Papers

Working towards community-based ecosystem management of the Lower Amazon floodplain[1]

David G. McGrath[2,3], Oriana Trindade Almeida[3], Marcelo Crossa[3], Alcilene Cardoso[3] and Márcio Cunha[3]

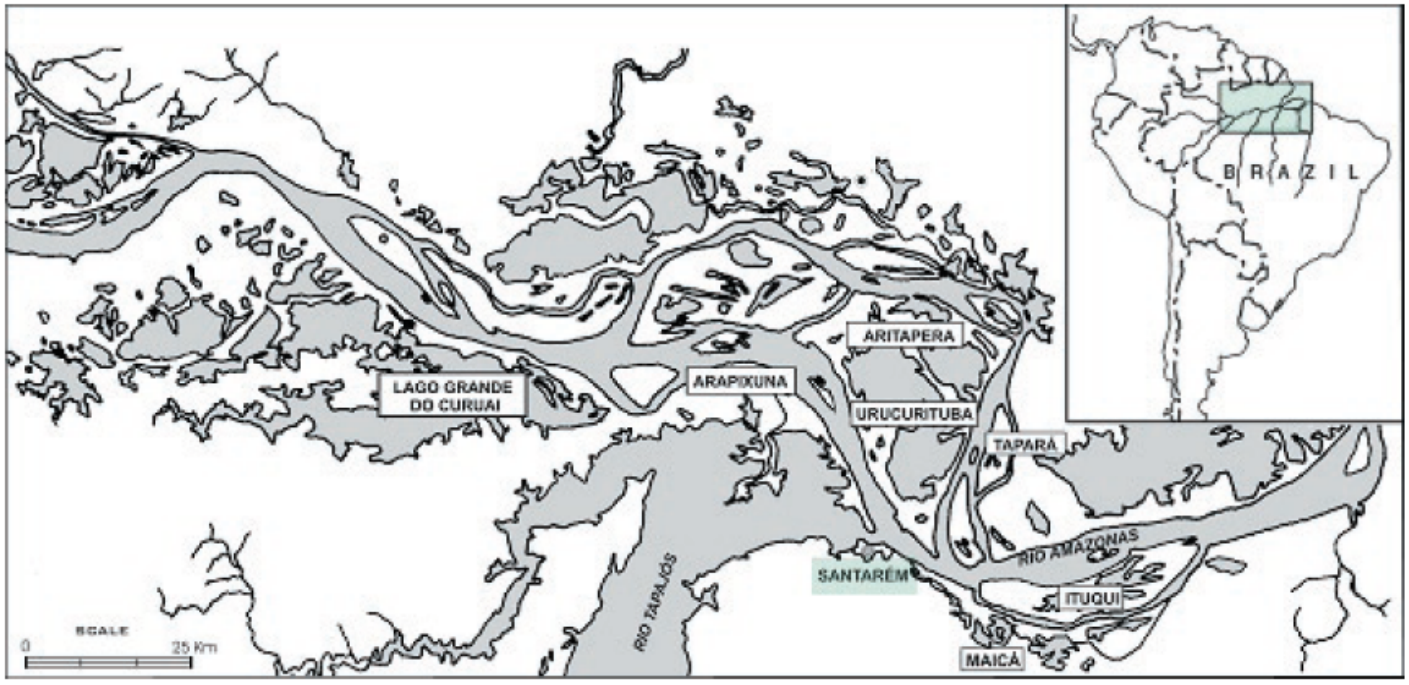
Introduction

During the first phase of PLEC the emphasis was on documenting smallholder use of agrodiversity and developing production and management systems based on the practices and cultigens employed by smallholders.
In the second phase the focus has expanded from the farm level to that of the community or region, from the practices and species farmers employ, to the ways in which they individually and collectively manage the regional ecosystem. This approach analyzes farmer management systems within the context of the local/regional ecosystem, to understand how smallholder land use interacts with ecological processes. While agrodiversity tends to focus on production systems, an ecosystem-based approach integrates productive and extractive activities to understand how farmers are consciously and unconsciously modifying the local landscape. As in the study of agrodiversity, the aim is to develop management systems, based on smallholder practices, which optimize local resource production while maintaining the integrity of local ecological processes.

