inland wetland study area of the demonstration project, located in southwestern and southern Dade County, is comprised of extensive low-lying gladeland contiguous to the eastern boundary of Everglades National Park (Figure 1). The environmental significance of the study area is based to a large degree upon the interrelatedness of the semi-aquatic ecology of Everglades National Park to its extra-jurisdictional hydrology. In addition, the study area's water storage and recharge functions are essential to the maintenance of downgradient municipal water supplies and the stability of the saltwater/freshwater interface in the southern and southeastern Dade County.

Within the study area three physiographic areas are identifiable. From north to south they are: 1) the Shark River Slough, 2) the Rocky Glades (the watershed for Taylor Slough which flows into the Everglades National Park), and 3) the Southern Coastal Prairie.

The Shark River Slough is essentially a shallow basin at an elevation of approximately six feet above mean sea level, with a northeasterly to southwesterly orientation. Surface water flow in the Shark River Slough is in a southwesterly orientation and seasonally supports water flow into the Everglades National Park. This area is especially valuable as a feeding area for a large population of wading birds during the early part of the dry season.

The Rocky Glades land is characterized by rough, rocky outcropping of limestone eroded into landform known as pinnacle rock. Its primary value is its role as a groundwater recharge and storage area. Precipitation collects in depressions in the eroded limestone and percolates downward to the water table where it adds to the freshwater head. This supports the characteristic surface flow of Taylor Slough into the Everglades National Park and helps to maintain the southwesterly surface flow from Shark River Slough into the National Park. It also helps maintain groundwater flow toward the public wellfields in the vicinity of Homestead and Florida City.

The Southern Coastal Prairie is the third identifiable physiographic province in the study area. It is critically linked to the functioning of the brackish water estuaries which are nurseries for infant shrimp and fish. Basic to the immense productivity of South Florida's estuaries is the terresterial inflow of fresh water from the Coastal Prairie which moderates estuarine salinities and transports detrital and other food sources for the juvenile marine organisms. Salinity is one of the most important factors in determining biological productivity in the estuary, and estuarine salinity is greatly influenced by adjacent upland water levels. Maintenance of a broad brackish zone and a gradual salinity gradient is a critically important function of the sheet flow from this part of the study area to the coastal estuaries.

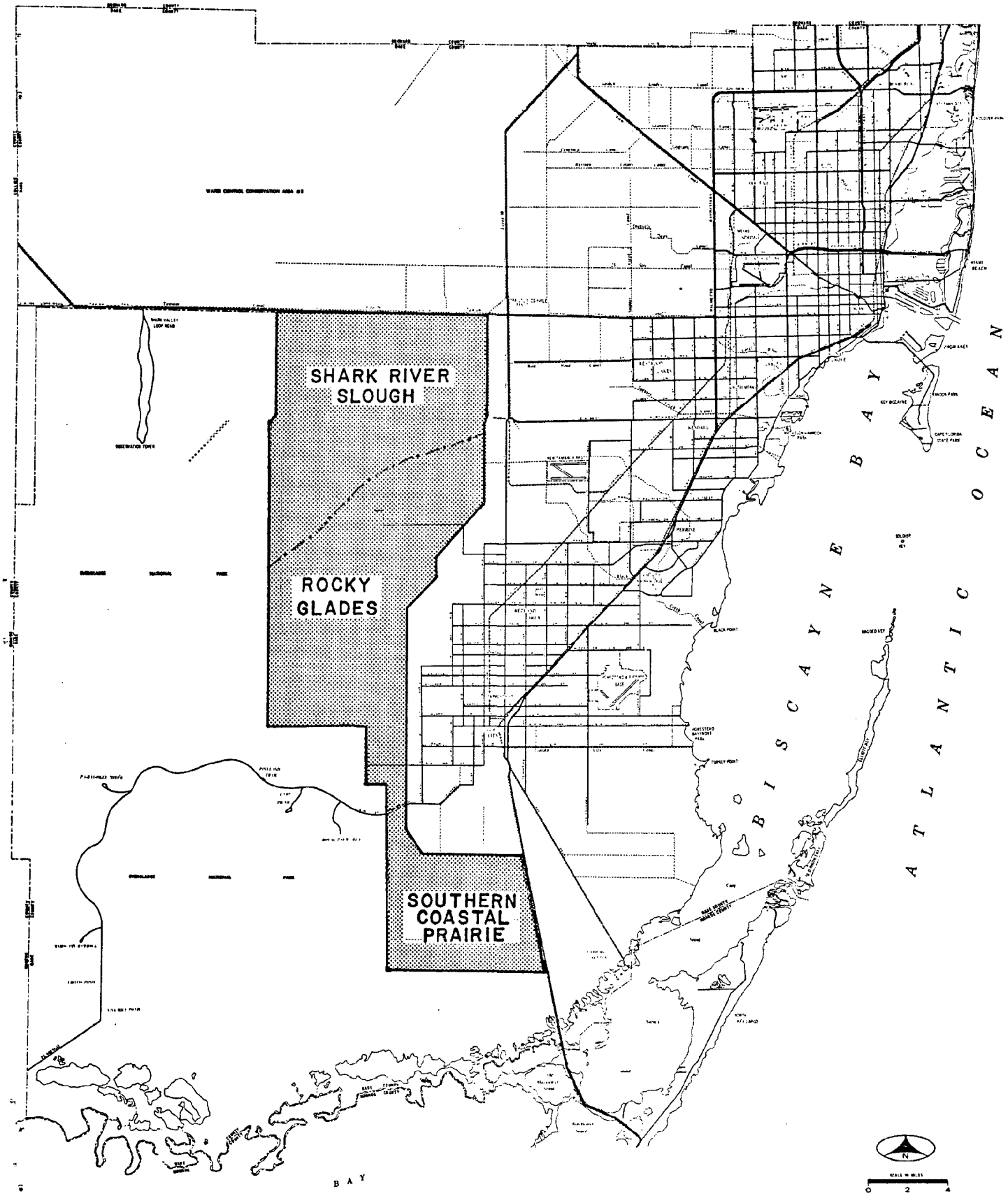

FIG. 1 EAST EVERGLADES STUDY AREA

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Problems of Development

Problems associated with development in the East Everglades are discussed briefly below:

1) Pollution of Groundwater Supply to Dade County. - Uncontrolled development within the area poses a serious threat to the quality of recharge to the Biscayne Aquifer. The placement of septic tanks or sewers in an area that is covered with water on an annual basis would likely present a severe health hazard to present and future residents of Dade County and consumers of Dade County produce. Similarly, runoff from urban and suburban environs, including streets, would be a serious threat to the quality of groundwater. Chemicals and products used as pesticides, fungicides, and fertilizers and mulch by agricultural operations in rockland substrate also present a potentially serious hazard to the quality of the Biscayne Aquifer. Studies have shown an increase in nitrates (to levels requiring treatment) in the shallow groundwater as the water moves down gradient under agricultural fields.

2) Pollution of Surface Water to Everglades National Park. - Septic tanks, sewers, urban and suburban runoff and agri-chemical use within the area pose similar hazards to the surface water supply of Everglades National Park. Pollutants picked up by physical filtration and chemical exchange with "soil" materials will concentrate there and later be released in unknown quantities at unpredictable times. Once in the surface water, excess nutrient load, disease pathogens, heavy metals, PCB's, pesticides and other pollutants from uncontrolled urban, suburban, and/or agricultural development act to reduce diversity and productivity, short circuiting the natural cycles of life at the base of the food chain. The potential hazard to the nursery grounds for the Gulf of Mexico and Atlantic fisheries, numerous bird species, and other Everglades biota make the dangers of uncontrolled growth in the area of far greater significance than simply providing a large tropical outdoor zoological park for tourists.

3) Reduction of Surface Water Flow or Further Deleterious Effect on Periodicity of Flow to Everglades National Park. - Equally critical to the health of the park is the seasonal fluctuation of water levels. The reduction of ground and surface water levels that accompanies urbanization, suburbanization, and some agricultural uses would result in a stress on the Park's existing life systems and begin a process of alteration of the East Everglades and Park biota, generally towards undesirable exotic species and reduction of marsh areas. In addition, lower water levels will accelerate the oxidation of the organic soils, both by fire and by biochemical processes.

4) Reduction of Groundwater Recharge to the Biscayne Aquifer. - The increase in surface water runoff from impervious cover and reduction in surface and ground water levels by positive drainage that has historically accompanied development of wetlands would pose a serious danger to the groundwater recharge of the Biscayne Aquifer if uncontrolled development is allowed to occur in the area. A reduction in high groundwater levels within the area would reduce the water available for drinking and irrigation and would reduce the freshwater head necessary to prevent saltwater encroachment.

5) Reduction of Flood Storage Capacity. - The creation of compacted roads, parking lots, roofs, and ancillary impervious and semi-impervious works, along with any attempt to remove ground or surface water would act to impair the historic function of the area as a floodwater retention basin. Furthermore, impairment of surface flow would increase flood stages upstream of the restriction, thereby affecting existing use of upstream lands. In addition, residential and/or agricultural development will without question create a constituency demanding water removal from the area.

6) Danger to Future Development from Flooding. - Most of the area is under water for extended periods of time seasonally, thereby constituting a danger to human health and safety on a regular basis. The southern part of the area is also subject to coastal flooding during tropical disturbances.

7) Irreversible Loss of Vegetation, Pinnacle Rock, and Wildlife. - The Everglades is a complex environment that has evolved over thousands of years to its present condition. The wildlife, vegetation, microbiota climate, topography, and soils are all interrelated elements of the system. Development by humans that alters a part of the system will have unavoidable effects on the other parts. Specifically, the clearing of vegetation, rockplowing, dredging and filling, and related activities that generally accompany development will have adverse affects on the organic and marl soils, will decrease the diversity of the landscape that support resident and migratory wildlife populations, will alter the historic hydrologic conditions that are the lifeblood of all of the systems, and will facilitate the spread of noxious exotic vegetation species (which will, in turn, cause a decrease in wildlife habitat).

Biscayne Bay

Biscayne Bay is a shallow (average depth 6') sub-tropical lagoon, 45 miles long and varying in width from less than 1 mile in north bay to approximately 10 miles wide in parts of central bay. (Figure 2). To the west the bay is bordered by the urbanized portions of Coral Gables, Miami, and northern Dade County, while to the southwest it is fringed by extensive areas of coastal mangroves. Along the eastern boundary it is partially enclosed by the barrier islands of Miami Beach, Virginia Key, and Key Biscayne; the Safety Valve flats; and the upper Keys. To the south, separated from Biscayne Bay by Cutter Bank lies the smaller and deeper Card Sound basin. Only the northern third of Card Sound is within Dade County.

There are seven generalized benthic communities within Biscayne Bay: turtle grass flats, shoalgrass flats, sparse turtle grass and algae, Sponge-Alcyonarian, open sand, rocks and pilings, and sandy mud. Turtle grass flats, which are considered to be the most valuable, cover about 30% of the bay bottom from Rickenbacker Causeway south. There are over 250 species of fish and 200 species of macro-invertebrates, which use the grass flats during some part of their life cycle. Since turtle grass blades grow, excise and decay within a ten week period, the grass beds contribute an enormous amount of detrital plant material to the bay system.

There are approximately 1200 animal species (macro-invertebrates and fishes) and two marine mammals (the bottlenose dolphin and the manatee) which are found in Biscayne Bay. Included are many species of fish which have economic value plus sponges, shrimp, lobsters, and crabs which are fished commercially. In addition, there are about 25 groups of birds which forage for food in the bay waters. Many other birds forage within the mangrove forests, and the top carnivores, the falcons, hawks and owls prey upon other animals throughout the bay system.

In order to preserve and protect a rare combination of terrestrial, marine and amphibious life, the federal government established the Biscayne National Monument (PL-90-606) in 1963 (see Figure 3). With very few exceptions, the National Park Service has total authority over navigation, construction, water quality, wildlife, and public access within the monument.

Socio-Economic Environment

Biscayne Bay serves many functions for bay users. It is a recreational site for boaters, swimmers, fishermen, skin divers, photographers, and birdwatchers. However participating in some of the activities may mean a long wait for boat ramp space or dockage or limited access and crowded conditions for swimmers.

