# *Environmental Problems in South Florida*

*Report of the*
Environmental Study Group
*to the*
Environmental Studies Board
*of the*
National Academy of Sciences
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# *Foreword*

The Environmental Studies Board expresses its deep appreciation to those who participated last August in the work of the Summer Study Group at Stanford University. The Summer Study concerned itself with two subjects of study: (1) Institutions for Effective Management of the Environment, which was the subject matter of Part I of this report, published in January, and (2) Environmental Problems in South Florida, which has to do with the possible environmental effects of construction of a jetport near the Everglades National Park in Florida and is the subject matter of this document. These two documents are significantly related, of course, Part I being concerned with a general problem—how we anticipate and deal with environmental effects in general—and Part II with the likely effects of a particular technological project, and what can be done about it.

Both of these documents are intended to bring fresh views of people in a variety of academic disciplines, public-policy positions, and related areas of concern bearing upon the nonsci-

entific aspects of environmental affairs. We believe that these study reports to the Board are significant contributions to the developing literature on the environment, and that they will warrant further discussion and broad consideration.

HAROLD GERSHINOWITZ, *Chairman*
Environmental Studies Board
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# *Preface*

In the spring of 1969, the Environmental Study Group undertook the organization of a Summer Study on Environmental Problems. We were concerned about whether there existed an adequate institutional base on which to deal with our mounting environmental problems so that future generations would not inherit an enormous environmental debt. In examining the institutional problem, we decided to select for detailed consideration a particular and pressing environmental issue, the Miami jetport and the Everglades National Park, which provides a pertinent, concrete case study. This is the subject of the following report.

In planning the study, we did not expect that the Study Group would necessarily present new insights into the problems of South Florida. However, the Group developed several innovative concepts that previously have not been adequately discussed. This report deals with these and what we consider to be the overriding issue—how South Florida can develop

in such a way that population of the region can increase and the Everglades National Park can be maintained in its present condition or, perhaps, may even be improved.

The study could not have been conducted without the support of the American Conservation Foundation, the Ford Foundation, the W. K. Kellogg Foundation, and the Rockefeller Foundation. We are grateful for the support and confidence of these institutions. The data supporting the Study Group's considerations came not only from the literature but also from personal discussions and briefings from a large number of parties interested in South Florida questions. The Study Group heard detailed presentations from representatives of the various agencies of the federal government, the State of Florida, the interested counties and regional groups, the conservation societies, and other groups in the private sector. While these contributors are not responsible for the conclusions of this study, the Study Group could not have reached them without the information provided by those concerned with South Florida.

Stanford University provided facilities for the study during the period August 4–29. We thank President Kenneth Pitzer and Professor Donald Kennedy for their hospitality. Special acknowledgment is due Professor Murray Gell-Mann of the California Institute of Technology for his invaluable contributions to the organization and conduct of the study. Administrative support was organized and directed by Charles K. Reed, Executive Secretary of the Environmental Studies Board. His contributions were essential to the project.

Finally, the Study Group endorses unanimously the substance of the major recommendations and conclusions. However, not all members have had the opportunity to comment on the detailed wording of the report.

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# *Major Conclusions and Recommendations*

1. The long-term commercial and residential development of the coastal regions of Southwest Florida and the preservation of the Everglades National Park both require an adequate water supply. Assurance of such a supply depends on the establishment of a water-conservation region in Monroe County, eastern Collier County, and possibly the adjoining portion of southern Hendry County. Regardless of future decisions with respect to commercial jetport location, we *recommend* the establishment of a natural water-conservation district, under local authority, perhaps the Central and South Florida Flood Control District, with the best possible guarantees that it will remain a natural conservation district.

2. A training jetport at the present site would not pose severe environmental problems provided adequate safeguards are instituted. These include control of flight patterns to avoid passing over the park at low altitudes, the control of water quality on the site, and the prevention of all commercial or residential

development in the vicinity of the jetport. We *recommend* that if the present site is to be used as a training jetport, these safeguards be instituted by both federal and local authorities.

3. The full environmental impact of a commercial jetport at the proposed site or any other suggested site is not known. We *recommend* that prior to the initiation of commercial jetport and associated transportation corridors at any site, a comprehensive regional plan be developed with adequate attention to environmental considerations. Such a plan would require the participation of local, state, and federal agencies. It should not be taken for granted that if a commercial jetport is built it must be at the site of the present training jetport.

4. Urban development near a tropical reservoir of insect vectors for serious diseases poses public-health problems. We *recommend* intensified research, both into diseases that could develop in the Everglades National Park and adjacent regions and into preventive measures to isolate any jetport and major population areas from the insect vectors.

# *Summary*

Three possible developments call for the most careful consideration of their likely effects on the South Florida region:

1. A training jetport north of the Everglades Park at the Dade-Collier boundary
2. A commercial jetport at this site, with associated highway and mass-transit facilities
3. Commercial and residential developments in inland Collier County

These developments, if not sufficiently controlled, could affect adversely the quantity and quality of water for urban uses, the health of the community, and the Everglades National Park. The first two appear controllable, with proper effort, but the third would appear most difficult to control sufficiently.

The training jetport alone would not appear to pose too severe a problem to the region, provided various safeguards are

instituted. These include control of flight patterns to avoid low passes over the Everglades, minimization of pollution at and around the training site, and, most important, stringent regulations in the surrounding areas to prevent new residential and commercial activities. The effect of jetport noise on bird population and the effect of birds on the operation of a training jetport do not appear to be significant.

A commercial jetport raises a variety of more serious problems. The large numbers of passengers passing through the jetport and the tens of thousands of required jetport personnel would produce substantial amounts of pollution, which, if not controlled, could eventually reach the Everglades and affect the park ecology. Such pollution would be augmented by the insecticide spraying that would be required routinely at the jetport site. In addition, noise and air pollution from the jet operations might affect the wilderness value of part of the park.

The location of an international jetport at a subtropical site close to the Everglade swamps raises two additional problems that require further study. First, it significantly increases the dangers that one or more tropical diseases could be introduced through the interaction of infected passengers with local arthropod vectors, that infected vectors could be brought in by aircraft arriving from tropical countries, or that arboviruses known to be present in the Everglades could be spread to a developing human population in the area. Second, the discovery of only a few cases of such human diseases could provoke a massive insect-control effort in the vicinity of the jetport and perhaps deep into the park itself—with disastrous effects on the ecology of the park.

Finally, unless protective measures are undertaken, a full commercial jetport would likely spur inland development in Collier County by attracting industry and labor and, indirectly, by providing a rationale for high-speed roads and mass transit between the jetport and coastal regions.

To cope with these problems, the Federal Aviation Administration and the Dade County Port Authority would have to take active roles in encouraging and providing a variety of safeguard measures. Insecticide controls would have to be implemented in consultation with park officials, as would waste-disposal procedures. Effective controls in landing and takeoff patterns would have to be devised.



There are medical dangers and attendant risks in large-scale insect- and rodent-control programs in the Everglades Park; these could be very damaging unless solutions are found that are compatible with the requirements of the ecology. For this reason, construction of the commercial jetport at a much greater distance from the park than is now planned is advisable.

A most important consideration is that many of the problems created by the jetport could be minimized if certain lands in Monroe, Collier, and Hendry Counties were left in their natural state.

It would be particularly important that rapid mass transit from the jetport to the Miami area be provided before a commercial jetport was permitted to reach full operation. Otherwise, there would be strong incentives to develop residential and other facilities in the inland regions for jetport personnel and associated services. It is ironic that the mass-transportation system required to prevent inland developments in the short term would eventually spur such developments in the long run. While it would be important to provide fast transportation between the jetport and Miami, access both to roads, such as Interstate 75, and to the mass transit would have to be severely limited in order to retard development of the inland region.

The most serious environmental threat would be inland developments in Collier County. Substantial commercial and residential activities in this area would adversely affect the quality and quantity of water flowing into the northwest section of the Everglades Park and, in addition, would affect the water available to the coastal populations of Southwest Florida.

It is not likely, in these eventualities, that any partial remedial effort, such as the preservation of north-south swathes through the Big Cypress along the natural sloughs into the park or the construction of dikes and canals in these areas, could preserve the integrity of the Everglades Park. Similarly, attempts to limit access to Interstate Route 75, zoning procedures, and other efforts to control the pace of development, while useful, do not appear to offer the certain prospect of preventing a severe challenge

to the survival of the Everglades Park, so long as the Big Cypress remains in private ownership.

Thus, the establishment of a large part of the Big Cypress Swamp as a natural conservation area appears necessary both to the preservation of the park and to orderly development along the coast of Collier County. It is imperative that approval for any jetport site in Southwest Florida be contingent on establishment of this water-conservation area and the other safeguard measures discussed in this report.

# 1 *Introduction*

The principal focus of most public discussion of the South Florida conservation problem has been the proposed jetport just north of the Everglades National Park and the possible effects of construction and operation of the jetport on the park.

The Study Group early came to the conclusion that the specific questions of the jetport and the Everglades Park are symptoms of broader problems affecting the future of the entire South Florida area. For this reason, the Study Group's conclusions cover a much broader range of considerations, including population growth and location, protection of water supplies against pollution and salt-water intrusion, proper allocation of resources for agriculture, sound development of public transportation, insurance of attractive living conditions, and protection of those unique national resources that are important to Florida and the nation.

This report examines several potential costs associated with various patterns of development in South Florida, including but not restricted to the construction of a new jetport and asso-

ciated transportation facilities. In this examination, while we have looked most carefully at environmental costs, especially those associated with the Everglades National Park, we have also considered other, hitherto neglected, costs that may result from the further commercial and residential development of the region.

In our discussion, we assume a national need for the amenity living and vacation resources provided by South Florida. As is discussed in detail in the Appendix to this report, we expect continued pressures for increased population in South Florida and increasing use of this region for winter vacations.

Three major conclusions have emerged from these analyses:

1. The costs to South Florida due to the expected economic development of the region, even apart from any detrimental effects on the Everglades Park, may be more varied and more serious than has yet been realized, despite several ameliorative measures that may be possible. At the very least, several research tasks may be identified that require considerably more attention than they have yet received.

2. Policies to ameliorate the environmental conditions of the South Florida region as a whole seem complementary (or identical) to those required to preserve Everglades National Park. We believe that this confluence of the interests of a community in preserving the amenities of its day-to-day life and of the interests of conservationists in preserving the integrity of an important ecosystem may be characteristic of all such situations.

3. Our most important specific conclusion is that maintenance of a large portion of the Big Cypress Swamp as a natural water-conservation area would serve several useful purposes simultaneously, with respect to preservation of the Everglades Park and to an orderly development of Southwest Florida, as well as preservation of the Big Cypress wilderness itself. It is imperative that approval for any commercial jetport site in Southwest Florida be contingent upon the establishment of this water-conservation area.

These conclusions are based on a study of a number of problem areas, which may be summarized as follows:



*Water Management in Southwest Florida*: Developments in inland Collier County, in the Big Cypress Swamp region, will affect the scope and cost of coastal developments along Florida's southwest coast, and will critically limit the water supply to the northwest section of the Everglades National Park.

*Water Quality in South Florida*: The jetport may, and commercial development of central and eastern Collier County surely would, aggravate already evident problems of water quality in the Everglades National Park and in the urban regions of the area. The jetport probably could be engineered so as not to affect the water quality seriously; it seems unlikely, however, that general commercial development could as a practical matter be sufficiently controlled so as not to be seriously harmful.

*Air and Noise Pollution in South Florida*: The commercial jetport and associated activities would produce appreciable amounts of air pollution and noise, though the effects of these could be minimized by the use of appropriate flight corridors.

*Impact on Human Health*: An international jetport located in a subtropical region gives rise to several novel and troublesome problems. In general, these would be more severe the closer the jetport is to the Everglades Park and similar marshy areas. Substantial health problems might well accompany dense urban development bordering on the park.

*The Everglades National Park:* The prospective developments in South Florida could adversely affect the Everglades National Park regardless of the existence of a jetport or of its location. This implies a very great need for careful planning of land use.

# 2 *History of Decision-Making in South Florida*

Before considering problems connected with the development of South Florida in detail, it is useful to retrace briefly the history of decision-making affecting the area. This review illustrates the many competing forces and interests that are involved in any environmental problem. While we have not prepared a detailed case study, we believe such a study would be very informative for future decision-makers.

The history of man's effect on South Florida goes back to the days of the Indians and of the Spanish explorers. Major changes came about only when South Florida was penetrated by a rail line along the east coast in the middle 1800's. The placing of the railroad along that coast guaranteed that this part of Florida would develop at a faster pace than would the rest of the state. In the 1800's, efforts were made by land-development speculators to obtain and drain inland areas for agriculture. These efforts failed because of insufficient information on the general hydrologic features of the country as well as inadequate engineering





practices. By 1926, substantial areas had been drained to the south of Lake Okeechobee, and this led to development of a thriving agricultural community. The agricultural development partially interrupted a drainage basin extending from the Kissimmee River in the north, through Lake Okeechobee to the Everglades in the south.

