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South Florida - A Case Study in Carrying Capacity

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Author	Arthur R. Marshall, B.S.; M.S. Director, Division of Applied Ecology Center for Urban Studies
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This paper explains in ecologic-economic terms some major reasons south Florida's Everglades and Gold Coast are degraded - and degrading. It discusses the stresses and overloads which have been placed on the air, water, space, and budgetary resources of these two integrated components of the south Florida ecosystem.

South Florida is a classic demonstration of the facts that growth and development cannot proceed endlessly without intolerable social costs; that the constraints of ecosystems ultimately clash with the economics of city budgets; that a holistic interdisciplinary approach to environmental problems is essential; and that the impoverishment of our large urban areas may be the yet unrecognized environmental catastrophe many have been awaiting to trigger the nation into action.

South Florida - A Case Study in Carrying Capacity

As a natural scientist who is disturbed by our disposition to arrogant and short-sighted treatment of the environment which supports us, I long have thought we would profit more by centering

our attention on the obvious faults of our behavior in lieu of our fixation with the obscure. Further, that while not abandoning our legitimate concerns with global or cosmic problems, we are more likely to begin to solve environmental problems by focusing on limited geographic areas.

The popularity and the problems of coastal south Florida present just such opportunities.

In recent years, south Florida has attained a new eminence. In tandem with and dimming its popularity, it has achieved great notoriety in the national media because of its environmental problems. I assure you that eminence is valid.

What Are These Issues?

The issues can be simply stated. Drainage of fresh waters to tide has **reduced** the carrying capacity of the Florida Everglades for its formerly abundant resources of water, wildlife, and muck. More recently the glades has acquired the disturbing specter of pollution.

Contrarily, the carrying or assimilative capacity of basic natural resources of the urban Gold Coast - air, water, and space - has been **exceeded** by an overload of people, their associated technological demands, and their wastes. As a direct result, municipal budgets are overloaded and unable to provide the facilities needed to compensate for the excessive population.

Though I have stated these tied irrevocably in one coastal as two separate conditions, both elements are life-support system (Figure 1)

Everglades Waterway

My accounting of the classic uncontrolled experiment in south Florida, which I offer in the belief that there is much instruction in the case, begins with the Everglades.

All life except that of the sea in the south Florida ecosystem depends upon a direct fresh water supply - water which in this case is derived directly from rainfall and is thereafter momentarily retained in what I prefer to call the "Everglades Waterway" - the area of the Kissimmee-Okeechobee-Everglades basin.

FIGURE 2: HISTORIC WETLANDS

In its pristine condition, this strange waterway arose in the lakes of the upper Kissimmee River and flowed south via the meandering lower Kissimmee River to Lake Okeechobee. In some very wet years, the Lake overspilled its southern rim into the sawgrass Everglades, adding that flow to the shallow surface sheetflow produced in the glades by direct rainfall. The greater part of the glades water was and is lost through seepage and primarily through evapotranspiration; the only significant surface flow to tide water historically was at the tip of the peninsula into Florida Bay. This shore of Florida Bay is now contained in Everglades National Park.

The eastern boundary of the waterway was the 10 to 15 foot high Atlantic Coastal Ridge; the western boundary in the glades portion was the 10 to 30 foot high sand plateau lands of the southwest coast.

It is difficult for one who has not seen the Everglades to imagine its flatness. Slope within the basin from Okeechobee to Florida Bay - a distance of more than 100 miles - averages about two inches per mile. This flatness, together with the friction of the dense marsh vegetation produces a southerly flow rate of less than one-half mile per day.

In its lower reaches, water flow curves to the southwest; its direction is emphasized by the axial alignment of thousands of elongate "tree islands" which stand two to five feet above the general marsh floor.

Heavy tropical rains come to south Florida in the summer and fall (Figure 3). Throughout the Everglades waterway the water rises out of its shallow scattered depressions - lakes, rivers, ponds, and sloughs. It sheets over the southern Everglades marshes in the form of a very broad river which historically was seven or eight feet deep at summer flood.