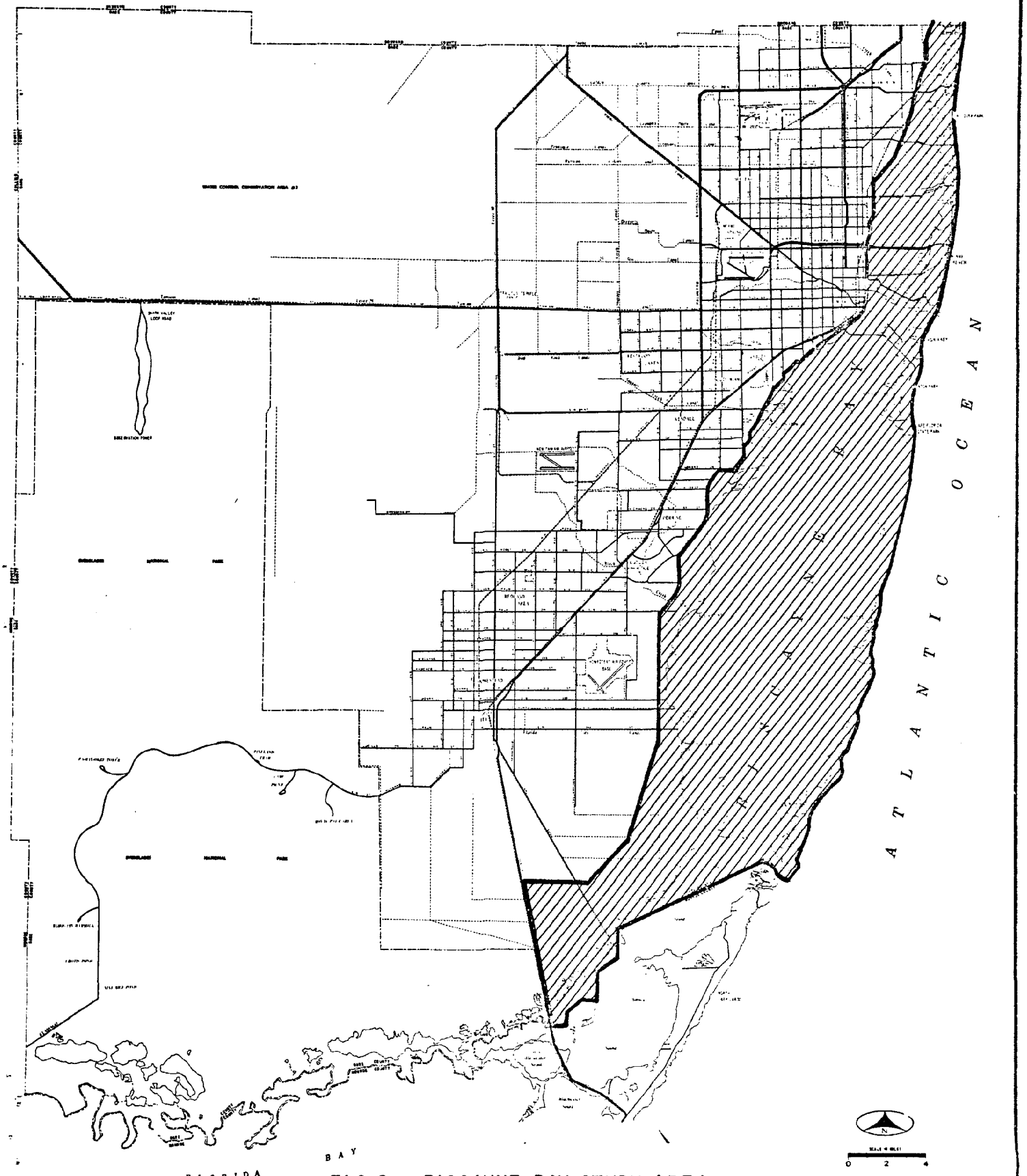

FIG. 2 BISCAYNE BAY STUDY AREA

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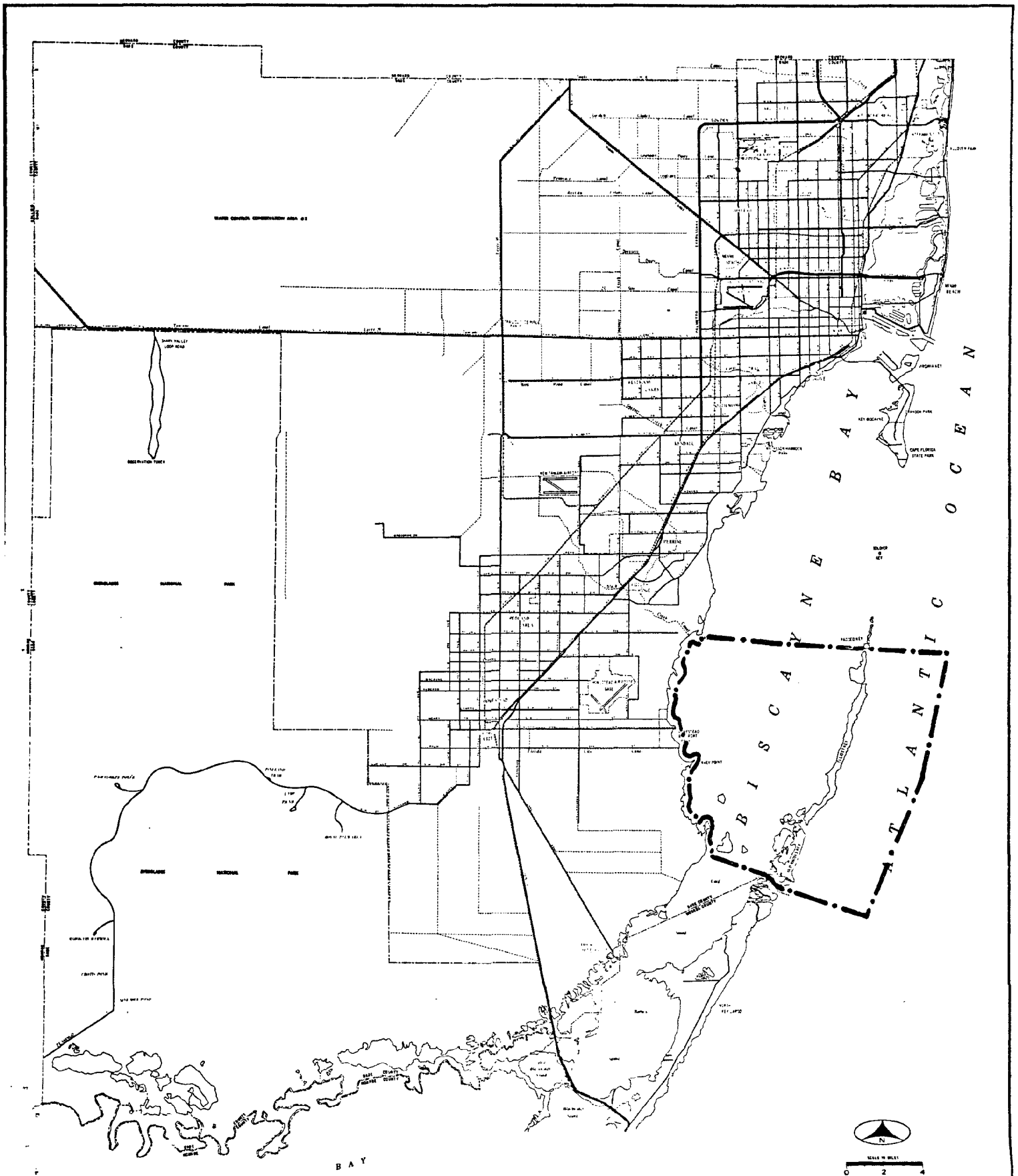

FIG.3 BISCAYNE NATIONAL MONUMENT

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To commercial interests the Bay represents a source of income, a valuable nursery ground, a transit corrider and a safe harbor for ships. For builders and developers, the shoreline is viewed as a prime location for various projects. For bayshore residents the Bay enhances land values, provides visual enjoyment, and is a point of access. It is an asset for tourist promotion; a resource for scientific exploration. To the various government agencies that have responsibility for the Bay, it functions as a unique natural asset; a receptacle for urban and agricultural wastes; a tourist and resident attraction; and navigable waters.

Reasons for Concern

For several reasons, some type of comprehensive approach should be utilized in making decisions about use of this resource. Primary reasons for concern include: decline in natural resources habitat; shoreline destruction; inadequate public access; and decline in water quality. These are discussed briefly below.

Decline in Natural Resource Habitat. - Many bay uses, if improperly managed, can contribute to the decline of the bay's natural resources. Habitats may be disturbed or ultimately destroyed. Flora and fauna may be overcollected and eventually eliminated from the bay. Dredge and fill, barge and boat scour, thermal effluent, pulses of fresh water discharge, net fishing and other fishing and collecting practices all have the potential to destroy major plant communities and bay habitats.

The functions of the various plant communities within the bay are relatively poorly understood. The single exception to this statement is the Thalassia turtle grass community which is known to perform many functions that are necessary to the maintenance and continued viability of the bay system. In addition to providing an important food source of the bay system, the turtle grass flats are recognized as valuable nursery areas for numerous species of fishes and invertebrates. Many commercially important species including snappers, spanish mackerel, mullet, and groupers spend some portion of their life cycle within the grass flats. Boat and barge traffic causes the grasses to be directly torn up or indirectly disturbed due to continuous siltation. The siltation can cause destruction of the grass flats, and cuts caused by boats going across grass flats leave the grass flats more susceptible to damage from storm tides and hurricanes.

Shoreline Destruction. - The shoreline functions as a transition zone between the bay and the inlands. As such it has many varied biological functions. It works as a two-way system, simultaneously buffering the interior lands from the bay and vice-versa. The natural mangrove vegetation stabilizes the shoreline, filters particles such as salt and pollutants from the air and the ground and surface water system. It provides shelter to the inlands from hurricane surges. The mangrove swamps are fertile fish and shellfish nurseries.

Litter produced by leaves, twigs, wood, and fruit from the mangroves is intimately related to the overall metabolic processes within the mangrove forest. Mangrove productivity and respiration are, in turn, directly related to tidal inundation and upland surface water runoff. Although a vital link between the litter produced within mangrove forests and fish productivity in the estuary of the North River in Everglades National Park has been demonstrated, the relative importance of the mangrove detrital cycle and the quantitative particle export to overall Bay productivity remains unknown.

Although the link between mangroves and coastal waters have been recognized for the past few years, the other essential link between upland terrestrial systems and mangroves is less appreciated. While mangroves thrive in areas that receive nutrient rich surface water runoff, much of the construction activity in Dade County has served to sever these forests from their upland sources.

Unfortunately, as development has occurred, these functions have been destroyed in increasing amounts. Because the mangrove forests restricted access to the bay and were generally viewed as a nuisance, they have been targets for wholesale dredge and fill actions during the past seventy years. Acute siltation from dredge and fill operations can destroy mangrove trees.

Channelization, drainage, and levee and road construction have severely altered overland flow into and through the mangrove forests along south bay. Channelization and drainage effectively "short-circuit" the overland flow, circumventing the natural filtering systems of the mangrove forests and inland marshes and rushing nutrient (and pollutant) rich waters off the land and into the bay. In this manner, the mangroves are deprived of valuable nutrient sources, and the bay becomes a potential dumping ground. Additionally, the period of freshwater run-off has been substantially shortened. During the rainy months freshwater pours into the bay, but in the drier months almost no freshwater is allowed to flow. Thus, substantial fluctuations in salinity are observed in the mangrove forests and bay waters along the western shoreline of the bay.

Inadequate Public Access. - Traditionally, shorefront lands have been considered available for the public's use as access points to the bay. It is only in recent times (with the expansion of private residences and commercial developments) that shorelands have often become closed to all but private use. Only a modest amount of the shoreline property has been developed for the public, with access to the bay provided at 54 public land areas (including ten public marinas), 56 private docks, marinas and boat ramps, as well as at private lands which have traditionally been used as public access points. Additionally, the bridges which crisscross the bay provide visual access.

In spite of these access points, there is an ever increasing demand for more public access. Unfortunately, the major concern has been almost exclusively for providing marinas or preservation (no development) areas. Several other uses -- such as shoreline fishing, viewing and swimming -- have inadequate bay access and have been almost totally overlooked.

Decline in Water Quality. - As development occurs both inland and on the shorelands, the potential for decline in the bay's water quality increases. Land development which significantly increases the amount of impervious ground surface area also accelerates the rate of surface water runoff and enhances the potential for higher concentrations of pollutants in the runoff water.

In addition to the impacts of upland sources on bay water quality, uses within the bay also have the potential to cause a decline in water quality, especially as the uses become more intensified. Flushing of bilge water by oceangoing cargo ships prior to entering the port causes tar and oils to be discharged. Some of these materials make their way into the bay and land on the shoreline. Boat traffic contributes to the turbidity of the water. Because of the bay's shallowness, the water stream created by boat propellers and turbojets tear up the sea grasses and stir up the bottom sediments when boats stray from the channels. The boats also deposit gas and oil materials which contribute to the pollution of the water. In addition, direct discharge of wastes in the bay by houseboats and live-abroad boats contribute to the pollution problem. The Belcher Oil barge, which daily travels the bay, stirs up the bay bottom and creates a turbidity plume which also contributes to a decline in water quality.

Other Problems

Other bay problems include the potential for overcrowding and user conflict and inadequate management of the bay. The lack of coordination among the various governmental entities who have interests in the bay contribute to the often fragmented and single-purpose approach to decision-making about this vital resource.