Two hurricanes were instrumental in changing the future course of development of South Florida. The 1926 hurricane washed away levees protecting farmlands adjacent to the western side of Lake Okeechobee, killing 300 people. Over 2,000 residents of the areas to the south and southeast of the lake lost their lives in the 1928 hurricane. As a result of the 1926 hurricane, the Army Corps of Engineers in 1927 prepared a study on widening the Caloosahatchee River to provide an escape valve for Lake Okeechobee during hurricanes and, at the same time, proposed erecting a flood-control dike around the south side of the lake. The decisions involved were based largely on flood-control considerations. The studies did not directly address the question of what might happen to the lower stages (Everglades) of the hydrologic basin of which Lake Okeechobee is a part. However, these early plans did take into account the water needs of the agricultural community that had developed south of the lake.

In view of a number of interests, Congress in 1928 authorized a study of the implications of establishment of a park in the tropical Everglades. Chief among these interests was that of the National Audubon Society in maintaining the Everglades region as a habitat for a great variety of birds. Following the study, Congress in 1934 authorized the establishment of an Everglades National Park. During these years the Corps of Engineers continued with its program of canal and levee construction with the long-term aim of reducing the flood threat. It was recognized that these Corps projects were important to the water supply of the rapidly developing east coast area. Following flooding of the east coast in 1947–48, the Army Corps of Engineers received further authorization to proceed with a yet more extensive series of canals. During this time, there was apparently little or no discussion of the water needs of the Everglades National Park. The primary concern of the Corps was with flood control and secondarily, with the provision of water for agriculture and for recharging aquifers in order to ensure adequate water supply to the east coast.

In partial response to the Corps of Engineers 1948 study, the State of Florida established a Central and South Florida Flood Control District in 1949. The Flood Control District established three water-conservation areas in a large area south of Lake Okeechobee and west of Fort Lauderdale–Miami. This land was used by the Corps of Engineers as an impounding reservoir to aid in lowering the level of Lake Okeechobee during the hurricane season. The accessible regions of the conservation areas soon became a valuable recreational resource for hunting and fishing (Figure 1).

Where the southern border of Conservation District 3 coincides with the Tamiami Trail, the Corps constructed four sets of flood-control gates to control the flow of water into the Everglades National Park. A period of diminished rainfall began in 1961 over the park area and continued for about four years. The flow of water into Lake Okeechobee during this period was greatly reduced because of severe drought conditions in the Kissimmee Basin; as a result, less water was available from that source to meet the requirements of South Florida. While the park is subjected naturally to conditions of heavy rain and occasional drought, the period 1962–1965 was one of extreme hardship for the park, because water in Conservation Area 3 that would normally have flowed south into the park was impounded for lengthy periods by closing the flood gates. The impounding of water in the conservation areas during this period served to maintain a head of water for the aquifer and a reserve for agricultural purposes. The drought dramatically drew attention to the water requirements of the park and a number of studies were initiated to determine the quantity and time-spacing of water that would be required to preserve the park. In addition, tentative agreement had been reached involving the Park Service, the Central and South Florida Flood Control District, and the Corps of Engineers to regulate the flow of water into the park, so that even in drought conditions the park could receive a major fraction of its water needs. The agreement was reached without detailed information on the water regime and its effect on life within the park, since only a few preliminary ecological studies have been conducted. Further, the agreement contained no requirements as to the quality of the water; this remains a major problem for the future, as does the need for a firm and binding agreement to protect the water supply to the park.



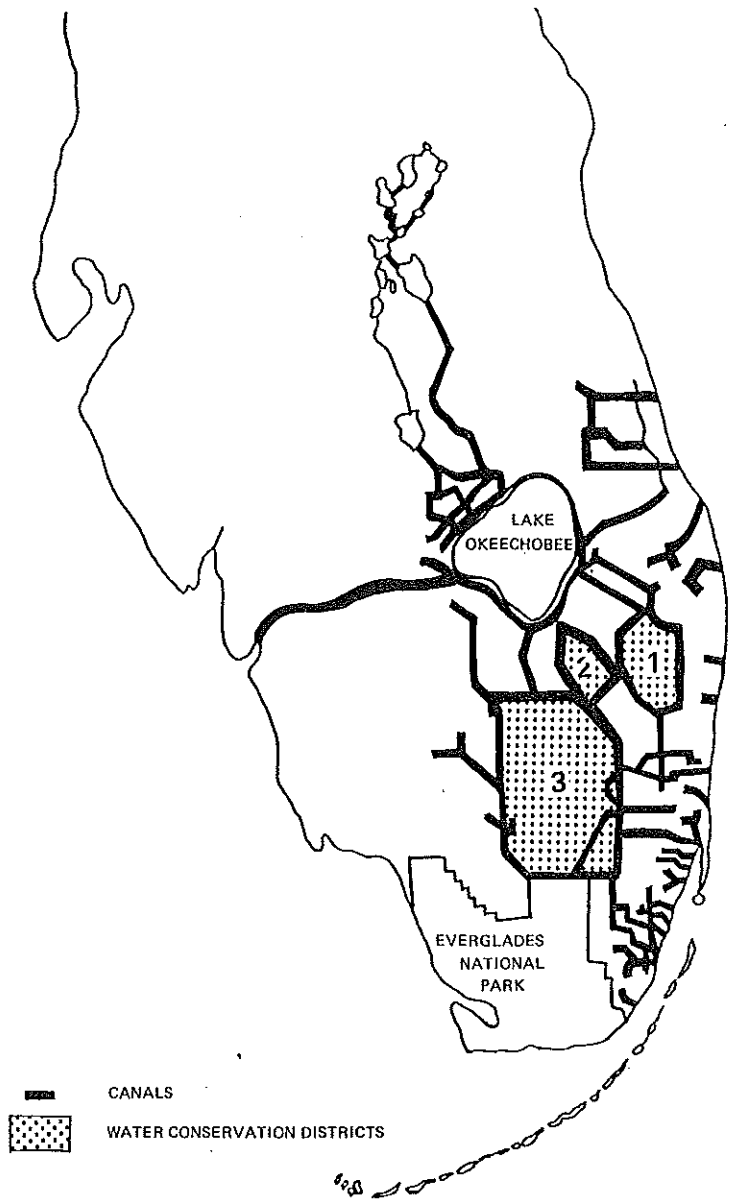


FIGURE 1 Map of South Florida showing the three water-conservation districts established by the Central and South Florida Flood Control District in 1949.

The rapid development of Dade County and surrounding regions in the early 1950's led to the commissioning by the County of a study of airport needs. This study, issued in 1952, forecast the saturation of the Miami International Airport and recommended the relocation of military, general-aviation, and air-carrier training flights. This was a first step toward the development of the now controversial jetport. In 1957, the Federal Aviation Administration began discussion with the Dade County Port Authority to relocate the Tamiami Airport so that this airport, serving general aviation, would not interfere with flights in and out of Miami International. This recommendation was based on an analysis of future flight needs and flight patterns in the general area. In 1959, the military began relocation from Miami International to Homestead Air Force Base, which the Defense Department had acquired. The relocation of military flights was completed in 1962 and provided a breathing space as the traffic in and out of Miami continued to grow. During this time, the Dade County Port Authority continued to update its projections of the total aviation needs for South Florida. In 1962, Opalocka Airport was activated and soon was to become one of the busiest airports in the country serving general aviation. In 1963, the Homestead Airport serving general aviation went into construction, and, in 1964, the new Tamiami airport was started, to be completed in 1967. These airports removed almost all general aviation from Miami International.

The early 1960's saw an increasing need for commercial aviation serving South Florida. The Dade County Port Authority, the air carriers, and the Federal Aviation Administration (FAA) undertook studies for development by the Port Authority of a new airport to serve as a training airport and thus relieve Miami International. Based on experience of airports near urban areas, the FAA established standards on air space and noise; the Dade County Port Authority undertook to meet these standards in its site selection (Figure 2).

The first site, selected in January 1967, was located in Central and South Florida Flood Control District 3; the County gave permission for the Port Authority to enter into discussions with the Board of Commissioners of the Flood Control District. The Board turned down the request of the Port Authority on the grounds that it would disturb the natural environment, which was



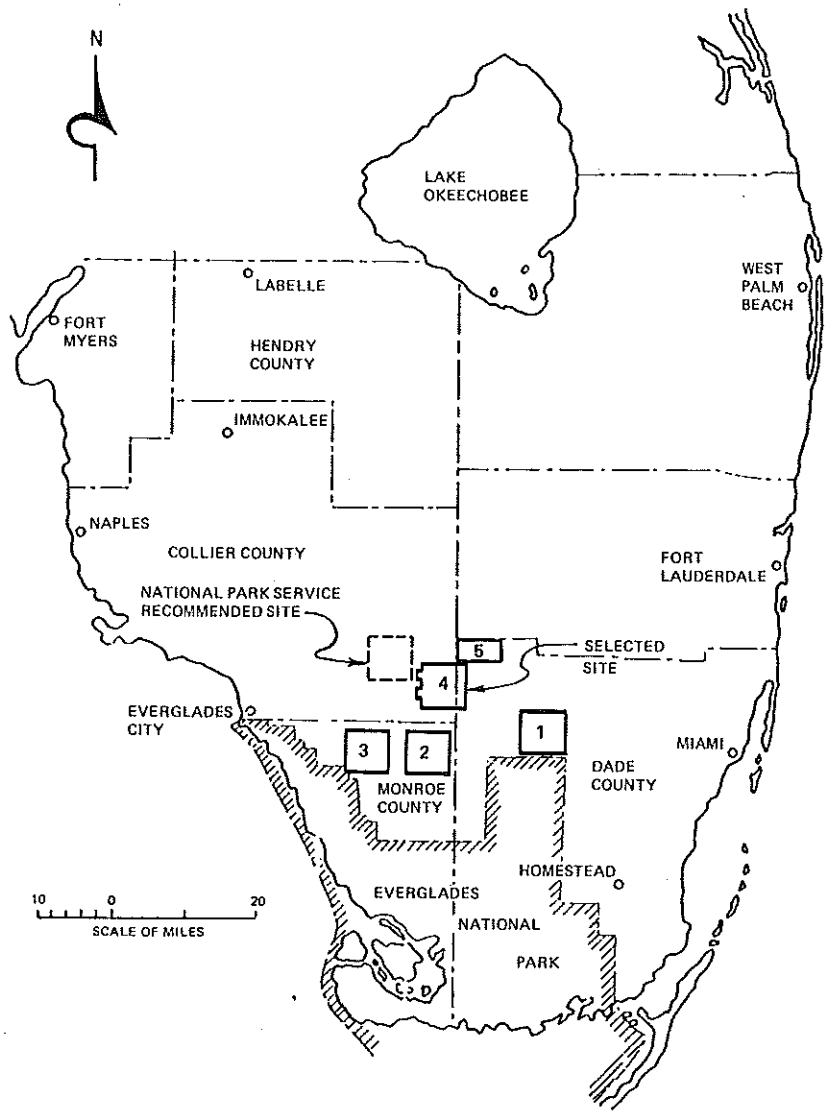


FIGURE 2 Map of South Florida showing proposed jetport sites, selected site, and site recommended by the National Park Service.

developing as a considerable recreational source. In April 1967, two sites in adjoining Monroe County were investigated, but these sites were objected to by the Superintendent of Everglades National Park on the grounds that they would disturb the Park wilderness environment. It should be noted that the Port Authority gave detailed consideration to air-space requirements and noise. Other environmental considerations were given little or no attention because the Port Authority believed it was outside their jurisdiction to consider the effect the airport would have on the surrounding areas. Instead the Port Authority informed a number of interested resource agencies, both state and federal, of its intentions. It received explicit concurrences from a number of agencies and, at this time, no objections were voiced. While a number of individuals within the National Park Service were well aware of the potential dangers of an airport, their apprehensions were apparently not widely circulated in the upper levels of the Department of Interior or to other concerned agencies. The immediate concern of the Park Service was with noise and its effect on the environment and on the direct pollution of the water by the jetport. Little or no consideration was given to the long-term effects of possible commercial, industrial, or residential development in the vicinity of the jetport.

Because of the objections of representatives of the Park, the Port Authority selected a fourth site partly in Collier and partly in Dade County (eventually, this was the final site). However, the early negotiations between Collier and Dade Counties failed to produce an agreement. It should be noted that this site is located approximately in an area suggested by representatives of the Park Service during discussions with the Port Authority of possible sites in Monroe County.

With the failure to obtain agreement between Collier and Dade Counties, the Port Authority, in May 1967, suggested a fifth site in Dade County. This site was judged inadequate by both the FAA and the Port Authority because it involved only 18 square miles rather than the desired 36 square miles. In June 1967, agreement was reached by Collier and Dade Counties to establish a training jetport at the fourth site, located in Collier and Dade Counties. This agreement was reached after extensive discussion



between representatives of the chambers of commerce of both counties. Again it should be noted that as late as May 1967, the regional office of the Park Service supported this site.

