THE BRAZILIAN PANTANAL AND FLORIDA EVERGLADES: A COMPARISON OF ECOSYSTEMS, USES AND MANAGEMENT[1]

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INTRODUCTION

In a time of increasing development pressure on water and water-related resources globally, it is important for researchers and resource managers to study the efforts of professionals working in different watersheds. Research results in one ecosystem may have direct or inferred value in others, while the development of management policies and practices may benefit from observing the outcomes of such approaches in other systems. The Pantanal and Everglades are both internationally significant freshwater ecosystems which share some essential characteristics, but that vary widely in location, scale, topography and ecological structure. Comparisons of ecological, cultural, socio-economic and legal conditions in the two ecosystems have the potential to contribute to the debates concerning management of both systems.

It is interesting to note that these systems represent watersheds at two very different points on the continuum, from undisturbed to highly disturbed. The Everglades represent such a system after approximately 100 years of drainage, manipulation and development, while the Pantanal ecosystem is still somewhat undisturbed by intensive development efforts.
For anyone familiar with the history and current status of Florida's Everglades, there are essential lessons to be observed about how *not* to manage a major watershed. Comparison of the structure, development and management of the two systems has the potential to generate some heat and light concerning principles for the sustainable development of large freshwater ecosystems in general.

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[1]In PROCEEDINGS OF THE SECOND PANTANAL SYMPOSIUM, Corumbá, Mato Grosso do Sul, Brazil (November 18-22, 1996).
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ECOSYSTEM STRUCTURE

Though the Pantanal and Everglades share important physical and biological characteristics, there are also important differences in structure and ecological functions, including contrasts in scale, hydrology, topography, vegetation and wildlife. The Everglades is a system of shallow sawgrass marshes, tree islands, wet prairies and aquatic sloughs that historically covered most of southeastern Florida, and extended from the south shore of Lake Okeechobee to the mangrove estuaries of Florida Bay. It is located at the bottom of the Kissimmee River/Lake Okeechobee/Everglades watershed which covers most of south and central Florida beginning just below Orlando in the middle of the state. The total watershed covers approximately 28,000 square kilometers. The Everglades themselves, below Lake Okeechobee, originally covered approximately 10,500 square kilometers, though that area has been greatly reduced by drainage and development.

Generally, one river and lake system supplies a wide, shallow flow of water to the Everglades. Elevations in the watershed range from approximately 30 to 35 meters in the upper reaches, to just above sea level in the lower reaches. The Everglades themselves are generally less than 6 meters above sea level, with a very gradual slope from Lake Okeechobee to Florida Bay at the bottom of the system.

The Pantanal is a very large alluvial plain, actually a related series of river floodplains, surrounded by highlands, within the Upper Paraguay River Basin in western Brazil, eastern Bolivia, and northeastern Paraguay. With an area of 140,000 square kilometers, the Pantanal is about 13 times larger than the original Everglades. Its watershed includes about 496,000 square kilometers, approximately 18 times the size of the Everglades watershed. The several principal rivers in the basin all originate in the surrounding *planaltos*. Altitudes range from 80 to 150 meters on the plains, to over 250 meters on the highlands. Primary drainage is to the south through the Paraguay River.

The Pantanal and Everglades both experience distinct wet seasons. Rainfall totals in the Pantanal watershed are from 110 to 150 centimeters per year, about 80 percent of which falls from November to March. Flooding eventually covers about 70 percent of the Pantanal plain, and

depending on location and elevation, ends from 3 to 9 months later. Average yearly rainfall in the Everglades is about 135 centimeters, with about 75 percent of that falling during the wet season from May to October.

In Florida, historically, water from the Kissimmee River basin meandered slowly south through the river toward Lake Okeechobee, then overflowed the lake's south rim and moved as shallow sheetflow through the Everglades and into Florida Bay and other coastal waters. Natural drainage occurred to the east through a series of breaches in the coastal ridge, to the south through several sloughs, and to the west through the Big Cypress Basin. On average, it would take eight months for water to flow from Lake Okeechobee to Florida Bay. Today, the volume of water flowing through the historic Everglades is much less, as a result of drainage and channelized discharges to the sea.

