The case of the Paraguay-Paraná waterway ("Hidrovia") and its impact on the Pantanal of Brazil: a summary report to the society of wetlands scientists

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(Website editor: My eldest son Simon, a tropical marine biologist at present working at the University of Queensland in Brisbane, sent me this article, which is highly relevant to the main objective of the website, namely to provide comprehensive information on the blue macaws and their conservation. Simon initially assisted me in the design and construction of the Blue Macaws website before leaving for Australia in June of this year (1998) and has his own website for the Seyshelles Marine Conservation Expedition.)

In l996, at the request of then-president of SWS Bill Mitsch, a small group of SWS members formed the ad-hoc Pantanal Committee with the goal of exploring an issue of international importance to wetland science. This issue involved the proposal to develop a 3,440-km long navigational transport artery through the heart of South America and the impact of this waterway ("Hidrovia ") on the Pantantal,140,000 km2 of tropical flood-pulse environment famous for its abundance and diversity of flora and fauna. Committee members met with NGO's, government organisations, scientists, and others knowledgeable about the Pantanal, the Hidrovia, and related matters. We collected scientific information on the issue, and reviewed the proposed project activities in light of our best understanding of wetland hydrology and wetland functions. This article to the SWS membership summarizes the history surrounding this waterway project, a turbulent case of large-scale wetland protection and management ruled by a battle of information and disinformation. The text of this summary, both in English and Portuguese, will be submitted to the different parties involved in the issue of the Hidrovia.

The Pantanal

Located in the heart of South America, the Pantanal (meaning "great swamp" in Portuguese) is an immense flood-plain mosaic of seasonally inundated grasslands, river corridors, gallery forests, lakes, and dry forests (Figure). This 140,000-km^2 alluvial depression, located in the upstream basin of the Paraguay River, stretches across western Brazil and parts of Bolivia and Paraguay. At roughly 10 times the size of the remaining Florida Everglades, the Pantanal has been referred to as the world's largest continuous wetland (Alho et al.1988). Plant and animal life are strongly influenced by distinct seasonal flooding with water levels during the rainy season as much as 5 meters higher than during the dry season (Junk and da Silva 1995). Periods of severe floods follow extreme droughts, and only a portion of the Pantanal remains inundated throughout the year (Hamilton et al.1996). The Pantanal is a key hydrologic resource in South America. It sustains flows in the

Paraguay River throughout the growing season, which has a major impact on both the ecology and economics of the region between the Pantanal and the Atlantic Ocean. It is also an integral part of the hydrologic cycle of South America due to its size and the quantity of water it temporarily stores annually (Ponce 1995).

eographic location of the Paraguay-Paraná Basin (modified from Ponce, 1995)

Figure: Paraguay and Paraná wetlands

The seasonal flooding regime supports a productive and diverse fauna (Brown 1986), including some of Brazil's most endangered species (The Nature Conservancy 1994). It is home to aquatic birds such as the jaburú (*Jabiru mycteria*), many herons and egrets (order *Ciconiiformes*), jacanas (*Jacana jacana*), and the anhinga (*Anhinga anhinga*). Caimans (*Caiman yacare*), capybara (*Hydrochaeris hydrochaeris*), piranhas (several genera including *Serrasalmus* and *Pygocentris*) and several species of monkeys (*Alouatta caraya* and *Cebus apella* being the most common) also thrive in this wetland, along with occasional jaguars (*Panthera onca*), srnall forest cats (of the genus *Felis*), anteaters (*Myrmecophaga tridactyla*), giant river otters (*Pteronura brasiliensis*), some 20 different species of bats (order *Chiroptera*), and the endangered hyacinth macaws (*Anodorhynchus hyacinthinus*). The region has one of the most diverse avian communities on the planet with more than 650 species of birds identified. More than 400 species of fish already have been listed for only a portion of the Pantanal (Marins et al. 1981) with many additional species identified in more recent studies (Por l995).The diversity of interacting habitat types and the direct connection with neighboring South American phytogeographic regions also produce a remarkable, albeit poorly known, plant diversity. The vegetation contains elements from the dry-savanna ("cerrado") of Central Brazil, the Bolivian "chaco" (semi-arid scrub forest), the Amazonian region to the north, and the Atlantic forest to the South and Southeast (Adamoli 1986). In spite of this extraordinary productivity and diversity, the Pantanal is an unknown tropical wilderness (Bucher et al. 1993) and our understanding of the forces that control the composition and functioning of its communities is meager at best. Furthermore, needed research in the Pantanal is

complicated due to the inherent problems of working in a large, inaccessible region where costs are high and where 98% of the land is in private ownership.