ISSUES IN RESOURCE ALLOCATION

The only reason for moving beyond the strictly individualistic behavior venerated in the notions of a "free and democratic society" is that individuals disagree as to the desirability of certain actions. Playing one's stereo is an individual matter unless one plays it so loudly as to disturb the neighbors. Building in the East Everglades may seem an individual decision which affects only the landowners. But if this building reduces the groundwater recharge to the extent that drinking water supplies are reduced, then this action comes into conflict with the wishes of others.

The problem is that the presumed rights of individual A to undertake actions by their very nature interfere with the happiness of individual B. When one individual's presumptive rights interfere with another individual's presumptive rights, one of the two parties will seek relief. If transaction costs are low relative to the anticipated gain, then individual bargaining will result and a solution may be reached. If transaction costs are high, then the situation may not be solved and the one with the presumed property right will prevail. If collective action arises, it may be possible to obtain relief. Some private coalition may form to control the noise of stereos in an apartment building. The collective of individuals is formed to carry out a defensive action and to help spread some of the costs.

Of course, strict collective action may be insufficient, and some form of public action may be necessary. A large part of the justification of public action arises from the significance of third party effects. If development in the East Everglades diminishes the amount of surface water flow to the Park and this causes a change in vegetation and wildlife habitats, people from Maine to Oregon might feel a loss. However, the geographic dispersion of those people makes it increasingly costly to enter the negotiations to prevent diminution of surface water flow. These costs (transaction costs) are one of the fundamental reasons for the transfer of many actions from collective action to public action.

It is important to recognize the crucial role played by the level of transaction costs and the significance of the incidence. Property rights are nothing more than the ability to impose costs on others. Indeed, the heart of conflicts over environmental issues is the presumptive property right of individual A to impose costs on individual B, and the ways in which these rights are redefined overtime in the face of new information and changing tastes and preferences.

In undertaking any collective action which attempts to affect the use of land and water resources, one needs to first define the nature of the presumptive entitlement in the action being considered. Then a decision follows whether or not that presumptive entitlement or current use is one which enhances the public interest or detracts therefrom. The essence of collective action is that some are benefited by change and others are not. All collective actions redistribute comparative advantages among individuals, and the essence of searching for that elusive notion of the public interest is to be certain that the sum of the gains is somehow greater than the sum of the losses and that those who are already the most disadvantaged are not made worse off, nor are the currently advantaged excessively helped.

On The High Cost of Sequential Decisions

Individual development actions may begin a sequence of chain-reactions that are difficult to halt once the initiating force is started. Consider the general process of residential settlement on the outskirts of a city. Initially there are a few service stations, some small service establishments, and perhaps a medium-scale commercial enterprise. A national fast-food chain sees an opportunity to establish an outlet nearby to capture some of the business. If a zoning change is required, this may not appear to be a very serious matter, and the change is approved. Then, with the presence of a food outlet a firm (again likely to be a national chain) specializing in, say, radio and electronic equipment decides to locate nearby. If all have been on septic tanks, or an existing municipal sewage system (or on a municipal water supply system), it may soon be discovered that such systems are inadequate to meet the needs.

The next step then is to meet this increased pressure by augmenting the services currently available. Since few public entities can justify the extension of sewer or water services merely to meet the needs of those currently in the area, there may be substantial over-capacity in the early years. Now, with ample services available, an area that was formerly unsuited for apartments is ripe for development and the first thing high-density housing is built. Suddenly, with this population density a further expansion of service establishments and small commercial firms is "needed." Then it is discovered that the roads are inadequate to handle the flow of traffic, and enlargements are requested. While a few will still refer to this sequence of events as "progress" or "development," most now recognize this process as the cause of urban leapfrog developments that create strips of urbanization along certain corridors, and leave farm land of questionable usefulness scattered among more urbanized land uses.

This sequence has been repeated in virtually every major city and town in the United States, and Dade County is no exception. Of course, no single decision must carry the full blame for this chain of events, but this epitomizes the "tyranny of small decisions" problem so often discussed among economists. The perverse nature of this sequence is that once it starts, the economic and political pressure to continue becomes virtually impossible to resist. For instance, once public services such as sewer or water are extended, the utility is under great financial pressure to hook up paying customers. Once a quick-service grocery store is up, the owners and manager are anxious for business to increase. All of these pressures build as the sequence advances, and it becomes more difficult to know when or how to stop.

The lesson from the foregoing is not that no steps should be taken; this is far too obstructionist; it is also naive and unrealistic. The answer is to be found in searching for a more complete specification of the real situation "with or without" a certain action. For nearly thirty years formal benefit-cost analysis applied to contemplated federal investments in dams, navigation channels, and other major structures has been criticized by economists for a failure to be cast in this "with-without" mold. Concern is not merely with the "before and after" but with the anticipated situation, under the most reasonable assumptions, both with a specific development decision and without that decision. It is this "with and without" concept which will be applied later in the development of a conceptual framework for making decisions about the East Everglades and the Bay.

The sequence of events may cause irreversibilities in the use of these resources. Diverting surface water flow from a portion of the study area may set in motion a sequence of events altering Everglades National Park from which the land can never be returned to its natural state. For example, in the Hole-in-the-Donut in the Everglades where the land had been extensively farmed, attempts to return the land to natural vegetation have met with very limited success.

Basic Natural Resource Characteristics

Natural resources can be classified as either stocks or flows. The former are not replenishable within a meaningful time horizon while the latter contain a "sustainable yield" which can be utilized without diminishing the basic resource. Stock resources are further classified as not seriously affected by natural deterioration or as affected by seepage, deterioration, or leeching. The flow resources are further classified as those for which the flow is not significantly affected by use (use independent) rainfall, rivers, solar energy and those for which the flow may be affected by human action (use dependent) timber, groundwater, fish.

The use-dependent resources are characterized by the presence of a critical zone: a general range of use rates above which a decrease in flow cannot be reversed economically under present or anticipated conditions. Frequently such irreversibility is not only economic, but technological.

Limestone rock is an example of a stock resource in the Dade County setting. The economic problem in the utilization of stock resources is to devise a system of incentives which will facilitate the extraction at a rate which is consistent with foreseeable demand, to monitor this extraction so that the resource is not completely exhausted before alternative sources of supply can be found, to encourage a search for such alternatives, and finally to encourage the development of substitutes for the day when the current resource is economically exhausted. Wise use does not mean non-use; it means a rate of extraction of the stock resource such that the present (discounted) value of all future net returns is as large as possible.

With flow resources, a crucial issue is present by virtue of the critical zone. Consider a groundwater aquifer. With all aquifers the natural rate of recharge is dependent upon the rate of withdrawal; if the aquifer is excessively pumped the walls of the aquifer become hardened and the ability for recharge is impaired. Thus aquifers, just as fish stocks, have a sustainable yield and use rates in excess of that annual flow comprise a threat to the integrity of the resource.

The existence of a critical zone implies that there is a rate of use beyond which the integrity of the resource is jeopardized. If a fish stock is fished at a level in excess of its annual sustainable yield for several seasons this may very well destroy the population; if an aquifer is overdrawn, it may be destroyed. In each case the spectre of irreversible actions looms large.

The concept of uncertainty relates to this matter of irreversibilities. Sometimes the initial effect of an action may be known. Suppose that development in the East Everglades decreases the amount of recharge to the Biscayne Aquifer. There may be uncertainty as to what will follow after this. Perhaps some wellfields will be affected, but it is not clear how many or to what degree.

While most of economics deals with goods and services which can be produced or not according to consumer tastes and preferences, environmental economics starts from the observation that much of the concern is with the confrontation between producible goods and services and non-producible goods and services. Apartment buildings, schools, frisbees,

highways, automobiles, and the like can be constructed and destroyed. To the extent that costs are not prohibitive, these production and consumption decisions are largely reversible. Environmental economics often deals with decisions which are not easily reversed. Of course, an urban (vacant) lot can be converted into a parking lot, and perhaps for a considerable sum returned to its original condition. Moreover, if there is a relative abundance of vacant lots, it may make little sense to spend the resources to create yet another of something which is in relative abundance. But it is not the number of vacant lots in the city which matters, it is their distribution. Assuming that vacant lots are tree covered or at least mildly aesthetic (rather than eyesores), increased value is attached to them as they become scarce within a specified location. If a vacant lot is unique to a community's environment and if the decision to pave it over is seen as rather irreversible, it takes on a social and economic significance far in excess of its (market determined) economic value.

In the framework to be developed, the concepts of risk, uncertainty, stocks, flows, uniqueness, and irreversibilities will play a central role.

PERTINENT ECONOMIC CONCEPTS

The basic nature of the decision problem has now been reviewed and some inherent attributes of the resources under consideration have been explored. Next, the discussion focuses on the economic concepts relevant to the issues under study. Four concepts - (1) an opportunity site for each economic activity; (2) demand versus "needs" or "wants"; (3) transaction costs; and (4) public goods - will be discussed in turn.

Opportunity Sites

The essence of location theory in economics is that economic activities seek their lowest-cost site such that the net value of their output is as large as possible. Indeed, the competitive economic system places constant pressure on the firm to search out whatever means possible to hold costs down. Those firms which are not effective cost-minimizers soon loose their competitive edge against more diligent managers. When the site of an activity is a variable in the analysis, the incremental income (net) generated in the lowest-cost location compared to the next most advantageous location is referred to as location rent. That is, if a firm earns $100 net income per time period in location A, and only $80 per time period in location B, then $20 represents the locational rent of site A, assuming all other costs and prices remain unchanged.

This issue can be illustrated in the context of protecting firms from flood problems. Assume that a firm located east of the study area would enjoy a net income of $45 per unit of time and that if located in the East Everglades in the wetter terrain, this net would fall to $40 for the same period of time, the reduction in net income owing to the increased private expenditures necessary for protection from the water. Now assume that flood control expenditures by the public sector were undertaken and the more favorable conditions in the East Everglades increased the firm's net income to $50 per unit of time. Since in the non-flood plain site the firm could earn a net income of $45 and in the protected flood plain it could earn $50 of net income, the correct figure for flood-control benefits is $5. Without flood protection the flood plain site is the opportunity site and the firm enjoys a locational rent by staying out of the flood plain of $5 ($45-$40). With flood protection the non-flood-plain location is the opportunity site (the higher-cost location) and the firm enjoys a locational rent of $5 by locating in the flood plain ($50-$45). From an economic point of view, flood-control benefits can be no larger than this locational rent -- $5 for this firm. The benefit-cost analysis would then compare the costs of providing the flood protection with this expected economic gain for this (and other) firm(s), net of moving costs. Notice that the relevant economic indicator is not the income which could be earned in the flood plain, this amount must be net of what could be earned in the opportunity site.

Now consider the cost side of the opportunity site issue. Here the issue is more intuitive than in the previous case and the relevant consideration is the increased cost made necessary by moving a facility from its preferred site in an engineering sense (perhaps) to some slightly higher-cost site. Consider agricultural activity. Just as in the net income example where concern was with an array of net incomes from locating in different places, here one is considering the cost side of that location choice; the factor that was responsible for the variation in net income among sites was the costs of carrying on economic activity there. If land preparation costs in the East Everglades are 30 percent higher for the same crops than in the area where water is less of a problem, or where the soil is a little better, then it is possible to construct a cost gradient for, say, tomatoes, across several possible agricultural sites.

The Concept of Demand

While the term demand is used frequently by many individuals, rarely is it used in a way synonomous with the economic meaning. To be specific, the demand for any item is the quantity which would be taken off the market by willing buyers and willing sellers at a variety of prices. This notion leads to a demand schedule or a demand curve showing alternative combinations of price and quantity to which the two willing parties would agree. This is no minor matter in the area of environmental economics. In the first place demand implies a willingness to pay. Everyone would like to have more leisure time, more good concerts, more beautiful neighborhoods and parks, better urban transportation, and so on. But what are they willing to pay for these things? It is not enough to want them or to "need" them. This is not, of course, to argue that nothing should be provided unless there is an economic demand for it. The public sector provides education, various cultural affairs, fireworks on the 4th of July, and a host of other goods and services without putting us to the test of aggregate willingness to pay. Neither does it imply that the public sector is obligated to provide things merely because one segment of the population wants them.

Curiously, the equally vague expression of need or want seems to carry less weight when one contemplates a decision not to build or "develop" something. It seems that the burden of proof rarely falls on those who want to build but invariably falls on those with different views. A general argument for preserving the South Bay or the East Everglades is discounted by many, who then immediately articulate an equally vague argument for yet another marina or another housing development. This asymmetrical treatment of needs and wants (often under the misnomer of demand) is crucial in environmental economics and merits careful assessment.

