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The Influence of Community Management Agreements on Household Economic Strategies: Cattle Grazing and Fishing Agreements on the Lower Amazon Floodplain

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Abstract: While the organizational dynamics of collective management systems have received much attention, relatively little work has focused on how households adapt their economic strategies in response to collective management regulations that impose constraints on the range of options available to households. In this paper we investigate the evolving interaction between household management strategies and collective management regulations for one, or both, of two ecologically interdependent resources: lake fisheries and seasonally inundated grasslands of the Lower Amazon floodplain in Brazil. Smallholder management strategies involve varying combinations of three main activities each associated with one of three main floodplain habitats: annual cropping on river levees, cattle ranching on natural grasslands, and fishing in lakes. These three activities play complementary roles in the household economy. Annual cropping is both subsistence and market oriented, with cash from crop sales often invested in purchase of cattle. Fishing, in addition to providing animal protein, generates income for household purchases while crops are growing. Cattle ranching is the main savings strategy for smallholders, providing funds for family emergencies and capital investments. Over the last two decades, communities

throughout the Amazon floodplain have developed and implemented collective agreements to regulate access to and use of local lake fisheries and grasslands. Depending on the measures included, the impact of these agreements on household management strategies can range from negligible to highly significant, requiring major adjustments to compensate for reduced income and/or savings potential. We identify conflict between collective and individual strategies for long-term security as the critical issue for floodplain resources and conclude proposing a more household-based approach to the study of collective management systems.

Keywords: households, commons, Amazon floodplain, artesanal fisheries, smallholder ranching, community management

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1. Introduction

Common pool resource management agreements are designed to resolve problems caused by unrestricted access to local resources, such as resource depletion, excessive and/or unfair competition, and conflict. While these agreements may resolve the collective problem, this resolution may entail significant short and even long-term costs for some or all users. How users adapt to the new rules and the success of their new economic strategies are both cause and consequence of the efficacy of the new management regime. Even when the overall impact of rules is insignificant, the consequences for individual families can vary significantly, creating pockets of resistance and free-riding in an otherwise well supported management system.

The impact of management regimes on household economic strategies can be even more complicated when users have access to two distinct, but interrelated common pool resources (Futemma and Brondizio 2002). Here implementation of rules controlling exploitation of one resource may lead to more intensive exploitation of the other. If the productivity of one or both resources depends on the other, then intensified exploitation of one resource may reduce the productivity of the second. In these cases, sustainability in managing individual resources may depend on management of the system as a whole. Where two resources play different roles in the household economy, the implications for the second resource of managing the first can be more complicated. In some cases it may not be possible to compensate for loss of income derived from the first by intensifying exploita-

tion of the second, as when the first resource serves an income function and the second a savings function.

The Lower Amazon floodplain provides an excellent laboratory for investigating these relationships between management regimes and smallholder economic strategies. Here in addition to farming, smallholders exploit two overlapping resources: floodplain lake fisheries and grasslands for grazing cattle. Over the last decade, a regional co-management system has been created that integrates informal agreements into the formal policy and institutional framework for fisheries management (McGrath et al. 2004). Within this regulatory framework, a number of communities have developed their own informal management institutions, often with more stringent regulations, that are focused on one or more species of high commercial value.

Management of the fishery, however, will not insure long-term sustainability because unregulated cattle grazing on floodplain grasslands is degrading floodplain habitat (Sheikh 2002). While many communities have implemented collective agreements for cattle, these do not adequately address the problem of overgrazing. Despite the fact that ranching is reducing the productivity of floodplain fisheries, families prefer to invest in increasing their cattle herds, which are private property, rather than in protecting fisheries habitat, a collective resource. So a key question here is under what conditions will smallholders choose to reduce herds to protect their fishery?

In this paper we investigate the relationship between household economic strategies and management regimes for both lake fisheries and grazing of cattle on community grasslands. The paper is divided into four parts. In the first we describe the data and methodology used in analyzing different management regimes and relevant aspects of the study area, including the floodplain environment and smallholder settlement and economic strategies. In the second we investigate how implementation of management regimes for fishing and ranching affect household strategies for these resources. In the third we investigate the interaction between household fishing and ranching strategies in five scenarios characterized by different combinations of collective agreements for fishing and ranching. Finally, we discuss the implications of these preliminary investigations into the interaction between household economic strategies and local management institutions for a household-centered approach to the study of common pool resource management systems.