More than a year after the final site selection, the Park Service and conservation groups objected to the final site. These objections were triggered by a controversy involving the Central and South Florida Flood Control District over the location of an access road in Water Conservation District 3. The objections were based on potential dangers to the park not only from a commercial airport with associated development, but also from the training port. An important issue was the lack of projections of the impact of the jetport on the adjacent lands. The Port Authority considered itself to have neither the legal jurisdiction nor financial resources to conduct impact studies of surrounding areas. To date, no known study of this nature has been conducted by any agency. However, the Port Authority has stated that it will cooperate and provide any information it has developed should such regional studies be conducted.

The first steps toward such regional studies have been taken in the establishment of a planning commission involving commissioners from Dade, Collier, and Monroe Counties. However, this planning commission is advisory in nature and there are substantial doubts as to what influence its recommendations would have on local authorities responsible for action. Moreover, those three counties do not cover the entire relevant hydrologic system.

It would appear that before any final decision at the federal level is made with regard to the future of the jetport and connecting transportation, rather comprehensive studies for Collier, Monroe, and Dade Counties would have to be undertaken. Such a task would require the following information:

1. Number of people, their economic characteristics, their environmental requirements, and the kinds of industrial and commercial establishments that can be reasonably anticipated
2. Basic data on physiography, hydrology, natural ecology, and weather, which must be understood in order to develop plans for protecting the environment and for aiding industrial-urban development

3. Methods to coordinate the planning and, most importantly, the methods of implementing the planning by the political jurisdiction that would be affected by this airport

As has been noted, none of the above studies has been made, and the data required for these studies are incomplete or unavailable.

From this brief history, the following generalizations can be drawn:

1. Decisions affecting the national resources (e.g., the Everglades National Park) can be made by local authorities (in this case the Dade County Port Authority and the Commissioners of Collier and Dade Counties). The interaction between the local authorities and federal and state officials is less than satisfactory. During the earliest stages of the development of the jetport site, the federal government was involved only through the activities of the Federal Aviation Administration, whose primary concern was enhancement of aviation in the South Florida region. The FAA had been assured by the Dade County Port Authority, in September 1968, that no objections to the project had been received and had been previously informed by the Acting Regional Director of the National Park Service that the Park Service found it heartening that a site in that general vicinity was under consideration.

2. Major involvement of upper-level officials in federal agencies in the Everglades controversy came only after public outcries by private conservation groups. These followed objections raised by the multicounty authority, the Central and South Florida Flood Control District. Elements of the federal government, in particular the National Park Service, were aware of the potential dangers of the jetport at an earlier stage. However, communication between the National Park Service and other agencies in the Department of Interior and other governmental departments was faulty. Communication between the federal agencies involved and the state authorities was also faulty.

3. Environmental data required to guide the decision-makers at the various levels of government were often not available. Those gaps in knowledge make difficult any prediction as to changes in the ecology resulting from construction of the jetport either as a training facility or as a commercial airport. The dominant problem is water, in both quantity and quality. Information on the source of water, its movement within and outside the Everglades National Park, is still much too fragmentary to permit predicting with certainty all possible changes in the Park ecology likely to result from the posed or projected development in areas adjacent to the Park.



In the following sections, we consider certain significant aspects of the problem of the development of South Florida. We emphasize that the problems are far broader than those surrounding the jetport alone or relating to the maintenance of the Everglades Park ecology. They involve national and regional considerations of long-term importance.

# 3 *The Everglades National Park*

## VALUE OF THE PARK

In this section, we attempt to assess the general value of the Everglades Park. The Everglades should be viewed as providing

1. A unique wilderness
2. A scientific laboratory
3. Recreational and educational resources, and
4. Commercial resources

While these values cannot be quantified in any conclusive way, they do suggest that the park, especially as a rare type of wilderness and as a scientific laboratory, has a worth that transcends its utility as a recreational resource, which in itself is significant.





1. *Posterity*: The Everglades is a complex wilderness inhabited by large numbers and varieties of wildlife, especially the unusual concentration of birds, many of them showy and some of them rare, that are the special attraction of the park. These birds include the limpkin, the anhinga, the roseate spoonbill, egrets and other herons (including the nearly extinct great white heron), the wood ibis (our only North American stork), some true ibises, the bald eagle (our national bird, now very rare), and several tens of other species. Such a wilderness appears to be an increasingly important national asset to this generation and a legacy to pass on to the next. Few such areas remain and, once committed to destruction, they are irretrievably lost. This simple concern to pass on to future generations a part of the wilderness and the richness of species that our generation has inherited provides strong motivation to preserve the Park.

2. *Scientific*: The Everglades Park must also be considered a national ecological resource. It contains the only marsh communities with tropical vegetation in the United States. The consequence of periodic flooding is to allow great surges in plant and animal life during the wet season, and concentration of water-dependent life into more restricted pools as water disappears. This specialized environment has existed for thousands of years. It has nurtured the long-term evolutionary development of many species whose ways of life are uniquely adapted to the local environment.

The most effective possible environmental management will be required to ensure the quality and variety and the stability of our environment. This management must rest on sound ecological principles. But ecology is just beginning as a distinct scientific discipline. The formulation of ecological principles will require complete studies of a wide variety of environments. The uniqueness of the Everglades is a valuable asset to that end. Unmodified ecosystems may well become as important to ecology as a scientific discipline as primitive tribes have been to anthropology. The midwestern prairies in their original form have completely disappeared, as have the virgin forests of the Northeast. The Everglades should not be allowed to go the way of these other environments, which were lost before they were understood scientifically.

3. *Recreational and Educational*: The extensive wil-

derness landscape of the Everglades and its impressive domain of natural vegetation and wildlife provide opportunities for recreational and educational experiences difficult to obtain elsewhere. In addition to the wilderness quality, visitors enjoy other more directly recreational features such as fishing, photography, camping, and canoeing. As the leisure time of most Americans continues to increase, the presence of such recreational opportunities will become increasingly valuable, especially to a region such as South Florida, with a substantial stake in providing its citizens and visitors adequate facilities in which to use and enjoy their leisure hours. In this regard, it would appear important that Florida develop a strong program to encourage visits to the Everglades and an understanding of its unique ecological characteristics. Potentially, the Park represents a most significant recreational and educational resource in the Miami region. However, further development of recreational use of the Park requires careful study to ensure that the Park would not be damaged.

4. *Commercial*: In the Park, salt and fresh water meet in the brackish mangrove-fringed estuaries. These estuaries have an effect on the marine life in the surrounding sea far out of proportion to their area. They are biologically rich and can supply food to large populations of animals. They also provide a nursery area in which the young of many species can develop free from the predation of the open sea.

A commercially important example is the shrimp, which constitutes the largest fishing crop in Florida. The life cycle of the shrimp includes three months of its early life in these rich waters, feeding and growing. Such a life cycle can tolerate little environmental change. It is safe to say that without the estuaries there would be no shrimp. With many commercial and sports fish the story is the same. The adults spawn in the estuaries and the young fingerlings develop there.

Estuaries, in general, are fast disappearing from our coast in the wake of harbor development and other man-related activities. Such areas in the park are among the most commercially valuable along our coast and should be preserved against any change that will endanger the useful species that are linked to them.



## IMPENDING THREATS TO THE PARK'S WATER RESOURCES

The proposed commercial jetport, associated transportation facilities, and commercial and residential development of Collier County and surrounding regions threaten both the quantity and the quality of water available to the Everglades National Park.

1. *Water Quantity*: The jetport itself should not significantly affect the quantity of water available to the Park. Full commercial jetport operation of 900,000 flight operations per year, one half to two thirds of these being passenger flights, would entail a passenger flow and attendant services perhaps equivalent to a city of 50,000 to 100,000 people. Given a nominal annual requirement of one-third acre-foot of water per person, the total annual water requirement of the jetport should be less than 30,000 acre-feet, a small fraction of the water requirements of South Florida.

Drainage and development of inland Collier County poses a far more serious danger to the water supply of the northwest section of the Park. Rainfall over the Park provides about 81 percent of the Park's surface water. About 19 percent flows into the park from outside its boundaries; of this about 6 percent comes from the Big Cypress area. Assurance of continued flow from this region would probably require the preservation of most of the Big Cypress Swamp as an undrained and undeveloped area. As is suggested elsewhere in this report, this may be necessary for extensive coastal development in Collier County as well. Other possible measures, such as preservation of a few north-south swathes through the Big Cypress or the construction of dikes and canals in this area, would, in our view, be likely to lead to deleterious effects on the quantity and quality of water flowing into the Park.

Quite apart from any prospective new developments in Collier County, the maintenance of an adequate supply of water to the Park, especially along the Shark River slough, is a matter for concern. The demands for water in South Florida appear to be

rising with sufficient rapidity to offset the expected increases in water storage due to improvements in reservoirs as now authorized. Repetition of the water-supply problems experienced by the Park in 1965 and 1966 consequently seems possible. In addition, water demands that could not fully be met by the shallow aquifer in southwestern Florida are likely to rise significantly. Therefore, it appears that the Park's water problems for the long term are unresolved. It is imperative that, before Collier County develops, the entire water-supply situation of South Florida be carefully assessed. It appears to us that there is a danger that Collier County planning may assume a water supply available from Lake Okeechobee simultaneous with planning in southeastern Florida, which ignores potential demands from Collier County, while planning in both areas ignores the needs of the Everglades Park.

2. *Water Quality*: Possible incursions of polluted surface water into the Everglades National Park are considered in a later section on water quality. It is evident from that discussion that both the jetport and commercial developments inland on the peninsula are potential sources of pollution, the latter being by far the more serious threat. A commercial jetport would produce considerable amounts of liquid and solid wastes from associated human activities, detergent washdown of aircraft, and pesticide controls at the jetport. Should one or two cases of a tropical disease be discovered at the jetport site, a massive pesticide control effort would doubtless be undertaken, possibly deep into the Park itself. Commercial developments in Collier County would very much increase these dangers.

## AMELIORATIVE MEASURES

Various ameliorative measures might be devised to cope with these threats. They are of two types:

1. Establishment of protective areas in which development activities would be severely restricted in various ways, and
2. Siting of the jetport at a different location from the one presently planned



We have already considered the value of buffer areas in Monroe and Collier Counties for assuring waterflow into the Park's northwest section; such a buffer would also diminish pollutant inflow into the Park. It is clear that preservation of the Big Cypress Swamp as a natural water-conservation area would be most desirable relative to the Park, and, as indicated in the section on water management, probably most desirable to orderly development of the South Florida region as a whole. It would also be desirable to buffer the Park against urban and agricultural developments pressing on it from the east in the southwestern parts of Dade County.

Location of the jetport at a site farther from the Park may be desirable in order to preserve the Park, partly because such a shift might change the time scale for developments in Collier County, and partly because it would reduce the pollutant threat to the Park due to the jetport activities themselves.

We have not investigated alternative sites in any detail. Of those sites that have been considered, the two most attractive lie directly above Conservation District 3, one at its northwest corner and the other just west of U.S. Route 27. The distances of these sites from Miami International Airport are comparable to the distance from the presently proposed location to Miami International. Thus, the distances of the alternative sites from urban areas do not appear to be of significant concern. The northwest site, though farther from U.S. Route 27 than the second site, is on land owned by the State of Florida and consequently may be the more feasible alternative. However, a new site for the jetport would not diminish the requirements for a water-conservation area in Collier County. Also, the environmental acceptability of an alternative site does not ensure its practical feasibility, because this also depends on a variety of commercial and political considerations of importance to the air carriers and to the sponsor of the airport (such as the Dade County Port Authority). If the Port Authority, or a similar local agency representing a different community, does not choose to build at an alternative site, an airport will not be built there, since the FAA does not build such airports, nor, to our knowledge, does the State of Florida.

# 4 *Human Health Aspects of Inland Development in Collier County*

## TRAINING JETPORT

If developments in the area do not proceed beyond one or two runways used for training purposes, the problem of health will be confined to the Miccosukee Indians now residing in the Park. They will suffer increased noise and annoyance but it seems unlikely that there would be important physical health effects. Acclimitization to noise is common if the noise is below the level that causes pain and is in a frequency range that is not annoying (generally the higher the pitch, the greater the annoyance). If the noise levels in the Miccosukee area can be kept below 100 PN db the disturbance to the Indians will probably be minimal.[1]

## COMMERCIAL JETPORT

Development of an international commercial jetport, especially in a tropical region, poses medical problems. The passage of millions of passengers, many from flights originating in tropical countries, through a region that is the home of several important insect vectors, raises the possibility that diseases that are endemic in South Florida could be carried elsewhere.