Transaction Costs

While the concept of transaction costs was raised previously, it is appropriate to discuss the matter here in greater detail. Of particular concern is the distribution of transaction costs as they fall on those seeking certain types of change and on the level of such costs compared to the potential gains. Consider the Everglades as a national, indeed an international, resource. In other words, the Everglades hold some significance for persons living beyond the immediate Dade County area. This concern could be economic, it could be purely ecological, or it could be a combination of both. To the extent that the integrity of the Everglades has an ecological impact on Florida Bay and the Gulf of Mexico (an assumption which seems very realistic) then those whose economic viability depends upon the ecology of the Bay and the Gulf (such as fishermen) have a direct interest in actions which affect them. Such individuals, however, are scattered from Key Largo to Galveston, Texas, (and perhaps beyond) and it is both costly and difficult to participate in those decisions which may have an impact on them. It is important to recognize that their distance from the local area in no way diminishes their right as citizens to have a say in its use; those removed from the Grand Canyon or Yellowstone National Park are no less interested in its ultimate fate than are those living nearby.

Yet, the cost for those who do not live in close proximity to be represented at each possible event concerning its use is very high. The creation of a national park is one way of reducing the need to be so represented; the strictures that accompany park status guarantee that one need not worry about some potentially unwanted uses. The Everglades as a national resource (and the Bay as well) also give rise to the presence of high transaction costs since there are those living some distance from the Miami area with an interest in the use of the resource. Proximity yields no special sovereignty to the residents of Dade County. Yet it does give some a decided advantage in land use decisions. That is, those who want to construct a variety of developments are near at hand and their transaction costs are low compared to the many who care located at great distances. Put another way, those who favor development stand a chance to reap significant economic gains while bearing small transaction costs; those who prefer the absence of development stand to gain a very small amount individually yet must incur substantial transaction costs to maintain the status quo. Such a situation favors development over preservation.

Public Goods

The final economic concept to be discussed here is that of public goods. A public good is defined as a good or service the consumption of which by one does not diminish the availability for others. Economists consider national defense as the classic example of a public good in that one's enjoyment of national defense in no way diminishes the amount left for others. It is this non-rivalry in consumption which makes other things public goods-the general level of education in a country, enjoyment of a radio broadcast of Mozart, and many other examples of use by many such that what is left for others is not diminished.

Environmental quality is, to a certain degree, a public good. That is, the existence of the Grand Canyon provides a certain amount of satisfaction to many and their enjoyment of that thought in no way diminishes that which is available for others. The only conflict arises when many attempt to visit the place at the same time--then there is definitely rivalry in consumption. But each takes satisfaction in knowing that it exists and in that sense reaps a major share of the benefits from its presence without decreasing that available for others.

The Everglades and the South Bay are examples of a kind of public good because everyone consumes--however indirectly--the environmental quality of each. If the Bay's aquatic life is changed or destroyed each "consumes" a lower level of environmental quality than previously; the same holds for the Everglades. Put somewhat differently, in the private market place each person can purchase the commodity with characteristics best suited to his tastes. But there is only one Everglades and no such choice exists. One either "consumes" it in its natural state, or one consumes something else (call it drained swamp land). However, each person cannot have a say as to what sort of Everglades is "consumed."

METHODOLOGICAL APPROACHES

A new approach for making resource allocation decisions is required in the case of wetlands and coastal areas. Regardless of the final method utilized for actually carrying out decisions (e.g. public purchase, development regulations, zoning, planning or relatively free market) a requirement for systematic consideration of the full economic effects of the resource use should be made.

One approach would be to attempt to estimate dollar values for all of the benefits which would arise from preservation. This would involve attempting to estimate the value to all those people for whom its existence is important, plus those benefits of its current use. Additionally, it would be necessary to estimate the benefits to those for whom option value is relevant. The sum of these various benefit categories might then be weighed against the benefits to be realized from development. One soon reaches a certain indeterminacy however. Because of ecological uncertainty--and because of our uncertainty as to how future generations will value the natural amenity--the benefit category for preservation will be incomplete. Of those benefits from preservation which can be quantified there are two possibilities. The first is that they can clearly exceed the benefits from development in which case the decision to preserve would be rather easy to reach. Or, the benefits from preservation may be less than the benefits from development; here there is a serious problem. The most obvious difficulty is that unborn generations have not had a chance to express their views on preservation versus development and since development would preclude them from enjoying the resource one might conclude that the benefits from preservation are underestimated.

Thus, when undertaking a benefit-cost analysis of the preservation-development decision, one is confronted with the problem of never being sure that all of the benefits from preservation have been counted. This leads to a decision rule of preserving unless the benefits from development are "so much greater than" the computed preservation benefits. Of course, one still must decide what constitutes "so much greater than."

Another approach, the safe minimum standard would be to adopt a posture which minimizes the maximum possible loss for society. Here, one leans toward the preservation of environmentally significant resources unless the costs of preservation, the foregone development benefits, are "too high". One still faces the indeterminacy of what is "too high," but there is a significant difference between the two approaches. In the benefit-cost approach the planner is confronted with somehow estimating the various categories of benefits which would then be compared with the

benefits from development; this would entail planners trying to estimate the benefits from recreational use of the East Everglades, the existence benefits, the option-value benefits, and so on. Needless to say, this would be a formidable task. In the other approach the planner is not faced with computing these types of benefits. Instead, attention is focused upon determining to what extent the would-be developer's claims of costs of preservation, in terms of development benefits foregone, are realistic and valid.

In summary, the benefit-cost approach stresses the quantification and monetary valuation of all benefits and costs in order to reach a development or no-development decision on the basis of a balancing of the gains and the losses. This puts the burden of proof on those who favor no development to show that the benefits from not developing are extremely high. The safe-minimum-standard approach favors no development unless the costs of this course are "too high". This puts the burden of proof on those favoring development to show that the costs of not developing are too great.

However, several problems arise on a frequent basis in urbanizing areas which are not well suited to the benefit-cost approach nor to the safe-minimum-standard approach. Land use decisions often have implications for local resources, and it is not only difficult, but virtually impossible, for local units of government--including their planning departments--to undertake full-blown benefit-cost analyses of all such decisions. More significantly, the relevant accounting stance for local government differs from that for the nation as a whole. That is, when talking of a major wilderness area, the concern is with an environmental resource of a scope and magnitude beyond the confines of the local governmental body. To expect all such decisions to reflect the tastes and preferences of all the citizens in the U.S. is to expect too much. Moreover, the empirical task is significant.

A second problem arises in reaching rational decisions about when the benefits from continued non-development are sufficiently high to warrant denying permits to those who wish to develop. This is a matter apart from being able to measure all of the benefits and goes merely to the matter of a decision rule: in the face of all of the evidence on preservation benefits and the like whether or not one action should prevail over the other.

A third problem is knowing--under the safe-minimum-standard approach--when the costs of not developing are "too high." Again, this is not to belittle the essence of the approach so much as to point out that there are still some difficult land use decisions which will have to be made under either approach.

An urban land use setting is once characterized by pressures to build a subdivision here, to extend a freeway there, to put in an additonal marina somewhere, or to extend a sewer line three miles further to the west. In each instance, the planning department is faced with a decision which on its surface seems rather straightforward. That is, the decision is one with a yes or no answer. What is often missing from the decision setting is the realization on the part of those advocating development, as well as those issuing permits for development, that there are alternatives available which may result in approximately similar outputs for the community at large with fewer of the anticipated costs. This is the notion of opportunity costs.

When a resource is allocated to use A, its opportunity cost is what must be sacrificed in order to achieve output A. If the resource could also be used to produce B, then its opportunity cost of yielding A is given by the value of B. It is thus possible to view A in terms of B; since so many units of B must be given up in order to acquire A, a tradeoff of B is is made for A. Relating back to the earlier flood-control example, the opportunity cost of the firm locating in the unprotected flood plain is $5 since that is what is sacrificed by the firm locating there rather than outside of the flood plain. In this way the opportunity site is related to the opportunity cost of doing business in one location versus another.

In opportunity-cost analysis (OCA) one is searching for possible alternative sites or measures where it is possible to obtain approximately the same output (result) with a different implied cost. To the extent that this search for alternatives helps to minimize the environmental costs of achieving certain desired outputs then it has helped in making explicit tradeoffs between environmental preservation and other goods and services. The primary advantage of OCA over the other analytical approaches is that it <u>starts</u> with the explicit presumption that every anticipated activity has an opportunity site and scope.

This is not to say that one cannot use the benefit-cost approach or the safe-minimum-standard approach to assess alternatives, but it is to say that the view of opportunity costs is less explicit in the other two approaches. A basic format is presented below for opportunity-cost analysis. These steps outline the general approach which can be tailored to meet the needs of a specific project. (The applications in the following section vary somewhat from the outline below.)

The Components of Opportunity-Cost Analysis

1. Evaluate the "felt need" for the proposed activity.
2. Describe the situation with the activity at several points into the future.
3. Identify the likely implications of the proposed activity.
4. Relate implications to individuals and to groups of individuals.
5. Identify reasonable alternative(s) and describe at several points into the future.
6. Identify the likely implications of the alternative(s).
7. Relate implications to individuals and to groups of individuals.
8. Display results of steps 3-4 and 6-7 for comparison and choice.

The "Felt Need" for Development

It is important to recognize that the first place to focus analytical attention is on the presumed "need" for the development. It is at this step that the decision-making body which must grant the permission to proceed should assess the supposed need to grant the permission. That is, the premise of OCA is that the decision body should not rely upon those advocating development to make the unchallenged case for the "need."

Describe the Situation with Development

A properly performed benefit-cost analysis must consider the situation both with the proposed development and without the development. The first of those situations is present here. To the extent that not all of the benefits can be expressed in monetary terms then physical descriptions must do. The second step of OCA is nothing more than the first part of the familiar "with" situation of standard benefit-cost analysis.

Identify Implications

The second part of describing the "with" situation in benefit-cost analysis is an assessment of the implications from the anticipated development. When impacts can be quantified and monetary values attached, the familiar benefit stream which is discounted to present value terms is illustrated. When the impacts are not so valued, one may end up with only physical descriptions of the implications. It is here that risk and uncertainty would enter for those impacts to which probabilities can be attached and for those for which no empirical basis exists for assigning probabilities.

The intent of the "implications" section is to provide as complete a description as possible of the probable situation with the anticipated development. Again, this is partly an attempt to counterbalance the optimistic boosterism of those advocating the particular development in

question. Planning staffs cannot effectively develop full scenarios of all that might happen in conjunction with the proposed development, but it is extremely important that a more realistic picture of the likely situation be provided.

Relate Implications to Individuals and Groups

The fourth step is the crucial linking up of the anticipated implications of the proposed development with those who would stand the greatest chance of incurring the impacts.

This linking of impacts with individuals and/or groups is merely intended to make the probable impacts more specific than they would otherwise be by their mere descriptions. Benefits and costs only have meaning with respect to a specific objective function and impacts from development only have meaning with respect to certain individuals who may then choose to define those impacts as beneficial or adverse. It is the function of this linking to facilitate the identification of impacts as beneficial or adverse--with such definition often taking place in the process of holding public hearings about proposed developments.

Identify Reasonable Alternative(s)

It is at this fifth step of OCA that the real opportunity costs of the proposed development begin to be highlighted. Remember that the function of identifying alternatives is to illustrate that approximately similar benefits can be obtained at a different configuration of implied costs. Then, whether the proposed development or one of the alternatives (which may be no development) is chosen, the implicit tradeoffs are highlighted.

In evaluating the benefits from an activity, say farming in the East Everglades, one might look to the ancillary benefits which will arise. However, one must consider whether these benefits are unique to that location or if they would accompany farming at any location in Dade County. Such ancillary benefits as increased labor hired, increased tractor sales, increased gasoline purchased, and increased fertilizers and insecticides sold would arise from more farming wherever situated in the County. Of course, the direct benefit of increased farm production would arise from any location.

If the benefits from the activity are equivalent regardless of the location, attention should focus on any cost differences associated with location. For example, by farming in the study area costs will include the potential for interference with the Biscayne Aquifer and surface

water flows. This cost will not be incurred in other areas. The opportunity cost of farming in the East Everglades is the risk of interfering with water movements. The opportunity cost of not farming there is the avoidance of the risk of interfering with said water movements. In the latter case, the opportunity cost is in fact a benefit. Since the crop will be produced either way and the induced economic activity will occur either way, the benefit is merely being shifted from one party to another and the risk of harm is avoided.

Another benefit of viewing the decision in an opportunity-cost analysis is that it directs attention to existing land uses elsewhere in the County. This will cause an evaluation of available agricultural lands elsewhere. The essence of the opportunity-cost approach is that it focuses attention on a fuller range of tradeoffs.

Identify Likely Implications of Alternatives

As with step three the concern here is with describing the likely stream of effects over the relevant planning horizon.

Relate Implications of Alternatives to Individuals and Groups

As in step four, the linkage between the alternative action and its implications and those individuals and/or groups likely to be affected must be established. It is the essence of the opportunity-cost approach to identify the explicit tradeoffs among different individuals within the polity (Dade County). This process is facilitated by the final step.

