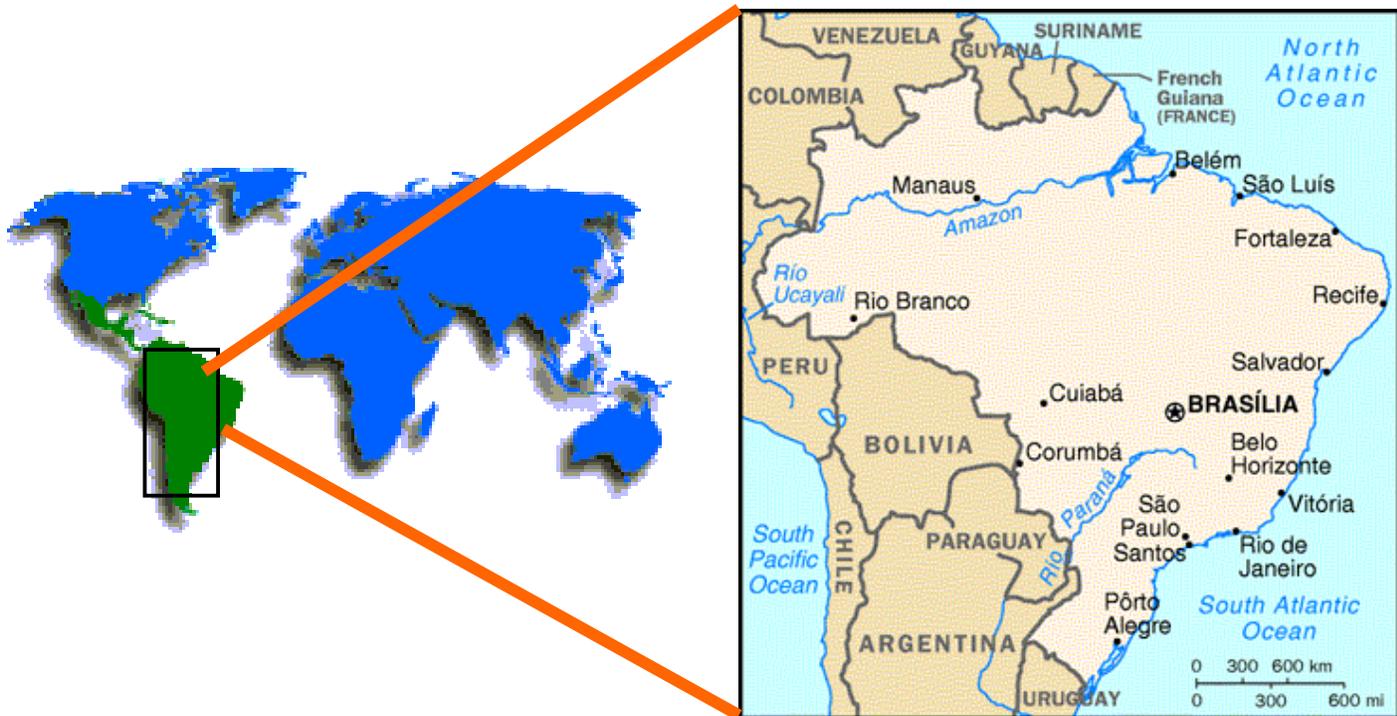


INCENTIVE MEASURES FOR CONSERVATION OF BIODIVERSITY AND SUSTAINABILITY: CASE STUDY OF THE BRAZILIAN PANTANAL



Biodiversity Conservation and Cattle Ranchers in the Brazilian Pantanal.

Overview

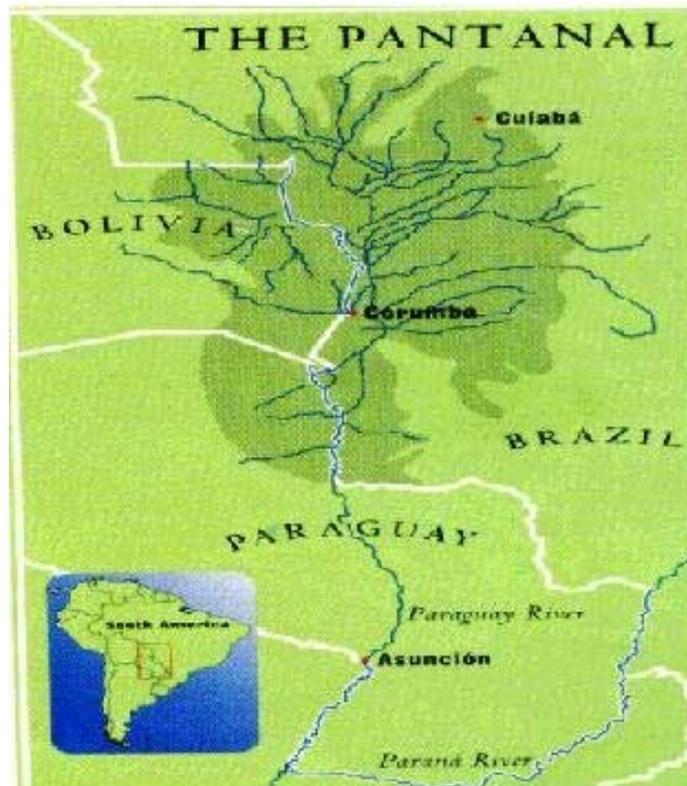
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Biodiversity Conservation and Cattle Ranchers in the Brazilian Pantanal.

By Andrew Seidl*

Overview

At more than 138,000 km² and coursed by a dozen principal rivers the Brazilian Pantanal is known as the largest freshwater wetland in the world. The Pantanal is located within the 362,000 km² Upper Paraguay River Basin (UPRB) in the geographical center of South America and at the headwaters of the Silver Basin. The UPRB lies between 59° and 53° West Longitude and 14° and 22° South Latitude and is bordered by the Amazon River Basin to the North, the Bolivian and Paraguayan Lowlands to the West and Southwest and the Parana River Basin to the East (Figure 1).