Over the last ten years the Várzea Project of IPAM (Instituto de Pesquisa Ambiental da Amazonia) has been working with floodplain communities, the federal environmental agency IBAMA-Provárzea (Brazilian Institute of Environment and Renewable Resources), the Santarém Fishers Union and other regional organizations to develop an ecosystem based approach to floodplain management that builds on community initiatives in managing local resources (Figure 1) (Almeida and McGrath 1999). The Project focuses on the following elements of an ecosystem management approach:

- research and extension to understand existing patterns of resource use,
- work with smallholders to increase both the sustainability and the economic returns derived from these activities,
- capacity-building activities to strengthen local and regional management organizations,
- educational programs for floodplain school curricula through which teachers and students explore the várzea environment and its use by the community, and
- policy initiatives to develop the legal basis for

Fig. 1. Santarém region, Lower Amazon floodplain, showing location of the Regional Fisheries Councils



1. The work described here has been financed by WWF, PLEC/UNU, DFID, HSBC and European Community Tropical Forest Program.
2. NAEA, Federal University of Pará (dmcgrath@amazon.com.br), Woods Hole Research Center.
3. Instituto de Pesquisa Ambiental da Amazônia (IPAM).

community-based management of floodplain resources. Now after more than ten years work with communities, we have developed an approach that brings together these diverse elements of the Várzea Program. In this paper we describe the main elements of this management approach.

Ecology of the floodplain and smallholder resource management

The Amazon floodplain or várzea varies considerably over its extent so that any description of the landscape must of necessity be restricted to a particular segment of the river. In the Lower Amazon the predominant features are the presence of large shallow lakes, ranging in size from a few hundred square metres to hundreds of square kilometres, and a vegetation cover that is 90% natural grasslands and 10% forest. From the perspective of smallholder resource management, we can distinguish four main landscape elements: the major river channels, forested natural levees bordering channels, permanent floodplain lakes that occupy much of the floodplain interior, and seasonally inundated grasslands that occupy the transitional zone between levees and lakes. The lakes are actually networks of lakes, varying in size and frequency of annual permanence (Figure 2). The resulting lake systems can cover large areas and have considerable spatial variability in environmental characteristics and resource abundance.

Land tenure typically reflects patterns of resource use. Private property is generally recognized and properties are measured in terms of metres of frontage along the river and extend inland to lakes or canals. This system guarantees each household access to the four main ecological zones. While private properties are recognized, there is a gradient from private to collective property and use inland from the levees to interior lakes. Levees, where virtually all household investments are concentrated, are clearly demarcated. Grasslands, while nominally private property, tend to be treated as commons on which all land owners may graze their cattle. Lakes inland are regarded as the common property of those who own the land around them.

There is a strong seasonal dimension to life on the floodplain resulting from the interaction between flood and precipitation. In the Lower Amazon the river rises gradually from December to June and then falls rapidly from July to early November. The rise and fall of the river coincides with local rainfall patterns, resulting in two seasons: a dry season of falling and low water levels extending from July/August through November/December and a rainy season of rising and high water levels from December/January to May/June. The period of most intense drought occurs in the middle of the low water season, effectively cutting the growing season into two periods, before and after. In terms of planting risk, the key issue is the interaction between when land becomes available for planting, the timing of the October dry season, and when it is inundated again. The height of the levee, vulnerability to drought and frequency and timing of flooding are key factors in developing management systems.

The essential dynamic of the floodplain ecosystem is captured in the flood pulse concept (Junk et al. 1989). Floodplain species have developed feeding and reproductive strategies that take advantage of this seasonal alternation between terrestrial and aquatic phases. Many tree species fruit during the flood season and aquatic macrophyte communities expand over the lake surface as floodwaters rise. Many fish species spawn at this time so larvae can be swept into lakes, which serve as nursery habitats for juveniles. Fish and other vertebrates follow the expanding edge of the water into forests to feed on fruits and nuts. During the low water season deposited sediments fertilize tree growth and turtles and many bird species nest on emerging sandbars, with eggs hatching as floodwaters begin to rise again.

Smallholder management strategies take advantage of the spatial and temporal variation in resource availability (WinklerPrins and McGrath 2000). Most agricultural activities take place on the higher levees bordering the river channel during the low water period. Farmers begin preparing the land in July or August, as soon as it is dry enough to work, and harvest the first crop in October. They may plant a second crop when the rains begin in December to harvest in February before the floodwaters reach the levee. Grasslands inland are used for grazing cattle during the low water season. As floodwaters cover