The Everglades developed as an oligotrophic ecosystem, with low levels of nutrients, and is therefore very vulnerable to slight increases in nutrients. Variability in the sub-basins of the Pantanal make it difficult to generalize about that ecosystem, but it appears that it evolved with higher nutrient levels associated with natural sedimentation processes.

The Pantanal region contains characteristics of three primary vegetative domains, including Amazon rainforest, *cerrado* scrub forests of central Brazil, and the *chaco* vegetation of Bolivia and Argentina. Eleven different ecological subregions have been identified. Principal vegetation includes native grasslands, scrub forest, gallery forest, and marsh vegetation. Principal vegetative communities in the Everglades include sawgrass, wet prairie, aquatic sloughs, bayheads or tree islands, tropical hardwood hammocks, cypress forests and mangrove.

The Pantanal supports a great diversity and abundance of wildlife, including over 650 species of birds and 250 species of fish. The region is one of the world's largest breeding grounds for wading birds and an important stopover point for migratory birds. There are about 80 mammal species, 50 species of reptiles and over 1000 species of butterflies. Some of the most unique animals in the world inhabit the Pantanal, including the giant anteater (*Myrmecophaga tridactyla*), giant river otter (*Pteronura brasiliensis*), maned wolf (*Chrysocyon brachyurus*), capybara (*Hydrochoerus hydrochaeris*), tapir (*Tapirus terrestris*), jaguar (*Panthera onca palustris*), puma (*Felis concolor)*, caiman or jacaré (*Caiman crocodylus yacare*), swamp deer

(*Blastocerus dichotomus)*, howler monkey (*Alouatta caraya*), blue hyacinth macaw (*Anodorhynchus hyacinthinus*) and the tuiuiú or jabirú stork (*Jabiru mycteria*).

Historically, the Everglades supported large total numbers of several wildlife species including several species of wading birds, alligators and other reptiles, and the Florida panther. Historically, and currently, species diversity in the area is relatively low, probably due to its young geologic age, a lack of diversity in aquatic and terrestrial habitats, and the fact that the region is located at the bottom of a peninsula. Still, at least 45 species of amphibians and reptiles, almost 400 species of birds and about 30 species of mammals occur in the Everglades. Out of the total, 33 species and subspecies native to the Everglades are considered endangered or threatened. Animals endemic to the region include the Everglades mink, the rice rat, the hispid cotton rat, the round-tailed muskrat, and the Cape Sable seaside sparrow.

USES AND IMPACTS

Human uses and their impacts have substantially altered the Everglades' natural systems and have had moderate effects on the Pantanal. Though there are differences in the intensities and impacts of human uses within each watershed, they can be generally grouped into several categories: large-scale water development projects, agricultural development, extractive and industrial operations, urban development, wildlife exploitation, and cross-scale threats.

Water Development Projects

The quality and quantity of water are key variables in the functioning of both the Pantanal and Everglades ecosystems. Both systems are highly dependent on the duration, distribution and timing of water flows. These characteristics, in turn, are subject to human manipulation through large scale water development, flood control and navigation improvement projects. The Everglades have been most significantly altered by such projects, but plans under consideration for navigational development in the Pantanal may significantly alter this system as well.

There has been extensive manipulation of water flows in the Kissimmee River-Lake Okeechobee-Everglades system by federal and state governments, beginning in the 1880s. Efforts to drain the region for agricultural purposes began as early as 1907, with the creation of the Everglades Drainage District. By 1927, six major drainage canals and many smaller canals had been built, including 1087 kilometers of levees and 16 locks and dams. In 1947, Congress

initiated the Central and Southern Florida Flood Control Project to provide urban and agricultural flood control and to ensure adequate water supply. The Army Corps of Engineers constructed a series of canals, levees, water retention areas, pump stations, and water control structures that extended throughout the entire length of the Everglades system. During the 1960s, channelization of much of the Kissimmee River, the northern component of the Everglades watershed, considerably altered the hydrology of that basin and led to the loss of between 16,000 to 20,000 hectares of wetlands.

Today, the water control system includes over 2250 kilometers of canals, levees, pump stations, and water control structures in and around Lake Okeechobee and the Everglades. These drainage and flood control efforts have opened up much of the area to farming and urban development, but have also caused a number of problems. Surface water levels and water tables have dropped dramatically, severely stressing wetland systems. There has also been extensive oxidation and loss of soils, loss of water storage capacity, and increased numbers of fires. The partitioning of the region into separate water control areas has also removed large parts of the historic Everglades from normal flow patterns.