The Pantanal is home to at least 650 bird, 260 fish, 80 mammal, 50 reptile, and

identified floral species (Pott 1997) and about 28,000 people (Silva *et al.* 1999). The region's most renowned species include: the jaguar, jaburu stork, blue hyacinth macaw, capybara, anaconda, giant anteater, coati and piranha (Alho *et al.* 1988). It is also an important part of the migratory patterns of many birds. Due to its recognized ecological importance, the Brazilian Constitution (Federal Law 5,197, Article 1) considers the Pantanal a part of the "national heritage," granting high priority to protective management of its natural condition. Although the mandate is not coincident with adequate financial support for its monitoring and enforcement, this law which states legally protects jaguars and other wild species:

Those animals of any species, in any phase of development which live naturally out of captivity are considered wild species, as well as their offspring, and their breeding areas, and are considered property of the state, making their utilization,

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persecution, hunting or apprehension prohibited (translated from the Portuguese) (Marson 1996).

The Brazilian Pantanal is an inland water system containing lands in forest and animal agriculture. A variety of aquatic, seasonally flooded, and terrestrial tropical ecosystems create a floral mosaic across the region (Figure 2).



Figure 2: Brazilian Pantanal in the wet season
Source: Anonymous 1995.

The most important regional ecological phenomenon is the hydrologic cycle which guides, if not dictates, all human and non-human activity. The rate of declination is very slight from east to west (30 to 50 cm/km) and from north to south (3 to 15 cm/km) (Brazil 1979), taking approximately 6 months to pass through the region (Carvalho 1986). Annual precipitation is between 300 mm and 1100 mm and is highly concentrated in the months of November to April (Pott 1994). Seasonal floods begin between September and December in the north and inundate as much as 70% of the Pantanal during 4 to 8 months yearly (Brazil 1979; Paiva 1984). Mean temperatures are from $32^{\circ}\text{C} \pm 3^{\circ}\text{C}$ in the summer to $21^{\circ}\text{C} \pm 6^{\circ}\text{C}$ in the winter (Pott 1994).

The Pantanal's principal economic activities are based upon its rich natural resources and include: fishing, mining, tourism, and cattle ranching. Each of these activities potentially affects the biological health and diversity of the region. In addition, enormous tracts of cropland (primarily soy) and cattle ranches dominate the landscape in the surrounding highlands at the headwaters of the Pantanal's main rivers. Finally, two major infrastructure projects (a transcontinental natural gas pipeline and the Paraguay-Parana Hidrovia dredging project) potentially threaten the region's natural environment.

Extensively managed cattle ranching have been the dominant economic activity in the region for the past two centuries. Understanding the motivations and implications of deforestation fomented by cattle ranchers and crafting policies to reduce that behavior are the central foci underlying the research and outreach efforts reviewed in this case study.

Objective, relevant, science-based information is scarce in the Pantanal. Good policy is based upon good information, which is derived from careful research integrated with the experiential insights available from local people. People are likely to react to the economic incentives they perceive they are facing. As a result, rather than suggesting/implementing specific incentive measures with

incomplete information, this case study takes the revelation of the current melange of incentives facing residents of the Pantanal as its primary thrust.

This portfolio of research and outreach efforts is the primary responsibility of researchers at the Center for Agricultural Research in the Pantanal (CPAP). The Brazilian Organization for Agricultural Research, or EMBRAPA (<http://www.embrapa.br/>), is a 25 year old governmental organization employing more than 2,000 researchers in several dozen research facilities, including CPAP (<http://www.cpap.embrapa.br/>).

CPAP has 35 researchers (27 M.S. and 7 Ph.D.), a base research station and a 4,000 has. experimental farm (Figure 3). CPAP determines its research program based upon national and regional priorities, and the challenges and opportunities revealed in consultation with local political and business leaders, NGOs, cattle ranchers, fishermen, and tourism service providers, among others.

External support of the research efforts contributing to this case study were contracted through organizations including the Inter-American Development Bank (IDB) and the International Institute for Cooperation in Agriculture (IICA). Many of the insights provided in this case study were a result of the experiences and information gained through approximately 2 years of research at CPAP between 1996 and 1999 while financially supported by these organizations.

Research results revealing the current and potential direct incentives facing Pantanal cattle ranchers with regard to the maintenance of the region's biological diversity include:

- a review of the principal correlates with land conversion;
- a discussion of traditional behavioral assumptions regarding economic incentives;
- estimates of the value of Pantanal land in cattle; and
- an appraisal of the feasibility of wood extraction from forested Pantanal lands.

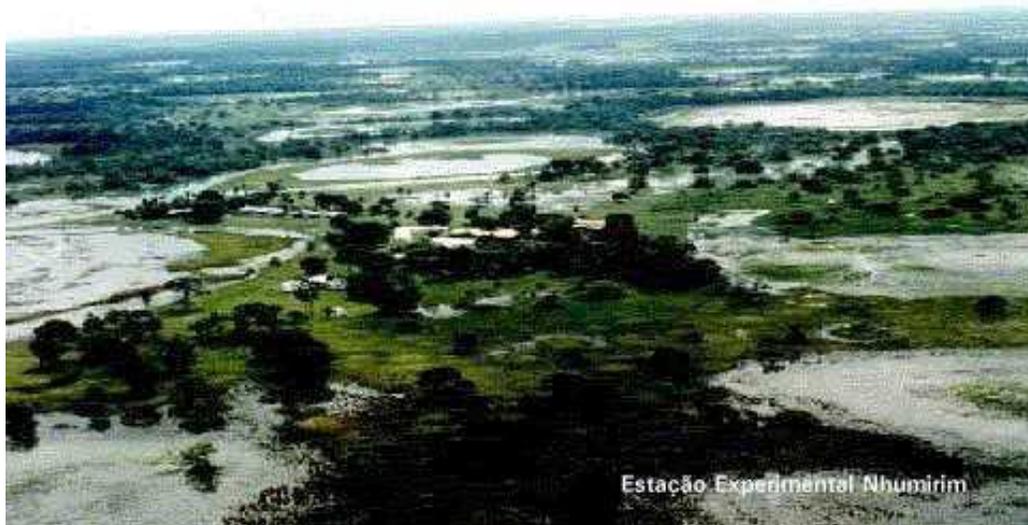


Figure 3: CPAP Experimental Farm Nhumirim, Nhecolandia, MS, Brazil (wet season). Source: <http://www.cpap.embrapa.br>

Reviewed measures of the indirect effects of rancher's stewardship of Pantanal on local, regional, national and international economies and values include:

- an assessment of the potential impact of cattle ranching on regional fisheries;
- an estimate of the global value of ecosystem services derived from the region;
- and a review of local nature-based tourism information.