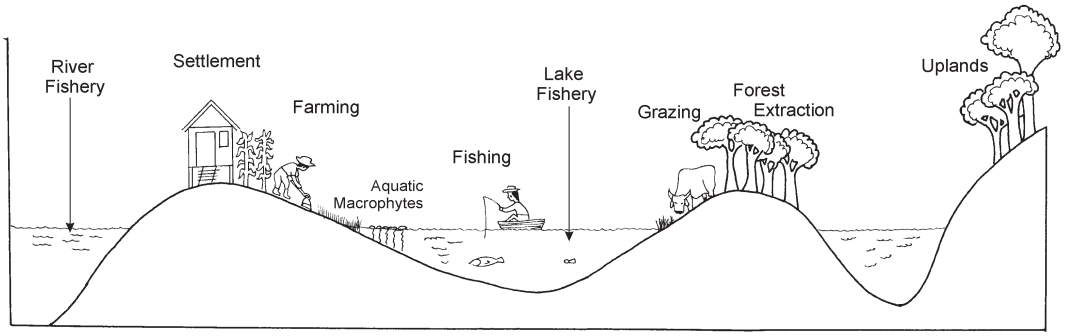


Fig. 2. Environments and land use on the Lower Amazon floodplain

the grasslands in March/April, cattle are either moved to raised platforms on the levee or taken to upland pastures until waters start to recede in July/August. Most fishing takes place in floodplain lakes. River fisheries are most important as the river level falls and schools of fish leave the floodplain and migrate upstream. At low water, fish that remain on the floodplain become concentrated in ever smaller bodies of water facilitating capture.

While the spatial and temporal distribution of economic activities potentially facilitates complementarity, in practice activities often conflict due mainly to unnecessarily destructive exploitation of resources and habitats (Goulding et al 1996). Agricultural fields are usually located in higher areas whose natural vegetation is forest. In the recent past, the expansion of jute farming led to the destruction of floodplain forests in the Lower Amazon and while the intensity of farming has declined, recovery of forests has been limited (Sheikh et al. in press). Extensive ranching is leading to the overgrazing of grasslands and contributing to the degradation of levee forests as cattle trample and browse seedlings and smaller trees (Sheikh 2002). The practice of burning grasslands also contributes to the degradation of forests and grasslands. Cattle and water buffalo occasionally invade fields causing considerable crop damage. These impacts on habitat quality reduce the productive capacity of lake fisheries, compounding the effects of increasing fishing pressure.

While there is a general recognition of the interdependence between the state of lake fisheries and the grasslands and forests, most communities lack institutional mechanisms to protect long-term individual or collective interests in the face of short-term individual gain. Thus people tend to invest in activities where the return to individual investment is most secure (Merry et al. in press). For example, while there is general agreement that lake fisheries are more productive on a per hectare basis than extensive cattle ranching, families will invest in cattle because they own the cow, while the fish belong to whoever catches them first. The result is the paradoxical situation in which the productive potential of the floodplain is both over exploited and underutilized.

Strategy for community-based management

Over the last decade we have worked to develop a more holistic approach to the management of floodplain resources that builds on the interdependence between habitats and resources, the smallholder household economy, and collective interests in the ecological productivity of the system. The basic management unit is the floodplain lake system, which integrates all the major habitats within a given region. It provides a framework for management that makes it possible to evaluate the costs and benefits of different resource management strategies in relation to the productivity and sustainability of the system as a whole. Lake fisheries are a central and also vulnerable element of the system, for the health of lake fisheries depends not just on the direct action of fishers, but also on the effects on habitat of other activities.

Management is based on a global approach that seeks to minimize negative interactions between different resource use activities and promote complementarities to optimize overall production rather than maximize exploitation of one or the other resource. Smallholders tend to employ diversified strategies involving fishing, farming and small and large animal husbandry. Within the household economy, a productive fishery provides a strategic subsidy, contributing animal protein for subsistence, and income for daily purchases, while any surplus can be invested in other productive activities (McGrath et al 1999). Artisanal fishers, unlike professional commercial fishers, tend to make limited demands on the fishery, because once basic needs are met, they devote their time to farming, animal husbandry and other household activities. A high productivity fishery strengthens the viability of smallholder management systems because it enables fishers to minimize the time needed to meet basic needs and dedicate more time to other productive activities.

From an ecological perspective the objective is to maintain the overall health and productivity of the floodplain lake ecosystem. The management strategy is based on the flood pulse and seeks to maintain or strengthen ecological interaction between terrestrial and aquatic habitats and species during the seasonal rise and fall of the river, by maintaining natural flood regimes and conserving forest and grassland vegetation. To reverse habitat degradation a major emphasis is placed on restoring floodplain habitats where appropriate.

Another aspect of community-based management systems is that management activities occur at different spatial scales—individual property, community, and regional lake system—so that each scale is best suited for dealing with specific activities of the overall management system. Most agricultural activity is practiced within individual properties. Cattle ranching takes place at the community level. While fishing may be restricted to lakes close to the community, the local fishery depends on the whole lake system, which is often shared with several communities. These spatial scales are associated with different kinds of property rights that belong to different though usually overlapping groups of stakeholders. Furthermore, the scales are interdependent, for example, decisions made at the level of the individual property (agriculture and forestry) or community territory (grasslands and local lakes) can have implications for the ecological health and productivity of the lake system as a whole.