FIGURE 3: AVERAGE MONTHLY RAINFALL IN THE EVERGLADES OF FLORIDA

Regenerative processes bloom with the rising spread of the water under the warm summer sun. Plant germination and growth flourish. Many aquatic organisms - insects, crayfishes, killifishes, reptiles - engage in an orgy of reproduction and in a few weeks their progeny can be seen in all reaches of the summer river.

After the rains let up, the sheet water recedes into the deeper ponds and sloughs and concentrates the summer's production of small organisms, making them available in essential densities to the waiting large predators. This phenomenon of flood-bloom-recession-concentration is a marvel of synchronization - for the summer's organic products are thus served up to the flocks of colonial birds who are then fledging their young and to the young and adults of many marine fishes which invade the brackish and fresh waters of the lower Everglades to forage there.

"Flood Control" Projects

Over an 80-year period, many canals have been dug in the basin for the primary purpose of leading fresh water more quickly to tide - a euphemism for drainage.

We now have an enormous $300 million public works project - an elaborate plumbing system with some 1500 miles of canals plus levees, pump stations, and assorted control structures draped liberally over the Everglades to control floods and to purportedly conserve its water (Figure 4). It is instructive to note that drainage and conservation of water are opposite goals. Despite the intricacies of this system, its essential nature can readily be determined by noting that its major canals serve to speed the flow of fresh water to tide. These are the Kissimmee, Caloosahatchee, St. Lucie, Palm Beach, Hillsboro, North New River, and Miami Canals.

FIGURE 4: CENTRAL AND SOUTHERN FLORIDA FLOOD CONTROL PROJECT

An inventory of the environmental effects of all this alteration must include:

1. A gradual lowering of summer high water levels over an 80-year period by about six feet in the sawgrass Everglades.
2. Reduction of the area of the Kissimmee marshlands by 65% and of the wetland Everglades by about 50%.
3. A drastic shortening of the surface flood period in Everglades National Park from 6 to 8 months down to 3 or 4. By recent Congressional action, the project now must deliver some water via canals each month into the northern rim of the Park.
4. Massive declines of the colonial wading birds - from about 1.5 million birds in 1935 to 150,000 in 1970. The wood stork alone has declined from about 100,000 to about 3,000 birds in the same time period.
5. Massive declines - in the order of 80% - of the alligator populations.
6. The classification of 20 animals in the Department of Interior's Rare and Endangered Species list.
7. Induced expansions of the Everglades deer herd in the lengthened dry periods, followed inevitably by cyclic highwater stress which decimates them.
8. Rapid loss of the organic muck soils in the agricultural area just south of Lake Okeechobee through atmospheric oxidation. The remaining life of this great peat and muck bed, a deltaic fan formed over a 5,000 year span of decomposing marsh vegetation in the overspill from Lake Okeechobee, is now estimated to be less than 25 years.
9. Extended fires throughout the Everglades, most often of accumulated plant debris, but intermittently of the muck itself.
10. The induction of salt water intrusion along the Gold Coast, brought about by lowering the head of fresh water in coastal aquifers.

Although it is not prescribed in law, he who controls water in south Florida effectively zones the use of much of its land, for removal of water from wetlands opens it to urban and agricultural use (Figure 5). Thus the water manager not only effectively commandeers the role of the zoner, he further augments demands for water and collaterally regulates its use through his storage and distribution system.

FIGURE 5: MUNICIPAL BUDGET DEFICITS IN RELATION TO CITY SIZE

In the spring of 1971, south Florida experienced critical water shortages - and now expects to experience even more critical shortages in early 1973. These are shortages generated by the short-run canal discharges to tide coupled with the increased demands so greatly generated by drainage - the simple expectable crossing of two lines on a graph.

Increases in water users have also raised the specter of pollution from sewage, industrial, and agricultural wastes. Lake Tohopakeliga of the upper Kissimmee River has already become eutrophic. Others, including Lake Okeechobee, are in an early eutrophic (over-enriched) state

and are exhibiting the customary symptoms of blue-green algal blooms, intermittent fish kills, bacterial death of fishes, birds and alligators, and rapid accumulation of organic ooze on their bottoms.