2. Methodology and study area

The research on which this paper is based has been carried out over the last fifteen years in the Santarém area of the Lower Amazon, at the confluence of the Tapajós and Amazon Rivers approximately midway between Manaus and Belém, the two major cities of the Brazilian Amazon (Figure 1). Over this period the authors have been involved in a longterm project studying the development of

participatory management systems and working with local smallholder and fisher organizations to develop collective management systems for floodplain fisheries and other resources. The main data source for this paper is a socioeconomic survey of 259 households undertaken by Almeida (2004) in 2001 comparing household economic activities in nine matched pairs of communities in which one half of each pair had an effective fisheries management agreement and the other did not. This paper also draws on the results of other research projects conducted over this period, including studies of household fishing activity in five floodplain communities (McGrath et al. 1998), the regional co-management system (Castro 1999; McGrath et al. 2004), local community management initiatives (Castro et al. 2002), and cattle ranching and its environmental impacts (Sheikh 2002; Sheikh et al. 2006; Merry et al. 2004). This paper is largely an exploratory essay that will help us to design a research strategy for investigating more closely the interactions described here.

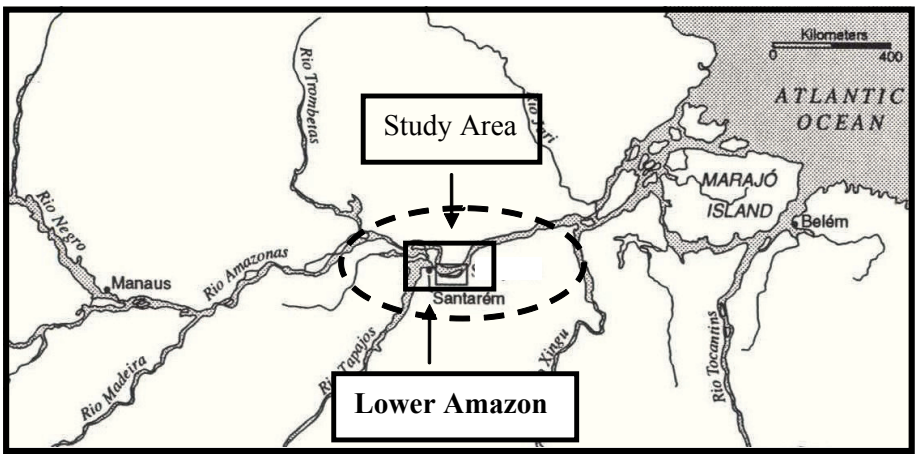

Figure 1: Lower Amazon and Project Study Area.
Source: Adapted from map by the University of Wisconsin Cartographic Lab.

2.1. Study area: location and characterization

The Lower Amazon is a cultural term for a region within the state of Pará extending from the Amazonas state border in the west to the mouth of the Xingu River in the east (Figure 1). From the perspective of local resource management strategies, the Lower Amazon floodplain consists of four main landscape elements: the main river channel and its ramifications; natural levees, often forested, which border river channels; the network of irregularly shaped lakes that occupy the interior of the floodplain; and seasonally inundated grasslands that occupy the transition zone between forested levee and permanent lakes. Forest cover is more limited than upstream and consists mostly of secondary forest varying in age. The

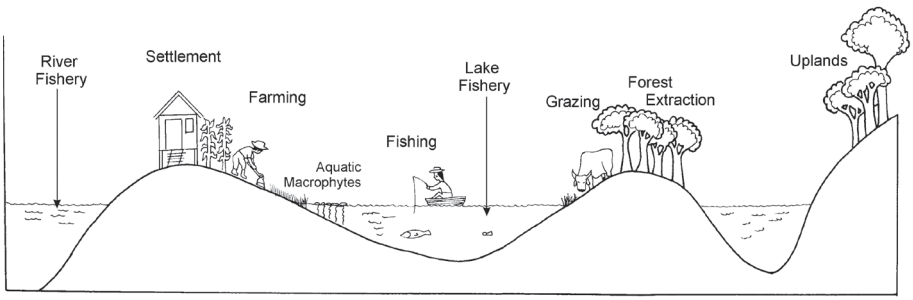

Figure 2: Major Habitats and Land Use on the Lower Amazon floodplain
Source: McGrath et al. 1993a

dominant vegetation of much of the floodplain is natural grassland composed of a variety of species of semiaquatic macrophytes (Junk et al. 2000).

Seasonal variations on the floodplain, or varzea as it is know in Brazil, are driven by the twin rhythms of the flood and precipitation regimes (Junk et al. 1989; McGrath et al. 1993a, 1998). The river rises from December to late May and then falls to its minimum level in early November. Annual precipitation, around 2200mm, is distributed over the year in a seasonal pattern that parallels that of the flood regime and the combination of these patterns results in two distinct seasons, referred to locally as *verão* (summer), the dry season when water levels are falling, and *inverno* (winter), the rainy season when water levels are rising. The relatively slow rise and fall have contributed to the evolution of a floodplain flora and fauna adapted to take advantage of both terrestrial and aquatic phases. Many plant species, for example, produce fruits and nuts during the flood season and many species of fish have adapted to take advantage of these resources (Junk et al. 1989; Goulding 1980). The seasonally flooded forests and grasslands are of great importance to floodplain fisheries, including many of the most important commercial fish species (Goulding 1980).