In brief, we learn that deforestation for implanting pastures is probably not economically justifiable at the individual rancher level and certainly not at greater spatial levels. We also show that wood extraction is not likely to be economically feasible for most landowners. We learn that policy interventions to encourage biological diversity at the local level may focus upon informational barriers, conservation education and maximizing the sustainable, managed harvest of extractive and non-extractive goods and services other than cattle ranching. Finally, we learn that justification exists for integrating environmental policy in the Pantanal from local through, potentially international levels due to the global value of the Pantanal's unique natural environment.

1. Identification of the causes of pressure on biological diversity

A. National policies

Other than the above quoted constitutional consideration, two federal policies may be considered to have particular influence on ecosystem health in the Pantanal; monetary and agricultural land use policy.

Since 1994 the "Plan Real" has been Brazil's national monetary policy. Until early 1999, the policy was intended to counter the reality and psychology of hyperinflation through active support of the new national currency, the Real. This policy can be argued to have positively influenced biological diversity in the Pantanal since it removed the incentive to hold cattle as a hedge against inflation. Absent of this perverse incentive, cattle herd and stocking rates are likely to decrease reflecting cattle production costs and market signals rather than financial markets, and decreasing the pressure on Pantanal lands.

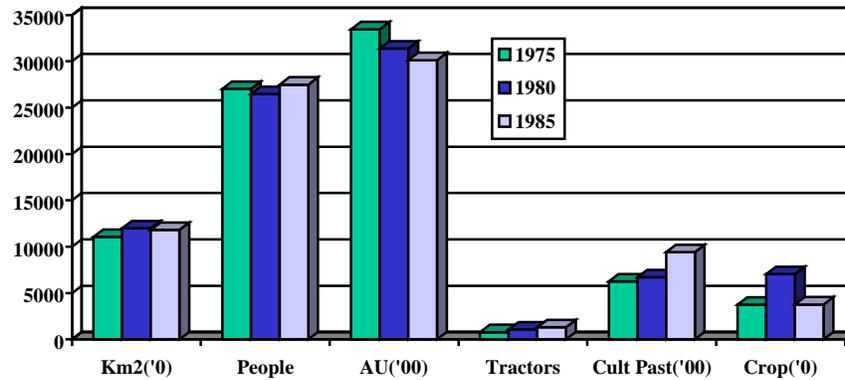
Rural property owners in Brazil are directed to preserve 20% of their lands in their natural state. Owners are provided with tax benefits for this set aside. This policy should create incentives to maintain biological diversity. However, cattle are not banned from using these lands, as pasture, monitoring and enforcement of this statute is nonexistent.

B. Geopolitics

In order to meet biological diversity conservation objectives, wetlands are best managed based upon geophysical delimitations (i.e., watersheds or catchments), rather than geopolitical (governmental) boundaries. The Pantanal and the UPRB are geo-physically-determined eco-regions. Governmental decisions are based upon geopolitical boundaries. Census data is reported geo-politically. Although about 90% of Pantanal lies within Brazil, the UPRB is located within Bolivia and Paraguay, as well as Brazil (Figure 4). Conflicting objectives and incentives for the three countries with regard to the Pantanal complicate and largely reduce management effectiveness. Traffic in drugs, arms, stolen goods, and wildlife is favored by the remoteness of the national regional boundaries.

1997, is formally protected as the Pantanal National Park and an indigenous reserve (Guato tribe, ppn ~400-1000) (Silveira 1999).

Table 1: Trends in Pantanal Rural Lands, 1975-1985, by feature



Note: An AU, or animal unit, is a way in which to compare animals across species and within species categories. For example, 1 cow = 1 AU and 1 calf = 0.25 AU.

The agricultural census compiles information on seven land use categories. Over the period from 1975 to 1985, data indicates an increase in the proportion of land in cultivated pasture and a decrease in the proportion of land in natural pasture. Nevertheless, forested land as a proportion of total land remained fairly constant over the period; the increase in cultivated pasture necessarily implies a decrease in forested land. Partially forested land may have been categorized as natural pasture by the census. Pantanal lands classified as "unusable" are continuously flooded. Their increase indicates the increase in precipitation over the period. Crop and reforested land are very minor proportions of total land use (Figure 5).