These changes in the historic hydrologic regime of the Everglades, in combination with other factors, have resulted in substantial impacts to the biological components of the system, including significant loss or degradation of native plant communities, destruction of wildlife habitat and disruptions in the foodchain. Wading bird populations have been reduced about 90 percent over the past thirty years. These changes have also contributed to problems associated with the quantity, timing and discharge of freshwater into several major estuaries, severely reducing their biological productivity.

The Pantanal is threatened with a similar type of large scale water development project. The proposed Paraguay-Paraná Waterway (Hidrovia) is a massive navigation project which would increase transportation efficiencies for several products of the Pantanal and surrounding areas. Though specific projects have not been identified, as presently configured, the Hidrovia would include two phases. The first, Module A, consists primarily of channel dredging, channel straightening and stabilization, cutting of meanders and channel marking from Nueva Palmira, Uruguay to Corumbá, Brazil.

Though the specific components of Module B are somewhat undefined, they appear to include the possibility of projects such as river dredging, course changes, channel straightening and stabilization, and construction of water control structures for navigational purposes between Corumbá and Cáceres, Brazil including additional work within the Pantanal.

There are concerns that the Hidrovia project could affect the Pantanal in several ways. As is illustrated by conditions in the Everglades and Kissimmee River, as well as the Mississippi River, there are many direct, indirect and cumulative impacts associated with such a project. Direct impacts include loss of riverine vegetation and habitat for lower components of the foodchain, changes in riverine and wetland hydrology resulting from greater channel capacity, increased downstream flooding and changes in the pattern of flooding, deposit of dredged material, and the physical effects of increased barge and ship traffic on the river banks.

In addition to these direct impacts, there is also concern that a related increase in indirect impacts from secondary development as a result of the Hidrovia would cause corresponding increases in pollution from agrochemicals, industrial and urban wastes, and need for additional flood control. Cumulative impact analysis recognizes that in the short-term, individual local projects may not represent significant damage, but when considered together, and over time, they can have substantial impacts on human-related and ecosystem-related functions. The cumulative impacts of dredging, straightening, and cutting of meanders, combined with those of secondary development could result in levels of disturbance in the Paraguay and Paraná river ecosystems that are orders of magnitude greater than currently anticipated.

Agricultural Activity

A second major impact in both systems is industrial agriculture. In the Everglades, the construction and operation of the water management system necessary to support agriculture and urban development has contributed to fragmentation of the historic Everglades, resulting in the loss of connections between the central Everglades and adjacent transitional wetlands. Drainage and physical destruction of wetlands have resulted in the loss of almost half of the original wetlands in the Everglades.

Sugar cane, grass sod for residential and commercial landscaping, corn and other vegetable crops are grown in the highly organic soils of the Everglades Agricultural Area (EAA)

south of Lake Okeechobee. Drainage of that area causes soil oxidation and release of nutrients, and in combination with fertilizer applications, has been shown to contribute significant nitrogen and phosphorus loads to receiving waters, including the Everglades. As a result, some native vegetative communities and wildlife habitats have been severely degraded.

Crop production in the east Everglades area typically requires "rock plowing," a process of crushing the surficial native limestone rock formation until it reaches a consistency which can be plowed and planted. The subsequent agricultural use requires intensive use of water, pesticides, herbicides, and fertilizer. Another agriculturally related impact involves nutrient runoff from dairy farms located north of Lake Okeechobee. Many of these dairy farms were located in the former floodplain of the Kissimmee River, and though recent programs and policies have reduced the number of dairies in the region, they have also had adverse impacts on the water quality of the lake and downstream waters.

Most rivers draining into the Pantanal have their sources in the surrounding highlands. The Brazilian government has been subsidizing intensive agricultural operations in these areas since the early 1970s. Much of this has been justified as part of the effort to service the national debt and bolster the economy. In several regions, very large percentages of the original *cerrado* forests have been clearcut and converted to industrial farming operations for soybeans, sugar cane, wheat and corn. Many streambanks have been deforested, and soils in much of the region are relatively poor. To maintain fertility and fight crop pests, there has been extensive use of fungicides, pesticides and fertilizers. Water management practices are not advanced. The combination of these factors has resulted in extensive agrochemical runoff, soil erosion and increased river sedimentation.