2.2. Floodplain settlement and economic activity

The people of the Lower Amazon floodplain or varzea, known locally as *varzeiros*, are of mixed Indian, European and African descent and have lived on the floodplain for generations. Settlement on the floodplain consists of smallholder communities of 30 to more than a hundred families interspersed between larger properties. These communities were in most cases organized by MEB (*Movimento de Organização de Base*), a program of the Catholic Church active in the region from the 1960s into the 1990s (Lima 1999). Communities consist of individual properties with houses located along the river. Each typically has a central area consisting of a Catholic Church, a community center, a school, and a football

field. Community organizations include a group of catechists, a mothers' club (*Clube de Mães*), a youth club (*Clube de Jovens*), one or more football clubs, and ~~in~~ the case of Santarém ~~a~~ chapter of the municipal Fishers' Union (*Colônia de Pescadores Z-20*).[1] The organization of community leadership varies with some having a council composed of the heads of the above mentioned organizations and others a presidential system with officers elected for one or two year terms. The leaders have no formal powers and their responsibilities include organizing management activities, maintaining community infrastructure, resolving disputes, organizing annual festivities for the patron saint, and representing the community in dealings with other communities and government authorities.

Land use patterns are closely associated with topography and vegetation (Figure 2). Settlement and most agricultural activities are concentrated on the levees as the frequency and duration of flooding is the lowest. The grasslands inland from levees are used for grazing cattle. Most fishing activity takes place in floodplain lakes although river fisheries are important at certain times of the year (McGrath, et al. 1998). Economic activities are closely tied to the annual cycle of the flood and precipitation regimes (Harris 1998). Households cultivate annual crops and graze cattle on grasslands during the low water season. Fishing is concentrated in floodplain lakes all year round and in river channels during the period of falling water when schools of fish migrate upstream.

Table 1: Frequency of Income Sources in Sample Household

Income source	Frequency	Percent household income
Fishing	84%	38%
Farming	81%	18%
Small Animal Husbandry	88%	-
Government Benefits	60%	31%
Cattle ranching	45%	3%
Salaries	16%	10%

Source: Almeida 2004. n = 259 households

Smallholder households on the floodplain employ diversified economic strategies. In a study of 259 floodplain households in the Santarém region Almeida (2004) found that 84 percent engaged in fishing, 82 percent cultivated crops, and 45 percent raised cattle. Small animal husbandry, practiced by 88 percent of the sample, is almost exclusively for household subsistence (Table 1). In addition, 60 percent of households in the study received some kind of government benefit

[1] Protestant evangelical religions are increasingly important in floodplain communities and because of the association between community institutions and the Catholic Church often do not participate in community organizations.

(retirement and unemployment benefits) and another 16 percent some kind of salary (teacher or ranch hand). Fishing accounted for the largest share of household income (38 percent), followed by government benefits (31 percent), agriculture (18 percent), salaries (10 percent), and ranching (3 percent). Note here the small contribution ranching makes to household income despite the fact that almost half the sample raised cattle. Government payments were second only to fishing as an income source.

Most families (70 percent of sample) engaged in two or more activities with 31 percent involved in three or more. The highest incomes in the sample were found in households practicing three or more activities. In the case of families involved in two activities, those raising cattle tended to have higher incomes than those that did not. Given ranching's small contribution to household income, this association is probably a result of cattle's role as an indicator of household income and investment capacity (Almeida 2004).

The three main activities play complementary roles in household economic decisions. Fishing provides a seasonally variable source of income and subsistence over the course of the year sustaining families through the agricultural season. Excess income from fishing is then invested into other economic activities. The fact that the low water period when most farming *activity* takes place coincides with the period of high fishing productivity reinforces the fishery's role as a natural subsidy (McGrath et al. 1998). Farming, in addition to meeting subsistence needs, may generate discrete quantities of cash that can either be saved or invested in other activities such as fishing and ranching. For most smallholders, cattle serve as a means of saving income generated by other activities and also as a strategy for capital accumulation through herd growth.

While the three main activities of the household economy are potentially complementary, in practice they are often in conflict. To the extent that most agricultural activities take place on the forested levees, farming contributes to deforestation reducing the quality of habitat available for fish. Ranching leads to the degradation of both floodplain forests and grasslands on a larger scale even than farming. In addition, cattle invade fields and damage crops. Also, when feeding on aquatic macrophytes in lake shallows, cattle frequently damage fishing gear. These negative interactions reduce the productivity of smallholder management systems. One important objective of management agreements is to reduce these negative interactions and strengthen complementarities among activities.

By Brazilian law, the Amazon floodplain is the property of the federal government, and residents do not have legal titles to the land they occupy (McGrath and Gama 2005). However, informal property rights are recognized by floodplain residents and the Lower Amazon floodplain is divided into individual holdings that are regularly bought and sold on the regional land market. Properties are defined in terms of meters of frontage along the river and extend inland to the margins of interior lakes or channels. Smallholder properties average about 100 meters of frontage by 2000 meters in depth for a total area of about 20 hectares, most of

which is underwater during much of the year. It should be noted though, that 25 percent of properties are up to 50 meters, so a large proportion of smallholders have holdings under 10 hectares (McGrath and Gama 2005).