The basis of floodplain ecosystem management is the organizational capacity to manage local resources and reconcile individual and collective interests in their use. The adaptive management approach, in which the user group develops and implements the management system, adjusting procedures along the way as needed, provides an effective methodological framework for building local organizational capacity. An important element of this approach is the continuous generation and evaluation of information on the performance of the system, providing both feedback to users on the results of management

practices, and also demonstrating to the group that their actions have a measurable effect. This is especially important for managing fisheries because the benefits are often diffuse (marginally more productive fishing effort in the context of great seasonal and inter-annual variation in fishing productivity), while the costs of individual effort expended in meetings and patrols or restoring vegetation, are very concrete and quite constant.

Project activities for ecosystem management

The overall Project strategy described here is a product of more than ten years of work in the region and reflects the history of trial and error learning, captured and missed opportunities, and human and institutional strengths and frailties. Here we describe the main activities undertaken in developing the management intervention strategy for the four spatial scales of project activities, individual property, community territory, lake system, and the regional co-management system.

Management transition

In most extension projects, technical innovations lead to short term gains in production. In contrast, the implementation of a fisheries management regime often results in at least a temporary reduction in total income for most fishers, while total labour expenditures may increase (Figure 3). In many cases this reduction is achieved by banning gillnets, which are the most productive gear, and permitting only cast nets, harpoons and different kinds of hook and line gear. The result can be a large reduction in either income, or a comparable increase in fishing effort or some other activity to maintain previous total income.

Because of the lower productivity of farming, fishers may expend even more effort to achieve their original household income if they choose to compensate for lost income by increasing labour in farming. As the fishery recovers, productivity will increase, eventually achieving the expected levels of the managed lake system, so that overall productivity, combining both fishing and farming, is higher than in the original case where fishing provides all household income. However, achieving a more productive fishery depends on the degree of community compliance with the new management regulations. This is the risk that households must face: will their sacrifice be compensated by a more productive fishery in the future or will free-riders simply take advantage of the situation to reap windfall benefits, condemning the management effort to failure?

To be effective, a strategy for implementing a new management regime must go beyond a concern with the fishery *per se* to consider the other main dimensions of a fully functioning management system. This includes implementing appropriate resource use rules, diversifying productive alternatives, modifying farming and ranching practices to reduce destructive impacts on habitats and resources, and restoring forests and grasslands to enhance recuperation of the productive capacity of the floodplain. All of this depends on strengthening the organizational capacity of the user group to develop, implement and enforce the management regime, so members have confidence that rules will be enforced and free-riding controlled. This depends in turn on the regional/national policy and institutional context in which the management system develops and the quality of the support this legal-institutional context provides for community-based resource management.

Individual property level management

The island lake system is subdivided into individual properties all of which cut across the main ecological zones of the floodplain. The main habitat affected by unilateral family land-use decisions is the forested natural levee. The relative extent of forest and farmland depends on total planted area and cropping frequency. The planted area includes house gardens, annual and perennial crops, and pasture with native or planted grasses. Forest extraction is largely limited to fuelwood gathering.

Annual and perennial crop production

With some important local exceptions, agricultural production in the region is low and only a small fraction of the available levee is currently being exploited for cultivation. Much is cleared land used as pasture or secondary forest. A major objective of the project is to diversify household income by increasing agricultural income. Here two concerns are to reduce risk of crop loss from drought and increase flood season agricultural income. Over the course of the project we have tested four main production systems: traditional annual crops (corn, beans, watermelon and squash), irrigated vegetables (tomatoes, green peppers and cabbage), perennials (bananas and assorted fruit trees) and raised planting boxes to produce flood-season vegetables (tomatoes).