Display Results for Easy Comparison

It is here that the full impacts of the several alternatives are highlighted. For this exercise, an impact matrix can be very useful. The type of information depicted in the impact matrix places in bold relief the nature and extent of the tradeoffs made if one plan is chosen over another. It is intended to make difficult choices as explicit as possible so that those making the decisions--and those advocating opposing positions--can clearly see what was given up to obtain a particular output. The advantage of the opportunity-cost approach is that it forces all parties to be explicit about the implied tradeoffs of one plan compared to the other.

Evaluation of OCA

Opportunity-cost analysis does not start with the desire to attach monetary values to all of those benefits where it is thought possible (such as recreation value, option value, existence, scientific value). While following benefit-cost analysis in attempting to assign monetary values to those aspects which normally pass through established markets, the analyst's time is diverted from the conceptually and empirically

taxing task of assigning shadow prices to a wide variety of impacts, and channeled instead toward the more tractable task of compiling a more complete description of the full range of important quantifiable impacts. This means that more planning resources can be devoted to the difficult job of assessing the impacts.

The approach being suggested here does not preclude judgemental input on the part of decision makers and policy makers. That will always be required and desirable. However, a technique which logically orders information within a definite analytical framework is called for and preferable. The fact that both theory and data may be deficient in some respects is not an excuse for inaction. Judgements will still be made and the highlighting of gaps in our knowledge and techniques will serve as a stimulus to further research and development. For example, even though the method is often misused, the explicit requirement for benefit/cost analyses of water resource investments has greatly improved both our theoretical and measurement capabilities with respect to these types of development. Hopefully, the same will be true in the case of wetlands development decisions.

APPLICATIONS OF OPPORTUNITY-COST ANALYSIS

To demonstrate the opportunity-cost analysis technique a proposal to farm undeveloped land in the East Everglades and a proposal for a new marina by Biscayne Bay were analyzed. These two examples are illustrative only and do not constitute a conclusive study nor do they represent any specific development project or plans. The formats utilized in the applications are adaptations of the steps previously presented.

Agriculture In The East Everglades

Any proposal to convert several thousand acres of land west of Levee 31 into agricultural usage is an example of large scale nonincremental incursion into an environmentally fragile area which commands public attention, mobilizes groups on all sides, and polarizes environmentalists and development interests. Local history indicates that agricultural development is only an initial step in a gradual process of land conversion from agricultural to residential and commercial uses. This is the process which occurs in urban areas, and it very likely would occur in the East Everglades area. After clearing a large area, rockplowing, and otherwise disrupting the natural characteristics of the land for agriculture, gradually a few houses would be built which would attract more houses, perhaps a few commercial facilities, and other forms of urban encroachment.

The other form of conversion is the incremental, gradual development of farming and a house on five-acre sites. The result of this type of cumulative development will eventually be to cause pressure for various types of public services, for example, roads, schools, and police protection.

The conversion of land from agricultural to residential and commercial uses east of the levee appears to be the primary source of pressure for more agricultural land beyond the reach of urbanization. Thus the real problem to be addressed in dealing with development pressures in the East Everglades is not the development per se, but the pervasive pressure east of the Everglades area (east of Levee 31) which is displacing agriculture. The East Everglades area is seen as a "safety valve" where farming can continue without the complications which arise from farming in close proximity to urban residences. Such problems as vandalism, crop stealing, and neighbors complaining about dust and noise are common when agricultural and urban residential areas are closely juxtaposed. Perhaps more importantly, in the urban fringe area rising land values make the land too valuable to farm. Often vegetable farmers lease land from development companies who willingly enter into these arrangements in order to obtain the low agricultural tax assessments. When the land becomes 'ripe' for development, however, the farmers must locate new land on which to grow their crops.

Scenarios

To investigate this conversion process, opportunity-cost analysis will be employed. Two scenarios will be developed: one which depicts the process of land conversion east of Levee 31 in the absence of any distinct land use policy and another which represents a possible outcome where the County engages in explicit efforts to slow the rate of conversion. In this second scenario, explicit agricultural zones would be assiduously retained while increased residential and commercial development would be channeled into designated urbanizing areas. These scenarios are presented in this section.

Scenario 1. - Over 15,000 acres of land in agriculture in Dade County in 1970 were converted to other uses by 1976. Another 22,000 acres of vacant land in 1976 were available for agriculture.[1] The total acreage utilized for agriculture has varied little in recent years. In 1969 about 79,000 acres were in farmland while in 1974 almost 81,000 acres were in farmland.[2]

By utilizing the conversion rate of agricultural land to other uses from 1970 to 1976 and by assuming that total land demanded for agriculture does not change, it is estimated that the supply of available vacant agricultural land east of Levee 31 will be exhausted within the next decade. If the questionable additional 26,000 acres could be utilized, an additional ten-year supply would be available. As the available agricultural land east of Levee 31 is depleted, pressure for utilization of land in the study area is expected to mount. Some farming already occurs in the study area.

As the growth continues, the land conversion process in the study area will escalate. The amount of land being disrupted in the study area will not necessarily be limited to the amount of agricultural land being lost east of Levee 31. Once intrusions are made into this undeveloped land, the process is difficult to halt. As pointed out earlier, once the land is rockplowed or otherwise disturbed, the land cannot be restored to its natural state. Gradually the urban conversion process gains momentum, and housing and other types of development begin to displace agriculture in the study area as well.

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[1] An additional 26,000 acres are potentially available for agriculture. However, the salinity of the soil and susceptibility to flooding make these areas of dubious usefulness for farming.

[2] U.S. Department of Commerce, Bureau of the Census, 1974 Census of Agriculture, Preliminary Report, Dade County, Florida, November, 1976.

Scenario 2.- This alternative provides for the retention of agricultural land east of Levee 31.[3] This could cause higher density development in other urbanized areas or existing zoning may be sufficient to accommodate the anticipated population growth.

Implications

Environmental Effects. - Under the uncontrolled alternative, destruction of the study area ecosystem will begin gradually. For example, a farm of 8,000 acres might involve the rockplowing of 8,000 acres of pinnacle rock, an irreversible process.

Tomatoes might be the first crop to be planted since they are the most profitable cash crop. The annual fertilizer requirements for this crop include a basic application of 45 pounds of nitrogen, 90 pounds of phosphorous (P_2O_5) and 60 pounds of potassium (K_2O) per acre. One to four supplemental applications each of 40 pounds of nitrogen, 60 pounds of P_2O_5 and 60 pounds of K_2O would be made. If the maximum number of applications is made, a total of 1,640,000 pounds of nitrogen, 2,640,000 pounds of P_2O_5, and 2,400,000 pounds of K_2O would be required annually for 8,000 acres. After three years of tomato crops, the land would lie fallow, and then a new crop, probably squash or beans, would be planted. The basic fertilizer application would be 45 pounds of nitrogen, 60 pounds of P_2O_5, and 60 pounds of K_2O per acre for a bean crop. One to two supplemental applications of 30 pounds nitrogen, 30 pounds of P_2O_5, and 30 pounds of K_2O would be needed. Assuming both supplemental applications are made, total use would be 840,000 pounds of nitrogen and 960,000 pounds each of P_2O_5 and K_2O annually.[4]

Varying amounts of pesticide would be utilized depending upon the actual pest problems encountered in a given year. The figures below are based on per acre amounts of pesticides used in 1976 by local farmers.[5]. A tomato crop on 8,000 acres would require pesticides as follows:

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[3]Of the 81,000 acres in agricultural use, over half the amount is devoted to vegetable crops. Most vegetable crops are still rotated although alternative methods are now available. If land is retained for rotation an additional 60,000 acres would be needed.

[4]Dr. J.D. Dalton, Cooperative Extension Service, Agricultural Center, Homestead, Florida, 1977.

[5]Ibid.

Insecticides

Azondrin - 15 applications - 24,000 gallons total
Toxaphene - 6 applications - 24,000 gallons total
Lannate - 11 applications - 22,000 gallons total

Fungicides

Mazate 200 - 20 applications - 400,000 pounds
Dithane M-45 - 6 applications - 96,000 pounds
Copper - 7 applications - 28,000 pounds

Herbicides

Paraquat - 2 applications - 1,000 gallons

Fumigant

Dowfume MC-33 - 1 application - 2,400,000 pounds.

The use of fertilizers and pesticides in these quantities has serious implications for the quality of both surface and groundwater. Pesticides and other pollutants entering the surface water supply of Everglades National Park would reduce diversity and productivity, and affect the natural cycles of life at the base of the food chain. This would cause a potential threat to the nursery grounds of the Gulf of Mexico and Atlantic Fisheries, bird species, and other fauna.

Groundwater pollution from pesticides, fungicides, fertilizers, and mulch would potentially pose a hazard to the quality of the Biscayne Aquifer and local drinking water supply.

As this development or others grow in the study area and residential development begins, additional degradation of the quality of ground and surface water can be expected. Use of septic tanks in an area inundated on an annual basis would pose a health hazard. Runoff from urban and suburban development would degrade the quality of groundwater and surface water.

Surface alteration, road networks, drainage systems and waste disposal that accompany development will reduce the quantity and periodicity of surface water supply to Everglades National Park. This would result in a stress on the Park's existing life systems and begin a process of alteration of the Park biota, generally towards undesirable exotic species and reduction of marsh areas.

The increase in surface-water runoff from impervious cover and reduction in surface and groundwater levels by positive drainage that has historically accompanied development of wetlands would pose a serious danger to the groundwater recharge of the Biscayne Aquifer if uncontrolled development is allowed to occur in the area. A reduction in high groundwater levels within the area would reduce the water available for drinking and irrigation and would reduce the freshwater head necessary to prevent saltwater encroachment.

Any destruction of the study area causes repercussions elsewhere. Uncontrolled development would irretrievably destroy the pinnacle rock outcrops present in much of the area. This would halt the food web process, the conversion of nutrients into organics. Clearing of vegetation has historically facilitated the spread of noxious exotic vegetation species and caused a decrease in wildlife habitat. Under the alternative plan of a more careful land conversion process east of Levee 31, some of the same problems which accompany agricultural development would occur east of the levee. Table 1 compares the environmental implications of the two plans.

The possible pollution of groundwater supply of drinking water and agricultural wells could occur. However, the threat to the Park from surface water flow problems and loss of animal habitat will not occur under this alternative. Pinnacle rock will be destroyed, but less native vegetation will be lost since invasion by exotics has already occurred in many areas. If development is constrained to east of the levee, the problem of reduction of groundwater recharge to Biscayne Aquifer would not occur east of the levee. However, the problem of reduction of flood storage capacity would exist.

Other Effects - The Park receives over one million visitors annually, many of whom are tourists. These tourists spend money locally contributing to the local economy. To the extent that development in the study area detrimentally affects the Park and in turn reduces the number of visitors, an additional impact is felt.

Under Scenario 2, negative impacts would include the problems associated with agricultural and urban uses being in close proximity: noise, vandalism, and so on. Some parts of the urban area may have higher densities, but this is not necessarily a negative implication. The configuration of the urban area would be improved, areas suited for development would be explicitly defined, and the leap-frog type of development would be constrained to some degree. Public services could be planned and provided in an orderly manner, reducing costs to the County and others responsible for these investments.

Redistribution Effects

By allowing alteration of lands in the study area, not only the citizens of Dade County but a much larger public would be affected. Destruction of wildlife habitat, and pollution and reduction of water surface flow that adversely affect Everglades National Park will harm all citizens of the country, even though they may never see the Park. In addition, by not protecting the Everglades, a unique natural resource will be lost for future generations.

Table 1

Comparison of Potential Environmental Problems
of Plan 1 and Plan 2
From Agricultural and Other Development

	Pinnacle Rock Destruction	Pollution of Groundwater Supply	Pollution of Surface Water to Everglades National Park	Reduction of Surface Flow or Periodicity of Flow to Everglades National Park	Reduction of Groundwater Recharge to Biscayne Aquifer	Reduction of Flood Storage Capacity	Loss of Native Vegetation and Wildlife Habitat	Destruction of an Operative Ecosystem
Plan 1	yes	yes	yes	yes	yes	yes	yes	Macrosystem Destruction
Plan 2	yes	yes	no	no	no	yes	some	Microsystem Destruction

To the extent that both alternatives reduce the quality and quantity of water supply, those dependent on wellfields or private wells in South Dade will be harmed.

Under the managed development plan, those holding agricultural land with anticipation of conversion to residential use will be disappointed. Those owning land in the study area will face restricted use possibilities.

Display Matrix

Table 2 illustrates how to compare the impacts of agricultural development east and west of Levee 31. Although this study did not supply data for all the categories, a more extensive study would attempt to present all needed information. Direct and indirect impacts and monetary and non-monetary impacts are included. This type of table enables the decision-maker to visualize the nature and extent of the tradeoffs made if one alternative is chosen over the other.