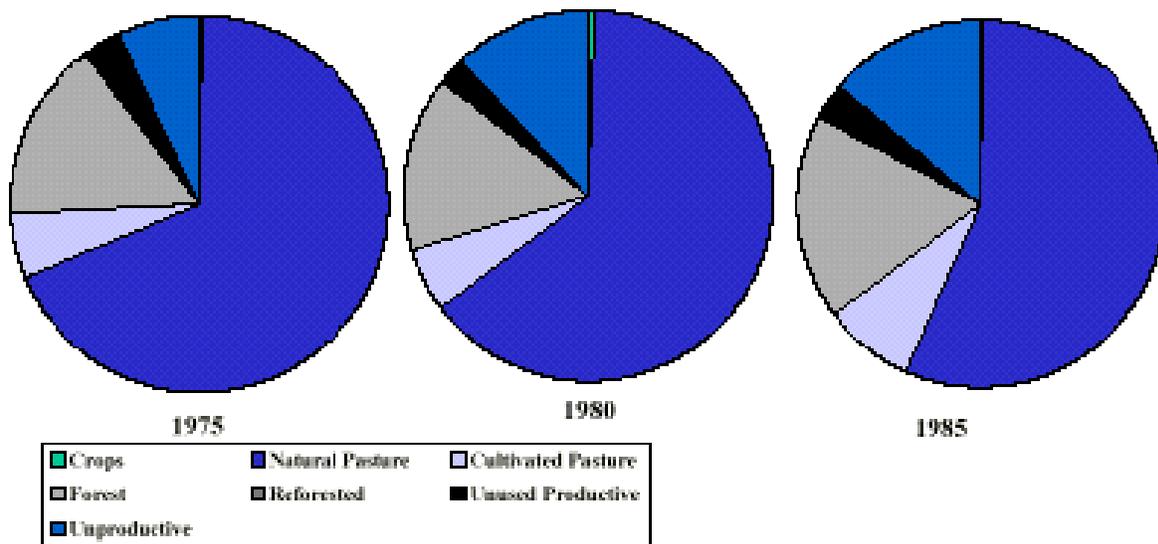
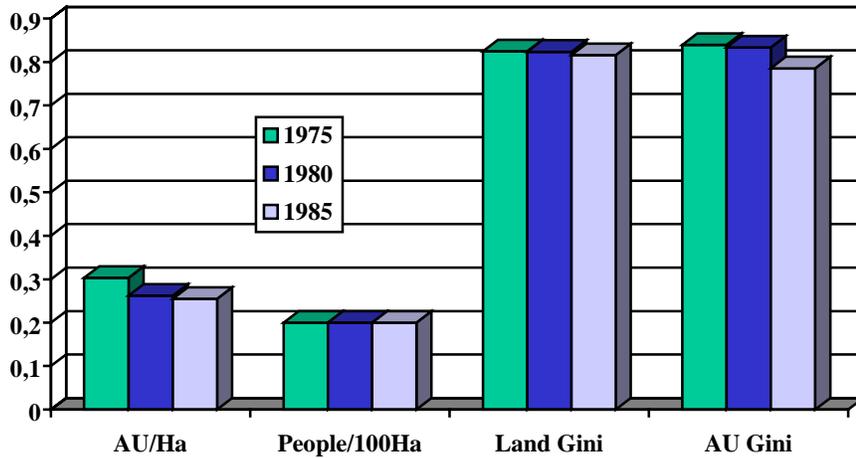


Figure 5: Trends in Pantanal Land Use, 1975-1985, land uses

Table 2 provides indicators of the state and trends in the concentration of wealth in the region. Human population densities remained low and constant over the period, whereas cattle densities diminished. A slight decrease in the number of very large operations and an increase in medium-sized operations were observed. This slight decrease in the concentration of animal and land wealth is illustrated through Gini ratios (Table 2).

Table 2: Trends in Pantanal Land Use, 1975-1985, indices



Note: A Gini ratio measures the degree of concentration of wealth or income. Gini = 1 means all wealth lies in one person's hands and Gini = 0 means equal wealth distribution.

The increase in medium-sized operations is fueled by the trend toward the division of large operations among two or more siblings. These divisions are changing land tenure in the region and causing additional pressure on biological diversity. Traditionally, agricultural holdings in the Pantanal were long and slim, rising from the river through seasonally flooded areas and into higher lands. This structure facilitated the movement of cattle to available forage throughout the year. Traditional ranches are now commonly divided width-wise, creating two more squarish holdings with either lowlands or highlands, but not both. As a result, siblings must either cooperate to maintain ranches that can sustain traditional cattle densities year-round or change their practices, including damming rivers (illegal, but not enforced) and implanting pastures on high ground.

D. Cattle ranching

Extensively managed cattle ranches dominate the Pantanal's landscape. Since the early 1970s, cattle ranchers have cleared land and planted pastures. Ranchers tend to plant pastures on the highest ground available, which also tends to be forested since it is not subject to regular flooding. Clearing the land in order to plant pastures has resulted in more than 500,000 has. of deforested land (13% of woodlands) over the past quarter century (Silva et al. 1998) (Figure 6).



Figure 6: Cattle ranching in the Brazilian Pantanal
Source: Cunha 1997.

Statistical analyses reveal that the number of cattle is positively correlated with the amount of land in cultivated pasture and negatively with forested area; cattle numbers are linked with deforestation rates. Similarly, human population, tractors and property size correlate with cultivated pasture; human immigration, agricultural intensification, and wealth concentration correlate with deforestation rates. In addition, analyses indicate that land in cultivated pasture is a strong substitute for land in alternative uses; all land types may be converted to cultivated pastures (Seidl et al. 1998).

These findings imply interesting policy alternatives. For example, if all lands are of similar value in cultivated pasture, there may be potential to convince (provide incentives to) ranchers to keep both densely and sparsely forested lands in their more native state by encouraging the implantation of pastures on native grasslands. Such an incentive could improve habitat for wild species, increase the likelihood of economic returns from non-cattle activities, and provide incentives for the nurturing of native biological diversity.

E. Agricultural production

Figure 5 shows that crop production plays a minor role in the Pantanal's agricultural economy. However, large-scale crop production, particularly soy, in the surrounding highlands may adversely affect the biological health of the Pantanal through chemical run-off and sedimentation of the region's principal rivers. In addition, soy producers in conjunction with industrial mining operations are the principal supporters of the Paraguay-Parana waterway project discussed in Part 2, Section H. below.

It has been argued that agricultural chemicals from highland agricultural operations are the cause of a common regional fish kill phenomenon, or "dequada." Alternative hypothesized causes include:

the decomposition of terrestrial plants during the flood season, ash from burning pasture lands, animal and human waste and heavy metals used in gold mining (see Part 2, Section H, below). "Dequada" can provoke massive fish kills, on the order of tens of thousands of tons, due to anoxia and high levels of carbon dioxide. Massive kills have been observed in the Cuiaba, Miranda, and Paraguay rivers (Calheiros & Hamilton 1998; Calheiros & Ferreira 1997).

Tentative inferences from recent research indicate that it is unlikely that land clearing practices (for cattle ranching or crop agriculture), mining or agricultural chemicals are affecting fish mortality in the UPRB (Calheiros et al. 1999). However, complementary research is required to understand these influences on fish populations closer to the sources of heavy metals and agro-chemicals, as well as an assessment of their impacts on migratory fish populations in reproduction, hatch rates and larval survival, for example.