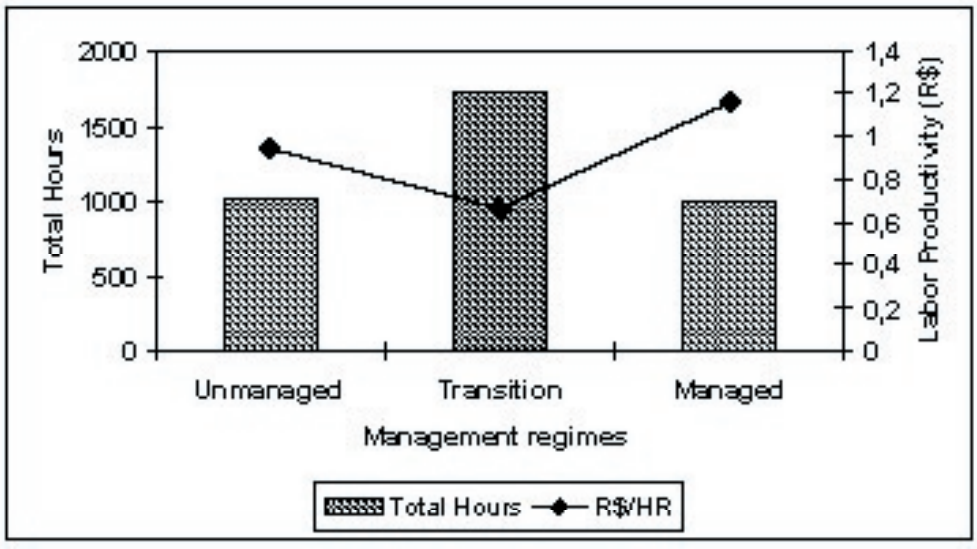


Fig. 3 Effect of fishery management on hours worked and labour productivity

Community farming activities are organized in associations and community seed funds, with overlap in membership around 100%. The seed funds are a potentially effective mechanism for accumulating capital for investment in farming activities. However, the tendency of the groups is to cut the repayment increment above the sum borrowed so low as to preclude any significant growth of the fund. This limits its potential as a mechanism for generating funds for larger capital expenditures.

Initial efforts revolved around roças experimentais where a group of farmers in collaboration with the project extensionists, tested different crop varieties and planting treatments, later using those that seemed most promising. We tested traditional annual crops and irrigated vegetables. Experiments, following a local method of producing vegetables with pump irrigation, were intended to permit farmers to cultivate crops through the dry season. Farmers eventually abandoned this approach. Two problems they cited were lack of sufficient land for adequate rotations resulting in weed and pest infestations and difficulties in marketing.

Work with traditional annual crops has proved more successful. In the five communities, annual crop production has grown despite some problems with pests. Perennial crops are an alternative especially for higher levees where the frequency and duration of flooding are lower. Though involving a smaller numbers of farmers, perennials, especially bananas, has been promising fairly high returns. We plan to expand the number of farmers and to include other fruit tree species, such as papaya and soursop, that do well and are sought after by local frozen pulp processors.

Producing flood season vegetables in raised planting boxes, was tested in two communities over the past year and proved quite successful, providing a significant income source for these families during a period when income from other sources is limited. In years when even the highest levees are inundated, this system could be a critical source of income.

Forest management:

In 1998 a farmer in Aracampina planted 100 pau mulato (*Calycophyllum spruceanum*) seedlings in a small area behind his house. Initial results indicate that growth rates are comparable to those observed by Pinedo and colleagues on the tidal várzea of Amapá. We are now talking with other residents of Aracampina interested in forming a group to plant a large enough area of pau mulatto and other species to sustain a community sawmill, similar to those studied by PLEC in Amapá (Pinedo Vasquez and Rabelo 2002).

Community level management

Community level initiatives involve management of lake fisheries, collective agreements for managing cattle on community grasslands and restoration of floodplain habitat.

Managing lake fisheries

Here we have concentrated on developing management systems for one species, the pirarucu, a large (up to 2.5 m) species of great commercial and cultural value whose sedentary behavior makes it well suited for management in floodplain lakes. The management of this charismatic species serves as a vehicle for developing lake management systems that eventually incorporate other species.

The project began as a participatory research project on the ecology and management of pirarucu involving researchers and local pirarucu fishers. An important initial objective is to overcome the problem identified earlier regarding smallholders' perception of the relative security of managing cattle and fish. Through the use of simple field-based population monitoring techniques, fishers can develop a concrete understanding of the dynamics of their local pirarucu populations comparable to their understanding of that of community cattle herds. Two characteristics of the pirarucu facilitate this association. They surface to gulp air at regular intervals and they form couples that care for their young during six months of the year.

The evolving monitoring system has three main components. Teams of fishers have been trained in a participatory census methodology based on wildlife census techniques so they can estimate reliably the number of adult and juvenile pirarucus in a given lake (Castello 2004). Second, they monitor breeding couples to obtain an estimate of the reproductive potential of the lake. Third, records are kept of all pirarucu caught in the lake including size (weight), date, location and gear used. Based on the information generated, communities develop management plans.

The number of fish in managed lakes has increased steadily over the last three years. One interesting observation from monitoring reproductive behavior is that lakes with little or no surface vegetation do not have breeding couples, evidence of the positive linkages between habitat quality and lake productive potential. The association recently completed an evaluation of the status of pirarucu populations in all the floodplain lake systems of the municipality and identified promising communities for expanding the pirarucu management project. Teams of fishers are also visiting communities in the Peruvian Amazon and other parts of the Brazilian Amazon to teach monitoring techniques and assist local fishers in developing lake management systems.