A few passengers each year will be incubating malaria, dengue fever, filariasis, and perhaps other less-important diseases (some cases of dengue arrived at Miami International in 1963). Less likely but even more dangerous is the possibility of introducing a passenger with yellow fever. The World Health Organization considers all Florida a yellow-fever-receptive area (an area in which the virus of yellow fever does not exist, but where the presence of *Aëdes aegypti* or any other domiciliary or peridomiciliary vector of yellow fever would permit its development if introduced). The proposed jetport site is surrounded by a swamp that harbors many varieties of mosquitoes. While it is unlikely, it is possible that *A. aegypti* mosquitoes in the area could feed on an infected passenger and subsequently pass the disease to the Miccosukee Indians. The current practice of relying on yellow-fever vaccination of travelers to prevent transportation of the virus from countries where it is endemic is not entirely satisfactory, since it relies on very skilled medical personnel, good circumstances, and effective vaccine.

It is also possible that mosquitoes in the Park area could feed on passengers infected with other diseases, such as dengue fever, hemorrhagic fever, and filariasis. The Park area now supports or is able to support *Anopheles* (malaria), *A. aegypti* (yellow fever), *Aëdes stegomyia* (hemorrhagic fever), and *Culex* (dengue fever, filariasis, several encephalitides). Similarly, arboviruses in the surrounding area could be transmitted to workers or passengers in the airport. Preventive measures would have to be considered. Current vector-control technology would involve spraying of the airport and surrounding area with DDT-containing insecticides, or other insecticides with equivalent insect-killing potency. The current practice at Miami International is to leave insect control up to the county, and *A. aegypti* persists in small numbers in the Miami area despite frequent spraying. Anopheline mosquitoes (malaria) are seldom found in the immediate area of Miami International, but they are frequently found in the outlying districts. If a commercial airport is constructed, a good argu-

ment could be made for giving all who reside in the area continuous malaria-suppressive therapy, since it is well known that thousands of passengers afflicted with malaria arrive in the United States by air every year. Not many years ago, a great epidemic of malaria raged in Brazil after introduction of *Anopheles gambiae* (a particularly aggressive species of mosquito) from Africa. The International Sanitary Regulations specify that a perimeter of 400 meters around an airport should be kept free of mosquitoes, and current regulations in vector control include spraying of passenger, crew, and baggage compartments of airplanes just before takeoff from areas in which arthropod-borne diseases are endemic.[2] However, the thoroughness of such procedures is open to question.

If, on the other hand, insect control is pursued vigorously, with routine spraying in the jetport vicinity, this in itself may cause pollution problems in any surrounding residential community, and in the Everglades National Park. Moreover, should only two or three cases of endemic tropical disease be reported in the area, a massive pest-eradication effort in the airport area and Everglades National Park might be called for.

Location of a major U.S. airport at such a great distance from major medical facilities is unusual and not without some risk, since it can be anticipated that a significant number of employees and passengers will require such facilities each year, though helicopter transport is possible.

## INLAND DEVELOPMENTS

Quite apart from establishment of a jetport, development of urban complexes in humid regions is a matter of considerable medical concern.[3] Urbanization with increase in *Culex fatigans* has resulted in increase in filariasis in urban areas.[4] India and the Soviet Union have experienced this unfortunate rise in the past few years. In Southeast Asia a hemorrhagic fever due to a dengue-like virus transmitted by *Aëdes stegomyia* has appeared. Dams, man-made lakes, and irrigation, coupled with the absence of predators on adult and larval mosquitos, create new areas for mosquito propagation.

In the summer of 1969, about 10,000 cases of dengue-like, nonfatal illness were reported in Puerto Rico. *A. aegypti* mosquitoes were implicated and a very intensive program of aerial and ground spraying with thiophosphate (malathion) insecticide was carried out over several hundred square miles of the island. If such spraying were done in the vicinity of the Park, damage would almost certainly be done to the ecology of the Park.



The existence of at least eight arboviruses in or near Everglades National Park has been established. Of these at least two constitute a serious threat to man. Among the Indians in the area (Miccosukee and Seminola), blood tests have shown that as many as 50 percent demonstrate serum antibodies to Venezuelan encephalomyelitis. Antibodies to St. Louis and eastern equine encephalomyelitis have also been found. It is not fully understood why such infections have not been detected among the visitors to the Park, but it is likely that infected persons escaped notice because they left the area before the disease became clinically apparent. Also, casual visitors are not apt to be bitten by enough mosquitoes to build up an infective dose of the virus, since most visitors leave the park before nightfall and the insect vector is a night-feeding *Culex* mosquito that prefers to feed on small rodents. This setting would be drastically altered were large numbers of people to live and work in the area. The problem is sufficiently serious to have prompted the U.S. Public Health Service to undertake studies in the area. A WHO report[5] has stated that there are as many as 200 known arboviruses, of which 25 percent are important to man. The greater prevalence of Rocky Mountain spotted fever in the eastern United States than in the mountain states, the reverse of an earlier situation, is still another indication that a disease may be introduced to a new host (foxes) in a new area by transplanting its vector—in this case a tick that prefers to live on small canines but attacks man at times.

Endemic arboviruses seem to be a regional problem, rather than a problem peculiar to the Park. One severe case of Venezuelan encephalomyelitis was identified near Homestead in the fall of 1968. More recently a probable case of this disease occurred at Vero Beach on the central east coast of Florida, and the long existence of an endemic focus of dengue fever in the Tampa Bay area is well known to arbovirus workers. In the case of Venezuelan encephalomyelitis and other arboviruses of generally more

tropical occurrence, the natural distribution may be the extreme southern peninsula and far northward along both coasts, as is true of many other tropical life forms in Florida. The reason a number of viruses are known only from the Park is simply that no comparable search has been made to find them in other likely areas.

Wherever urbanization and concentration of human population occurs, the public-health problems are multiplied. Increased warming may increase virulence of some viruses[6] and changes in humidity are known to affect the biting effectiveness of the rat flea that transmits the *Pasteurella pestis* microbe of plague. The seriousness of such matters is evident from the ghastly cycles of Asian influenza that kill thousands of people across the world every few years. The airplane is known to be important in the rapid spread of passengers ill with influenza. Plague is endemic in Southeast Asia, especially Vietnam, and great care must be taken to prevent its spread. That the small-animal population of the Everglades National Park area can support plague is proven, and a necessary precaution in the area, should large numbers of people live in the vicinity, would be a careful rodent-control program. Similarly, animal and human rabies are more common in Florida than in most other areas of the United States, and control of bats and other small animals that can transmit this virus would constitute still further disturbances in the ecology of the area.

## NEEDED MEDICAL RESEARCH

Research into the cause, prevention, and cure of infectious diseases present in the Park should be expanded. The arboviruses, their hosts, their vectors, and the full range of their effects are poorly understood. More intense study of resident Indians, park personnel, other host animals, and appropriate control groups is needed.

Since it is possible for aircraft to bring infected persons or insects from abroad, research into adequate preventive measures, including the development of nontoxic pesticides and improved detergents, should be carried out. WHO Technical Report No. 406 mentions that one study suggests that the degradation products of the newer biodegradable detergents are more toxic to fish than are the older detergents.



While these medical problems require considerable further thought before it would be prudent to establish a major commercial facility at this location, it is not assumed that they would necessarily be determinative as to site selection. They are difficult, but presumably solvable.

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# 5 *Air and Noise Pollution*

## POLLUTION FROM JET AIRCRAFT

Pollutants emitted by jet aircraft are identical to those produced by automobiles.[1] The most prominent are carbon monoxide, unburned hydrocarbons, oxides of nitrogen (mainly nitric oxide), and particulate material (principally carbon). The visibility of jet aircraft exhaust trails is caused only by the particulate material, whose mass is less than 1 percent of the total pollutants emitted during aircraft operation near an airport. The relative proportions, as well as the absolute amounts, of the pollutants depend on the mode of operation, that is, whether the aircraft is landing, taxiing, or taking off.

Air pollutants are harmful to plant, animal, and human life. In addition, they damage property, reduce visibility, and are aesthetically displeasing. In the case of the Florida jetport, the possibility of damage to plant and animal life surrounding the airport is the more immediate concern, although effects on human





health may become important if the adjacent areas of Collier County are extensively developed for commercial and residential use.

Although each of the pollutants emitted by aircraft can be damaging to plant or animal life when present by itself, it is the combination of nitrogen oxides, unburned hydrocarbons, and particulates that is most harmful because it results in "photochemical smog" when subjected to irradiation by sunlight. The products of this photochemical reaction in the atmosphere are mainly ozone, peroxyacetyl nitrate, and other oxidants, which are more damaging to plants and animals than the pollutants from which they were formed. Photochemical smog can be manufactured within a few hours in the atmosphere when pollutants accumulate to concentrations of several hundred parts per billion in the presence of strong sunlight.[2]

Photochemical smog has been observed only in large metropolitan areas, where high concentrations of automobiles exist and where a stable atmospheric layer deters dispersal. These smog-producing situations are more common in western cities such as Los Angeles than in eastern cities, but they occur occasionally in most large cities of the United States. The differences among cities in incidence of smog is due more to differences in meteorological variables than to variations in automotive emissions.

## A METEOROLOGICAL MODEL FOR AIRCRAFT POLLUTION

For pollution from automotive emissions, which are more or less uniformly distributed over a wide area, two meteorological variables affect the ambient concentration of pollutants. The first is wind speed. As wind sweeps over a city, it dilutes the pollutants by the mixing of fresh air high above the ground with polluted air near the surface, where the pollution sources are located. For a given level of automotive use per unit of city area, the ambient pollutant level will vary inversely with the wind speed. The second important variable is the degree of atmospheric stability. In a very stable atmosphere, such as occurs during a temperature inversion, mixing of the pollutants near the ground with fresh air above is greatly reduced, so that pollutants build up to

high ambient levels near the ground. The reverse is true when the atmosphere is unstable. The combination of low wind speed and a stable atmosphere near ground level leads to high pollutant levels in metropolitan areas.

In all studies of pollution from aircraft to date, the aircraft emissions have been compared either with total metropolitan emissions or with average emissions per unit of surface area. Either method of comparison tends to underestimate the contribution of aircraft to local pollution in the vicinity of an airport because important meteorological features unique to aircraft pollution are ignored. These features result from the fact that aircraft deposit pollutants vertically through the atmosphere during descent and ascent and that this deposition occurs along a path parallel to the wind direction. Both of these effects tend to increase the concentration of pollutants downwind of an airport, in contrast with the more or less uniform distribution of pollutants from ground sources, to which aircraft pollution is often compared.

Airport landing and takeoff patterns affect the distribution of pollutants. Each descending or ascending aircraft passes through an air corridor approximately parallel to the wind direction and about a mile or two in width. As aircraft approach or leave the airport, they successively deposit pollutants within this corridor, which subsequently drift slowly downwind. There is only slow mixing of these pollutants with air on either side of the corridor, because of the great transverse distance of a mile or so to which the pollutants must be transported before encountering cleaner air.

As the polluted air near the ground mixes vertically with the air above, it encounters equally polluted air, for the aircraft deposits approximately an equal amount of pollutant per foot of ascent or descent while traveling through the corridor. Unlike pollution emitted from ground sources, vertical mixing does not reduce the average concentration of aircraft pollutants but merely smoothes out the variations in pollutant concentration within the corridor.

The net result of these factors is the formation of a narrow trail, extending downwind of the airport, within which the aircraft pollutants are found. Because of the slow horizontal mixing, the pollutant concentrations will decrease only gradually with downwind distance, perhaps requiring a travel distance of 10 miles to decrease by half and 30 miles for a reduction factor of 4. The consequently long travel times during which this concentration remains high could very well lead to a photochemical-smog trail downwind of an airport. Such an effect would exist independent of atmospheric stability, unlike normal smog formed from ground-source emissions.



Measurements of ground-level particulate concentrations in the vicinity of John F. Kennedy International Airport lend support to this model.[3] During this study, aircraft mostly used the east-west runway, even in light northerly or southerly winds (less than 17 mph). In addition, an east-west belt parkway borders the northern edge of the airport. When the wind direction was approximately parallel to direction of movement of ground and air traffic, particulate concentrations were nearly twice as high as on those occasions when the wind was transverse to the traffic flow. The excess of pollutant levels measured during east-west winds over those for north-south winds might well be caused by the local east-west ground and air traffic superposed on the generally very high background of pollutants that exist throughout New York City.

## AN ESTIMATE OF AIRPORT POLLUTION LEVELS

Measurements of pollution near airports have been inconclusive as to the effect of aircraft because the airports studied—Los Angeles and John F. Kennedy—have been surrounded by a highly polluted urban atmosphere.[3,4] We attempted to estimate the annual average levels of pollutant downwind of an airport using the model previously described.

For a prototype calculation, we assumed a single-runway airport operating at a maximum capacity of 250,000 operations per year, or 15 landing-takeoff cycles per hour. In each cycle, a four-engine jet (such as a Boeing 707) consumes approximately 4,000 pounds of fuel during operation below 3,000 feet of altitude.[1] Thus, approximately 20 pounds of fuel per hour are burned for each foot of elevation within the operating corridor.