Within individual holdings, the three main habitat types are associated with different property rights and there is a continuum from private to common property as one proceeds inland from levees to permanent lakes (McGrath et al. 1993a). The river in front of the community can be used by anyone, though communities may object to the presence of outside fishers. Levees are considered private property and lateral boundaries are usually fenced to protect house gardens and crops. While lateral boundaries are recognized and in some communities are fenced, grasslands behind the levee are usually treated as a commons on which community residents may graze their cattle. Lakes are also considered common property available to all community residents, and outsiders may or may not be permitted access. This system of defining property in terms of frontage assures each household access to the river and to the main ecological zones of the floodplain. Because lakes inundate floodplain grasslands and forests during the flood season, households engaged in fishing and/or cattle ranching exploit overlapping common pool resources. These are partially conflicting economic strategies because of the impacts of ranching on fishing gear and floodplain habitat.

3. Impact of fishing and cattle management agreements on household fishing and ranching strategies

3.1. Fishing agreements

The main productive unit in the Lower Amazon fishery is a canoe powered by sail and or paddle, one or two fishers, and their gear (McGrath et al. 1998). Fishers use a variety of types of gear-depending on the season, the species, and the habitat-with gill nets being responsible for 70-80 percent of the catch, followed by a variety of traditional gear types. The distinction between subsistence and commercial fishing tends to be one of degree in the sense that all commercial fishers reserve some of the catch for household consumption, and virtually all subsistence fishers sell fish on occasion. However, Almeida (2004) was able to distinguish distinct subsistence and commercial fishing strategies in her sample. Subsistence fishing strategies were consistent with the Chayanovian logic of the relationship between labor productivity and total effort. Subsistence fishers spent less time fishing as productivity increased because they needed less time to meet their needs. In contrast, commercial fishers spent more time fishing.

Fishing agreements grew out of a concern that commercial fishers-especially larger scale outside commercial fishers-were depleting local lake fisheries (Castro 1999; Lima 1999; McGrath et al. 1993a). Today, two general types of fishing agreements can be distinguished: formal co-management agreements created

during the last decade and informal local community agreements that may be far older. During the 1990's, informal fishing agreements provided the basis for development of a formal co-management system in partnership with IBAMA (*Instituto Brasileiro de Meio Ambiente e Recursos Renováveis*), the federal institute responsible for the environment (McGrath et al. 2004). The basic organizational unit of the co-management system is the Regional Fisheries Council, an inter-community council composed of representatives of all the communities sharing a given lake system. Fisheries Councils are responsible for preparing and implementing fishing agreements. These are then submitted to IBAMA for legal recognition via an administrative decree (*Instrução Normativa*). Monitoring and enforcement activities are organized by Volunteer Environmental Agents (VEAs) who are community members trained and accredited by IBAMA. VEAs serve as intermediaries between the community and IBAMA. They have the power to cite those breaking rules and submit the citations to IBAMA for prosecution. By 2002, the entire 2600 km^2 area of floodplain in the municipality of Santarém had been organized into seven Regional Fisheries Councils integrating some 170 communities and roughly 35-40,000 people, each with its own legal fishing agreement and community VEAs (McGrath et al. 2004).

These co-management agreements have several objectives.[2] First, they seek to maintain or increase the productivity of fishing effort. Second, they insure more or less equal access to the fishery by removing more highly capitalized fishers and discouraging what are considered to be 'predatory practices'. Third, many agreements seek to reduce pressure on the fishery during the low water season when fish are concentrated in shallow bodies of water and are vulnerable to overexploitation (Castro and McGrath 2003). Fishers are less concerned about the spawning season because it coincides with the period of rising water when fish disperse in an expanding volume of water that provides natural protection.

A productive fishery is sought because smallholders employ diversified economic strategies and need to allocate labor among different activities as efficiently as possible. The higher the productivity of fishing effort, the less time families must spend fishing to meet basic needs, freeing up more time for other productive activities. In this way, a highly productive fishery constitutes a natural subsidy that enables families to diversify economic activities and increase their household incomes (McGrath et al. 1999). Although Almeida (2004) found little difference between managed and unmanaged lake fisheries in terms of fishing practices, fishing productivity was 60 percent higher in managed lakes. She attributes the higher productivity of managed fisheries to the exclusion of outside commercial fishers. In these cases, the management regime apparently has no significant impact on most household fishing strategies because it is designed primarily to eliminate abusive practices and protect local norms.

[2] See Castro and McGrath 2003 for an analysis of fishing agreements.