Implementation

Although implementation is not a part of opportunity-cost analysis, the discussion has been added to illustrate ways to implement the alternatives considered. Implementation of Scenario 2 would require some basic steps. First, a program of realistic, enforced zoning would be essential. Lands zoned for agriculture or conservation could not be changed to other types of zoning. Secondly, a program such as transfer of development rights could be used to compensate those who would be allowed only agricultural use of their land east of the levee, and to compensate land owners in the study area who would not be allowed to develop.

Transfer of development rights allows the transfer of density to parcels of land which may not be contiguous or in the same ownership. Through police-power regulation, parcels where development is not desired or only agricultural use is desired are placed in zones, and no other development is allowed. Compensation occurs by selling the unused development potential to the owners of "transfer zone" land. These are areas which have been designated to have greater than presently allowed density. Increased density will be allowed if the owners of such lands purchase development rights from owners of the restricted land. In this way landowners are compensated for restricted use by the ability to sell their rights to develop in the marketplace, and to receive fair market value for them.[6]

Such a plan would allow preservation of the study area and assure an adequate supply of agricultural land within Dade County.

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[6]Miner, Dallas and Schnidman, "Transfer of Development Rights: An Introductory Statement," Urban Land, January, 1975.

Table 2

IMPACT MATRIX FOR AGRICULTURE (8,000 acres)

	East Everglades West of Levee 31	East of Levee 31
Annual Production Costs Land Costs Land Preparation Costs Transportation Costs Fertilizer and Pesticide Costs		
Annual Revenues		
Annual Taxes Paid		
Induced Economic Activity		
Pounds of Fertilizer Annually*	6,480,000	6,480,000
Amount of Pesticide Annually*	2,924,000 pounds 71,000 gallons	2,924,000 pounds 71,000 gallons
Acres of Wetland Destroyed	8,000	0
Acres of Zoned Agricultural Land Utilized	0	8,000
Acres of Pinnacle Rock Destruction	8,000	?
Potential Pollution of Groundwater Supply	yes	yes
Potential Pollution of Surface Water to Everglades National Park	yes	no
Potential Reduction of Surface Flow or Periodicity of Flow to Everglades National Park	yes	no
Potential Reduction of Groundwater Recharge to Biscayne Aquifer	yes	no
Potential Reduction of Flood Storage Capacity	yes	yes
Potential Loss of Native Vegetation and Wildlife	yes	some
Potential Destruction of an Operative Ecosystem	macrosystem destruction	microsystem destruction
Local Residents Affected	yes	yes
Public At Large Affected	yes	no

*for tomato crop

Marina Development Options On Biscayne Bay

Need for Marinas

The need for and impact of new marinas along Biscayne Bay are local issues currently being debated. One local boating group projects that 6,500 additional wet-berth slips will be needed by 1985 if anticipated demand is to be met.[7] This figure purportedly was based on data supplied by Dr. Bruce Austin from his research on recreational boating in Dade County.[8] Dr. Austin's own projections, however, show a need for only 1,000 additional wet-berth slips by 1985.[9] Based on 1975 wet berth ownership rates and utilizing the 1985 population projection range, another figure indicating a need for 600 - 1,300 additional slips by 1985 was calculated.[10]

These comparisons readily show that projections may vary widely depending upon the assumptions made and techniques utilized. Decision-makers should be aware that each set of projections may be valid within the particular context in which it is prepared. Thus, there is no perfect set of projections and the choice of one over another is in part a function of the purpose for which it is used.

The long waiting lists at existing marinas are often referred to as an indication of the current shortage of boat slips. However, this is not an accurate indication because boat owners may register on several lists and may already have berths and are trying to obtain more desirable ones.

For purposes of this demonstration, an intermediate figure of 2,000 additional slips by 1985 will be utilized for the analysis. The purpose of this project is to show how to apply the opportunity-cost technique, and the number chosen is not as important as the application.

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[7] This figure includes commercial, documented, and out-of-state boats as well as locally registered recreational boats. The Impact of Recreational Boating on Dade County, Marine Council, 1976.

[8] C. B. Austin et. al., Recreational Boating in Dade County, 1975-76 (Miami: University of Miami Sea Grant Program, 1977).

[9] Ibid., pp. 108-109.

[10] The population projection range for 1985 is from 1,620,000 to 1,820,000. Population Projections, Metropolitan Dade County, 1970-2000 (Miami: Metropolitan Dade County Planning Department, 1971), p. 27. In 1975 there were 4,831 berthed boats in Dade County (excluding 103 out-of-state boats). C. B. Austin et. al, p. 109. 1975 estimated population was 1,442,000. Population Change in Dade County, Florida, April 1, 1975 to April 1, 1976 (Miami: Metropolitan Dade County Planning Department, 1976), p. 4.

Assuming a demand does exist for an additional 2,000 wet berths, more discussion of this demand is merited. Existing rate structures upon which projections were made do not provide for self-supporting marinas. The public subsidizes a portion of marina costs currently. This subsidy goes to only a small portion of the community. In 1975 about six percent of local households were boatowners, of which approximately one-seventh owned berthed boats.[11] Should the County provide these services merely because the demand exists at current prices, or should rate structures be raised to cover costs? By increasing the price, the quantity demanded at the higher price would probably be less.

Many external factors could affect the future demand for boating facilities. The mix of leisure time activities could change or the cost of boating could increase drastically and affect demand. For example, how would demand vary if gasoline prices tripled or the cost of boats doubled? The County population may not grow at projected rates; the age or income structure of local residents could change; or economic conditions could vary.

Any discussion of demand and supply and associated prices for marinas would be incomplete if environmental effects are not considered as a part of the economic analysis. The market system does not reflect environmental considerations usually because these factors affect third parties or the general public who are not participating in the market transaction. Other effects such as crowding, bay user conflicts and noise similarly affect third parties. Many of these costs cannot be assigned a dollar value, and some cannot even be quantified, but they must be considered. The opportunity-cost technique offers a way to array these costs so that they are included in the decision-making framework.

Options

If there is a legitimate demand for increased marina capacity, the critical planning issues are the capacity and location of the facilities. All of the increased capacity could be added at one site, or it could be allocated to several sites. Of course, the determination of the total number of new sites should not be made in isolation from their ideal allocation among several sites.

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[11] Austin et. al., p. 108.

This analysis compares three options for marina development to demonstrate how location affects the impact of the marina. For each option, 2,000 boat slips will be added. Enough increased ramp capacity and parking for cars and trailers will be added to meet 1985 trailer boat needs.[12] Table 3 depicts existing marina capacity for the relevant sites on Biscayne Bay. Notice that with trailered capacity there are two types of constraints: 1) actual ramp capacity, and 2) parking capacity. Table 4 shows the three options for increasing wet-berth and trailered boat capacity.

Since parking is the limiting factor at Haulover, North Bay and Matheson, Option 1 assumes 50 additional parking spaces at each of these sites. The major aspect of Option 1 is the addition of 2,000 wet berths at Homestead Bay Front Park, 2,000 accompanying parking spaces, a 60 foot widening of the ramp, and 80 additional car-trailer parking spaces.

Option 2 is an alternative which attempts to limit increased boating in South Bay and the Biscayne National Monument. It consists of 1,000 wet berths and 1,000 associated car parking spaces, 125 foot-wide ramp, and 150 new car-trailer parking spaces at both Chapman Field and Black Point.

Option 3 attempts to disperse the increased usage to minimize environmental impact from the concentration of use and to build where the least harm would occur to the land and the bay. Option 3 consists of 800 new berths and associated parking at North Bay; and 1,200 wet berth slips and accompanying parking, 125 feet of ramp, and 170 new car-trailer parking spaces at Virginia Key.

Once the planner has developed several scenarios for the increments to capacity, it is necessary to make certain assumptions regarding increased use at the various sites. Table 5 depicts assumed use based on data taken from Recreational Boating in Dade County 1975-76. The basis for these assumed use rates depends on the type of boat. For berthed boats, the increased use figures are based on current utilization rates by site. For trailered boats summer use is based on 100 percent utilization of capacity. The year-round weekend day use is based on the current proportion of year-round to summer use.

Implications

The next step in assessing the implications of marina development is to compute the land use and water use impacts. Some of these will be rather obvious, while others will be somewhat tenuous. Examples of the obvious impacts are shoreland required for wet slips, parking facilities, and ramp construction. These land use implications are shown for the various plans in Table 6. It represents aggregate figures for all marinas while Table 7 shows the same impacts by individual marinas. Table 8 compares the land impact with the number of boaters associated with each plan.

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[12] Ibid., pp. 108-109.

Table 3

CURRENT CAPACITY AND USE AT EXISTING MARINAS[1]

	Parking Spaces	Ramp Width	Trailered Boats Per Day			Berthed Boats Per Day		
			Design Capacity	Use		Design Capacity	Use	
				Summer Weekend	Year-Round Weekend		Summer Weekend	Year-Round Weekend
Haulover	145	300'	200	127	96	0	0	0
North Bay	130	150'	200	83	65	0	0	0
Crandon	266[2]	300'	375	345	201	125	37	28
Matheson	194[3]	213'	275	219	154	156	101	70
Homestead	167	90'	225	232	133	72	37	32

[1]C. B. Austin et al. Recreational Boating in Dade County, 1975-76 (Miami: University of Miami Sea Grant Program, 1977), pp. 38, 59-63, 65. Use figures from boater survey, and capacity based on activity mix and resulting time curves. Thus, capacity is based on length of time boaters are on the water and on peak load. Homestead is the only location where ramp capacity, not parking spaces, constrains use.

[2]275 additional parking spaces are available for cars without trailers.

[3]An additional 140 parking spaces are available for wet berth boat owners.

Table 4

ALTERNATIVE MARINA FACILITY PLANS
(Development Assumed as of 1985)

	Existing[1]			Increased Capacity								
				Option 1			Option 2			Option 3		
	Berths	Ramp	Parking Spaces	Berths	Ramp	Parking Spaces	Berths	Ramp	Parking Spaces	Berths	Ramp	Parking Spaces
Haulover	0	300'	145	0	0	+50	0	0	0	0	0	0
North Bay	0	150'	130	0	0	0	0	0	0	+800	0	0 / +800 [2]
Crandon	125	300'	266[3]	0	0	+50	0	0	0	0	0	+50
Matheson	156	213'	194[4]	0	0	+50	0	0	0	0	0	+50
Homestead	72	90'	167	+2000	+60'	+80 / +2000	0	0	0	0	0	0
Virginia Key	0	0	0	0	0	0	0	0	0	+1200	+125'	+170 / +1200
Chapman Field	0	0	0	0	0	0	+1000	+125'	+150 / +1000	0	0	0
Black Point	0	0	0	0	0	0	+1000	+125'	+150 / +1000	0	0	0

[1] C. B. Austin et al. Recreational Boating in Dade County, 1975-76 (Miami: University of Miami Sea Grant Program, 1977), p. 38.

[2] Upper number is ramp-related parking spaces, lower number is berth-related parking.

[3] 275 additional parking spaces are available for cars without trailers.

[4] An additional 140 parking spaces are available for wet berth boat owners.

Table 5

EXISTING AND PROJECTED MARINA USAGE
(Number of Trips)

	1975-76*		(Increased Usage -1985) Option 1		Option 2		Option 3	
	Wet Berth	Trailer	Wet Berth	Trailer	Wet Berth	Trailer	Wet Berth	Trailer
Haulover								
Summer Weekend Day	0	127	0	+75	0	0	0	0
Year-Round Weekend Day	0	96	0	+57	0	0	0	0
North Bay								
Summer Weekend Day	0	83	0	0	0	0	+360	0
Year-Round Weekend Day	0	65	0	0	0	0	+269	0
Crandon								
Summer Weekend Day	37	345	0	+75	0	0	0	+75
Year-Round Weekend Day	28	201	0	+44	0	0	0	+44
Matheson								
Summer Weekend Day	101	219	0	+75	0	0	0	+75
Year-Round Weekend Day	70	154	0	+53	0	0	0	+53
Homestead								
Summer Weekend Day	37	232	+1,098	+145	0	0	0	0
Year-Round Weekend Day	32	133	+ 792	+83	0	0	0	0
Virginia Key								
Summer Weekend Day	0	0	0	0	0	0	+540	+250
Year-Round Weekend Day	0	0	0	0	0	0	+400	+163
Chapman Field								
Summer Weekend Day	0	0	0	0	+549	+225	0	0
Year-Round Weekend Day	0	0	0	0	+396	+144	0	0
Black Point								
Summer Weekend Day	0	0	0	0	+549	+225	0	0
Year-Round Weekend Day	0	0	0	0	+396	+144	0	0
Total								
Summer Weekend Day	175	1,006	+1,098	+370	+1,098	+450	+900	+400
Year-Round Weekend Day	130	649	+ 792	+237	+ 792	+288	+664	+260

*C. B. Austin et al, Recreational Boating in Dade County, 1975-76 (Miami: University of Miami Sea Grant Program, 1977), p. 65.