F. Tourism and Recreational Fishing

The first tourist agencies opened in Corumba and the first package tours from Sao Paulo arrived in 1977 (UFMS 1997). Brazilians take most tourist visits to the Pantanal for recreational fishing purposes. However, recreational fishermen have indicated that their primary reason for visiting the Pantanal was not to catch fish, but rather to experience an exotic place and to see unique wildlife (Moraes & Seidl 1998). Corumba is a common spot on the "back-packer circuit" for those passing through from Bolivia and Peru (often, Lake Titicaca and Machu Pichu) to Brazilian destinations (typically, Iguazu Falls or the Atlantic Coast). Well-healed American and European tourists are increasingly attracted to the Pantanal for its wildlife. Recent articles in popular magazines (e.g., Audubon, Terra, Veja, New York Times Magazine) and glamorization of the region in two popular television soap operas (i.e., Pantanal and Rei do Gado) have contributed to the increase in tourism demand. John Grisham's popular 1999 novel, entitled the Testament, is likely to have a similar effect (Figure 7).

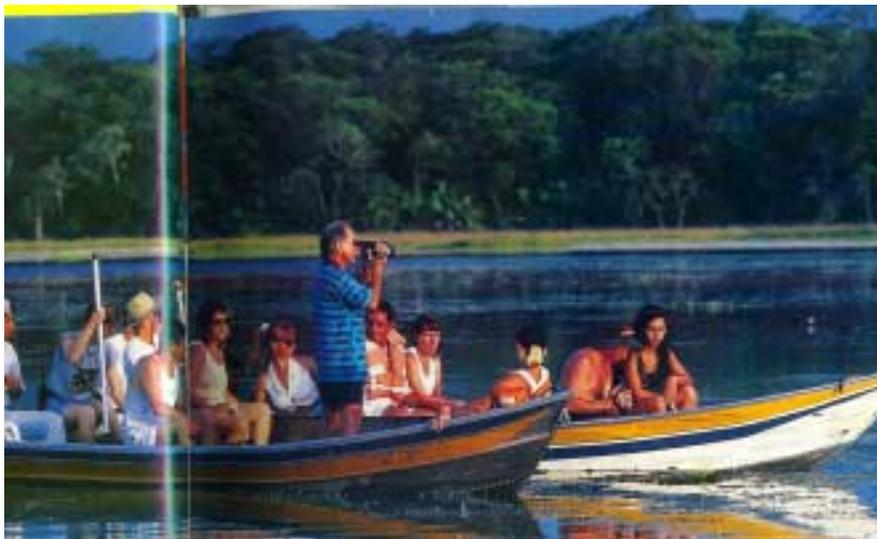


Figure 7: Pantanal Tourists
Source: Nogueira 1997

Tourism development in the Pantanal continues to be a two-edged sword with regard to the natural environment. Local people are increasingly conscious and proud of the value of their rich natural heritage. Local government increasingly invests in infrastructure and training to favor tourism development. However, misplaced trash and waste disposal are an increasing problem. Wildlife products and the pet trade (e.g., snakes, macaws, piranha, and caiman) are fueled by increases in tourism. Extractive ("predatory") fishing by tourists and ill-enforced catch limits are affecting the

success of commercial and artisanry's fisheries. While evidence of overfishing is not yet convincing, the 10 species facing the greatest fishing pressure may soon demonstrate these signs (Catella et al. 1996). As of May 1999 there was some movement among local government officials to restrict or prohibit some types of fishing. Supporters of "catch-and-release" recreational fishing are becoming increasingly vocal. Finally, most recreational fishermen pre-purchase packages in one of Brazil's major cities (Moraes & Seidl 1998). As a result, the majority of the benefits of tourism purchase never reaches local people and doesn't accrue to the local government to pay for environmental education, monitoring and enforcement programs.

G. Mining

Both industrial (manganese, limestone, and iron) and individual (gold) scale mineral extraction exist within the Pantanal and impose environmental damage on the ecosystem. Industrial operations have an impact on air and water quality through discharges, impact viewscapes by employing strip mining techniques, and influence fish stocks through barge transport. Although not found responsible for "dequada," an estimated 60% of the mercury used in regional individual gold mining efforts finds its way into the food chain, principally through fish. Gold mining in the Pantanal is concentrated in the north and is in rapid decline. Unauthorized dredging of the Paraguay River just north of Corumba raised detectable amounts of heavy metals in 1998 (Calheiros 1998).

H. Infrastructure

Little human-made infrastructure exists within the Pantanal. One paved road runs around the Northern, Eastern and Southern edges of the wetland. Seasonally passable sand roads, used mostly for transporting cattle, are the only terrestrial accesses to most of the region. Many rural residents use small planes and boats. Postal service is slow and unreliable. Rural electrification and telephone communications are proceeding at a slow pace. Most ranches use expensive and noisy diesel generators for their electrical needs and a rural radio service for telephone communications.

The lack of local infrastructure has an ambiguous effect on biological diversity conservation objectives. Remoteness and difficult conditions limit the attractiveness of Pantanal living and immigration pressure, leaving much of the region wild and relatively untouched by humans. However, difficulty in communications and logistics limits the effectiveness of research and outreach efforts, encourages staunch individualism, and diminishes the ability of disincentive-based policies to be monitored and enforced.

I. Infrastructure projects

The shortest transcontinental trade route passes from the Atlantic Port of Santos/Sao Paulo, Brazil, through Corumba, to Santa Cruz de la Sierra, Bolivia and onward to the Pacific Ocean. Truck and automobile traffic is arduous at best, as the road is only paved from Sao Paulo to Corumba (arriving 1986), is subject to extended seasonal flooding, and is in a constant state of disrepair. An ill-used rail line and a recently completed (1998-1999) transcontinental natural gas pipeline follow this route. Concern over these infrastructure projects include:

- facilitating travel in the region will increase illicit trade (i.e., drugs, arms, stolen goods, and wildlife) and immigration;
- high speed roadway traffic kills a large number of wildlife seeking refuge on or crossing the roadway;
- infrastructure disrupts important wildlife habitat corridors and wildlife behavior; and
- the possibility exists for a leak, spill or other human induced environmental crisis.

The Paraguay and Parana rivers provide the only ports to the sea for otherwise land-locked Paraguay and Bolivia. River trade made Corumba, the southern gateway to the Pantanal, a city of certain import at the turn of the 19th century, boasting some six consular missions in the bustling port town. Vestiges of its colonial period wealth are still evident in the aging city infrastructure as well as in its current local ethnic diversity. A continued strong naval presence is testament to the

historical strategic importance of the Paraguay River as a national frontier. Proposed river trade development initiatives commonly hearken to the city's "golden years" for popular support.