One means of fostering collective interest in a community fishery, is to organize collective fishing trips where the proceeds are invested in benefit of the community. Participants catch a predetermined number of pirarucu, sell the catch and invest the funds in community projects. Any surplus can be divided among the families that have participated in management activities over the course of the year. To promote management and organize marketing,

an association of pirarucu fishers was formed with 78 members from seven communities.

Managing turtle nesting beaches

In addition to lakes and grasslands, another important resource are the turtle nesting beaches adjacent to communities. Three species of river turtles are widely hunted for their meat and eggs and populations have been steadily declining. Three years ago Grupo Renascer[2] of Aracampina mobilized the community to protect a nearby nesting beach. Over the last three years the number of turtles nesting has increased from 122 to 395 with all three species showing steady increases.

This increase cannot be attributed to greater reproductive success, as the species takes more than two years to reach maturity. It must be the result of other turtles being attracted to protected beaches. A similar process may explain the increases in pirarucu populations in managed lakes. If this is the case, it represents an additional and powerful positive feedback for management as it increases the rate of response beyond the productive capacity of the local population.

Managing cattle on floodplain grasslands

The other major common property resource of the floodplain is the seasonally inundated grasslands of the floodplain interior where cattle are grazed during the low water season (Sheikh et al. in press). Ranching has been a major source of conflict between floodplain resource users. Together a group of governmental and nongovernmental organizations is developing a legal mechanism called a "Term of Adjustment of Conduct" (TAC), to provide a legal basis for collective agreements that define rules for raising cattle and water buffalo on the floodplain. Concerns addressed in these agreements include defining the period when cattle may be grazed in community grasslands and stipulating procedures for compensating farmers for damage suffered when cattle invade fields. To date some 54 agreements have been created. While enforcement is patchy, TACs do provide the most effective legal mechanism available for controlling the major cause of environmental degradation and a major source of risk for floodplain smallholders.

Restoring foodplain forests and grasslands

A third element of the Project involves restoring floodplain habitats, especially forests and grasslands. Between 1999 and 2003 a group of 13 farmers of the community of Aracampina, the Grupo Renascer, undertook a pilot reforestation project on an island in front of the community. The aim was to improve the quality of fish habitat in a lake on the island by planting species that produce fruit or nuts consumed by fish. A second objective was to identify a group of species that can be used successfully for reforesting lake margins. After four years, sections of the lake margin are successfully reforested and trees are producing fruit that are used by fishers to catch fish in the understory during the flood season. Based on this experience, the Renascer group shifted efforts to major lake levees on the main island behind the community where most fishing is concentrated. Here they initiated two projects: reforestation of the margins of a central canal that provides habitat for fish during the dry season, and replanting canarana grass in a fenced area close to the community to provide a nearby source of grass for cattle during the flood season. Grupo Renascer is also working with other communities in the region to restore their forests and grasslands.

Regional management

The basic management unit is the regional lake system, the network of lakes linked together by canals to form a more or less continuous body of water over a large part of the annual flood cycle. It integrates all the main habitats and resources, as well as the resource use activities of the local population and can encompass from one to dozens of communities and ranches.

The regional lake system is the scale at which lake fisheries management takes place. There are two aspects of management. The first has a regulatory objective, and seeks to insure that all members have more or less equal access to the fishery and that fishing pressure is within sustainable levels. The second has an economic objective, in which a group of fishers manage a local fishery to generate income from it. The pirarucu management experience is an example of the latter. In this section we describe an example of the former, development of a co-management system for floodplain fisheries of Santarém.

Background

The present co-management system, developed out of the regional grassroots movement to take control over access and use of lake fisheries and limit commercial fishing pressure in floodplain lakes. Beginning in the early 1980s, floodplain communities throughout the region began developing collective agreements, called acordos de pesca, to define rules of access and use of local lake fisheries. In the 1990s IBAMA in collaboration with the Municipal Fishers' Union, local NGOs and floodplain communities, sought to develop a co-management system for regional fisheries that incorporated these fishing agreements into the formal structure of fisheries management.

This effort focused on three main questions: stakeholder representation, institutional structure, and policy framework. The first problem with the prevailing system was that there was no mechanism for insuring that all stakeholders participated in the development of agreements. Agreements tended to be drafted and voted upon only by those in favor of reducing fishing pressure. Second, there was no explicit inter-community institutional structure responsible for formulating and implementing inter-community fishing agreements. Third, there was no legal basis for community fishing agreements so actions

2. Literally means the reborn group, referring to reforestation and not spiritual transformation.

taken to enforce measures were illegal unless also covered by existing fisheries regulations.