Threats to the Pantanal

Because it is one of the most unyielding places on earth, this large and rich ecosystem has remained relatively untouched. There is, however, increasing evidence that this area is threatened by a number of activities. For some time, these threats have included mining, illegal hunting and fishing, agricultural development, and deforestation. Careless use of mercury in gold mining, particularly in the northern Pantanal, may result in acute or chronic ecosystem disruption (Hylander et al.1994; Nogueira et al. 1997). Wildlife poaching and live animal trade are widespread although hard to quantify. During six months in l985, an estimated 18,800 kg of skins (representing more than 500,000 animals such as jaguars, maned wolves, caimans, and snakes) were exported to European, Asian and North-American markets (Anonymous 1985). Only a fraction of this trade is confiscated and, although enforcement has improved, the majority of offenders are never captured. Pet collectors not only focus on parrots and macaws but also capture monkeys. A pair of hyacinth macaws has a market value between $8,000 and $ 10,000 in the USA and Europe (Mittermaier et al. 1990). Large-scale agricultural development of upland savanna introduces toxic chemicals into the floodplain. Laws regulating the use of agri-chemicals are difficult to enforce and pesticides (including toxics such as disulfan, endosulfan, and thiodan) are freely used and sold (Alho and Vieira 1997). Removal and burning of forests, needed for farm expansion, not only removes natural communities but also increases soil erosion which clogs rivers and destroys benthic habitat.

In addition to these threats, the area has now been discovered by new kinds of invaders. They are engineers, business people, and consultants involved in intensifying agriculture, expanding mining, organizing unplanned tourism, and promoting a large river-channelization project. These combined activities contribute to progressive alterations of the natural landscape, the disappearance of species, the accumulation of persistent toxics, and other ecosystem damage. As a result, scientists and conservation organizations now focus attention on the Pantanal, setting the stage for a classic conflict between conservation and economic development.

Hidrovia

Without a doubt, the development of a 3,440-km long, north-south navigable waterway from Cacares (Brazil) to Nuevo Palmira (Uruguay) will have a substantial impact on the Pantanal hydrology and ecology. While officially still a proposal, this "Hidrovia" (Spanish and Portuguese for waterway), or Paraguay-Paraná waterway, is by no means a new idea and has been navigated for many decades. Nor is it the only hidrovia planned or operated in Brazil. More than 100 years ago, politicians and entrepreneurs already dreamed about a channelized waterway into the heart of South America. In the late-1980s, the La Plata Basin countries (Argentina, Bolivia, Brazil, Paraguay, and Uruguay) resolved to initiate this huge project as a step toward the integration of the Basin countries (Bucher et al. 1993). They created an Intergovernmental Committee on the Hidrovia (CIH) to

promote and oversee the development of this commercial waterway. The waterway would link the five countries and would promote a regional integration among countries of the Mercosur (i.e., southern common market) by ensuring year-round navigational transport of minerals and agricultural products (primarily soybeans) from landlocked regions to major markets along the Atlantic coast. The goal was to transform the meandering river into a deepened channel, navigable for barges up to 2.8 m draft during the low water months. Presently, the river allows much smaller barge transport. An economic feasibility study (Internave 1990) actually showed a positive net return for an engineered system of major channel straightening, dredging, and removal of flow-impeding rock outcrops. The Internave report failed, however, to adequately consider large environmental costs including changes in water quality, flood amplitude (Bucher et al.1993), and loss of wetlands. It also contained a number of mathematical errors in the cost-benefit analysis of the project. Recently completed feasibility studies estimated the cost of the Hidrovia around US$ I billion over a period of 25 years (IUCN 1997).