The Paraguay-Parana Hidrovia project proposes to provide year-round navigation for large barges of soy, cement, minerals and other products some 3,300 km from Caceres, Brazil (see Figure 1) to Nueva Palmeira, Uruguay. The project includes dredging, course changes, and the regulation of water flows (Bucher & Huszar 1995). The most controversial portion of the project involves the stretch of river between Caceres and Corumba; the Pantanal. If approved, the Hidrovia project would have negative impacts on the quality of the Pantanal's natural environment through increases in river traffic and the incentives to plant soy and extract minerals due to lower transportation costs. Likely negative impacts include: increases in siltation, coastal erosion, water pollution, (particularly aquatic) biodiversity loss, decreases in other natural resource based industries (particularly fishing), and induced changes of unplanned development (Bucher & Huszar 1995).

In short, infrastructure projects to facilitate trade may improve the local industrial economy. However, they also create a variety of perverse development incentives counter indicatives to the objective of biological conservation and to sustainable economic development based upon the unique natural resource qualities of the region.

2. Selected Incentives

Our research begins with an understanding of the current and potential direct economic incentives facing Pantanal land owners as opposed to other local people, regional, national or international interests for a number of reasons. Having revealed the incentives facing landowners, local, regional, national and/or international policies might be crafted to adjust the incentives and guide behavior toward biological diversity conservation objectives.

The dominant role of private land management, coupled with the ineffectiveness of regulation-based policy tools due to cronyism and the remoteness of the region, indicates that successful efforts to conserve the Pantanal's unique biological diversity must gain the tacit support of land owners, particularly cattle ranchers. Regulation-based policies will be either highly ineffective or costly to enforce due to these factors. Due to the low human population, it is likely that attempts at enforcement would result in corruption either in the form of extortion by enforcement officials or selective enforcement along familial or political lines. In brief, a "bottom-up" approach and a voluntary incentive-based strategy are likely the most effective manner in which to pursue currently external biological diversity conservation objectives.

Ranchers tend not to consider any economic alternatives to cattle production on Pantanal lands. As a result, ranchers deforest land and implant pastures in order to increase the carrying capacity of the land for cattle without consideration of either alternative economic activities on forested land or, possibly, the economics of cattle ranching itself.

Given the objective of biological diversity conservation, a number of potential avenues of inquiry present themselves. The appropriate choice of approach depends upon the behavioral norms of land owners (i.e., profit maximizing or satisfying) and the factors fueling decision-making, (e.g., information-base, culture, opportunity); what are the incentives, and how do people react to them.

Traditionally, research and extension efforts have concentrated on improving the profitability of Pantanal cattle production. Greater profits from cattle will decrease the pressure on forested lands only if the rancher tries to attain some level of income adequate to maintain his or her lifestyle; satisfying with respect to income. Otherwise, greater cattle profits increase the opportunity cost of land not in pasture and increase the incentive to cut trees and implant pastures. On the other hand, increasing ranch profitability through sustainable alternatives on forested land will unambiguously increase the incentive to nurture land in forests and therefore promote biological diversity. In an innovative way, we determined to first reveal the incentives facing ranchers and then to work with them to improve the profitability of their ranches without addressing cattle profitability *per se*.

Economic valuation by the relevant stakeholders can provide guidelines for the formation of appropriate policies to effectively manage the Pantanal's unique natural resources. At least three categories of stakeholders can be identified: direct, indirect, and diffuse. Direct ones are as those that hold legal claim to the natural resource base in question and are principally responsible for its management. Here, Pantanal landowners are considered direct stakeholders.

Indirect stakeholders stand to benefit or lose directly or indirectly as a result of the management of natural resource base but have no direct authority or claim on it (e.g., fishermen, restaurant and hotel owners, lay citizens). However, they may hold voting rights over policies, which influence the individual volition of direct stakeholders. Here, most non-landowning residents of the UPRB could be classified as indirect stakeholders. To the extent that national policy influences the dispensation of Pantanal resources, other citizens of Brazil may be considered indirect stakeholders.

Diffuse stakeholders are those individuals who currently or potentially value the health of the natural resource base, but have no legal claim whatsoever over its management, and have no potential to derive pecuniary benefits from its state. These exhibit positive non-use values including bequest or existence values for the natural resource base. Individuals who live in northern nations and who may be enticed to contribute to a fund or NGO dedicated to the management of Pantanal lands for biological conservation objectives provide an example of diffuse stakeholders.

We calculate the mean profits (direct use value) of Pantanal land in cattle pasture as \$205/ ha. (Seidl *et al.*, 1998). If the potential direct benefits accruing to individual ranchers from alternative practices on forested lands exceed \$205, it can be expected that educational, production, and/or marketing outreach programming should provide sufficient impetus for guiding behavior toward more environmentally benign practices. Should these private direct benefits be less than \$205, but the indirect benefits to the local community exceed \$205, then an incentive-based policy mix could be crafted between the locality and the land-owner for the difference between net community and private benefits. Analogous policy frameworks could be envisaged for the relationships among different direct, indirect, and diffuse stakeholder groups.

Wherever appropriate, we propose to first take advantage of existing or potential local, regional, national and international markets for sustainable forest products in order to benefit both direct and indirect stakeholders. Sustainable timber operations present an obvious potential. However, we find that wood extraction is economically not feasible for most ranches as well as most wood products due to the slow growth rates of timber species and the relatively high cost and great distances of transportation within the region (Seidl *et al.* 1999a). Increasing the feasible range of wood extraction through improvements in intraregional infrastructure runs counter to biological conservation objectives due to unintended external effects.