Assuming a corridor width of two miles and an average annual wind speed of 10 miles per hour, it can be calculated that about 2.5 million pounds of air flow through the corridor per pound of fuel burned. For each pound of fuel consumed, $3.2 \times 10^{-3}$ pounds of oxides of nitrogen and $2.2 \times 10^{-2}$ pounds of hydrocarbons are formed. Therefore the annual average mass fractions of oxides of nitrogen and hydrocarbons in the downwind corridor would be $1.3 \times 10^{-9}$ and $9 \times 10^{-9}$ respectively, or the mass loading of these pollutants would be 1.3 and 9 micrograms per cubic meter.

An annual mean concentration of oxides of nitrogen of 1 microgram per cubic meter is about 10 percent of the annual mean for an eastern city such as Washington, D.C., and 2 percent of the annual mean for San Francisco, where chronic photochemical smog exists.[1] It is therefore exceedingly unlikely that a present-day airport of less than 250,000 operations per year would give rise to noticeable air pollution downwind of the airport.

## POLLUTION FROM POTENTIAL COMMERCIAL JETPORT

Development of the training port into a full commercial jetport may give rise to serious air-pollution problems. Compared with the levels calculated for a single runway, we would expect a factor of 4 increase in operations when the airport expands to four runways, a factor of 2 increase in fuel usage per operation due to larger aircraft, and a factor of 2 increase in the amount of oxides of nitrogen formed per unit weight of fuel consumed as a result of increased pressure and temperature in future jet engines.

Since the prevailing wind is from the east, any development of Collier County to the west of the jetport would be subjected to this pollution. In addition, pollution from automobiles and industrial sources would add to that from the airport. The effects of this pollution on humans, animals, and plant life to the west of the jetport might become as severe as is now encountered in cities in southwestern United States. Because of the wind pattern and expected air-traffic pattern, a comparable effect would not appear likely for the Park itself.



## AIRCRAFT NOISE

It is impossible to predict the effect of aircraft noise on wildlife, except that it is extremely unlikely to be beneficial. Aircraft noise levels are rated on a "perceived noise" decibel scale, which rates the noise power on the basis of the perceived frequency response of the average human ear. Aircraft noise, especially jet noise, is rich in very high frequencies, even beyond the normal hearing range for humans. Animals with a more sensitive response to ultrasonic frequencies than man may therefore perceive aircraft noise differently than do humans. Animals, birds, and fish that depend on sound for aid in locating food or avoiding predators may conceivably avoid the environs of an airport even though aircraft noise is not continuous but only occasional; this is speculative, however, given the present stage of knowledge.

Since nearly all major airports are located in urban rather than rural environments, there are no unequivocal examples of damage to wildlife independent of that which might have occurred in urban environments. Rats, pigeons, and sea gulls thrive in all urban regions, and their presence near an airport would hardly establish its ecological viability.

A more subtle problem is that associated with the importance of the wilderness aspect of the Everglades National Park. Persistent noise from aircraft can degrade the unique experience available to park visitors as well as partially spoil the recreational use of the conservation areas in Dade County. Although the number of people so affected may be small, the activities rate high on the list of attractions of the southern Florida region. Control of aircraft altitude and flight patterns will certainly be necessary if the recreational value of the Park and conservation areas is not to be diminished.

## SUMMARY

It is very difficult to predict the effect of air and noise pollution from the jetport on the plant and animal life in the adjacent areas of Everglades National Park, Big Cypress Swamp,

and Conservation District 3. Because existing airports are embedded in noisy and polluted urban environments, the incremental effect of the airport activity on pollution has not yet been clearly determined. Furthermore, since the variety of plants and animals in urban environments is limited to a few hardy species that can survive the unnatural stresses to which urban life is subject, we have little information for inferring how less-common species will respond to urban noise and air pollution superposed on the nonurban environment in which they are presently found. We believe both of these aspects need further investigation.

The analysis we have given above suggests that airport air pollution should be detectable for long distances downwind of the airport. It appears quite feasible to check this hypothesis and to measure the ensuing levels of pollution by conducting a suitable field test at Miami International Airport. Because of the great influence of meteorological variables on the levels of pollutants, it is advantageous to conduct such field tests under meteorological conditions similar to those that will be experienced at the jetport site. Miami International Airport would meet this requirement. However, such a field test would require great care in planning and execution if the data collected are to be useful in predicting pollution levels near the jetport.

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# 6 *Water Management in Southwest Florida*

Water management in Southwest Florida is likely to be a critical matter not only for the viability of the Everglades National Park, but also for the viability of Collier County. One need only recall what happened to the water resources of Dade County early in this century when extensive inland drainage was undertaken. The water table dropped to such an extent that there was extensive salt-water intrusion into the Biscayne aquifer, especially along the drainage outlets—the Miami River and the Tamiami Trail—subsequently requiring elaborate and costly construction in the form of water-conservation districts to drive the seawater back out of the aquifer.

The hydrological situation in Collier County is perhaps more delicate than in Dade County, and uncontrolled drainage inland would have dangerous consequences both along the coast and inland. In this report, the establishment of a large natural water-conservation area in Collier and Monroe Counties is proposed as the best means of meeting the demands of the antici-

pated development of Southwest Florida while sustaining the present level of water supply to the northwest portion of the Everglades National Park.

## HYDROLOGY OF THE REGION

In some respects, the shallow aquifer under Collier County and the Biscayne aquifer in Dade County are similar. Both are nonartesian limestone aquifers, and they are of similar shape: a few feet thick near the middle of the peninsula (the two aquifers do not appear to join one another) and broadening to a thickness of 100 feet near the respective coasts. The average annual rainfalls in the two regions are comparable (50 to 60 inches).

In most other respects, however, the shallow aquifer in Collier County is inferior to the Biscayne aquifer as a source of water for the needs of man. The shallow aquifer in Collier County is more highly mineralized than the Biscayne aquifer in Dade County, the water is barely drinkable in several locations on the west coast, and in general there appear to be widespread pockets of brackish water. The shallow aquifer appears to have a lower recharge rate from rainfall, in part because of a semipermeable layer of marl that caps some of the shallow aquifer. The storage capacity per unit volume of aquifer for the shallow aquifer is about half that of the Biscayne aquifer. The average transmissibility of the shallow aquifer is several times less than that of the Biscayne aquifer. These differences all point toward the conclusion that the maximum population that can be sustained by the natural water supply in the southwestern part of the state is considerably less than that in the southeastern part of the state; an upper limit of roughly one million people in Collier County may be realistic.

In contrast to the situation in Dade County, there is a lack of information about the detailed hydrological conditions in Collier County. The preceding discussion is based on the best available information but we feel it is imperative that more systematic analyses be made and, in particular, that this be done before development proceeds further to the stage at which the water table is seriously affected.



## NEED FOR WATER PLANNING

The optimum development of southwestern Florida cannot be achieved without proper water management. The supply of fresh water in Southwest Florida is a precious resource, and it is threatened from several directions. It is threatened by invasion from above, in the form of improper waste disposal (this is discussed in the following section). It is threatened from below, in the form of upward leakage from the Floridan aquifer, a mineralized (typically 1,000 ppm chlorides) artesian aquifer lying below the shallow aquifer, separated from it by impenetrable rock. The upward leakage has proceeded by means of uncased deep wells, creating serious problems in areas of Lee County and elsewhere. Finally, the shallow aquifer is threatened by seawater intrusion.

A simplified explanation of why seawater intrudes into an unconfined aquifer will provide a useful introduction to a more detailed look at Collier County's water-management problems. The essential fact is that seawater is 2.5 percent more dense than fresh water and hence exerts 2.5 percent more pressure at a comparable depth. Seawater literally pushes the fresh water back along a surface where the two come in contact. The fresh water can hold the salt water back only by building up to an elevation above sea level; below any point on land, the boundary between the fresh and salt water occurs at a depth at which the fresh-water depth is just 2.5 percent greater than the depth below sea level. Thus, for an aquifer like the shallow aquifer of Collier County, which is 100 feet thick (i.e., below 100 feet one encounters an impervious material), one will find salt water intruding inland into the aquifer until it reaches a line at which the water table has risen to a height of 2.5 feet above sea level. Everywhere between that line and the coast there will be some seawater intrusion.

According to this elementary model, it is essential that the water table near the coast be high. Salt-water intrusions on Florida's east coast, for example, became particularly serious after inland drainage reduced the height of the coastal water table. Any drainage of the interior regions of Collier County would have

two deleterious effects on the water supplied to the west coast region through the shallow aquifer. First, the accompanying reduction in height of the water table above sea level in the interior would cause a proportional decrease in the flow through the aquifer, and hence in the maximum supply of water available to the coastal region. Second, there would also be a proportional increase in the distance of penetration of the seawater into the shallow aquifer, enlarging the area of salt contamination. A double penalty of reduced quantity and quality of water would be the price exacted from the downstream (coastal) user by the upstream (interior) developer.

Drainage in a coastal region can also affect water quality. An indication of the kind of trouble to be expected is provided by the Golden Gate development project south of Naples in Collier County. Here the drainage of approximately 200 square miles of wetlands caused extensive salt intrusion into the coastal area.

The problem of salt-water intrusion can be met in a variety of ways. The way adopted by southeastern Florida is perhaps the simplest and most straightforward: an inland water-conservation area sustains a head of fresh water at the coast. This is one of several arguments suggesting the desirability of a comparable water-conservation area in the southwest.

## ALTERNATIVE SOURCES OF WATER

Even if the water quality is protected from contamination by pollutants, artesian aquifers, and salt water, a serious question of water quantity must ultimately arise. There are four sources from which Southwest Florida could ultimately draw its water: the sea, the deep (Floridan) aquifer, the storage areas of Southeast Florida, and its own shallow aquifer system. The first two sources, involving respectively salt and brackish water, require desalination.

There are several obstacles to desalination as an alternative or an addition to a managed natural watershed. These are cost, thermal (and perhaps air) pollution from the accompanying electrical power or heat source, and disposal of the highly salinated waste stream.



At the present time the wholesale cost of desalinated water of potable quality (less than 250 parts per million mineral content) is seldom less than about $300 per acre-foot. This may be compared with a cost of about $10 per acre-foot for water from the Central and South Florida Flood Control District. Even the most optimistic projections for reduced cost through improved technology indicate costs three times the present cost of natural water.

Some processes, such as electrodialysis, are cheaper if brackish rather than seawater is available. The deep Floridan aquifer could provide a supply of water containing about 1,000 parts per million chloride, although it is not known with certainty how this salinity might change if the aquifer were to be extensively pumped. For small demands in the near future, water from this source might be cheaper than seawater.

The most economical processes for desalinating seawater (flash distillation or vacuum freezing) or brackish water (electrodialysis, reverse osmosis, or ion exchange) require by-product heat or electrical power from a thermal power plant. If all water for an urban area were supplied by a desalination process of a type now available, the power plant required to provide the additional desalination demand would be about twice the size required for normal uses of power. The attendant air-pollution and thermal-pollution problems would be severe, even if the desalination plant were located on the coast.

The disposal of the higher-salinity effluent from the desalination plant presents some problems, especially on the west coast. Offshore disposal would increase the salinity of the water in the shallow areas of the Gulf of Mexico, unless the effluent is carefully dispersed. Pumping the salt-rich mixture back into the deep aquifer would reduce the quality of this reservoir of nearly fresh water, jeopardizing its future use. These costs do not make desalination impossible over the long run. In the next one or two decades, however, resorting to desalination does not appear practical.

Another possible source of water for Southwest

Florida, the water stored in the water-conservation areas to the east (those administered by the Central and Southern Florida Flood Control District), can be summarily dismissed. Apart from the legal obstacles, the essential fact is that the population centers on the east coast are already tapping this inland water to an increasing extent each year, with a projected usage of the entire supply when an east coast population of four million is reached. Furthermore, Everglades National Park must have its share of this water. Thus, the water-storage areas to the east will not be available at a time when Collier County will need them.

Southwest Florida will have to rely on its own resources. The long-range perspective makes it evident that the water supply inland from the west coast—for example, the eastern half of Collier County—will be essential. Extensive drainage of inland Collier County is certain to entail future risks.

## PROPOSED NATURAL WATER-CONSERVATION DISTRICT

It is important to realize that drainage of an inland area is an almost irreversible step. Once an area is drained, it becomes populated, and government becomes committed to maintain a lowered water table permanently, so that the settlements are not subject to flooding. Thus a water-storage capacity is lost once and for all.

As in the Southeast, it appears that sufficient water for optimal development of Southwest Florida can be obtained only if this development is primarily confined to the coastal region. We recommend that the inland region be set aside as a natural water-conservation area, comparable in size to the water-conservation area in the Southeast. The conservation area should include at least the eastern half of Collier County, the northern portion of Monroe County adjacent to Everglades National Park, and possibly the southeast portion of Hendry County. This includes a large portion of the Big Cypress Swamp.