There are also a few concerns with cattle ranching, the primary human use of the Pantanal. The tradition of cattle ranching in the area goes back almost 200 years, and approximately 95 percent of the lowlands have been subdivided into large *fazendas*. Cattle densities are low, and it is generally thought their impacts on native ecosystems and wildlife have been relatively small. However, additional research is needed on the effects of grazing and uncontrolled fire on vegetative communities and rates of sedimentation, and on the systemic effects of manure from the large numbers of cattle in the watershed. Exotic pasture grasses have also been introduced,

and additional research is needed to understand their potential for long-term impacts on native vegetative communities.

Extractive and Industrial Operations

Extractive and industrial operations have the potential for several significant impacts in the Pantanal. Direct impacts from iron, manganese, diamond and gold mining in the watershed include destruction of terrestrial and riverine vegetation and habitat, soil erosion and river sedimentation, changes in river bed topography and water pollution. Gold mining represents a significant environmental and human health risk in parts of the Pantanal. Large amounts of mercury are being used by miners in order to amalgamate gold particles contained in the mined soil and mud slurry. Additional research is needed to better understand the pathways and fates of mercury in the ecosystem, but there are serious questions concerning how carefully mercury is being handled, and how much is being released to the environment. There are several documented cases of significantly elevated mercury levels in native fish and birds, particularly in the northern Pantanal.

Mining activity in the Everglades region has primarily involved limestone, which has destroyed considerable amounts of habitat in the eastern Everglades, but is generally thought not to have widespread negative effects on water quality or quantity. Oil drilling has occurred in the Everglades region, but to date commercially viable operations have occurred only in the far western regions. Pipelines carrying oil from those wellfields east across the Everglades have ruptured in the past, with localized negative impacts on water quality and habitat.

Urban Development

Currently, there are 4.5 to 5 million people living within the Everglades and on the low coastal ridge separating the Everglades from the Atlantic Ocean. The urbanization of this region has had considerable impacts on water supply, vegetative communities, wildlife habitat, groundwater recharge, and water quality of the Everglades system. Agricultural lands east of the Everglades continue to be converted to urban development, forcing farms further west into areas closer to the perimeter canals and levees which border the remaining Everglades.

Approximately three million people live in the Brazilian portion of the Pantanal basin, and surrounding highlands. Direct habitat losses to conversion of land for urban development are, for

the most part, restricted to a few population centers in the upland areas of the Pantanal. Consumptive uses of water for urban purposes in and around the Pantanal are probably small, relative to the amounts of freshwater available. However, millions of gallons of untreated domestic waste enter Pantanal waterways each day, resulting in significant contamination of surface waters.

Wildlife Exploitation

The history of both systems has included periods of intense wildlife exploitation. Though in the past, the killing of wading birds and alligators took place on a massive scale in the Everglades, current wildlife populations experience relatively little stress from direct exploitation. The much greater threat to wildlife in the Everglades is loss of habitat from direct conversion to agricultural and urban uses, and from the effects of changes in the quantity, quality, timing and distribution of water within the system.

In the Pantanal, current trends in wildlife harvesting have improved but are probably not sustainable, particularly for certain species of fish and birds. With about 30,000 fishermen in the region, one problem involves fishing throughout the year. The situation is problematic during *pericema*, or spawning season. Enforcing a ban on fishing during this season is extremely difficult. Until recently, the widespread poaching of *jacaré* for skins was essentially unregulated, but has been somewhat slowed by increased enforcement. The taking of animals for the illegal trade in pets has also damaged populations of such animals as the hyacinth macaw, parrots, parakeets, several species of monkeys and anacondas. There is great potential in both the Pantanal and Everglades for increases in ecotourism, a type of wildlife "exploitation" that does relatively little harm to habitats or wildlife populations when designed and administered correctly.

Cross-scale Threats

In addition to localized anthropogenic impacts on watershed functioning, management of the Pantanal and Everglades may be influenced by cross-scale threats with wide ranging sources and effects. A potential example includes shifting weather patterns as a result of global warming. Even slight differences in the amounts, location and timing of rainfall can have unanticipated and greatly magnified effects in terms of ecosystem functioning. Larger trends and effects related to economic conditions and trade policy should also be appreciated as potential cross-scale threats,

since intensity of development in a region may be closely associated with national and state efforts to respond to such conditions.