Within the co-management system some communities have their own informal agreements for local lakes that may include more stringent measures, such as the exclusion of outsiders, which are not permitted in formal co-management agreements.[3] They may also restrict the use of gill nets and/or the marketing of fish outside the community so as to reduce the total catch and enhance the productivity of fishing effort. Because community management agreements can be more stringent, they can have a significant impact on household incomes in the first few years after implementation. For example, the prohibition of gill nets can reduce the productivity of fishing effort by 30 percent or more (McGrath et al. 1993b). While after a few years fishing productivity may exceed that with gill nets at the time the new agreement was implemented, the abrupt drop in the productivity of fishing effort and income during the transition from an unmanaged to a managed fishery constitutes a significant barrier to the development of these more intensive management regimes. The success of these initiatives then depends on the availability of alternative income sources and the capacity of community management institutions to enforce rules and control free-riding so as to maintain member confidence during the transition.

3.2. Cattle ranching and collective agreements

A traditional activity on the floodplain, ranching has expanded considerably over the last few decades as a result of innovations in transport technology, colonization of uplands adjacent to the varzea, and subsidized loans for pasture formation (Sheikh et al. 2006; McGrath et al. 1993a). While in the past cattle were maintained on raised platforms, called *marombas*, and fed cut grass through the flood season, now ranchers and many smallholders move their cattle between floodplain grasslands in the low water period and upland pastures during the four months of peak flooding (Sheikh et al. 2006, WinklerPrins 2002). The seasonal movement of cattle between floodplain and uplands eliminates the major bottleneck to the growth of floodplain ranching, the need to maintain cattle in raised platforms, and permits smallholders and ranchers to put much larger numbers of cattle on floodplain grasslands during the low water season than could be maintained in *marombas* during the flood season, with predictable negative consequences for floodplain grasslands and forests.

As with the fishery, two distinct ranching strategies can be distinguished: that of larger scale land owners who specialize in raising cattle and water buffalo and maintain sufficiently large herds to generate a regular income from ranching, and that of smallholders who engage in various activities and have too few animals to generate a significant income. In the latter case ranching serves primarily as a way to store savings for family emergencies. As noted earlier, 45 percent of

[3] Under the formal co-management policy agreements can specify how people fish but not who has the right to fish in lakes covered by the agreement.

smallholder households in Almeida's (2004) survey raise cattle. The average herd is around 20 head. This figure is skewed upward by the 8 percent of cattle owners with more than 100 head. In fact, more than half of those with cattle have less than 17 head (Almeida 2004). In many if not most cases, smallholder returns from raising cattle are very low. However, the tradition of raising cattle, combined with its role as a mechanism for savings, seem to provide sufficient motivation.

The role of cattle as a savings strategy is reinforced by two institutions: the cattle society (*sociedade*) and largely unregulated access to floodplain grasslands. Cattle societies are partnerships in which one person lends a quantity of cattle to a second person to raise for a specified number of years. At the end of the contract the calves produced are divided equally between the two and the original complement of cattle returned intact to the owner. Almeida (2004) found that some 85 percent of cattle owners surveyed were currently involved in a cattle partnership. In another study, Merry et al. (2004) found that 53 percent of cattle owners had started their herds through a partnership. The importance of these partnerships is in large part due to the fact that families have had unregulated access to community grasslands enabling them to care for more cattle than their own properties could support (Sheikh et al. 2006; Merry et al. 2004).

The result is a classic tragedy of the commons in which individuals pursuing their own short-term economic interests contribute inevitably to the overexploitation of community grasslands (Hardin 1968). In general, cattle densities tend to be significantly higher in community territories than in adjacent ranches. Câmara and McGrath (1995), for example, found that on average smallholder herds were several times larger than the estimated carrying capacity of their properties. The system is viable because cattle owners are able to exploit the grasslands of those without cattle.

While research to support this conclusion is limited, there is a general consensus among *varzeiros* and floodplain researchers that cattle and water buffalo ranching is the main contributor to the degradation of floodplain habitat in the Lower Amazon (Goulding et al. 1996; Junk et al. 2000; Sheikh 2002; Sheikh et al. 2006). Burning and excessive grazing pressure leads to the selective removal of the more palatable grass species along with those species unable to withstand periodic burning. These activities also reduce the total biomass of the aquatic macrophytes communities that provide essential habitat for many aquatic vertebrates and invertebrates (Junk et al. 2000). Burning of forest margins and browsing of seedlings reduce forest cover and the regenerative capacity of forests (Sheikh 2002). Cattle and water buffalo also compact floodplain soils and churn up sediments, reducing photosynthetic activity and modifying water quality. The combination of these impacts reduces the productive capacity of floodplain habitat for many important commercial fish species; exacerbating the direct impact of fishing itself.

As cattle herds have grown, so has the number of complaints and conflicts resulting from damage to crops and fishing gear (Sheikh et al. 2006). In response, communities have sought the assistance of government agencies and local NGOs to help resolve the problem. Beginning in 1997, collective agreements have been negotiated between communities and cattle owners (who may be community members or neighboring ranchers) to regulate cattle ranching on the floodplain. Known as Terms for Adjustment of Conduct or TACs, these collective agreements are legally binding for all who sign them and are monitored and enforced by the Public Ministry together with other local institutions. To date, some 42 TACs have been signed covering much of the Santarém floodplain (Ipam Varzea Project Database).