After the failure of the Internave studies became clear, the Inter-American Development Bank (IDB) and the United Nations Development Program (UNDP) provided more than ten million dollars in technical assistance to the CIH to perform a thorough engineering, economic, and environmental assessment of the proposed waterway project. These studies started in 1995, were carried out by several international consortia of consultants, and concluded in 1997. They produced a remarkable turmoil among environmental, political, and economic factions and information/disinformation became the weapons of choice in the battle for the Hidrovia. The fact that public participation and input in the assessments were not encouraged made an accurate evaluation of the study activities and direction difficult. Indigenous people in the affected areas were mostly overlooked, and environmental approval processes were bypassed by "undercover" waterway construction activities, financed by national budgets or by private sources interested in the project's implementation. Independently, Ponce (1995) focused on the hydrologic aspects of the proposed Paraguay-Paraná waterway in a study sponsored by the Mott foundation. The Hidrovia, which until then received mostly North-American and European press coverage, now became front page news in South America (Gomes 1997).

Impact Assessments

The CIH assessment received harsh criticisms from reviewers. A panel of specialists reviewed the results of the hydrological analyses that served as the basis for assessing the technical and economic feasibility and the environmental impacts of the project. They concluded, based on the limited information that was actually presented to them, that the engineering studies were incomplete, did not address the long-term implications of water-level changes on the flood-plain, and that a thorough environmental assessment was lacking. In particular, the panel questioned whether the proposed dredging and rock blasting in the Paraguay River would lead to additional blasting requirements once the river adjusted to a new hydrologic equilibrium. In addition, the panel expressed serious considerations about the one-dimensional flow-routing models that were used and their suitability for depicting the complex interactions between surface and groundwater, their spatial and temporal variability, and the interactions between

the river and the flood-plain, including effects on the flora and fauna of the Pantanal. The panel findings were similar to the conclusions reported independently by Hamilton (1996) in a report to the Rios Vivos Coalition. This report also used a model to predict that large losses of flooded area were possible with seemingly minor decreases in river levels, particularly during the dry season, when such areas serve as critical refuges for fauna dependent on aquatic environments. For instance, lowering the level of the Paraguay River by an average of only 25 cm, certainly a realistic estimate, would reduce the flooded area of the Pantanal by 22% at low water (Hamilton 1996).

Potential flood hazards downstream were also poorly represented in the impact assessment. The majority of the water which enters the Pantanal leaves through evaporation after remaining for months in flooded areas of the basin (Ponce 1995). Navigational improvements (e.g., dredging, river straightening, rock-blasting, and dike construction) would accelerate the velocity of the water, rather than maintaining the natural flow and allowing the water to pulse into the flood-plain. Such pulses help disperse nutrients and sustain productivity and diversity in this wetland (Junk et al.1989). By storing flood waters, the Pantanal contributes to the separation of the flood peaks of the Paraná and Paraguay Rivers downstream. Historically, the Paraguay River adds its flood stage to the Paraná River south of Resistencia (Argentina) about two to three months after its own flooding. Already with the present increase in agricultural development of the flood plain and dredging of the river, the peaks of the Paraguay and Paraná already have become less separated and have started to produce unusually high discharges. Dredging and rock blasting associated with the Hidrovia would aggravate this risk of flooding. During l998, one of the largest recorded floods in the history of the Paraná displaced more than 100,000 people in Santa Fe (Argentina) alone. Even though this flooding was linked to "E1 Niño" weather phenomena, experts agreed that it was worsened by the anthropogenic changes occurring in the Paraguay-Paraná basin.

Storage of water in the flood-plain and reduced water velocity in the rivers may also have water quality benefits. This is particularly important for people depending on the river as a source of drinking water. Mineral uptake by plants in the productive wetlands, settling of sediments (and the chemicals sorbed to sediments) from stagnant water in the flood-plain, and active microbial processing influence the chemical composition of water that flows through the Pantanal. Reduced storage, increased river flow, combined with dredging, rock blasting and river transport of hazardous materials (such as mining products and fuel) may threaten the drinking water supply of millions of people downstream. For instance, the Viñas Cué water uptake for 1 million people in Asunción is immediately downstream from an area where river rock-outcroppings are planned to be destroyed with dynamite (Switkes 1997).