Local and regional markets for medicinal and aromatic herbs, palm fruit products, and handicraft uses of forest products tentatively appear more promising. Coustinho *et al.* (1997) list more than 50 spices, 5 herbs, and about one dozen artisanal uses of local forestlands and native pastures currently possessing local and national markets. Both Souza and Guarim (1996) and Goncalves (1996) cite more than 100 plants used for medicinal purposes in the northern Pantanal. Mendelsohn and Balick (1995) estimate the potential value of undiscovered medicines from the tropics from \$3 to \$4 billion to commercial concerns and almost \$150 billion to consumers. The number of local herb vendors has approximately doubled over the past year. Herbal products are important to a number of traditional and hybrid religions experiencing resurgence in popularity in Brazil. Herbal remedies are enjoying a strong increase in demand in the United States as the cost of pharmaceutical drugs (substitutes) has markedly increased. Further, increases in regional tourism should increase the demand for handicraft forest products.

Several wildlife or feral species may have potential to provide additional sources of income to the Pantanal rancher. Caiman (*Caiman crocodilus yacare*), capybara (*Hydrochaeris hydrochaeris*), wild pig (*Sus scrofa*), and rhea (*Rhea americana*) each have local meat and products markets. All,

except for perhaps capybara, have national and international markets. However, regulatory barriers exist. Both the Pantanal's special constitutional designation and, in some cases, CITES (Commission on International Trade in Endangered Species and Wild Flora and Fauna) accords raise barriers to policy alternatives which could provide incentives to biological diversity conservation. A history of poaching damages public opinion in regards to the efficacy of these alternatives (Gowdy 1997). Challenges parallel the debate over the active management of African elephant herds through hunting and certified ivory trade.

Non-extractive uses of natural lands also show potential for ranch level profit-generation. Rural, archeological (Peixoto & Boeira 1996) or ecological tourism (Bordest et al. 1996; Coutinho et al. 1996; Gowdy 1997; Geist 1994) may provide economic incentives to conserve forested habitat and biological diversity in the region. Geist (1994) estimates that the total economic benefit from the protection of wildlife in all U.S. national parks is more than \$70 billion. Power (1991), finds that recreation, rather than mining, timber or ranching, is the greatest generator of income and jobs in the Greater Yellowstone area of the United States. Costanza et al. (1997) estimates that recreation contributes \$574/ha-yr in value to the earth's wetlands and \$491/ha-yr to swamps and flood plains. Although comparable local research information is not available, Pantanal ranchers, tour operators, and communities are not yet garnering anywhere near this level of returns.

Finally, perhaps in a tangential manner at this juncture, if the benefits from biologically sustainable alternatives directly accruing to Pantanal landowners remain insufficient to entice the desired alteration in rancher behavior, other incentive-based policy alternatives may be justified. Potential community, regional, and national initiatives aside, using Costanza et al.'s (1997) estimates of the global value of ecosystem services gleaned from the region, Pantanal lands contribute approximately \$6,000-\$10,000/ha to the common welfare of the planet (Seidl et al. 1999b). Therefore, it is potentially justifiable to create a global fund to purchase the right to alter the natural disposition of Pantanal lands from ranchers. Not unlike a Purchase of Development Rights (PDR) program, such a fund would compensate ranchers to adhere to global objectives while leaving them with the other rights of land ownership including the ability to manage their ranch extensively.

In brief, locally or regionally initiated education, production, and marketing programming designed to augment the private direct incentives of Pantanal land owners to voluntarily comply with practices to maintain biological diversity on their lands, are suggested. The programs rely on revealing and developing individual economic incentives, are bottom-up and locally driven in approach and are voluntary in nature. The incentives employed by this project are largely social service-oriented. Technical assistance, public education, outreach, and applied research are at its center. Indirect incentives such as eco-labeling and market creation are anticipated recommended outcomes of a number of our research efforts.

It is suggested that economic incentives may develop in existing or potential markets sufficient to provoke direct stakeholder behavior in line with the biological conservation objectives of indirect and diffuse ones. In addition, the potential for a national or international fund to provide financial incentives by diffuse to direct stakeholders to voluntarily comply with these practices is forwarded, but not explored further at this time. This approach is suggested because these are practical, feasible programming alternatives that have some likelihood of success in view of local conditions.

3. Requirements for incentive program implementation

Our approach is based in locally driven community economic development programming methodologies. This approach requires active participation and integration of the efforts of various stakeholder groups potentially including: land owners, elected officials, agency researchers, local entrepreneurs, educators, and lay citizens. Landowners likely have the most to gain or to lose from the Pantanal's biological diversity. Generally speaking, the larger the property, the greater the stake in benefits or losses. If tourism is a likely beneficiary of biological conservation, then potential retail and service industry workers would benefit, but not likely on the same scale as the land owners and primary service providers. Cooperation of local elected officials, powerful land owners and other

local leaders is required to direct existing incentives toward biological conservation objectives and validate efforts in their nascent stages.

The implementation and dissemination of objective, science-based research is required to trace the biological and economic implications of economic development alternatives available to Pantanal communities and to describe the efficacy of various public financing options available for local investment in incentive plans. Education by researchers of local leaders is required to communicate the economic potential of alternative environmentally sound management practices. Public hearings are required for various stakeholder groups to come to consensus on the objectives of the community with regard to social and economic development and environmental quality. Skills in public issue education, facilitation and moderation are required to reveal the challenges and opportunities available to the community groups and to generate an acceptable strategic and comprehensive plan.

The potential avenues available to explore the direct value of the Pantanal's biological diversity to landowners will all require financial and temporal investment and some amount of change. Assuming that products and markets supporting biological diversity can be found or developed in an economically viable manner, a more diversified portfolio of economic practices should yield lower variation in mean incomes; financial risk should decrease through diversification. However, it may not yield the maximum total profits over time. Market and product researches are required to estimate potential income streams and preferred alternatives given the potentially diverse risk tolerances of the directly effected individuals. Research is currently underway to estimate the market of a number of currently or potentially locally marketed forest products found in several different common land types to local ranchers. Local markets are a logical starting point, but regional national and international markets will be required to generate sufficient demand for most biodiversity supporting activities.