One of the three water conservation areas of the sawgrass Everglades - Conservation Area Number 2 - now has organic oozes 8 to 12 inches deep covering about two thirds of the bottom of this 10 year old pool. This is significant, for the pool is usually only 3 or 4 feet deep and it is the only one of the three conservation pools which is more a reservoir than an evaporating pan. Fertilizer- laden waters pumped into this pool from adjacent agricultural lands energizes the bloom of algal masses along with that of other plants, the decomposition remnants of which form the watery ooze.

That is a summary story of the Everglades and its tribulations.

The Gold Coast

For the past dozen years, a handful of natural scientists, and many more citizen-conservationists, have noted, quantified, and publicized the growing plight of the Everglades. For much of that time, many of them voiced their intuitions that the "Everglades is the miner's canary of the Gold Coast" or "that as the Everglades goes, so goes the Gold Coast." We know it now, in true ecosystem fashion. Their importunings had little effect, however, for they were considered to be "for birds and not people" and were labeled "anti-progress."

Their motives, which stemmed from concerns for wildlife, were good; their strategies were wrong. They also should have been noting, quantifying, and publicizing the "wood storks" of the Gold Coast. Some of them are:

- water shortages
- water pollution
- air pollution
- traffic and transport problems
- overloaded schools, parks, beaches, courts, and jails
- crime
- shortages of power and problems of power generation
- spread of depressed areas
- overloaded municipal budgets

Had these stresses not developed in the Gold Coast, the future of the Everglades would be brighter - in true ecosystem fashion - and certainly the emigration from the Gold Coast cities of those who can afford to emigrate would not now be causing rumblings of concern in Martin and Marion Counties to the north. Further, we may have avoided such degradations as that of the coastal estuaries by shore-line filling and pollution, the near-shore continental shelf by pollution, and coral reefs by pollution and siltation. The moon over Miami is substantially dimmed by the gloom over Miami.

It is often said that we must take a holistic view of our environmental problems. That has not been easy to do for the Everglades, for no one finds it easy or objective to add or even to compare aborted water, declining wood storks, muck, and alligators. At best, we must subjectively adjudge this array. Actually the Nation has done that for the Everglades. It has made a subjective choice for its preservation which forestalled the construction of a giant jetport there; has induced the Congress to legislate a water supply for Everglades National Park; now impedes the construction of an interstate highway across the heart of the sawgrass Everglades; and has encouraged Florida's Cabinet, Senators Chiles, Jackson, and Gurney, and Congressmen Haley, Saylor, Fascell, Rogers, and Burke, and the National Administration to seek enactment of a bill to protect through purchase more than half a million acres of the Big Cypress portion of the wetlands remaining in the Everglades basin.

The City Budget as Indicator

Despite those gains and hopes, the task can be more holistic and objective in the city. The medium is the city budget.

When so many people occupy an area that they exceed the assimilative or carrying capacity of its air for their wastes; its water for their supply or assimilation of their wastes; its space for driving, recreating, educating, garbage disposal, etc.; we can select one of two courses of action. We can let the overloads remain burdensome - our normal course - in which case the quality of life drops. Alternatively we can purchase something, either land or technology, to try to accommodate the burden of the overload to the resources of the region. At that point the municipal budget enters, and the picture becomes holistic - our much sought goal. Since it involves dollars rather than wood storks, it also becomes more socially acceptable.

One of the earliest overload problems we encounter in urban areas is pollution of water bodies by the wastes of human bodies. If we do anything about it, we buy sewage treatment technology. From disposal of raw sewage into water bodies, we advance to primary treatment, then to secondary and, fashionably of late, to advanced treatment systems. This is simply necessary escalation in treatment efficiency. For, if a receiving water body can assimilate the raw wastes of 10,000 people without harm to its resources, we must advance to primary treatment or 50% removal with 20,000 persons, to secondary treatment or 90% removal with 100,000 persons, and to advanced treatment or 99% removal with 1,000,000 persons, to retain the same beneficial values in that water body.

As every engineer knows, exponential increases in efficiency in technology routinely carry with them exponential increases in cost. The cost progression in the several levels of sewage treatment for a 10 million gallon per day plant (100,000 persons) - both for construction and for operation and maintenance - is in the approximate ratio of 1-2-4.