With economic benefits to the region as the main driving force behind the Hidrovia planning, a careful analysis of all relevant and cumulative costs (including environmental) should have been conducted. Navigational improvements to enhance transportation can have great benefits in terms of economic integration of the region, lowering transportation costs for agricultural and mining products, and access to ports for land-locked countries such as Bolivia and Paraguay. As a

matter of fact, such considerations generally have driven commercial waterway construction in the past, including massive works along the Mississippi, Rhine, and many other rivers. Such trade routes promote urban and industrial development and open new areas for agricultural expansion. The construction sector will greatly benefit with essentially a never ending workload scenario of infrastructure and flood control projects. The navigation industry will also prosper with continued dredging and channel maintenance contracts, and large agribusiness will benefit from, at least theoretically, reduced transportation costs. For Argentina, in particular, the waterway is vital since 75% of its population lives in the La Plata Basin, the region most affected by the project (Gomes 1997). Paraguay and Bolivia are both still dependent on road transport of agricultural and industrial products through Brazil.

The CIH directed assessment, however, fell short of a comprehensive analysis of the costs involved in this project. Consultants overestimated the project benefits, such as the value of iron ore and soybean exports, and underestimated its significant costs, such as the loss of fisheries. Environmental costs were not fully assessed. In ways, the analysis seemed to follow the same pattern that was applied to many of the world's large rivers in the past when they were developed into complex waterways. Only in recent times have the enormous environmental costs (including erosion, flooding, chemical contamination, and disruption of natural communities) of such developments become obvious. Even the existing economics of the Pantanal seemed not fully considered. Traditional cattle-ranching, which has co-existed with the flood-plain and its wildlife for centuries, will suffer greatly when grazing lands receive less nutrient-rich floodwater during the rainy season. These large cattle ranches, some up to 2,500 km², make up the majority of the land in the Pantanal. Cattle are kept at densities that the land can support during the wet season, when some ranches are 90% under water.

In addition, the economic feasibility study carried out by the CIH did not consider alternative transportation routes for Brazilian products including the Ferronorte railroad (between Cuiabá and ports in Southeastern Brazil) and the railroad between Corumbá and Baurú (in the State of São Paulo), which is being improved. Also, existing hidrovias through the Madeira-Amazonas (between Porto Velho and Itacoatiara) were not addressed. Even the existing Paraguay River is navigable during at least half of the year (Filho and Coelho 1997). Soybean harvesting and shipping in the Pantanal occurs in April, May and June, when the river is full and presents little problems for navigation. Studies even failed to assess impacts on tourism in the Pantanal caused by development of a shipping industry (Switkes 1997).

Finally, channelization of the river will negatively affect the livelihoods of thousands of indigenous people in this vast region. These vulnerable populations, many already close to extinction (e.g., Guarani, Kaiowa, Guatos, and others) and never really included in the planning of this waterway, have none or limited rights to remain in their traditional territories. They will likely lose these lands, vital grounds for their survival, to entrepreneurs and land speculators (IUCN 1997). This, in turn, will eliminate their traditional economies and result in despair and forced displacement. Shameful disregard for indigenous populations has been a

common feature of large-scale waterway projects throughout the world. The Hidrovia waterway seems to repeat these sad mistakes.