Typically, these agreements include rules for separating areas for grazing and farming, define procedures for compensating damage to crops and gear, and establish a period during which cattle must be removed from floodplain grasslands. While this last measure does reduce conflicts, it also raises costs for cattle owners because few have sufficient upland pasture to maintain their cattle during the flood season and must rent pasture from upland colonists. A fourth measure seeks to limit herd size to that of the owner's property. Interestingly, only a few of the forty-two agreements implemented to date include measures to limit the size of individual herds, despite the fact that this is the underlying cause of the problems associated with cattle ranching (Ipam Varzea Project database). The lack of size limits reflects resistance to measures that might constrain the potential for accumulation via growth of cattle herds. Because, as is the case with fishing agreements, most TACs seek primarily to reduce or eliminate abusive practices, they have little or no direct impact on household ranching strategies.

3.3. Impact of agreements on household fishing and ranching strategies.

Before investigating how management regimes affect the interaction between economic activities within the household economy, four points should be highlighted from the previous discussion. First, both fishing and ranching agreements seek to curtail abusive practices and avoid rules that might have a major impact on prevailing patterns of resource use. Second, agreements are as much concerned with reducing conflicts and insuring equal access to resources as they are with conservation, and include measures to restrict capacity and discourage practices through which individuals could appropriate a disproportionate share of the resource. Third, contrary to the claims of critics (Goulding et al. 1996; Smith 1999), these measures, even when they do not significantly modify normal practices, do seem to improve the productivity of lake fisheries and reduce some of the negative impacts of cattle ranching (Almeida 2004; McGrath et al. 1993b). Fourth, there is a temporal dimension as management interventions change the productivity of the fishery, and/or constrain ranching activity, forcing households to adapt their economic strategies to evolving conditions in the fishery and in the grasslands. As these adjustments spread through the community they may create new pressures

on floodplain resources requiring further collective action in a long-term process of adaptive learning at household, community, and regional scales.

Fishing and cattle ranching are the two poles of the household economy, and the relationship between them is at the core of household economic strategies. A basic question here is the relative efficiency of the two activities in terms of labor and area. While there is as yet no definitive answer to the question, existing studies indicate that fishing is the more economically productive in terms of labor and area under most conditions (Junk et al. 2000; Ohly and Hund 2000). This is probably even more the case in the Santarém region due to the dismal quality of the animals and depressed market conditions for floodplain cattle.

The presumed higher productivity of floodplain fisheries has led some writers to argue that it makes more sense to cultivate 'fish orchards' and manage fish than to raise cattle (Goulding et al. 1996). The problem with this suggestion is that it does not take into account differences between fish and cattle with regard to their role in the household economy, the nature of the property rights associated with each, and their characteristics as a resource. Fishing and ranching serve different economic functions. One generates income and the other savings, so they are not interchangeable at the scale they are practiced. Furthermore, they are subject to different property rights. Cattle are private property and the rights of owners are guaranteed by law, while fish are public/collective property and belong to whoever catches them. Finally, the two have different characteristics as biological resources. Cattle are terrestrial, can be visually monitored, and are controlled with little difficulty. Fish are aquatic and are very difficult to monitor and control. Consequently, there is much greater uncertainty regarding the status of local fisheries than there is regarding that of individual cattle herds.

These different characteristics of cattle and fish tend to outweigh questions of their relative economic efficiency. Here the main issues are the security of property rights and confidence in the competence of collective management organizations. In fact, smallholders are operating very much as Popkin (1979) would have predicted, by investing in the family for long-term security and in the community for short-term benefits. Based on this logic, cattle are clearly the better long-term investment, while smallholders seek short-term gains from the fishery. In this section we will examine how management agreements influence household economic strategies ~~-es~~especially with regard to the roles and relationships between fishing and raising cattle ~~-by~~ briefly looking at five scenarios of institutional arrangements: fisheries co-management agreements, community managed fisheries, cattle agreements, cattle agreements with herd restrictions, and piraucu (*Arapaima gigas*) management initiatives.

The first scenario involves the implementation of formal co-management agreements. We noted that while there is little difference in fishing practices between managed and unmanaged lake fisheries, fishing in managed lakes is significantly more productive. Earlier, we argued that a high productivity fishery serves

as a direct and indirect subsidy for other household economic strategies liberating more labor and/or generating money that can be invested in other activities. From this perspective how does the increased productivity of the fishery affect household management strategies? Do households invest the gains in raising more crops or in ranching? To the extent that households invest in farming, increased income from crops might also be invested in cattle, so that one outcome of the increased productivity of the fishery is likely to be a greater number of families with cattle and larger average herd sizes. This tendency is not evident in Almeida's (2004) data set as the sample of households from managed and unmanaged lakes show virtually no difference in farming activity. While herd size is on average larger in communities with managed lakes, the difference is not significant, due to the great variability within each sample.