It is important to observe that the region just described can function as a water-conservation area without elaborate and costly construction of levees, canals, and gates. Since flood



control is not a problem, little further construction for this purpose is necessary. The alteration of surface runoff is also inadvisable, because a part of that runoff is generally southward, and is essential to the ecology of the northwest section of the Everglades National Park and the character of the coastal estuaries. If there is no such construction, the Big Cypress Swamp can be preserved in its natural state.

At this time, the portions of Hendry and Monroe Counties under discussion are part of the Southern and Central Florida Flood Control District, but the portion of Collier County is not. As we understand the situation, action by the Florida legislature would be required to include Collier County in the Flood Control District. We propose that this district, which already coordinates the water needs of 18 South Florida counties, rapidly acquire water easements in Collier County sufficient to bring the natural water-conservation area into existence.

To bring about the proposed extension of the Flood Control District will require the cooperation of a number of agencies at the state and federal levels. We recommend that the relevant agencies make the development of a commercial jetport in South Florida, irrespective of the site, contingent on the establishment of this natural water-conservation area.

## SUMMARY

The setting aside of a natural water-storage area would help serve four important purposes: (1) prevention of salt-water intrusion into the water supply of Collier County, (2) maintenance of an adequate water supply for future development of the southwest coast, (3) maintenance of a natural and sufficient supply of water to the northwest portion of Everglades National Park, and (4) preservation of the Big Cypress Swamp as a natural area.

One must envision some conflict between the interests of developers of inland Collier County and the interests of other parties, notably the coastal populations concerned about the quality of their drinking water, populations of both coasts interested in recreation regions, and naturalists from all over the

world concerned about the preservation of the Big Cypress Swamp and the water supplies to Everglades National Park. Over a longer period of time, the limited supply of inland water will have to be shared by the coastal population and the Park, just as on the east coast. Only regional planning can ensure wise and fair resolution of these conflicts.

# 7 *Water Quality in South Florida*

The quality of water in the natural areas of South Florida is related to the well-being of the component biological communities. The kinds and amounts of suspended materials and dissolved substances in the water of the ponds, lakes, glades, coastal marshes, and estuaries are reflected in the structure of these communities. The fresh water in the natural areas is generally of high quality relative to human needs. For example, one can safely drink water from the Everglades or Big Cypress Swamp without danger to health. However, as will shortly be discussed, the water-quality needs of other animals and of plants are more demanding.

Generalized water pollution exists in the agricultural and urban regions of South Florida. By pollution we mean the deterioration of water quality by the activities of man. Large volumes of untreated or partially treated sewage and agricultural nutrients and pesticides are released into the hundreds of canals in Southeast Florida restricting water-use to fewer categories and

producing health problems and the destruction of aesthetic values. Excessive coliform bacteria, plankton blooms, and fish kills occur regularly in many canals and borrow pits. The Dade County Pollution Control Officer reports that only two of 95 treatment facilities (municipal, large hotels, industrial, etc.) discharge suitably treated effluents into the canals and ocean. Without a drastic change in the attitude of urban planners and in the enforcement of pollution laws in South Florida a similar situation is certain to develop in Collier County with the advent of urban and industrial growth. The growth will occur with or without the proposed Dade-Collier jetport. The threat to the integrity of the water quality in the Big Cypress–Everglades ecosystem is that rapid, speculative development already occurring in limited areas will lead to random canal digging, inadequate sewage treatment, and the addition of industrial pollutants that will damage the ecosystem.

Two categories of dissolved substances deserve special consideration relative to potential irreversible damage to the biota in both the Big Cypress Swamp and the Everglades National Park. These are (1) nutrients and (2) persistent or "hard" pesticides.

1. *Nutrients*: The effects of nutrients on plants are of concern because plant communities form the landscape and provide the base for the animal food chains. An ecologist generally looks at the concentration of macronutrients, such as nitrogen and phosphorus, as an index of water-quality conditions.

Nutrients enter the ecosystem by water inflow and by rainfall. High nutrient levels cause nuisance algal blooms and shift the species composition of plants and animals. Further, nutrients become incorporated into the biomass of algal mats and aquatic vegetation. The degradation products of algae and macroscopic plants are marls and peats that fill the water basins of ponds, marshes, and wet prairies through geologic times. An increase of nutrients in the water can greatly accelerate the natural aging process of an ecosystem.

The average base-level concentrations of total nitrogen and total inorganic phosphorus in the Big Cypress–Everglades ecosystem are approximately 1.5 parts per million (ppm) and 0.1 ppm, respectively. In comparison, the respective figures for sewage effluent from secondary treatment are 20 to 30 ppm and



1 ppm or greater. No treatment or inadequate treatment is the general rule for municipalities in South Florida. Thus, the proposed back-pumping of water form coastal canals into the Everglades deserves careful investigation. Florida has a classic example of man-induced eutrophication in Lake Apopka. The formerly clear body of bass-laden water is now a turbid, sediment-filled lake containing gizzard shad. The nutrients from urban populations are usually moved to some point at which they will do minimal harm to man or to natural communities. Miami pumps most of its municipal wastes into the Florida Straits and the Gulf Stream, and for the foreseeable future the Atlantic Ocean can dilute them sufficiently. A lesser volume of untreated or partially treated sewage is released into Biscayne Bay. The tendency in an inland situation is to dispose of sewage in the ground. In this case, local surface water in canals, borrow pits, and glades will eventually show enhanced productivity because of nutrient accumulation. Particularly high concentrations can result from gradual buildup if there is no through flow in the area. If wastes are released into the aquifer, either purposely or inadvertently, the quality of the water on the coast will eventually drop. This makes it unlikely that extensive local ground disposal of wastes will be tolerated by the coastal population, which now includes most of the people.

An alternative is to pipe the wastes out of the interior region to the coast. This is more costly and still presents a problem. The west coast has no Gulf Stream to sweep them away. It has a shoal topography and very inactive local circulation. A pipeline would have to be extended a considerable distance offshore in order to dilute the wastes into a sufficient volume of water.

A more expensive alternative is to remove the phosphates and nitrates from the sewage by what is known as tertiary treatment. This is technically feasible but its added cost would be a deterrent to inland development.

2. *Persistent or "Hard" Pesticides*: The use of pesticides in Florida is increasing and is heaviest in the central citrus belt and the truck-farming regions in the central and southern parts of the state. By mid-1968, the citrus industry encompassed nearly one million acres and 75 million trees. In addition, 420,000 acres are occupied by vegetable, melon, potato, and strawberry crops. Sugar cane is grown on 200,000 acres. Agricultural acreage

is expanding in rural areas, while it is being replaced by homes and industrial plants in the cities. In Dade County, approximately one million pounds of persistent pesticides are used annually. In addition to agricultural uses, pesticides are used for lawn care and in homes, and would be routinely applied in the vicinity of any large airport such as the proposed jetport.

The chlorinated hydrocarbon class of pesticides is introduced into the environment mainly by application to certain crops; these pesticides are found in most living organisms. Persistence leads to biological magnification, a phenomenon in which these toxins move through food chains with negligible loss and become highly concentrated in the terminal organism of each chain. The following table presents average values for the total concentration of DDT+DDD+DDE in various community components in Everglades National Park and Loxahatchee National Wildlife Refuge (Conservation District 1):

| Component | Sum of DDT+DDD+DDE in Parts per Billion |
|---|---|
| Surfacewater + groundwater | |
| Fresh and estuarine | 0.02 |
| Rainfall | 0.08 |
| Marsh soil | 40. |
| Algal mat | 200. |
| Small fishes | 500. |

Birds at the top of the aquatic food chain have chlorinated hydrocarbons in their tissues at concentrations nearly sufficient, in some cases, to destroy their ability to produce viable offspring. The biological concentrations of these pesticides form from extremely dilute water solutions. The water of South Florida generally contains a concentration of 0.02 parts per billion (ppb) of DDT and its toxic metabolites DDD and DDE. Rain contains even higher concentrations (0.08 ppb). Thus the pesticides are introduced into the Everglades Park by both groundwater and aerial dispersion.

Soils in Shark River Slough and in Loxahatchee National Wildlife Refuge have concentrations of the DDT family in



an order of magnitude of 1,000 times greater than that in the overlying water. From parts-per-trillion concentrations in water, algal mats and macroscopic plants concentrate DDT in their tissues to the parts-per-billion range. Mosquitofish—carnivores that are a few tropic levels higher than the herbivores—had average tissue levels of 700 parts per billion. Marsh, wading, and raptorial birds concentrate these toxins to even higher levels. Analysis of six bald-eagle eggs collected in the Park in January 1969 revealed residues of the DDT family averaging approximately 12 ppm. Such levels have been shown to cause the formation of thin eggshells that crack from the mother's weight during incubation, thus preventing successful breeding. The bald eagle, in fact, is in danger of extinction. Thus, seemingly insignificant concentrations of DDT can have drastic effects at higher levels of the ecosystem.

APPENDIX

# *The Miami Jetport and the Everglades*

## THE LARGER CONTEXT OF THE PROBLEM

### CONCLUSIONS

The major national considerations that affect the South Florida system and that appear to us to be most relevant to the jetport–Everglades problem are the following:

1. The desirability of preserving the Everglades National Park
2. The desirability of having as much land as possible available in South Florida for amenity living and winter vacations
3. The desirability of preserving high-grade agricultural land for the production of citrus fruits and table vegetables

We have come to four rather specific conclusions regarding the procedures that will be necessary if the Everglades

National Park is to be preserved and the problem of the jetport is to be solved.

1. There must be a South Florida development plan that is coordinated with a federal plan and that provides for effective regulations of the use of land for amenity living, retirement living, and recreation. This is essential if water and air pollution are to be kept in close bounds and if the South Florida environment is to be preserved.

2. It is necessary to make a decision at this time to determine what specific actions must be taken to preserve the Park, to determine the relative cost of various courses of action, and to establish the optimal procedure. We believe that preservation of the Park will require a guaranteed source of water supply, isolation of the Park from the population that surrounds it, and limitation and control of the access of people to the Park.

3. We believe that additional sources of water for the Park and for the human population will be required. We believe that this should be determined relative to an anticipated population of 7.5–10 million people in the South Florida region by the year 2000.

4. Additional airport facilities will be required to provide for the needs of the future population of the South Florida area. Potential sites should be carefully examined in terms of their overall effect on the environment of South Florida.

## 1. INTRODUCTION

We have considered the concepts and principles that appear to be important for the solution of human-ecological problems over a long span of time. We have used the problem of the location of the Miami jetport as a prototype of such an ecological problem, and we have examined some of the procedures that we believe to be essential if a problem such as this is to be dealt with adequately. Out of this consideration, some important indications have evolved concerning the characteristics of a scientific and technical advisory organization intended to undertake the solution of ecological problems in our society. We have not attempted to suggest a direct solution of the Miami jetport problem itself, but have merely indicated some of the considerations that must go into the approach to a solution.



## 2. HISTORY OF DEVELOPMENT IN SOUTH FLORIDA

The surface drainage system of the central and southern part of the Florida peninsula is unusual in several respects. This part of the very low peninsula is bordered along the Atlantic coast by a ridge of slightly higher land rising only 15 feet above sea level, which extends down the coast and is the present site of much of the human habitation. The central parts of the peninsula from about the level of Orlando southward are lower than this coastal ridge. Before the beginning of the present century, eastern and southern Florida from the region of Lake Kissimmee southward formed a single long, wide, shallow drainage area. At the northern end of this drainage area there was a series of lakes and watercourses draining into Lake Okeechobee. Overflow from this lake, in turn, moved slowly southward through a series of broad swamps down the central and eastern half of the peninsula, to empty into the Gulf of Mexico in the region that is now the Everglades National Park. The land along this watercourse slopes southwestward at a rate of approximately one foot every 10 miles. In effect, the surface drainage of central and southern Florida originally was provided by a very broad, swampy, shallow river 150 miles long and 50 miles or more wide, down which water moved at a rate of approximately one quarter of a mile per hour. From time to time during periods of heavy rainfall in this watershed, overflow might move down the drainage basin in larger amounts. At other times during periods of low rainfall, the southward movement of water might be substantially diminished.

As people moved into Florida in increasing numbers in the first half of the 20th century, the area between Lake Kissimmee and Lake Okeechobee was drained and became valuable agricultural land. This land and other land in central Florida was found to be uniquely useful for the production of citrus crops. The citrus industry developed rapidly to the point at which it was supplying a major part of the citrus fruit consumed in the eastern

United States. Simultaneously, railroad systems were developed that provided rapid transportation of the crop to northeastern population centers. These soon made citrus fruits available at reasonable prices and in large amounts. The development of the Florida citrus fruit industry in the first half of the 20th century contributed to the improved nutrition of the American population during this time, and especially to improvement of the nutrition of infants and children. At the present time, the Florida citrus industry still provides 80 percent of the American production of citrus fruit. A considerable part of this agriculture is located in the Kissimmee drainage above Lake Okeechobee.

An extensive production of truck crops has also developed in the same region. Through the same unusual combination of good agricultural land, warm climate, and ample means of transportation, central Florida has become a major producer of winter vegetables for the nation. The region around Lake Okeechobee is particularly important for vegetable production.