Lessons from the Past

As the Mercosur is planning to develop the Hidrovia, other countries are trying to undo the massive damage that dikes and artificial waterways have done to many of the world's large rivers such as the Missouri-Mississippi river system, the Florida Everglades/Kissimmee River complex, the Rhine, Danube, and many others. This irony has certainly not gone unnoticed with proponents of the waterway project. They emphasize that these engineered hydrological systems have been developed in many parts of the world (including in the United States and western Europe, where some of the most vocal opposition against the Hidrovia originates) and have produced significant industrial and agricultural benefits for those regions. The United States uses its rivers for commercial navigation and has a network of some 47,000 km of hidrovias, transporting about 670 million tons of products annually, nearly 17% of its total production. In the early 1990s, the 170 km long connection between the Rhine and the Danube Rivers in Europe as completed, connecting the North Sea with the Black Sea along a continuous hidrovia of 3,500 km (Padilha 1997). Opponents of the Paraguay-Paraná hidrovia, on the other hand, point to the tremendous long-term costs that have resulted from these same projects, particularly in terms of what economists like to small "externalities". These costs (monetary or otherwise), borne by someone other than the individuals using a resource, include damages due to flooding, deteriorating drinking water quality, displaced populations, pollution, loss of wetlands and wildlife, and damage to fisheries (cf. Bucher and Huszar 1996).

In one of the largest ecological restoration efforts ever undertaken, hundreds of millions of dollars are spent to take farmland out of production and restore a more natural flow of fresh water across the Florida's Everglades. Earlier, some 700 million dollars (l992 estimate) were allocated to help restore the Kissimmee River, a major tributary to the Everglades, to a semblance of what it looked like before a major channelizaion project drained an entire Central Florida valley. Restoration of the Kissimmee River needs to be viewed in he context of the effort to restore the Florida Everglades. The channelization of the river started in the 1960s and changed the 150 km-long shallow meandering Kissimmee River to a 93 km-long, 10 m deep channel. It destroyed thousands of square kilometers of wetlands, eliminating their water filtering and storage capacity in the process, and contributing to water quality problems and an hydrological chaos downstream in Lake Okeechobee and the Everglades. Wading bird populations were estimated at only 5% of what they were before the first drainage efforts began in the 19th century (Brumbach 1990). In an effort to prevent the same mistakes from occurring in the Paraguay-Paraná Hidrovia,the U.S. State Department took a Paraguayan delegation (including President Wasmosy) on a tour of South Florida and the Mississippi basin in April of 1997. The American experience may be very helpful in the Pantanal.

Similarly, the impacts from the development and use of the Missouri-Mississippi river system may be used as a comparison, although there are several apparent differences between this navigable waterway and the Paraguay River within and

downstream of the Pantanal. These differences include climate, soils, and precipitation patterns. There are, however, enough similarities in scale, flow, channel geomorphology, and connectivity with riparian habitats between these river systems that impacts of water-related developments on the lower Missouri-Mississippi Rivers during the past 170 years may help illustrate some likely impacts of the Hidrovia on the upper-Paraguay River and the wetlands of the Pantanal in the next 100 years.

Since 1825, works have been undertaken on the Mississippi and Missouri Rivers to improve navigation, control flooding, and stabilize banks. A series of floods, from the 1880s through the 1980s, were the impetus for this long progression of projects aimed at altering the rivers' flow and structure. Channels were dredged to make them deeper and wider, earth embankment levees and dikes were constructed to keep flood waters within river channels, meanders were removed to straighten these channels, and rip-rap was used to stabilize hundreds of kilometers of river banks. The impact on downstream sections were never fully considered during the planning process. Today, the Mississippi and Missouri Rivers hardly resemble what early explorers found two centuries ago. Gone are the broad river channels, with numerous islands, sandbars, chutes, and backwater areas. Flood-plain wetlands have been reduced by 90% (Gore and Shields 1995) and, in many areas, converted to farmland. Today, these rivers have highly-controlled. less dynamic flows (except during floods). Historically, the lower Missouri hydrograph displayed flood pulses in early spring and, especially in early summer coinciding with the spawning of many flood-plain dependent fish species. The present hydrograph shows a regulated stage increase in early spring that is maintained through autumn to allow navigation (Galat et al.1997). Dikes and levees have eliminated connectivity with adjacent wetlands and the Mississippi has been shortened by 229 km (Gore and Shields 1995). Straightening and channel improvements for navigation have reduced the water surface area and barge traffic has contributed to bank erosion and high turbidity levels in a river now known as "The Big Muddy". Benthic habitat suitable for invertebrate colonization has declined by nearly 70% and commercial fish production has decreased by as much as 80% since 1940 (Galat 1996). Ironically, even with dikes and levees for flood protection and navigation, the costs associated with floods have been enormous. In fact, data show that the flood frequency and magnitude has increased following these "improvements" (Moore 1994). The Great Flood of l993 alone resulted in US$ 12 billion in damage when the river attempted to reclaim its flood-plain.