The situation is somewhat different under the second scenario where more stringent management rules are implemented. Here, the relative roles of cattle and fishing may change considerably through the transition to a managed fishery. In the first phase, immediately after the prohibition of gill nets, the productivity of fishing effort drops and families must intensify other activities such as annual cropping to compensate for lost income. In this phase of the transition to a managed fishery not only is investment in cattle likely to cease, but households may sell animals to support themselves until other income sources can be developed. The stagnation or even decline of the community herd may reduce pressure on habitat and aid recovery of the fishery. As the productivity of the fishery recovers, investment in ranching may begin to increase leading to renewed pressure on grasslands and forests that eventually may affect the productivity of floodplain habitat. Here, as in the first case, the benefits gained from managing one common pool resource may simply contribute to the more intensive exploitation of the other once the productivity of the former has recovered.

The third scenario involves the collective regulation of ranching activities. As noted earlier, most cattle agreements seek to mitigate the problems generated by extensive cattle ranching, and very few include measures to limit the number of cattle families can graze on community grasslands. One measure that is aimed not just at reducing damages to fishing gear, but also seeks to protect fish habitat, is a rule regulating the period that cattle can remain on floodplain grasslands. This measure seeks to protect aquatic macrophyte communities from grazing and permit the growth of these 'floating meadows'. It is one of the very few measures that favor the fishery over ranching.

In the fourth scenario agreements restrict the number of cattle households can maintain on the floodplain to the estimated carrying capacity of their property. Since, as noted, few agreements seek to limit cattle herds and even these give maximum stocking rates well above sustainable levels, they have little impact on individual herds. While there are as yet no examples of such a situation, it is worth exploring what the impact of such a regulation might be. Approximately 50

percent of smallholders with cattle have less than 17 head. If a rule of one head per hectare were applied, the average property of 20 hectares (one hundred meters of frontage versus two thousand meters long) could maintain at most 20 head. However, since a large part of the 2000 meter length of the property is underwater much of the year, the effective area for grazing is much smaller, perhaps only 1000 meters or 10 hectares. Since many properties are even smaller, this measure would drastically reduce the potential for smallholders to use ranching as a long-term investment strategy, although its function as accident insurance would remain viable for most families.

A significant reduction in the potential for expansion of herds could affect household economic strategies in a number of ways. However, it should be noted that the value of cattle ranching as a savings strategy is being undercut by the integration of smallholders into the formal economy, including access to formal savings accounts and government social benefits. Given the dubious economics of smallholder ranching under prevailing conditions, herd size restrictions could lead to a greater than expected reduction in the number of families raising cattle and in average herd size.[4]

These changes could help conserve fishery habitat (Sheikh 2002). If ranching becomes less attractive as an investment strategy, households might be more inclined to invest in the management of the fishery and also in implementing rules that seek to conserve floodplain habitats. This possibility is supported by the fact that the successful implementation of collective agreements for fisheries and cattle reinforces confidence in the efficacy of local management organizations and thereby reduces insecurities with regard to the risks involved in making long-term investments in managing the fishery. In this way, the barriers to investment in community fisheries management identified earlier might be significantly reduced. However, reduction of these barriers will depend on endowing fish with those attributes of a cow that make it a more favorable alternative from the perspective of smallholder investment strategies.

The fifth scenario, in which communities adaptively manage local pirarucu fisheries, shows how this transformation might be achieved. In several communities groups of fishers with the support of a local NGO are implementing management systems for the pirarucu, *Arapaima gigas*. The pirarucu has several features that make it a promising species for management in floodplain lakes. It is one of the largest fish species in the Amazon and has great commercial and cultural value. Also, it is a sedentary, lake dwelling species that rises to the surface on a regular basis to gulp air and forms couples to care for young during the first 4-6 months after spawning (Castello 2004). A participatory census technique was developed at the Mamirauá Sustainable Development Reserve that takes advantage of these characteristics of the pirarucu (Castello 2004). Using this technique, teams of

[4] However, the opposite response may be equally prevalent as casual observations suggest families often invest part of government payments in cattle.

experienced fishers can estimate the number of adult and juvenile pirarucus in a lake. By combining this information with that on the number of breeding couples and data on the local pirarucu catch, fishers obtain a very concrete understanding of local pirarucu population dynamics. They can then establish annual quotas for the fishery. An important feature of this kind of management system is its linkage to a collective marketing strategy. For example, many communities harvest the annual quota collectively. Income from the sale of the catch is then distributed among participants according to their contribution to management activities, with a proportion of the total going to a community fund.

This approach reinforces confidence in the collective management system in several ways. First, the methodology for monitoring fish populations reduces one of the main problems with managing fish; the fact that they are largely invisible so there is no simple way of determining the status of stocks. Second, the system generates a highly visible and concrete benefit that is distributed according to each individual's contribution to the management system. Third, a portion of catch income is allocated to a community fund, thereby reinforcing the collective value of the fishery. Finally, the tightly organized management system assures that free-riding will be discouraged and that benefits will be consistent with individual investments. As these kinds of management systems develop and proliferate in the region, they are likely to influence smallholder propensity for investing in the management of common pool resources.