In the Everglades, the most obvious example is sugarcane production, which has been heavily subsidized by price supports and import quotas. In the Pantanal, agricultural development on the *planaltos* was rapidly accelerated and subsidized beginning in the early 1970s, in response to national economic goals to increase foreign exchange and service the debt to international lending sources. These and other types of cross-scale threats such as the Hidrovia can have significant negative impacts on a watershed, and are extremely difficult for regulatory authorities to anticipate and to control.

MANAGEMENT AND REGULATION

Key issues relating to management and regulation involve jurisdictional divisions, legal authority and institutional capacity. In both ecosystems, there are significant jurisdictional divisions based on geography and subject matter. Though the Everglades lies entirely within the state of Florida, there are significant overlaps in jurisdiction between local governments, several types of federal and state authorities, and a regional water management district, a semi-autonomous political divsion within the state regulatory structure.

Regulatory authority for the Pantanal is geographically split between the states of Mato Grosso and Mato Grosso do Sul, and jurisdictionally split between environmental agencies in those states, federal environmental agencies and local governments. One of the biggest problems faced in both the Everglades and Pantanal has been the inability of institutions with different jurisdictions, constituencies and mandates to develop or implement an integrated approach to watershed management.

There is generally adequate legal and regulatory authority to control activities in the Everglades and much of the Pantanal, but the authority in both regions is weakened by exemptions and gaps in the regulatory scheme. Much of this is the result of a patchwork approach to environmental regulation which fails to recognize the need to consider all ecosystem functions on a watershed basis. Article 225 of the Brazilian Constitution specifies the Pantanal as one of several areas which are identified as part of the "national patrimony," requiring additional protection. Research has indicated that there are also approximately 120 federal laws related to

the environment in Brazil, which include provisions requiring environmental impact assessments, public review and comment, protection of vegetation along river banks, protection of wildlife, controls on effluents allowed into various classes of surface waters, and controls on agrotoxics among others.

The federal agency, IBAMA, has responsibility for applying many of these laws, though under recently adopted policies, states can now take concurrent authority over many topics. The state environmental agencies in Mato Grosso and in Mato Grosso do Sul apply environmental laws that generally track federal legislation, as well as some that are more specific to the Pantanal. In both states, the Forest Police provide some environmental protection and preventive policing. A remote Pantanal national park in Mato Grosso covers about 138,000 hectares, but this and another national park in the northern highlands have very little infrastructure and essentially no operating funds.

There is a strong federal presence in the Everglades, as both a regulator and land manager. The Army Corps of Engineers designed and built most of the system of levees, canals, pumps and spillways that controls the flow of water through the system. The Environmental Protection Agency (EPA) plays a role in wetland permitting, with authority to veto Corps permits and establish the criteria for permit issuance. The discharge of all other pollutants is subject to regulation by EPA, except that Congress has exempted agricultural discharges from regulation.

The U.S. Fish and Wildlife Service assists the regulatory agencies through commenting and technical support, and through research and recovery programs for endangered and threatened species. The Service also manages a significant part of the Everglades through a lease of Conservation Area 1, the Art Marshall Loxahatchee National Wildlife Refuge. The National Park Service owns and manages the Everglades National Park, at the bottom of the watershed, as well as the Big Cypress National Preserve, which protects an important part of the Everglades watershed.

The state agencies or entities with primary responsibility for managing the Everglades include the Florida Department of Environmental Protection, the Florida Department of Community Affairs, and the Florida Game and Freshwater Fish Commission. Applicable state regulations deal with the management of water quality and quantity impacts from development,

environmental planning for specified surface water bodies, control of urban growth, regulation of impacts to groundwater, and control of pesticide use, among others.

One significant difference between the Everglades and Pantanal is that in the Everglades at least one agency has jurisdiction over the entire watershed. The South Florida Water Management District has the potential to address impacts to the basin under a watershed approach. Until recently, however, the district did not have what would be considered a complete mandate to manage all water related impacts.