In the Gold Coast, the rising rate of sewage treatment cost will exceed the average, for we are ensnared in a debate regarding the disposal of effluents eastward via ocean outfalls (into areas where coral reefs are dying and diseased fishes abound); westward into the already troubled Everglades (from which we drink); injecting it downward into deep aquifers (of which we know

little or nothing); pumping it northward 100 miles to rural counties (which are not likely to be overjoyed with the gift); or just blowing it upward in technicolor.

Unfortunately, we aren't persistent in acquiring such costly technological solutions. As a consequence, the quality of life declines with increasing pollution in water bodies. That is the case in south Florida.

In like fashion, the per capita cost of supplying water has also increased with population even though the municipal budget doesn't show it. Early Miamians supplied their own water from private wells near the mouth of the Miami River. City well fields established in subsequent years have steadily retreated farther upstream to evade the encroaching sea. A major well field which pumped up salt water in the drought of 1971 is eight miles up river. Though it doesn't show in the urban water user's monthly bill, some complex prorata portion of the $300 million canal system supplied him water in the drought of 1971 - from Lake Okeechobee some 100 miles distant - and it will be called upon to do the same or better in 1973.

Another way in which municipal per capita costs rise exponentially with population growth is in the acquisition of land for all public purposes. Park lands can be purchased in rural areas of Florida for $300-500 per acre. In Dade County a new State Park cost nearly $10,000 per acre and two small areas now being considered for urban parks are priced at $35,000 and $100,000 per acre. Similar cost increases are experienced in buying lands for roads, schools, and other public buildings.

These are a very few examples of accumulative effects on municipal budgets of increasing population overloads. The evidence is that just as in increasingly efficient mechanical systems, cost rises exponentially in essential urban systems. We have barely scratched the surface in making analyses of this kind. However, there is an appreciable amount of partial studies, some broad and some very specific, which support the concept of an exponential rise in city costs accompanying continued increases in population. A few of the more extensive studies show that the rapid rise in costs outdistances the rise in revenues, and that the gap continues to broaden at successively greater population levels. One such analysis, made by Boulder (Colorado) Zero Population Growth, indicates that per capita costs exceed revenues in relation to city size generally in accord with the following graph:

FIGURE 6: MUNICIPAL BUDGET DEFICITS IN RELATION TO CITY SIZE

In simplest terms, it appears that once a city is insolvent, it becomes more insolvent by getting bigger.

For those who wish to pursue this subject, I suggest some additional publications:

1. Barada, W. R., "People Pollution," *ENFO Newsletter*, Environmental Information Center of the Florida Conservation Foundation, Winter Park, Florida, October, 1972.
2. Hammer, L. I., *The Best Buy is Open Space*, Preservation Society of the EAST END, INC., East Hampton, New York, 1970.

3. Institute of Environmental Sciences, Rollins College and Winter Park Chamber of Commerce Symposium, "Toward a Quality Environment for Central Florida," Winter Park, Florida, April 15, 1972.
4. Little, Malcom G., "Report of a Study of Housing Developments and their Effects on County Fiscal Capacity," Georgia Institute of Technology, 1970.
5. "Regional Planning and Urban Prospect," Part V of *Basic Issues in Environment*, Ira J. Winn [ed.], Charles E. Merrill Company, Columbus, Ohio, 1972.
6. Veri, Albert., *An Analysis of Density as it Relates to Future Environ- mental Quality of Naples and Coastal Collier County, Florida*, A. R. Veri Associates, Coconut Grove, Florida, November 1, 1972.

Economists join the engineers in recognizing that costs rise exponentially with increasing efficiency above some optimum. In their analyses of the micro-economics of particular operations, they find diseconomies of scale in association with small size and again with large size, with optimal economies of scale in between (Figure 7).

FIGURE 7: ECONOMIES OF SCALE IN RELATION TO SIZE OF COMMERCIAL OPERATIONS

Most mayors of large cities agonize over these very issues. Yet because of the historic addiction to the growth ethic, many of them have remained convinced that a large population would improve their situations. There is a time in the history of each municipality when this is, or was, true. Apparently, the fault in their reasoning is that they think in terms of straight lines rather than in terms of the curves of the micro-economic theorists.