Original efforts to drain the Kissimmee–Okeechobee area were adequate to establish much valuable crop land, but were not adequate to protect the human population against disastrous flooding in times of heavy rains. The floods after major hurricanes in 1926 and 1928 caused over 2,000 human deaths. Consequently the Army Corps of Engineers was called upon to provide more effective flood control. Dikes were built, and arrangements were made to drain off excess water from Lake Okeechobee directly into the Atlantic Ocean. These have been effective in preventing further floods, but it should be noted that they have also diverted flood waters from the southern drainage area, and they have, in effect, cut off Lake Okeechobee and the region above it from the swamp drainage that once led into the Everglades. The citrus and table-vegetable agriculture of this region is so important in the national ecosystem, and the present flood control measures are so important for the protection of human life, that it is quite unlikely that these man-made alterations of the upper part of the southern Florida drainage system will be changed.

As the city of Miami and other population centers developed rapidly along the southeast coast of Florida in the 1920's, it became apparent that an automobile road across the southern peninsula would be useful. Thus, a modern paved highway, the Tamiami Trail, was built across the southern part of the peninsula from Miami to Naples in the late 1920's. This road was build across the Everglades on a long earth-fill, which was pierced from time to time by causeways and culverts. In effect, this road created a long man-made dike across the drainage system, with various openings through which water could pass to the south of it. Although it has not been shown that this road in itself interfered with the drainage into the parkland south of it, it seems very reasonable that the slow southward passage of surface water may have been somewhat altered and impeded by the presence of this road.



As the population centers on the east coast of Florida grew and expanded, it became evident that the watershed between Lake Okeechobee and the Tamiami Trail also would have to be protected and conserved since it provided the major source of water for the human population. For this reason, the various Florida water-conservation areas were established in the period after World War II. These have been developed by the Corps of Engineers in collaboration with the State of Florida over the past two decades. They have provided a further control of the amount of water flowing south into the Everglades National Park. During a recent series of severe drought years, it is apparent that the amount of water that came south through these drainage areas to the Park was far below that which the Park might ordinarily have received. How much of this may have been due to human interference with the park's water supply and how much may have been the natural consequence of a period of dry years has been a matter of contention.

The area called "The Everglades" originally included all the land south of the Tamiami Trail and included in the Everglades National Park, as well as that part of the original surface drainage system that lay between Lake Okeechobee and the Tamiami Trail and now included in the various water conservation areas. West of the conservation areas and north of the Tamiami Trail, there is a large area referred to as "The Big Cypress Swamp," not because most of the cypress trees on it are large, but because it is swampland, large in area, and covered for the most part by scrub cypress. This is not, strictly speaking, a part of the Everglades, although some of the water supply for the western part of the Everglades National Park comes from this region.

The Everglades National Park was established in 1947. Essentially it covers the area south of the Tamiami Trail between the Trail and the Gulf of Mexico. It is the sole remaining undisturbed unit of the large watershed that once covered the entire state from the center of Florida to the Gulf of Mexico. It is the only undisturbed tropical wilderness area in the continental United States. Even in its truncated form, it represents a unique ecosystem, which is invaluable because, it it were destroyed, it could not be replaced. It is the home of a number of species of birds and mammals that would probably become extinct if the Park were destroyed. The continued existence of the Park in its present state is essential to the marine life within the estuaries and along the shore of the Gulf of Mexico at the mouth of the Park.

The primary importance of the Park in the national and international system lies in its role as a biological museum, in which an ecosystem that is in many ways unique and not fully understood can be preserved for future study, and for the preservation of the species that are dependent on it. The Park is less useful as a recreational area; although there are many visitors to it every year, their activities are usually limited to brief sightseeing trips. The swamp wilderness does not lend itself to camping, hiking, or similar forms of recreation, and it can be argued that the whole swampland ecosystem would be endangered if people were allowed to intrude upon it in any large number.

After the Florida East Coast Railroad pushed southward to Miami in the early 20th century, the "Gold Coast" region along the southeast Atlantic shore developed rapidly as a winter vacation area for people from many parts of the nation. The part of Florida below Lake Okeechobee is one of the few areas in the continental United States far enough south so that midwinter temperatures are reliably warm enough to attract people as winter vacationers. The mean monthly temperature of the Miami region varies from 66.5 degrees F. in January to 81.4 degrees in August. The recorded extremes of temperature are 27 degrees and 97 degrees. The equable climate, the ready access to beaches, and the many natural and man-made waterways that attracted vacation visitors also attracted many permanent residents who came to Florida because it was a desirable place in which to live. It provides "amenity living." During the period from 1900 to the



present, the number of people living in the area between Miami and Palm Beach, along the shore east of the water-conservation districts and south of Lake Okeechobee, has grown to 2.4 million. The population of this area has grown four times as fast as the national population and has doubled every 10 to 15 years. The west coast of South Florida, which is less accessible, has been less popular and has grown less rapidly in the past. There are now only 100,000 people, more or less, in the area between Naples and Fort Myers, but this population is now growing as rapidly as that on the east coast.

The tourists who go to Florida and those who travel there for winter living or move there for amenity living come from all parts of the eastern United States and Canada. Although they originally represented the relatively wealthy upper and middle classes, most of them now come from middle-income groups and from steadily employed wage earners. The size of Florida tourism can be indicated by the fact that approximately 1.8 million visitors came to the state in 1927, and this number had grown to 20 million visitors annually by 1968. They provided $5.5 billion to the Florida economy.

Such movement of people has been dependent on a highly developed transportation system. The railroads, which carried the majority of Florida visitors before World War II, have now been replaced by the automobile and the airplane. Flights into Miami International Airport and airfields in the surrounding area are now approximately 10 million a year. Flights from the northeast and north-central regions of the country to Florida provide a major source of income for Eastern Airlines, National Airlines, Delta Air Lines, and Northeast Airlines. The Miami area is an important terminus for Pan American Airways and for other airlines flying overseas from the United States to South and Central America. Because the Miami area is a turn-around point for their planes, several of the airlines have established repair and maintenance facilities at the Miami airport, and have located some of their administrative offices there. Because of the availability of airplanes between scheduled flights, the Miami airport has become a center for pilot training for these airlines. Similarly, the requirements of automobile travel have led to the construction of a major highway system down the east coast. For some time there has been a

demand for improved highway facilities down the west coast to the Fort Myers–Naples area to make this equally accessible to motorists.

Fundamentally, it was the demand for new transportation facilities to handle the anticipated growth of traffic into the South Florida area that led to the proposals for the establishment of the new jetport and for the construction of the new Interstate Route 75. In selecting a site for the new airport, the Miami Port Authority appears to have been guided by the considerations of providing a facility that would (1) be equally accessible to the east and west coasts of South Florida, (2) be large enough to accommodate the supersonic jets of tomorrow, (3) be far enough away from population centers on the east and west coasts to minimize the problems created by aircraft noise, and (4) be in an area in which it would not disturb land that has been set aside for conservation or was potentially highly valuable for agriculture or for urban development. An additional practical consideration was that the Dade County Port Authority was the only governmental agency of the South Florida region capable of financing the development of a major airport. This consideration made it desirable that at least part of the airport lie in Dade County.

The site that was finally selected is some 40 square miles in area. It lies just west of Water Conservation District 3 and just north of the Tamiami Trail, 50 miles from Miami. Approximately one fourth of the site is in Dade County and the other three fourths in Collier County. The entire site lies in the largely uninhabited region of swampland referred to as "the Big Cypress." One runway on this site has been constructed. It is evident that the Port Authority plans to shift the aircraft training flights from the Miami airport to the Everglades airport as soon as possible. Later it anticipates moving the aircraft-maintenance facilities to this region, and ultimately much of the passenger traffic for South Florida will be centered here, though detailed planning for this is not yet complete. To make this development feasible, a new high-speed land-transportation system is to be developed that will make it possible for a traveler to move from downtown Miami to the airport in 15 minutes.

Similar considerations have gone into the planning for the extension of Interstate Route 75. This route now ends on



the west coast in the Tampa–St. Petersburg area. The plan is to continue it down the west coast past Fort Meyers and Naples, and then across the state parallel to and north of the present Tamiami Trail. This will have the effect of opening up the west coast to recreation and amenity living on a scale comparable to that of the east coast. It will also have the effect of creating another man-made dike across the Florida peninsula at the level of the Tamiami Trail. Presumably it will have some effect on surface drainage from the north to the south, unless it is constructed largely as an open-pile causeway.

The controversy about the jetport arose primarily because those who are concerned with the survival of the Everglades National Park believed that the construction of this new jet airport and the construction of Interstate Route 75, with the attendant growth of human population on the borders of the Park, would so impair the support facilities for the Park that it would not be able to survive. Chiefly, they are concerned about the fatal impairment of the Park's water supply and the pollution of the water and air entering the Park with products of human civilization that may destroy some essential parts of the complex ecological system upon which the survival of the Park depends.

## 3. SOUTH FLORIDA AS PART OF THE NATIONAL SYSTEM

It was immediately apparent to us that the problem of the location of the Miami jetport and the preservation of the Everglades National Park must be considered in terms of the total systems of which these are a part. The immediate local system, of which both the jetport and the Park are obviously a part, is the South Florida regional system. The jetport is also clearly a part of the overall transportation system of South Florida. This, in turn, is closely related to the human population of South Florida and to its activity in recreation, industry, amenity living, and the production of citrus fruits and table vegetables. All of these—the human population, agriculture, the tourist industry, and amenity living—are dependent on the same water supply, the same air shed, and the same climate as is the Everglades National Park. No change can be made in one without changing the other.

Furthermore, it was evident to us that each aspect of the South Florida system has an important relation to the national and international systems of which it is a component and with which it has a reciprocal and complementary relationship. Thus, the integrity of the agricultural industry of Florida is important to the national nutritional system, for which it supplies three quarters of the citrus fruit and a large proportion of the table vegetables. Any change in the use of the Kissimmee-Okeechobee region for agriculture, therefore, has important implications for the national agricultural economy and for the freight transportation system that delivers Florida agricultural products to market.

Likewise, the tourism of South Florida and the amenity living provided by this section of the state have major implications for the larger national system. Florida has become a major winter vacation area for people from all parts of the eastern United States and Canada. As patterns of occupational activity have become increasingly independent of seasonal trends, and as an ever larger proportion of the population has had an opprotunity for paid vacations and an increased amount of vacation time, winter vacations have become increasingly popular. This is not merely an amenity of modern civilization; occupational activities in urban industrial societies have increasingly tended away from self-paced physical activity toward sustained purposeful activity carried out under a time schedule that is independent of season and of time of day. Both the industrial worker and the white-collar worker are increasingly engaged in activities that do not depend on heavy physical labor but do demand attention to detail and the meeting of time schedules. In such a regimen, a break from ordinary routines of activity in the form of a brief vacation is becoming an important part of the pattern of life. It has become increasingly desirable for many people in the northeast to take all or parts of their vacations in the winter months. This often implies travel to a warmer area where such a vacation is possible. Within the eastern United States, the part of Florida below Lake Okeechobee is one of the few regions available for such activity. Therefore, there is good reason to believe that South Florida will play an ever more important role in the patterns of human life in the eastern United States in the next half century. How much of Florida is available



for this sort of activity and what sort of transportation facilities are developed there are thus matters of national importance.

That even the national system is not a large enough system for consideration of this aspect of the problem becomes evident when we consider that already some Florida tourism comes from the eastern provinces of Canada. Probably, as these areas grow and industrialize, this source of Florida tourism will grow also. At the same time, the Caribbean Islands compete as sites for winter recreation and amenity living for people of the eastern United States and Canada. The pressure upon Florida to provide facilities for these will be determined to some extent by the availability of other facilities in the Caribbean. The determinants of the availability of the Caribbean Islands for this purpose are not only economic; they are also political. If there are political developments in these islands similar to those in Cuba, many of them may not become available as sites for winter recreation for Americans. The pressure on Florida for this purpose may thus be increased.

The Everglades National Park is also a component of the South Florida system with important national, and even international, significance. If the maintenance of the Park in its present form is essential for the preservation of a unique ecosystem, then the destruction of the Park would be a scientific loss to the nation as a whole and, indeed, to all of science. In fact, the destruction of the Park or the serious alteration of the now open areas of South Florida might defeat the very purpose for which people are now coming there. If South Florida were heavily urbanized and the Park destroyed, there is good reason to believe that there would be local alterations in the climate, as well as in the marine life of the surrounding waters, which would in effect destroy the amenity living that is the principal attraction of the area. On the other hand, if the Park is maintained as a biological entity in close proximity to extensive urban centers, particularly with its bird life migrating freely in and out to the areas northward and eastward, it might represent some threat to the human population. The Park area is a tropical ecosystem supporting the small mammals, the birds, and the insects that are the natural hosts and vectors for a variety of arboviruses, some of which cause serious human disease, such as yellow fever, encephalitis, and some forms of hemorrhagic fever.