Using the Mississippi and Missouri experiences to evaluate waterway development of the Paraguay River and the Pantanal seems justified. For the North American rivers, the initial intent was to modify the channels for commercial navigation. The ensuing industrial, urban, and agricultural development in the flood-plain required additional river modifications, primarily designed for flood control. Gradually, over more than l70 years, the rivers were transformed into canal-like waterways, losing much of their productive and diverse aquatic life. No less important, the dynamic river flood-plain connection was disrupted. Wetlands that were not drained through ancillary activities, became isolated from the rivers main channel through diking and lost many of their fish and wildlife species. Changes to the structure and flow pattern of the Paraguay River could lead, based on the

Mississippi-Missouri model, to a similar disruption of the link between that river and the Pantanal. Even though the focus of the Hidrovia is on navigational improvements, this waterway will inevitably evolve into a multi-faceted, economic development enterprise where a multitude of seemingly independent decisions and projects compete for the same resource. The Hidrovia may become another lesson of Alfred Kahn's (1966) "tyranny of small decisions", an economic concept applied to environmental degradation by Bill Odum (1982). Odum described how the Florida Everglades, for example, were not transformed by one single adverse decision. Rather, these South Florida wetland deteriorated from a multitude of ostensibly independent, smaller-scale decisions. In the Pantanal, these decisions might include bringing additional farmland in production, the construction of yet additional port, additional rock-blasting to allow navigation in shallow river stretches that develop under a new hydrologic regime, another drainage canal to prevent flooding, and one more road construction to improve access. No one is making the deliberate choice to destroy the Pantanal flood-plain system. Yet, because of the cumulative effect of all the actions, the Pantanal of the 21st century may well be as different from its present state as the Everglades and the Mississippi-Missouri Rivers differ from their present pre-1900 condition.

Current status

The most significant recent development has been the announcement, in early 1998, by Brazil's Federal Environmental Agency (IBAMA) to abandon plans for construction activities along the Brazilian portion of the waterway. The Brazilian court system actually ordered a suspension of all studies and engineering works by the federal government for the implementation of the Paraguay-Paraná Hidrovia. Brazil will now emphasize smaller, structural improvements. The government of Paraguay, based upon consultation with the U.S. Army Corps of Engineers, is also hesitant to proceed with plans to further dynamite obstructions along the Paraguay River.

Does that mean that the project is history? Other countries in the region still seem determined to carry out dredging and channel straightening along the course of the rivers. Dredging of the Tamengo channel, Bolivia's link to the waterway near the Brazilian city of Corumbá, is continuing day after day. The Argentinian government continues to dredge the stretch of the Paraná River between Buenos Aires and Santa Fé. Recently, the Brazilian Transport Ministry submitted an environmental impact assessment for maintenance dredging in the river stretch between Caceres and Corumbá (G.Switkes, 1998 pers. Comm., International Rivers Network, Cuiabá, Brazil). Transportation interests, agribusiness, mining sectors and construction companies still push for a commercial waterway, which may be implemented in a piecemeal fashion. Dredging and river straightening downstream will still impact the hydrology and ecology of the upstream Pantanal. The whole system is interdependent and separate smaller projects, less subject to comprehensive planning and environmental oversight, may actually produce a worse outcome than a comprehensively planned project. As Odum (1982) pointed out, such cumulative effects of smaller projects can only be avoided if planners, politicians, scientists and engineers adopt a large-scale, holistic perspective, similar to the ecosystem approach recently outlined by Sparks (1995). A perspective that includes a consideration of the cumulative impact of all their little decisions and

bypasses the pressures of short-term rewards obtained by short-sighted solutions. Only then will we not repeat the same blunders made in so many other large river and wetland systems.

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