In my search for studies of the economic aspects of urban communities, I concentrated for many years on those problems in large cities. I was pleased recently to find in the *Yearbook of Agriculture for 1971* development of the concept that rural communities must grow to achieve economies of scale and quality of life. Eldridge, on page 246, presents a graph which indicates that rural communities will benefit through growth (Figure 8).

FIGURE 8

Note: The horizontal axis indicates size or volume of firm or institution. The vertical axis indicates the cost of producing each unit of product or service.

From USCA "A Good Life for More People:' 1971 *Yearbook of Agriculture*

DISTRIBUTE GROWTH

Perhaps in the face of our growing national population, that concept offers some hope for our large cities and therefore for the coastal zone of south Florida. Certainly the particular growth problem of south Florida - immigration - is one which neither ZPG nor even zero birth rate could readily solve. Some 3000 non-contraceptible, non-foetuses are moving into south Florida each month and the rate is increasing.

The growing cities of the Gold Coast and the Everglades are tied ecologically and culturally in myriad ways. Some of them are:

1. The agriculture industry - in which there are exchanges of machinery, chemicals, fertilizers, food, and dollars.
2. The wildlife of the region. Some move back and forth. All depend on habitats of some minimum size, with certain kinds of vegetation and standards of quality of water. The quality of water factor relates directly to the well-being of hundreds of marine species.
3. The plant and animal habitats of the Everglades also serve as park and recreational areas for people.
4. Water. Intermittently both city and wildlands have suffered from shortages. If the cities continue to grow into drained wetlands, the intermittent overbalances will become more frequent and severe in each part of that water-based ecosystem.

The views which I have presented are ecologic, centering on the limitations of life-support systems, including man's cultural and financial life-support. They are holistic, interdisciplinary. I have done no more than present a fragile framework by which we may measure our environmental conduct and health both in and around urban areas. There are many places in that framework which must be fleshed out by persons of many professions. Obviously the matter requires the continuing input of the sciences, for knowledge of how life-support systems work or fail is fundamental. Natural science alone, however, cannot do the whole job. Economists are required, as are planners, political scientists, communicators, and a host of others. Additionally, resolution of the problems require new cultural ethics and a vast amount of social decision.

It appears that the south Florida ecosystem has approached severe degradation much more quickly than many degraded areas in other states. Miami, for example, is less than 80 years old. While enormous population growth partly explains the rapid degradation of south Florida, natural factors also play a significant part. As practically all lakes, streams, and enclosed bays are no deeper than 16 feet, they are very vulnerable to pollution. Florida's soils and fresh waters are generally quite infertile; cultural addition of small amounts of nutrients rapidly alters their biota. Many marine organisms are naturally very close to their upper temperature limit in the summertime; a rise of only 2 or 3 degrees from heated waters can be lethal. South Florida is so nearly flat that change of water levels of 3 or 4 inches can dewater or flood thousands of acres. For these and other reasons, I believe we must accept that south Florida's ecosystem - both urban and wild - is relatively more sensitive, more responsive, to alterations than many of those of the north.

I see our alternatives as these:

1. Continue as we have been doing, which surely in south Florida will lead to further degradation of our cities, their budgets, and impoverishment of the area's natural resources.
2. Slow our growth rate, stop it in some areas, and re-distribute it to others where natural and budgetary resources are not overloaded. Do not allow such areas to become overloaded.

3. Reduce the intolerable demands of our life style - in resource consumption, treatment of land and water, generation of wastes. In my opinion, the benefits which have accrued to us, material and cultural, from two hundred years of American history dictate a responsibility to its future.
4. Learn the truths of life-support systems and respect them.
5. Acknowledge that despite our great wealth, we cannot afford to "carry" 80% of our people in the cadillac-style which the exponential costs of large cities require.
6. Re-order our priorities.

We have already taken large whacks out of the quality of human life and of the natural resources of Florida's subtropical coastal zone. It seems to me the expected environmental catastrophe which would trigger us to action is already with us.

The lives of the people in our cities are degraded. Our basic unit of American government - the city - is impoverished. As Oliver Wendell Holmes once said, "We need education in the obvious more than investigation of the obscure."

I have to believe, as all scientists should, that the more exactly we define realities, the closer society will adhere to them. If this is not true, then many of our careers are personal opiates rather than contributions to hope in the world.