Table 6

LAND IMPACTS OF ALTERNATIVE
MARINA DEVELOPMENT PLANS

	Option 1	Option 2	Option 3
Land for Berths*	260 Acres	260 Acres	260 Acres
Land for Parking	23 Acres	24 Acres	23 Acres
Shoreline for Ramps*	60 Feet	250 Feet	125 Feet
	283 Acres and 60 Feet	284 Acres and 250 Feet	283 Acres and 125 Feet

*Land devoted to berths and parking estimated from these assumed requirements: 1) 13 acres per 100 wet slips; 2) 800 square feet per parking space for trailered boats; and 3) 400 square feet per parking space per wet berth.

Table 7

CURRENT AND ADDITIONAL LAND USE
IMPLICATIONS OF MARINA DEVELOPMENT BY SITE

	Existing	Option 1	Option 2	Option 3
Haulover				
Berths *	0	0	0	0
Ramps	300 Feet	0	0	0
Parking*	2 2/3 Acres	1 Acre	0	0
North Bay				
Berths *	0	0	0	104 Acres
Ramps	150 Feet	0	0	0
Parking*	12½ Acres	0	0	7¼ Acres
Crandon				
Berths *	16 Acres	0	0	0
Ramps	300 Feet	0	0	0
Parking*	4 3/4 Acres	1 Acre	0	1 Acre
Matheson				
Berths *	20 Acres	0	0	0
Ramps	213 Feet	0	0	0
Parking*	4 3/4 Acres	1 Acre	0	1 Acre
Homestead				
Berths*	9 Acres	260 Acres	0	0
Ramps	90 Feet	60 Feet	0	0
Parking*	3 Acres	20 Acres	0	0
Virginia Key				
Berths*	0	0	0	156 Acres
Ramps *	0	0	0	125 Feet
Parking	0	0	0	14 Acres
Chapman Field				
Berths*	0	0	130 Acres	0
Ramps	0	0	125 Feet	0
Parking*	0	0	12 Acres	0
Black Point				
Berths*	0	0	130 Acres	0
Ramps	0	0	125 Feet	0
Parking*	0	0	12 Acres	0
	62 Acres and 1,053 Feet	283 Acres and 60 Feet	284 Acres and 250 Feet	283 Acres and 125 Feet

*Land devoted to berths and parking estimated from these assumed requirements: 1) 13 acres per 100 wet slips; 2) 800 square feet per parking space for trailered boats; and 3) 400 square feet per parking space per wet berth.

Table 8

COMPARISON OF LAND IMPACTS WITH NUMBER OF BOAT USERS

	1975-76	Option 1	Option 2	Option 3
Land for Parking and Berths	61 Acres	283 Acres	284 Acres	283 Acres
Shoreline for Ramps	1,053 Feet	60 Feet	250 Feet	125 Feet
Summer Weekend Day Trips				
Wet Berth Boats	175 Boaters	1,098 Boaters	1,098 Boaters	900 Boaters
Trailer Boats	1,006 Boaters	370 Boaters	450 Boaters	400 Boaters
Year-Round Weekend Day Trips				
Wet Berth Boats	130 Boaters	792 Boaters	792 Boaters	664 Boaters
Trailer Boats	649 Boaters	237 Boaters	288 Boaters	260 Boaters

Each plan would impact public services. Depending upon what services are currently provided to the sites, the improvements needed would vary. For example, at Homestead greater road capacity would be needed to provide easy access to the marina. Water and sewer lines might need expansion or extension.

In some cases, traffic to the marina might contribute to traffic congestion. For example, Rickenbacker Causeway is currently congested on weekends, and the addition of the Virginia Key marina would add to this problem. Each site would have some problems associated with it, and one should consider these costs in the site selection process.

Marina construction costs would vary primarily by size. The design of the facility and existing site conditions would also affect costs. Some ancillary development can be expected to accompany marina development. Possible eating facilities, bait shops, service stations, even hotels, motels and residential development may locate near marinas. The effect on the character of the existing neighborhood should be carefully evaluated.

Environmental Effects. - The development of some of the marina sites will cause mangrove destruction, and this is shown in Table 9. Mangroves serve several important functions. The mangrove ecosystems intercept and filter surface water runoff, preventing large scale nutrient losses to the open sea. This helps maintain water quality. Their complex root structure serves in the accumulation of organic and inorganic materials, and the mangrove also acts as mechanical energy buffers to strong winds and storm tides.[13] Decaying leaf matter or detritus suspended in the freshwater sheet flow form a highly productive brackish zone which acts as a basis of aquatic food chains along the coast. In addition many types of fauna are dependent upon mangrove swamps at some time in their life cycle.[14]

Approximately 280 acres of mangroves will be destroyed by the Homestead marina if all the land utilized is covered by mangroves. At Chapman Field, if the existing twenty-five acre lake is utilized to create the proposed 130 acre basin, little mangrove destruction would occur. However, widening of the current access channel to 300 feet would destroy at least 18 acres of mangroves directly and probably much more as the channel would have to widen at the basin approach.

At Black Point the upland damage could be minimized since extensive areas have previously been filled. No mangrove destruction would occur at Pelican Harbor; and at Virginia Key, the direct damage would be minimal although some dredging of mangroves might be required.

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[13] Models for Planning and Research for the South Florida Environmental Studies (Gainesville: University of Florida, 1971), pp. 37-38.

[14] Comprehensive Development Master Plan for Metropolitan Dade County, Florida (Miami, 1975), p. 38.

Marina development would impact the bay in varying degrees depending upon the location as shown in Table 9. In Biscayne National Monument channel width is limited to 150 feet and the location of channels allowed in the Monument has been designated by law. The current easement for a channel from Homestead would not be sufficient to serve a 2,000 slip marina. In order to provide additional bay access, it would be necessary to connect to other channel easements to the north and to the south.

The closest channel easements are located 1 3/4 miles to the north and 2 miles to the south at Turkey Point. The north channel currently does not exist and would have to be dredged. In order to connect to both channels, north-south channels along the coastline would be required. These north-south channels are not desirable because they will cut through the grass flats along the coastline which are generally the most valuable in the bay. In addition these channels would be a likely location for accumulation of debris and sediment carried by the prevailing easterly winds, the literal drift along the shoreline, and the outflow from the mangrove swamps.

The existing Homestead channel would have to be deepened to minus six feet and lengthened for two miles. Constructing needed channels would destroy approximately 170 acres of grassflats. Also in those areas where dredging will necessarily cut into the limerock basin (eliminating the possibility of using a "mud cat dredge"), siltation is always a possible damaging side effect (even though turbidity screens would certainly be required during the dredging process). If the screens allow sediment to escape during the dredging, then other surrounding grassflats could be destroyed. The amount of destruction would depend upon the amount of dredge materials which pass through the turbidity screen and upon current velocities.

At Chapman Field, Option 2, bayward of the channel entrance point the water is very shallow, and an extensive area of sand is usually exposed during low tides. To the south and west patchy to fairly dense grassflats extend out to the six foot contour, and dredging of the fine material and limerock could cause potential siltation problems. However, the degree of grass damage would probably be less than at either Black Point or Homestead Bayfront Park.

At Black Point, grass flat damage would be extensive. Channel length is anticipated to be approximately three miles, with about two miles passing through valuable grass flats.[15] This will destroy about 73 acres of grass flats directly plus an unknown amount due to probable siltation. At Pelican Harbor damage would be minimal. At Virginia Key a channel would need to be dredged on the ocean side out through Norris Cut. This could cause siltation, but there would be little for the silt to damage if the inflow were confined to the Norris Cut area.

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[15]For all channels except for the Homestead marina channels (where channel width is less because it is in the Biscayne National Monument) a channel minus six feet and 300 feet wide would be required.

Table 9

POTENTIAL NATURAL RESOURCE DESTRUCTION
ASSOCIATED WITH DIFFERENT MARINA FACILITIES

	Land Changes	Bay Changes From Dredging[2]
Option 1		
Haulover	0	0
Crandon	0	0
Matheson	0	0
Homestead	280 acres of mangrove destruction from marina and parking construction[1]	Approximately 170 acres of grassflats plus probable siltation damage
Option 2		
Chapman Field	At least 18 acres of mangrove destruction from inland channel[2]	Probable grassflat destruction but less than at Black Point
Black Point	Little mangrove destruction[2]	73 acres of grassflat destruction plus probable siltation damage.
Option 3		
North Bay	0	0
Virginia Key	Some mangrove destruction	Probable siltation damage.

[1]Assumes all land utilized has mangrove coverage.
[2]Assumes already-developed land will be utilized.

Grass flats are also affected in another way from dredging. Sea grasses grow in an oxygen poor sediment environment, and many of the chemical cycles which are believed to contribute to the high productivity in turtle grass beds require the maintenance of the anaerobic sediment environment, and thus dredging could contribute to additional grass flat destruction.

Other Effects. - If boaters stray outside of marked channels, surrounding grass beds could be harmed. Smaller boats notoriously fail to heed channel markings. Once a suspected navigable depth is reached, the direction of travel desired overcomes channel markings in navigation decisions. Cuts through the grass flats could cause turbidity which in turn may cause a decline in grassflat productivity. Also the cuts would leave the flats more susceptible to hurricane damage.

Redistribution Effects

Marina expansion may affect individuals due to locational differences or due to the size of the marina. Those residents in the higher income groups associated with boat ownership will receive a direct benefit from increased slip and ramp availability. Over 50 percent of Dade County boat owners received incomes over $20,000 per year in 1975-76.[16] To the extent that non-residents utilize the increased facilities, local boat owners will not gain increased access to the bay.

However, current bay users may feel that marina expansion would negatively affect them. The presence of more boaters on the bay may reduce boating enjoyment because of crowding, increased noise, and other effects. Figures 4 and 5 show destination patterns under the various options.

If a given site causes an increase in road traffic that increases congestion, other drivers will be detrimentally affected by that marina. Land values adjacent to marinas may be positively or negatively affected depending on the location and existing land uses. The construction of a large marina could cause existing suppliers to lose business or it could mean increased sales.

Boaters may suffer from user conflicts on the bay. Tables 10 and 11 show that the potential for conflicting uses is greatest in South Bay during the summer. Almost 40 percent of the boaters are cruising; another 25 percent choose swimming or skiing; more than 20 percent are fishing and another 15 percent engage in diving or spearfishing. Also most of the boaters destined for South Reef or South Stream travel through South Bay adding to the conflict potential. At the bayward entrance to Caesar's Creek (which provides access to the ocean) the channel is very narrow as it cuts between a shallow sandy shoal and the mangrove shoreline at one approach, or through the shoal on another. The increased boat traffic associated with the Homestead expansion may cause navigational problems at this point. Within the Creek the channel