A number of modifications were introduced. Regional Fisheries Councils were created for each of the main lake systems of the Santarém floodplain. These are intercommunity councils composed of representatives from each of the communities located within the territory of a regional lake system. The Council is responsible for organizing the formulation of a fishing accord. At the same time, IBAMA revised existing fisheries management policy to define criteria and procedures for legalizing community agreements. Finally, IBAMA implemented a program to train Volunteer Environmental Agents (VEA) for each community who are responsible for organizing local enforcement of fishing agreements. There are now 7 Regional Fisheries Councils (8 if the Santarém urban Council is included) with a total of 135 communities and a population of 35-40,000 people, covering approximately 266 km^2 of Amazon floodplain (Figure 1). With these changes a regional system was created in which Regional Fisheries Councils formulate lake management agreements. IBAMA evaluates the agreements and if approved transforms them into law. The Regional Fisheries Councils, together with Environmental Agents, are responsible for implementing fisheries agreements at the community level.

Ecological performance

A recent study indicates that these lake management regimes are having a significant effect on the productivity of local fisheries (Almeida 2004). A comparison of fishing activity in lakes with and without functional fishing agreements found that fishing activity in the two types of lakes was essentially the same. However, on average fishing in managed lakes was 60% more productive, although there is considerable variation in the difference among the 9 matched pairs of communities. Since there is no significant difference in fishing activity, the reason for the difference in productivity seems to be due to the exclusion of large commercial fishing boats in lakes with fishing agreements. This study shows that lakes can be effective management units for floodplain fisheries.

Two telemetry studies of the behavior of the pirarucu suggest a more complex situation. In the first study, four pirarucus circulated within the same lake system for over two years until radio batteries gave out. In the second, 24 pirarucus were fitted with radios, 12 each in two different lakes almost 40 km apart. Those in one lake left the lake and circulated through the floodplain, eventually entering the lake of the other group, before slowly making their way back to the lake they where they were tagged. This study suggests that while there is as yet no evidence of long distance migratory behavior, pirarucu in the Lower Amazon may circulate from one lake to another within a larger region of floodplain. Thus, while individual lake systems are useful as management units, populations of even highly sedentary species may circulate through larger sections of floodplain than that of individual lake systems.

Organizational performance

Organizational performance is more problematic. Problems with co-management policy (criteria and kinds of actions permitted) and the performance of different stakeholder groups (IBAMA and communities) jeopardize the institutional sustainability of the co-management system. With regard to policy, constitutional constraints prohibit the closing of lakes to outsiders and charging user fees. This creates a situation where outsiders and free riders have access to all the benefits of community management, and also eliminates the most effective way of financing management. The policy also limits the powers of VEAs in enforcing agreements. To compound matters, IBAMAs support for co-management has been weak with little presence in the field. Its agents are also accused of ignoring citations brought by VEAs, thereby undermining their authority in the community. The result is that some 50% of VEAs have dropped out and there is considerable grumbling that things were better before when communities could take enforcement into their own hands. However, construction of the co-management system has been a process of adaptive learning and IBAMA and Provárzea have shown themselves to be committed to supporting refinements of the system to improve performance and institutional sustainability.

Integrating scales through the floodplain land tenure system

The challenge now is to effectively integrate the scales of management, creating mechanisms through which Regional Fisheries Councils can enforce rules at different levels. In this way, Councils can insure, for example, that land use at the property level is consistent with the quality and extent of vegetation cover needed at the regional lake system scale, that community policies with regard to cattle address the needs of farmers and fishers, and that actions taken by communities and large land owners are consistent with the ecological integrity of the lake system as a whole.

One of the key differences between this and many other regional management experiments is that it is taking place outside the context of a government reserve. The floodplain is legally government property. Only use rights can be recognized and land-use regulations are quite stringent. However, the government has never asserted ownership. Nor has it ever sought to enforce land-use regulations. Residents consider the land they occupy to be their property. Land is routinely bought and sold, though without legal titles. Consequently, land use has developed according to the norms of private property and regional market opportunities in which individual landowners are free to make more or less unilateral land-use decisions. With no government authority to make final decisions on land and resource use, individual land owners cannot be coerced into entering collective agreements and complying with provisions that they consider to infringe their interests.

While the floodplain is not a reserve, it does have many characteristics of a reserve. The most promising strategy

for institutionalizing local collective control over private land-use decisions and strengthening links between scales, is to take advantage of its semi-reserve status and make recognition of rights to land conditional to lake system management plans (Benatti et al. 2003). While formal private property rights cannot be recognized, the federal government can create a concession system for use rights in which maintenance of individual concessions depends on compliance with regional land-use plans. We are now working with the three main federal agencies responsible for regularizing floodplain use rights to develop a viable proposal that strengthens collective control over land-use activities. In this way the main zone in which private property rights are recognized, levees bordering the channels where settlement and forests are concentrated, can be brought under the effective control of the Regional Fisheries Councils.