There are fairly large differences in the institutional capacity of agencies in the two watersheds. Federal, state and regional agencies in Florida have access to sophisticated equipment, training and communications, allowing for relatively good planning, research, monitoring and enforcement capabilities. The Brazilian economic situation, combined with uncertain attitudes toward environmental regulation, has resulted in a relative lack of institutional capability for most agencies in the Pantanal. A recent emphasis on decentralized regulation, combined with a growing cultural appreciation of the need for environmentally sustainable development, have translated into more institutional development and regulatory authority at the state level. However, there is still a crucial need for funding to support adequate research, planning, permitting, monitoring and enforcement for environmental purposes in Brazil.

The problem of political will affects the efforts of agencies in both ecosystems. For many years scientific information on the Everglades has documented a system in environmental decline, yet despite debate and increased regulatory authority and institutional capabilities, the degradation continued. It has taken near crisis conditions, and a federal lawsuit, to create the possibility of an effective response. A low level of perceived environmental threat to the Pantanal, combined with politically powerful interests and a national drive for economic growth have also allowed for some ill-advised agricultural, industrial and mining operations in the Pantanal watershed, particularly in the highlands. The potential problem is multiplied in relation to the Hidrovia, since the combined political and economic aspirations of five countries are involved in that decision.

CONCLUSIONS AND RECOMMENDATIONS

There are several conclusions and recommendations suggested by comparison of the two systems. The first is that effective management for sustainable use and development must be

grounded in a fundamental scientific understanding of a region. Many of the mistakes that have been made in managing the Everglades might have been avoided with better scientific knowledge. Even today, management of the Everglades, one of the most heavily researched systems in the world, continues to be constrained by the limitations of available information. There is an even greater need for research in the Pantanal. Major projects such as the Hidrovia cannot be properly evaluated without, for example, sufficient understanding of the hydrology of the area and the response of plant and animal communities to hydrologic alteration.

Continued financial support of collaborative research between universities, research institutes, regulatory and planning agencies and non-governmental organizations is crucial. To encourage optimum use of scientific research, it is also important to support wide dissemination of research findings, including clearinghouses for scientific information, regular conferences at which researchers and policymakers can share and discuss findings, and computer networks for data transfer and on-line discussion of issues by natural resource managers and researchers.

Funding, resources and enforcement ultimately depend on political will, which in turn is related to cultural recognition of and support for certain values. Thus, environmental education of policymakers, stakeholders and the general populace plays a crucial role in fostering widespread informed debate on environmental policy development, and in creating and implementing sustainable management strategies. Despite the immense financial and institutional resources of regulatory and planning agencies with jurisdiction in the Everglades, management decisions have consistently failed to protect ecosystem functions. In the case of the Pantanal, this relationship between environmental education and sustainable management policies is particularly important, in the face of strong development pressures and low enforcement capability.

A second conclusion involves the significance of planning for and maintaining all water-related functions in a system. A failure to recognize, evaluate and manage for a broad range of values has placed the Everglades on the list of endangered ecosystems. Management policies in the watershed which sacrificed many functions of the system in favor of flood control and drainage for agriculture and urban development have led to a water control system that is now among the most complex and expensive in the world, and which is not capable of sustaining the ecosystem.

Economic gains derived from agriculture and urban development have come at tremendous economic and environmental cost in the Everglades. Efforts to understand the functioning of the ecosystem, create technical and managerial approaches for restoring its viability, and to replace lost functions have cost hundreds of millions of dollars, and will require many hundreds of millions more. General estimates are that at least US $2 billion will be required. Many environmental and economic values of the ecosystem will never be fully regained.

The current hydrological regime of the Pantanal also serves a large number of ecosystem and human-based functions, most of which appear to be relatively intact. However, the development approaches taken have already begun to favor intensive, quick profit economic uses and manipulations which threaten to significantly alter the structure and function of the system in ways which will reduce its long-term sustainability. Policymakers in Brazil have an opportunity to observe the failures and successes of management schemes for the Everglades, and develop or adjust policies for the Pantanal which will allow for the sustainable development of the watershed. Accounting for and properly managing all functions helps avoid a crisis management approach which has characterized the situation in the Everglades for many years.

Another conclusion drawn from comparing the two systems is the crucial importance of a basinwide management approach. Many problems in the Everglades have developed as a result of single purpose, localized water development and management decisions which failed to consider activities in the watershed as a whole. Decisions made to channelize the Kissimmee River greatly increased levels of nitrogen and phosphorus in Lake Okeechobee. Efforts to protect the water quality of Lake Okeechobee resulted in shifting the discharge of nutrients into the Everglades. Drainage of the East Everglades has deprived Florida Bay of freshwater inflow.