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[16]Austin et.al., p. 42

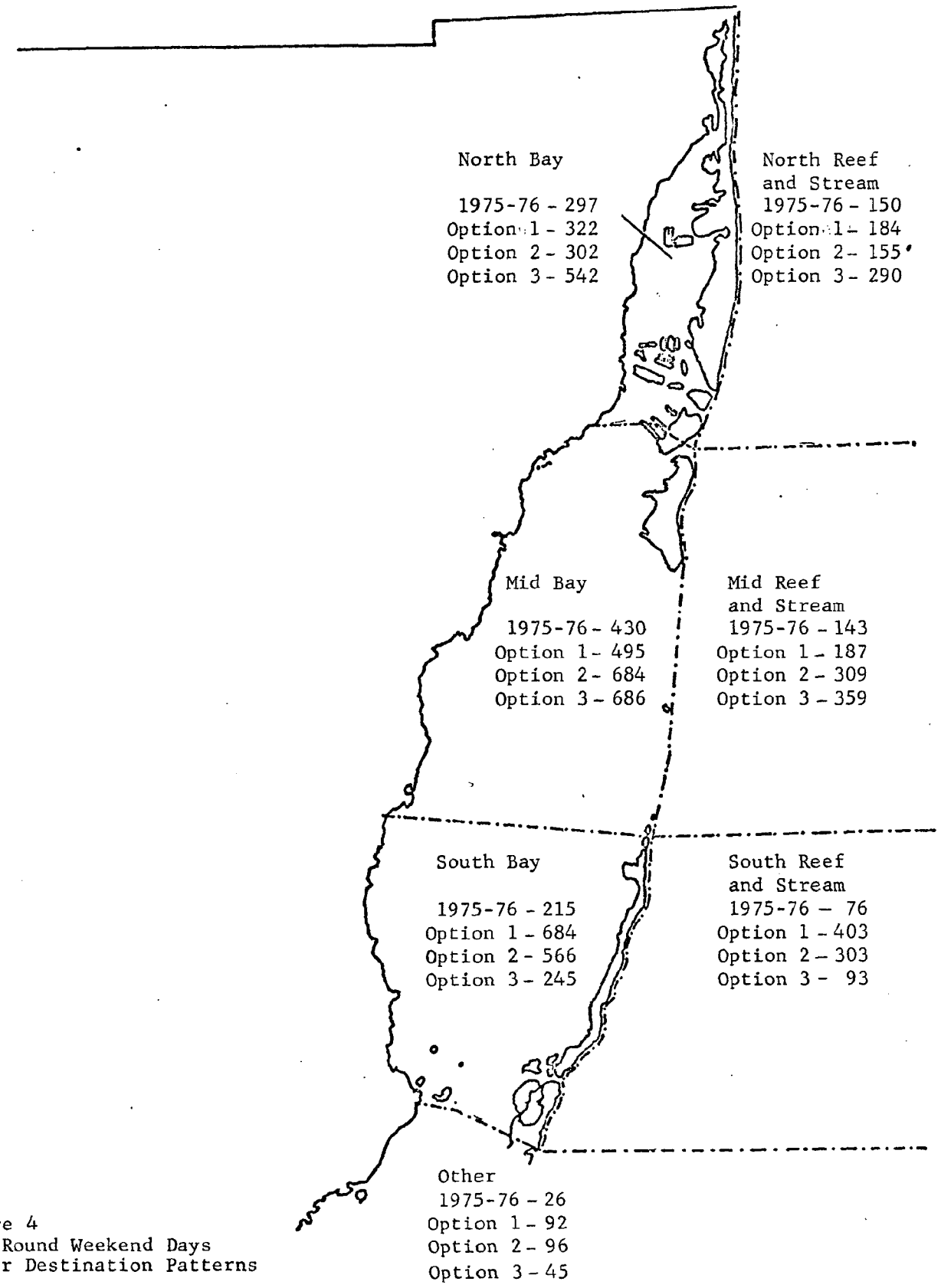

Figure 4
Year-Round Weekend Days
Boater Destination Patterns

*Options include 1975-76 figures

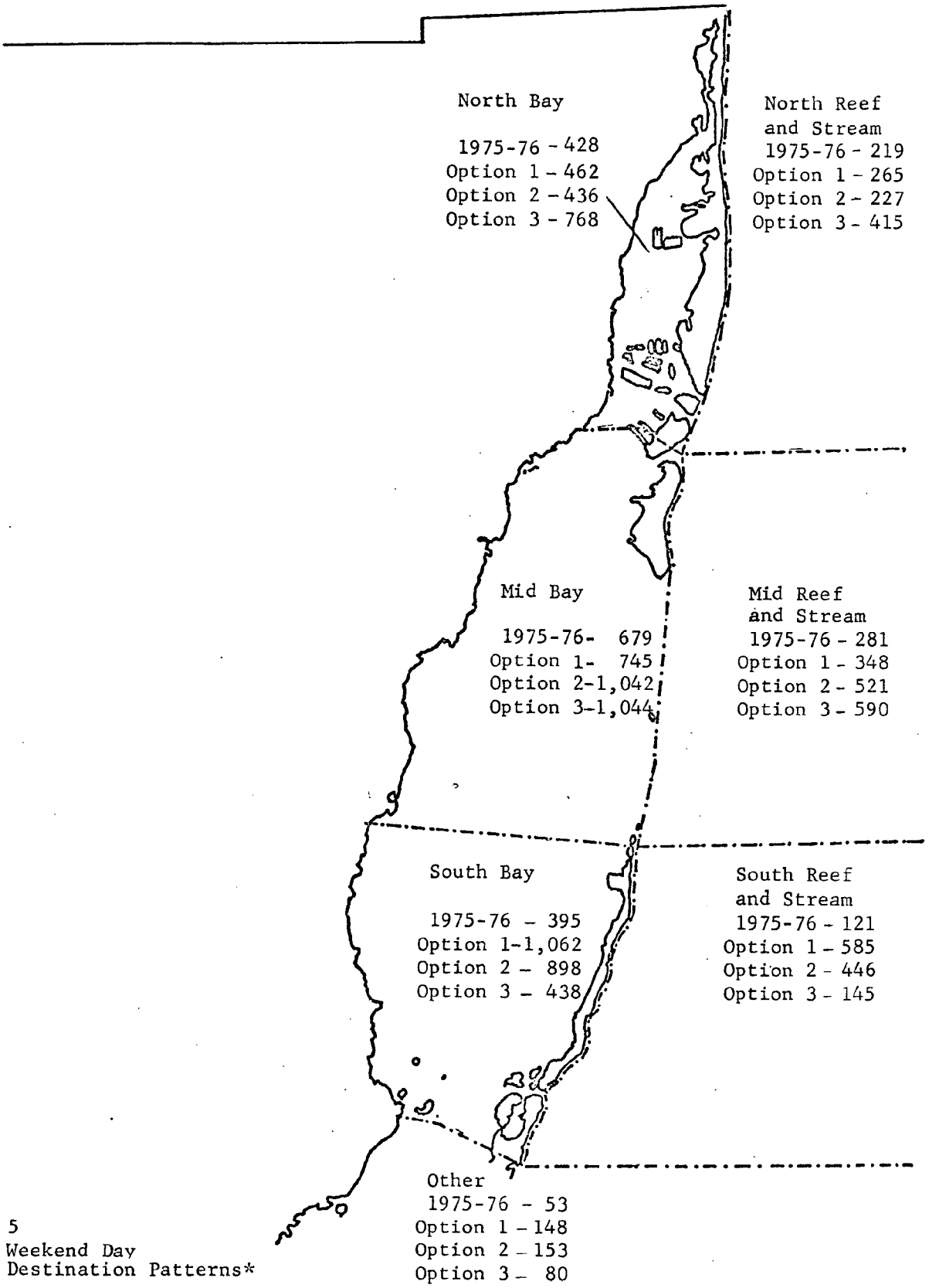

Figure 5
Summer Weekend Day
Boater Destination Patterns*

*Options include 1975-76 figures

Table 10

BOATER RECREATIONAL USES BY DESTINATION AREA FOR SUMMER WEEKEND DAYS[1]

1975-76

	North Bay	North Reef and Stream	Mid Bay	Mid Reef and Stream	South Bay	South Reef and Stream
Cruise	199	13	365	26	151	5
Swim/Ski	115	7	121	4	93	5
Linefish	83	180	98	208	84	83
Dive/Spear	3	17	57	43	63	27
Other	27	3	38	1	5	0
Total	428	219	679	281	395	121

Option 1 (1985)

	North Bay	North Reef and Stream	Mid Bay	Mid Reef and Stream	South Bay	South Reef and Stream
Cruise	215	16	401	32	406	25
Swim/Ski	124	10	133	5	250	25
Linefish	89	216	107	257	225	404
Dive/Spear	4	20	63	53	169	132
Other	30	4	42	1	13	0
Total	462	265	745	348	1,062	585

Option 2 (1985)

	North Bay	North Reef and Stream	Mid Bay	Mid Reef and Stream	South Bay	South Reef and Stream
Cruise	203	13	561	48	343	19
Swim/Ski	117	8	186	7	211	19
Linefish	84	185	150	385	190	308
Dive/Spear	4	18	88	79	143	100
Other	28	3	58	2	11	0
Total	436	227	1,042	521	898	446

Option 3 (1985)

	North Bay	North Reef and Stream	Mid Bay	Mid Reef and Stream	South Bay	South Reef and Stream
Cruise	358	25	562	54	167	6
Swim/Ski	207	15	186	8	103	6
Linefish	148	338	150	435	93	100
Dive/Spear	6	32	88	90	70	33
Other	49	6	59	2	5	0
Total	768	415	1,044	590	438	145

[1]Each option includes existing usage of the bay. Distribution of activities based on existing patterns of recreational use by location in C. B. Austin et al, Recreational Boating in Dade County, 1975-76 (Miami: University of Miami Sea Grant Program, 1977), pp 69-73. Column numbers may not equal totals due to rounding.

Table 11

BOATER RECREATIONAL USES BY DESTINATION AREA FOR YEAR-ROUND WEEKEND DAYS[1]

1975-76

	North Bay	North Reef and Stream	Mid Bay	Mid Reef and Stream	South Bay	South Reef and Stream
Cruise	149	7	221	13	90	3
Swim/Ski	56	3	46	2	39	2
Linefish	67	133	129	111	63	58
Dive/Spear	4	6	17	16	22	14
Other	21	1	17	1	3	0
Total	297	150	430	143	215	77

Option 1 (1985)

	North Bay	North Reef and Stream	Mid Bay	Mid Reef and Stream	South Bay	South Reef and Stream
Cruise	161	9	254	17	285	13
Swim/Ski	61	3	53	2	122	9
Linefish	73	163	149	146	198	307
Dive/Spear	4	7	20	20	68	73
Other	23	1	19	1	10	0
Total	322	184	495	187	684	403

Option 2 (1985)

	North Bay	North Reef and Stream	Mid Bay	Mid Reef and Stream	South Bay	South Reef and Stream
Cruise	151	7	352	28	236	10
Swim/Ski	57	3	73	3	101	7
Linefish	68	137	206	242	164	231
Dive/Spear	4	6	27	34	57	55
Other	22	1	26	2	8	0
Total	302	155	684	309	566	303

Option 3 (1985)

	North Bay	North Reef and Stream	Mid Bay	Mid Reef and Stream	South Bay	South Reef and Stream
Cruise	272	14	353	33	102	3
Swim/Ski	102	5	73	4	44	2
Linefish	122	257	206	281	71	71
Dive/Spear	7	12	27	39	25	17
Other	39	2	26	3	3	0
Total	542	290	686	359	245	93

[1]Each option includes existing usage of the bay. Distribution of activities based on existing patterns of recreational use by location in C. B. Austin, et al, Recreational Boating in Dade County 1975-76 (Miami: University of Miami Sea Grant Program, 1977), pp 69-73. Column numbers may not equal totals due to rounding.

is well marked, but conflicts between linefishing and diving activities, which currently are numerous in this channel, would arise since practical channel uses would be reduced. Option 1 directs the largest percentage of boaters to South Bay of the three options. The potential for conflict increases as the number of users grows especially when they participate in divergent activities.

Display Matrix

Table 12 compares the advantages and disadvantages of the different marina locations. Due to limitations of this demonstration, not all categories have values assigned to them. The matrix does not enable one to tally up the columns and arrive at a total numerical value for each option. It is a way to display choices so that the nature and extent of the tradeoffs among the different plans are made explicit.

Table 12

IMPACT MATRIX OF MARINAS

	Option 1	Option 2	Option 3
Acres of Grassflats Destroyed	170	73 plus	Minimal
Acres of Mangroves Destroyed	280	some	some
Siltation and Other Effects	most	some	least
Conflicts Among Bay Users			
cruising and fishing	most	some	some
cruising and water contact sports	most	some	some
fishing and water contact sports	most	some	some
Congestion on Access Highways			
Costs of Extending or Improving Services			
Change in Neighboring Land Values			
Potential for Induced Economic Activity			
Effects on Income Groups	benefits higher income groups	benefits higher income groups	benefits higher income groups
Psychological Effects on Bay Users (Crowding, Noise)			

CONCLUSION

This portion of the demonstration project has attempted to present the relevant concepts and considerations needed for efficient decision-making in the use of scarce natural resources. A framework has been offered to demonstrate a way to rationally evaluate the impact of different alternatives. It is only when decision-makers understand the full implications of each choice that unanticipated and undesired repercussions can be avoided. This awareness is crucial if a community wishes to effectively utilize the natural resources of an area in a socially optimal sense, i.e. where total benefits exceed total costs to the greatest extent possible. Actual attainment of this lofty goal is probably beyond the present capabilities of our social, political and economic institutions, even if the technical issues were resolved, and they are not.

Opportunity cost analysis or other techniques are only improvements to the decision making process if properly utilized. They are analytical tools which may explicitly recognize the direction and gross magnitude of certain effects, help to clarify alternatives in terms of the incidence of benefits and costs, and provide a systematic rationale for making land use decisions.

The demonstration project provides useful insight as to the feasibility of incorporating this approach on a regular basis in a planning or similar organization. First, the application of OCA or a variant of it should probably be reserved for rather large scale or unique project proposals. It would be analytically more difficult and quite inefficient to utilize the approach for a single small marina or a few hundred acres of agricultural land for example. This is also in keeping with the desirability of looking at entire natural systems rather than pieces of them. The staff resources and skills involved are not extraordinary. The examples in this report were carried out by essentially one person, an economist by training, and were developed over one year on about a fifty percent time basis. Much of the data and information required for OCA would be collected or generated in the course of normal planning efforts. Still, filling in the display matrix is not an easy task and certain information may be very difficult or impossible to obtain.

Finally, with respect to its ultimate impact on decision-making, the jury is still out. Political decision-makers should have no difficulty in understanding the method but may be uncomfortable with the admitted imprecision of this approach vis-a-vis benefit-cost type analysis where some alternative is numerically "proved." Likewise, the emphasis placed on distributional effects is not necessarily welcome by politicians whose tenure in office is determined by how successful they are at appearing to help everyone somewhat and not hurting anyone at all.

This publication is one volume of a three volume report prepared by the Metropolitan Dade County Planning Department as a result of a special study to improve the planning process, provide new information, and aid decision makers in environmental resource management.

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