Prospects

Over the last ten years this multi-institutional collaboration of stakeholder organizations, including floodplain communities and associations, municipal fishers unions, government agencies, NGOs and foreign donor organizations, has embarked on a major regional experiment in the community-based management of floodplain lake ecosystems. It has been greatly facilitated by remarkably stable regional economic conditions, resulting in little conflict or polarization among floodplain stakeholders. But while the basic framework for management at regional lake, community and property levels has been constructed, it is far from consolidated. As this paper shows, significant structural adjustments are necessary, and much work must be done at community and property scales to consolidate this regional management structure.

Unfortunately, there is little time available for achieving this consolidation. The stability of the last decade is over and the region is in the early stages of a major transformation. Soybeans are now being planted in sight of the Amazon River. Cargill, the multinational grain company, has constructed a port facility in Santarém harbour. Agroindustry is moving into the Lower Amazon and brushing aside the protestations of those who claim the Amazon is not appropriate for mechanized, chemical intensive commercial agriculture. Government and business interests are negotiating the paving of the precarious dirt track that links Santarém to the soybean heartland of western Brazil.

Sooner or later, pressures on the floodplain will intensify, mechanized agriculture, aquaculture and intensive ranching could, individually or together, rapidly transform the Lower Amazon floodplain, as has happened to many other floodplains of the world. How this process plays out will depend in large measure on the capacity of the smallholder-community co-management organizations described here to control destructive pressures and take advantage of economic opportunities that these regional changes may offer. Much depends on how quickly the changes needed to consolidate the fragile management system can be accomplished. While the future is by no means certain, a process of collective, adaptive learning has been put in place through which progressively more effective management systems can be developed. This collective learning capacity may be more important than any given management system, for successfully adapting to the coming regional transformations.

References

Almeida, O.T. 2004. Fisheries Management in the Brazilian Amazon. Ph.D. Thesis Deparment of Environmental Science and Technology, Imperial College London.

Almeida, O.T. and McGrath, D.G. 1999. Research and intervention for the participatory management of várzea resources. Instituto de Pesquisa Ambiental da Amazônia. Belém.

Benatti, J.H., McGrath, D.G., Mendes, A.C. 2003. Políticas públicas e manejo comunitário de recursos naturais da Amazônia. *Ambiente e Sociedade* VI(2): 137-154.

Castello, L. 2004. A method to count pirarucu Arapaimas gigas: fishers' assessment and management. *North American Journal of Fisheries Management* 24:378-389.

Goulding, M., Smith, N.J.H., Mahar, D.J., 1996. *Floods of fortune; ecology and economy along the Amazon*. Columbia University Press, New York.

Junk, W., Bayley, P. and Sparks, R. The Pulse Concept in River-Floodplain systems. In Dodge, D.P. (ed.) *Proceedings of the International Large River Symposium (LARS) Canadian Special Publication of Fisheries and Aquatic Sciences* 106: 110-127.

McGrath, D.G., Castro, F. de, e Câmara, E. 1999. Community management of floodplain lakes and their role in the sustainable development of Amazonian fisheries. In Padoch, C. et al. (eds). *Diversity, development and conservation of the Amazon floodplain*. Advances in Economic Botany 13: 59-82.

Merry, F., Sheikh, F. and McGrath, D. The role of informal contracts in the growth of small cattle herds on the floodplains of the Lower Amazon. *Agriculture and Human Values*. In press

Pinedo Vasquez, M. and Rabelo, F. 2002. Sustainable management of an Amazonian forest for timber production: a myth or reality? pp 179-185. in Brookfield, H. et al. (eds). *Cultivating biodiversity*. UNU Press, Tokyo

Sheikh, P.A. 2002. The impacts of cattle and water buffralo ranching on the Lower Amazon floodplain: an ecological and socioeconomic comparison. Ph.D. Thesis. Biology Dpt. Pennsylvania State University.

Sheikh, P.A., F.D. Merry, and D.G. McGrath. Water buffalo and cattle production on the Lower Amazon: comparisons and conflicts. *Agricultural Systems* In press.

Sparks, R.E. 1995. Need for ecosystem management of large rivers and their floodplains. *Bioscience* 45(3): 168-182.

WinklerPrins, A. and McGrath, D. 2000. Smallholder agriculture along the Lower Amazon floodplain, Brazil. *PLEC News And Views* 16: 34-42.