Determining and cultivating the direct benefits of biological diversity conservation to non-land owners adds another level of complexity and opportunity. Should the direct benefits to the municipalities (e.g., restaurant and bar, hotels, retail) from tourism, for example, exceed the sum of the direct benefits to Pantanal land owners, there may be an opportunity for a municipal policy of subsidizing biodiversity friendly practices on the ranches. Public finance issues in the communities of the Pantanal are anything but trivial. Allocating public funds to tourism services is likely to leave other services waiting. Moreover, any additional revenues collected by the government are potential targets for corruption and cronyism. Generating additional public funds through a local bed tax or a toll on the only road connecting the towns would shift the burden away from local people. The same logic holds for direct and indirect benefits at regional, national, and international level. However, the research, education, implementation, monitoring and enforcement issues become in a commensurate way more challenging as the scale increases.

4. Process of implementation

The role of scientific research in community development is to provide objective, science-based information of the implications of potential alternatives. Scientists can then facilitate the process of community decision-making by helping communities to define their objectives, assets, alternatives and challenges and to create a plan to link their current situation with future objectives. It is not to provide an "answer" or make blanket recommendations. The philosophical basis is strongly democratic; the community of stakeholders must choose for itself the path it will follow. As stated earlier, good information is the basis of good policy and good decision-making.

Two parallel and interdependent processes are at work: 1) research and 2) community planning and decision-making. The research agenda should anticipate community needs, but also address unanticipated questions raised through interaction with community members. Researchers should regularly and publicly present their research plans and results and develop innovative educational materials to enhance their communication abilities. The public should indicate their priority information needs and dedicate themselves to learn the information available to them.

Communities in the Pantanal do not practice strategic and comprehensive planning. The culture of independence among landowners, the difficult logistics of the region and the need for the coordination of multiple jurisdictions to capture management priorities on a watershed basis complicate planning. The community development and strategic planning process has been out of the realm of professional expertise and personal comfort zone of CPAP researchers. All permanent CPAP researchers are biological or physical scientists. Only a few CPAP researchers actually hail from the region. Although several have lived in the Pantanal for decades, they are generally considered and consider themselves outsiders.

To date, CPAP scientists have devoted themselves to the research side of the equation. Research efforts have concentrated upon providing the relevant science-based information in anticipation of community needs and in consultation with key groups of community members (e.g., local university educators, elected officials, NGOs, and individual producers). Stakeholder participation has included data collection and provision, voluntary participation in experimental farm plots, close individual consultation with informants, and public meetings with ranchers, researchers, and public officials.

Innovative educational tools including computer simulations and interactive maps of research results are in development. These tools would allow researchers to work with individual ranchers to reveal the current and potential profits from their lands using a visual financial and geographic interface. This information would then be used in educational (e.g. capacity building, job training) programs targeted to ranchers and others. Programs would attempt to develop public-private partnerships to encourage environmentally friendly ranching practices and to develop diverse economic alternatives to promote the conservation of biological diversity and the standard of living of *pantaneiros* simultaneously. Completion of these computerized decision support systems (DSS) is anticipated in 2002.

5. Effects of the measures employed

Potential local measures at least partially attributable to the effectiveness of these applied researches and outreach efforts include:

- increases in the number of ranchers keeping records;
- increases in the number of ranchers attending meetings and volunteering to participate in applied research and data collection efforts;
- decreases in the amount of deforestation for cultivated pastures;
- decreases in the local illicit wildlife trade;
- increases public dialogue on natural resource management issues;
- increases in demands for information from the research center.

At least in part due to the urging of CPAP researchers, the state government of Mato Grosso do Sul and the municipal government of Corumba have taken steps to clean up the cities in areas commonly frequented by tourists and to provide improved tourist services. They have also stepped up efforts to control fish catch limits and to patrol for poachers. Greater numbers of ranchers have requested participation in EMBRAPA research activities and the quality of data collected from ranchers is improving. Research efforts have been featured in the local newspapers and regional and national newspapers have interviewed CPAP researchers and magazines regarding research efforts and the types of changes the research recommends. Arguably, a portion of the credit for these positive changes should accrue to these research and outreach efforts. In addition, potential national or international measures of the effectiveness of these efforts may be partially measured through publications in refereed journals, increases in research interest, increases in research funding, increases in notoriety of the research center.

Formal biological diversity preservation efforts in the Pantanal are still in their initial stages. Hopefully, the national and local economies are in transition from unstable to more stables, providing improved general welfare. A stable Brazilian economy would provide greater certainty of a prosperous future and greater incentives for investment in private or local economic development efforts. These changes influence the incentives facing cattle ranchers and, potentially, their decisions about deforestation. They may tend to obscure the impact of our efforts in either a positive or a negative manner. The current impacts of our efforts are both difficult to measure and likely to be smaller than they will be in the future.

6. Lessons learned

Information provision and the role of risk and uncertainty are essential to these research efforts. When traditional practices and values maintain institutional memory of up to two centuries, the evidence in favor of change has to be overwhelming. Cattle ranching may not be making a lot of *pantaneiros* rich anymore, but to consider land as anything but pasture for cattle are highly unusual. To educate either strict disciplinary researchers or rural people anywhere, not only a remote and unique area like the Pantanal, to view land as a multiple attribute good potentially contributing to household welfare through a diversified portfolio of products and practices, is a long and arduous road rife with incomplete information, uncertainty, mistrust, and risk.

The multi-agency, -disciplinary, and -national collaborative effort to understand and guide natural resource management in the Pantanal has benefited from a number of lessons from which others might benefit including:

- the lack of land/resource use and management data/information in the region is a primary constraint to exploring policy alternatives;
- the importance of stakeholder involvement/knowledge in crafting policy solutions;
- the importance of embracing traditional institutional and personal arrangements in crafting new policies;
- the importance of including the locally influential individuals and the community at large in the business of the research center, particularly where action on their part is anticipated or required;
- the attractiveness of incentive-based, private and voluntary programs in an environment lacking adequate institutions and traditions for the monitoring and enforcement of disincentive-based policies;
- the appropriateness of beginning with direct stakeholder incentives to initiate regional planning and policy; and
- the inability to functionally and financially separate social, economic and natural resource policy decisions.

The difficulties facing researchers and local people in collecting the necessary information and crafting appropriate and workable solutions stand as an example that others may face in this

pursuit, particularly in developing nations or regions. These lessons are transferable to many situations characterized by ineffectual or corrupt governance, remote locations, weak infrastructural development, and incomplete information.

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