The Pantanal is a much larger watershed, but a holistic strategy is equally important here. Like the Everglades, the Pantanal is vulnerable to poorly planned and managed development in the watershed. The effects of mining, agricultural development and flood control and navigation improvement projects must be considered as part of a comprehensive watershed management plan. There is a crucial need for the development of a coordinated watershed plan, incorporating regional plans for all sub-basins. The research, training, institutional development and regulatory

initiatives funded under recent programs have the potential to contribute to such plans. The challenge for Brazil is how to accomplish this in a much larger basin which is under several jurisdictions with different political constituencies, and under economically difficult conditions. The long-term economic, environmental and social benefits of such an approach will greatly outweigh the time and expense involved.

Finally, as related to the previous conclusion, there is a need to coordinate the programs of all authorities which have a role in implementing a watershed management approach. Though the Everglades watershed has, since 1972, been under the jurisdiction of the South Florida Water Management District, the permitting and regulatory authority granted to the District has not allowed it to address all potential impacts to the system. As a result, many regulatory and planning bureaucracies have reviewed potential project impacts. Until recently, there was relatively little coordination or planning among those bureaucracies, resulting in management goals and priorities which sometimes worked at cross purposes. The lack of a coordinated and cooperative approach by all agencies worked to slowly but inevitably degrade ecosystem function in the Everglades watershed.

Given the degree of jurisdictional partitioning in the Pantanal watershed, regulatory and planning authorities in Brazil face a difficult task in developing cooperative approaches to managing the watershed. However, it is critical that this occur. At present, there is almost no coordination between planning, permitting and development decisions in the Pantanal. There has been recent cooperation on policy between environmental agencies in the two Brazilian states, but there is no evidence that planning or permitting decisions have been coordinated. It is important that management structures be conceived and created to allow for the coordination of such decisions.

Natural resource management programs must also be coordinated with economic, trade and social programs. In the case of the Everglades, many of the problems of agricultural water pollution may be related to U.S. trade and agricultural policies, which have supported a domestic sugar industry. The expansion of urban areas in South Florida, and the resulting demand for drainage and water supply, may be related to U.S. immigration policy. In Brazil, subsidies for agriculture in marginal areas may not only be related to trade policies, but ironically, to efforts to

reduce air pollution by creating a domestic fuel alcohol industry from sugar cane. Trade and development policies encouraging industrial zones in the Pantanal will also severely complicate efforts to properly manage the watershed. Until all such programs with potential effects are coordinated, sustainable management of both the Everglades and Pantanal will be more difficult to achieve.

The true long-term interests of Brazil, as well as the other Mercosul (Mercosur) countries, will require careful evaluation of the total economic and environmental costs and benefits associated with the Hidrovia proposal. This is an inherently complex analysis, but at the least, it should include general consideration of the interrelationship between the economic value of well-functioning ecosystems and the economic costs associated with degraded or destroyed ecosystems. Specific examples include the economic value of an intact Pantanal which produces beef cattle, farmed *jacaré* and capybara; supports significant and potentially large amounts of ecotourism; provides water quality protection; and which prevents the enormous economic losses which could occur from downstream flooding as a result of river channelization.

A recent environmental impact assessment (EIA) of the Hidrovia, completed by a consultant to the Interamerican Development Bank, questioned the economic viability of the Hidrovia, based on the fact that Ferronorte and other transport corridors will take much of the traffic that might otherwise use the Hidrovia. The EIA did not attempt a long-term or complete environmental evaluation, since there has been very little information provided by sponsors concerning specific projects in the river stretch from Corumbá to Cáceres.

If the cumulative environmental costs of projects in that stretch of the river are added to the potentially tremendous economic costs associated with increases in downstream flooding, it appears that the economic and environmental advisability of the Hidrovia will be reduced even further. These comments are based on the executive summary of an EIA which has not addressed specific projects. Large amounts of additional research will be necessary in order to provide a more accurate and in-depth analysis of the potential impacts. As has been conclusively demonstrated in the Everglades, a coordinated and sustainable approach to management of the Pantanal will require no less.