4. Discussion: implications for a household based approach to the study of common pool resource management systems

The tension between individual and collective interests is a central theme in the literature on the management of common pool resources. How this tension is resolved, the success of these resolutions, and the factors that influence performance over time have been central concerns of the field for most of its history. This tension is expressed in the interaction between household economic strategies and the management institutions they have created and continue to modify. It is at the core of common pool resource management systems because these institutions are designed to address resource problems that households cannot resolve unilaterally. They are in consequence an extension of the household economic strategy, and their success in addressing households' needs is critical to the long-term sustainability of the system. At the same time, implementation of management systems is not unproblematic because a) it involves some limitations on individual autonomy to pursue economic interests, b) implementation of management regulations can result in significant short and long term costs, and c) these costs may disrupt the functional organization of the household economy and impair its ability to meet basic needs. Willingness to adopt and comply with proposed regulations then depends not just on confidence in the management institution, but

also on the impact of new regulations on household income and ability to maintain key household functions.

In this paper we have investigated these issues through a study of the evolving interaction between household and management systems on the Lower Amazon floodplain. Earlier we noted that Popkin (1979) makes a critical distinction between individual and collective strategies for addressing long-term security needs. From this perspective we can distinguish two overlapping phases in the evolution of Lower Amazonian management systems. In the first phase, from the mid 80s to the late 90s, the problem was one of declining productivity of fishing effort, threatening day-to-day subsistence. In response, households entered into collective agreements to increase the productivity of the fishery so daily subsistence needs could be met more efficiently. Increasingly, they were willing to go beyond simply eliminating what they considered unfair practices and make significant short-term sacrifices when they were confident that these would eventually result in greater benefits from the fishery. In the second phase, from the late 90s to the present, communities are increasingly concerned with the impact of cattle ranching on the productivity of floodplain fisheries. This situation brings two household functions into potential conflict, meeting day-to-day subsistence needs on the one hand, and providing for long term security needs on the other.

Because of the interdependence of fishing and grazing and their different roles in the household economy, the long-term sustainability of the system will depend on how households resolve the problem of providing for their long-term security needs without degrading the system that also provides their day to day subsistence. Here we have argued that the problem is only partially about collective versus individual strategies because there is also greater uncertainty regarding the status and the property rights associated with the fishery. These uncertainties simply exacerbate concerns about organizational capacity. Consequently, willingness of households to use collective strategies for long term security depends not only on their confidence in the organization but on the development of management practices that reduce uncertainties regarding the fishery, such as the participatory monitoring techniques described in the pirarucu management scenario. As groups of fishers gain confidence in the management system, their willingness to invest in fisheries for long-term security may increase.

We feel that the main contribution of this paper lies in its focus on household economic strategies and the collective management agreements that these same households have worked together to create. The emphasis in this analysis is on households as economic actors who implement economic strategies to exploit the different opportunities available through varying combinations of unilateral and collective initiatives. This appears to be a relatively underdeveloped area within the study of common pool resource management systems, despite the theoretical origins of commons research in game theory with its focus on individual strategic behavior under different game conditions (Ostrom et al. 1994). While drawing on

this theoretical base, especially that of collective action theory, the literature on common pool resource management is dominated by systemic approaches concerned with the structure, organization and functioning of management institutions, and the factors that influence their performance (Ostrom 1990; Agrawal 2002). This systemic orientation to the study of management institutions derives from the fact that the field developed to a large extent as a response to Hardin's 'tragedy of the commons' paper and the resulting need to better understand common pool resource management systems (Agrawal 2002; Hardin 1968; Dietz et al. 2002; Ostrom 1990).

Rather than focusing exclusively on the aggregate characteristics of the user group of a given CPR, more attention should be paid to households as strategic actors in order to analyze how they interact with the management institutions they have created and maintained (Angelsen and Kaimowitz 1999). Development of such a household economy approach to the study of common pool resource management systems could contribute a great deal to our understanding of factors influencing household choices, unilateral and collective, in pursuit of their interests (Wey, Ostrom, and Meretsky 2005, pp. 39-44). This approach places the focus on the tension between individual and collective strategies for pursuing household interests, and the frictions (transaction costs) that make sustained collective action so problematic (Pereira 2004). It also emphasizes the range of options available in any given situation and the factors that influence household decision-making in designing economic strategies. More generally, this approach can contribute to a restructuring of the prevailing institution based analytical framework to make households, and not simply the user group, the central causal agent and collective institutions the instruments employed by households to address resource use problems they cannot resolve unilaterally. By restructuring in this way, we can better capture that essential tension between individual and collective action, which is at the core of common pool resource problems and more generally of human social evolution.

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