At the present time, the Park does not appear to be an acute threat to the human population, but there is always the possibility that rapid air transportation of infected people or insects might introduce into the Park a viral agent that might then be disseminated out of it to a surrounding urban population.

Thus, clearly, the decision as to the location of the Miami jetport or what must be done to preserve the integrity of the Everglades National Park can be made only within the context of the role of each of these in several complex systems. Their immediate roles in the local system of South Florida appear to be determined in part by their roles and the role of South Florida in larger systems. A very important characteristic of decision-making with regard to human ecological problems is the necessity to consider these problems initially within the largest context to which they are relevant. A beginning in determining the answers to the problem of the Miami jetport and the Everglades must be made by first considering the role of the entire South Florida system in the national system, and in the international or world system, in the reasonably foreseeable future. When the limiting roles, the possible roles, the probable roles, and the optimal roles of South Florida in the larger systems have been evaluated, it then becomes possible to see more clearly the range of choices that are open for the solution of specific local problems and the possible consequences of each decision. These, in turn, will determine the advisability of various solutions to the immediate and concrete questions that are at issue.

We believe that rational solutions to ecological problems are not derived solely by moving from the specific to the general or from the small system to the larger system. From the beginning, there must be consideration of the effects of alternative strategies on larger systems, and the implications of these strategies for the smaller systems, which are the components of the larger ones. This committee could have prepared scenarios about the consequences of various decisions that might be made concerning the Miami jetport. We could have modified these later in the light of broader considerations. However, we have found such a procedure to be impractical because necessary modifications develop into an infinite series as progressively larger external issues are



raised. Thus, it becomes evident that the problem must be approached from the opposite direction, that is to say, from the larger end—broad ecological problems—rather than by beginning at the smaller end—in this case, the specifics of the jetport question. This approach is dictated by the fact that, once one has made certain types of policy decisions, one has, in effect, committed oneself to the first of an $n$-step sequence of developments that may entail unacceptable social costs at several steps beyond the first. Therefore, our outline for a long-term program related to the advisability of the jetport deals first with the largest possible issues that we can conceive as relevant to the decision in the near and foreseeable future. The following sections of the outline suggest a possible way of dealing with these larger issues.

## 4. NEARER-TERM DECISION PROBLEMS IN FLORIDA

The question of whether the jetport should be built just north of the Everglades National Park does not appear to us to be the most important near-term question that Florida must face. The introduction of the training jetport itself may impose some noise pollution on the Park, but the chances of substantial atmospheric pollution or water pollution in the Park resulting from the jetport seem small provided adequate safeguards are instituted. On the other hand, large industrial developments in South Florida would cause a population explosion near the Park, which would have very serious long-term consequences.

A somewhat different way of approaching the problem is to look at the broader main activities in the southern half of Florida and to allocate the resources available among these four important long-term activities. The four important activities are agriculture, resort and vacation activity, amenity living and its associated activities, and the ecological laboratory and museum that is the Everglades National Park. As our discussion progresses, we will see that actually these four activities are very much in competition with each other for the natural resources of the area, and that they tend somewhat to be mutually exclusive.

*Agricultural Activity*

The present production of citrus fruits in Florida is approximately 8 million tons annually, and the total production in the United States for 1966–67 was just less than 11 million tons. The nearest state to Florida in production of citrus fruits was California with 2.2 million tons.

With the projected population growth by the 2000, the demand for citrus production in the United States will develop to just under 20 million tons. A preliminary survey of the alternatives to Florida citrus production in the United States suggests that, because of the climate required for citrus fruits, the alternatives for citrus production would be largely outside of the United States. It could always be asked whether Florida would not have other more profitable alternatives to using its land area for citrus production. This is a question of balances of world trade and what the alternatives might be for the use of the land in Florida.

One simple way to estimate the value of the Florida land for citrus production is to measure the annual dollar return per acre from citrus production. The usual annual return per acre in California for citrus production at present is around 140 boxes per acre; on the market these sell at about $4.25 a box. This produces approximately $700 annual return per acre. Of course, this $700 per acre annual return is a gross, not net, return. It is very likely that the net return might be from one fourth to one half of the gross return; the computed value of the land, therefore, might be around $3,000 to $4,000 per acre if it is used in citrus production.

Another set of alternatives to citrus production in Florida would be synthetic production of substitutes for citrus crops. Some of this production is already available; substantial substitute production could probably be developed in the next 10 to 20 years. The costs and the values of such technological alternatives as synthetic citrus crops remain to be computed.

The annual return to Florida from citrus production is approximately $400 million. The competitors for the land thus used at present come from phosphate strip mining. As the population increases, the use of the land for living space will compete with agriculture, and added demands for water may compete with irrigation for agriculture.



*Resort and Vacation Activity*

The largest economic return to Florida comes from resort and vacation travel. In 1967 19.5 million vacationers traveled in Florida, and they spend about $5 billion. The rate of growth is shown in the fact that, in 1950, 4.7 million tourists visited Florida; in 1960, the total was 11 million; and in 1967, 19.5 million. The classification of the tourists by means of travel shows that 80 percent, or over 15 million, traveled by auto; 16 percent, or approximately 3.2 million traveled by air; and the remainder, or approximately 4 percent, traveled by rail and bus. At present, most of the tourists to Florida still travel by automobile in the summertime. During the month of July, there were 2.4 million visitors; the winter high was 1.8 million in March. The lowest rate was approximately 1.2 million per month between September and November.

Projections of the demand for resort and vacation travel to Florida over the next 25 years are indeed uncertain. The percentage of vacation travel is very sensitive to the economic prosperity; moreover, the greatest amount of travel is summer travel and there are many developing vacation spots for summer travelers that will be competitive with Florida. It would appear that all up and down the Atlantic coastline from the New Jersey coast to Florida there would be a substantial competing demand for beach activity. The development of the Appalachian Highlands as a resort area will no doubt compete sharply with Florida as a summer vacation area. There is a substantial competition for winter tourists from the West Indies and from the Mexican beaches, where the probability of warm air and water activity every day is somewhat greater than it is even in southern Florida.

A measure of the total demand for vacations is found by combining two sets of tables. First, refer to Table 23 in Appendix 5, page 229, of the book *The Changing Travel Market* by Lansing and Blood of the Survey Research Center of the Institute of Social Research, University of Michigan, 1964 edition. The indi-

cation is that those families with incomes from $7,500 to $10,000 made a mean expenditure of $150 per year on vacations. Those with $10,000 to $15,000 incomes made expenditures of $260 per year, and those with more than $15,000 incomes made a mean expenditure of $610 per year for vacations. In the current population report on consumer income from the Department of Commerce, series P-60 No. 59, dated April 18, 1969, Table A on page 1 gives the number of families and unrelated individuals grouped by total money income in the United States. The number of families with incomes of $7,000 to $8,000 is 4.4 million, of $8,000 to $10,000 is 7.66 million, of $10,000 to $15,000 is 11.15 million, and above $15,000 is 5.99 million. Thus we see that about 10 million families spend $150 per year on vacation, 11.15 million spend an average of $260 a year on vacation, and 5.99 million spend $610 a year on vacation. Thus the annual travel and vacation expenditures could be estimated at about $8 billion in vacations costing above $150. (These total numbers may be at variance by a factor of two with the Florida travel picture because of the difficulty in projecting auto travel.)

The fraction of the total winter resort travel volume that could be claimed by Florida is critically dependent upon how well it can compete with the winter vacation facilities in the West Indian islands and the Mexican and Central American coastal resort areas, as well as with such places as Arizona and Texas. The elasticity of the demand for Florida vacations is very high and the variation in Florida's share is also very great. However, it is not easy to foresee Florida vacation income doubling over its present levels in the next decade, as it has in the past.

One last comment with regard to Florida's part in the vacation and resort industry: at present vacation activity is increasing tremendously in Hawaii and in other places, and the availability of large-capacity jet aircraft with very modest fares for even fairly long distances will probably change the vacation habits of many of the people of the United States.

*Amenity Living*

The largest overall factor in the growth of Florida over the next 25 years probably will be associated with those



managerial services and footloose industries that could be located in a place like Florida because of the attractiveness of general living conditions there. The availability of year-round water sports, recreation facilities, and pleasant climate, especially with the availability of air conditioning in the summer, make Florida a very attractive place for amenity living. The electronics and computer industries, the aircraft industry, the space industries, many business-consulting services, and possibly many of the headquarters activities of large companies would consider Florida an attractive place to locate. The 6 million population of Florida at present could easily increase to a population of approximately 10–15 million in the next two or three decades, particularly with this sort of development.

The prices of residential land and industrial land in amenity-living areas run from approximately $10,000 per acre up to approximately $30,000 per acre, depending on the density of population and whether it is used for purely residential or commercial purposes. The pattern of development in California over the last decade has been conversion of much of the agriculturally productive land to residential living. It is fairly easy to see that, as a higher proportion of the population becomes involved in planning and development and technological activities, location in areas such as Florida is a very clear possibility. The level of development in Florida could very easily match that in the areas around San Francisco and Los Angeles over the last decade. Aside from possibly putting some of the agricultural land out of production, it does not seem that this transition will be very costly, except for the pollution that might be generated as this group of high-energy users moves into the Florida area as residents. Other than to refuse to admit such development possibilities, the proper strategy is probably to put enough controls on the growth process so that pollution does not become too great.

As the general income level in the United States rises so that most of the population becomes more concerned with a fuller and better life, a bigger fraction of the population will desire to live in all-year-round outdoor climates. With increased automation and faster and lower-priced transportation, there will be relatively many more technologically based and management-oriented employment opportunities. Radical changes foreseen over

the next decade or so could drastically change employment patterns so that management could be remote from both production and marketing. Communication may be substituted for transportation on a very large scale. In this kind of technological environment, the relative attractiveness of Florida over most of the other east coast living areas will increase. Extremely strong measures taken now to preserve Florida's environment will pay sizable dividends later when it becomes relatively even more attractive than at present.

Some insight into the possible development patterns of Florida can be gained by looking at a comparison of Florida's and California's industrial patterns. In 1965 Florida gained $2.5 billion in industrial activity. California gained $18.9 billion. Food processing accounted for 20 percent of Florida's activity and 14 percent of California's. Metal fabrication, machinery, and transportation equipment accounted for 20 percent of Florida's activity and 40 percent of California's. Printing and publishing accounted for 5 percent of the industrial income of both Florida and California. California has developed a sizable activity in instruments and computers. Substantial growth in the high-technology industries appears possible in Florida. California apparently has developed more extensively in these industries than has Florida.

Local industries that support amenity living for employees must be chosen very carefully so that the environment they create leaves Florida in a strong position to compete for the most attractive industries for the next decade or so. Great benefit would accrue to the state from developing an outstanding technological research and university base so that it would be competitive in attracting the most profitable and environmentally desirable industries.

*Ecological Laboratory and Museum*

Everglades National Park is not only a park in the usual sense, but a significant ecological laboratory and museum. Once one makes the change from thinking of it as a part to seeing it as an ecological laboratory, one must ask, What is the critical size of such a laboratory? Attempting to compute the minimum size, one might assume it to be determined by the requirements of the largest creature in the Park that lives in a natural state as a



predator, and would first determine the area needed per creature. Next one might compute the size of the minimum herd necessary to guarantee the survival of the species. Combining these computations, one can estimate the critical size of the Park. Using this kind of scheme, we estimated that, for the alligator population to survive, the size of the Park probably could not be reduced.

*Summary*

The resources to be shared among the four activities we have discussed are land and water. An additional vital factor is the level of atmospheric and water pollution.

Since the Everglades National Park has to be supported from governmental funds, its support must be determined by laws and restrictions rather than by the functioning of the marketplace. The total federal expenditures of $136 million on the national park system in 1966 clearly indicates that the Everglades Park's share is not at present such that really strong pressure can be built to expand the operation of the Park. The main question is more one of preserving what already exists. The need of the Park for water supply probably will be in competition mostly with agricultural water. The Park will not pollute the area but probably will have to be isolated from heavy interaction with the airport travelers to preserve the natural ecosystem and to avoid risk of disease to air travelers. The other condition necessary to the Park's viability is 800,000 acre-feet of water per year flowing into the Park from the north.

The highest-priced demand for land and water will be from resort and vacation activity. The intensity of this demand is very great, but the total volume probably will not double again in the next decade or so. Resort travel alone probably does not pollute either air or water if properly controlled.

The strongest future demand for land and water probably will be for industrial, managerial, and technological development to go along with amenity living by employees. Because the land prices associated with such residential and commercial uses are from $10,000 to $30,000 per acre, this use of land will force out all other uses except vacation and resort use until the demand is satisfied. Shoreline property will be developed

first, then the most attractive land nearby, and later agricultural land. Water resources used by this sort of activity are in the range of one-third acre-foot per year for each person in the area. If proper controls are exercised, there will be a satisfactorily low level of pollution of air and water by such activity. Uncontrolled development of such land would lead to irreparable damage to the environment.

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