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Water buffalo and cattle ranching in the Lower Amazon Basin: Comparisons and conflicts

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Abstract

From 1975 to 2000, the water buffalo population in the Brazilian Amazon increased at nearly 13% per year, making it one of the fastest growing herds in the world. On the floodplains of the Amazon River buffalo are managed in a similar manner to cattle, but often earn superior production figures. This production advantage, however, is tempered by the role buffalo play in conflicts between landowners; buffalo are prone to altering the floodplain environment and interfering with production activities such as fishing and farming. In this research, we show that buffalo are kept on the floodplains 24% longer than cattle throughout the year, and 37% longer than cattle during periods when landowner conflicts are most likely to occur. We also show that buffalo productivity is greater than cattle in this system, which gives an opportunity to design management regimes for buffalo that may increase production costs, but that will lower the environmental and social problems that involve buffalo. Specifically, when the waters begin to rise, buffalo should be removed from the floodplains at the same time as cattle. Although this will not lessen the damage done while the buffalo is on the floodplain, it will place buffalo on the floodplain during the dry season when the erosion potential is at its lowest, and reduce the time that buffalo may interfere with other production activities such as

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fishing. The additional production costs incurred by early removal will not dissipate the production advantage over cattle. Without specific management that addresses the socio-economic and environmental problems caused by buffalo, the continued high growth rate for the buffalo population on the Amazon floodplains may not be sustainable and conflicts will become commonplace.

Keywords: Brazilian Amazon; Water buffalo; Cattle ranching; Floodplains; Conflicts

1. Introduction

Although water buffalo (hereafter referred to as buffalo) have been domesticated for centuries, their role in production systems varies greatly throughout the world. In Asia and the Far East, buffalo are primarily raised in small herds for dairy production, transportation, and animal traction (Nanda and Nakao, 2003). For example, in the Philippines, 81% of buffalo herds have less than three animals (Alviar, 1990), while in India, which has the largest buffalo herd, animals are normally kept in herds of less than five animals (Shastry et al., 1988; Devendra and Thomas, 2002). Furthermore, over 90% of buffalo owners in the Indian Sub-continent and Near East extract milk from buffalo for subsistence or market and although out-numbered three to one by cattle, buffalo provide up to 60% of the national dairy production in India (Mahadevan, 1992). In China and Thailand, over 80% of farmers with buffalo use them for draught and in China, Thailand, Indonesia, Malaysia, and the Philippines, buffalo provide 20–30% of the power for rice production (Sanh et al., 1995). In South America, however, buffalo are strictly production animals.

Introduced to the Amazon basin in 1895, buffalo have steadily gained acceptance as an alternative to cattle, and indeed, throughout South America buffalo perform favorably in both beef and dairy production. Buffalo impress ranchers by their resistance to common bovine diseases, superior weight gain than cattle, high quality dairy and meat products, and the ability to fatten on a wide range of grasses. These characteristics and reputation are part of the reason that buffalo herds in the Brazilian Amazon have increased at a rate of nearly 13% per annum from 1975 to 2000 compared to cattle herds, which have increased at 4% per year during the same period. The rate of buffalo population growth in the Amazon from 1975 to 2001 was also more than three times higher than the rate of buffalo population growth in any other country in the world where data are available (Fig. 1). The buffalo herd in the Brazilian Amazon now stands at approximately 1.5 million head, of which approximately 160,000 are located in the Lower Amazon floodplain. Buffalo ranching, however, is relatively new in many parts of the Lower Amazon Basin; buffalo were introduced to the Lower Amazon in 1950 but were not widely distributed among counties in the Lower Amazon until the 1980s (IBGE, 1985).

Despite harsh, wet, and variable conditions, ranching is the dominant land use on the Amazon floodplain (McGrath et al., 1993). While cattle suffer badly during the

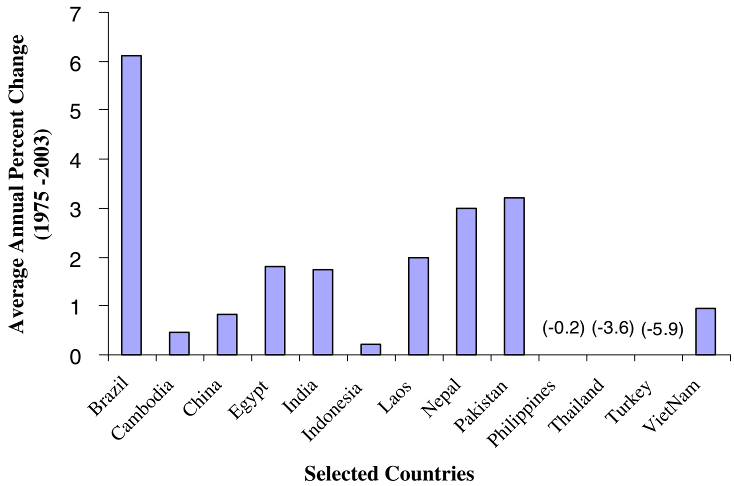

Fig. 1. The average annual percent change of national buffalo herds from selected countries around the world from 1975 to 2003.

transition from dry to wet seasons, these conditions present few obstacles to buffalo. Indeed, the ability to withstand, and even thrive under, difficult conditions on the floodplain seem to have made buffalo a popular choice among floodplain ranchers. On the floodplain, however, the favorable characteristics of buffalo ranching have been tempered by claims that they are a potential threat to the ecosystem and to traditional land use practices (Arima and Uhl, 1997; Goulding et al., 1996; Smith et al., 1995). Community members and ranchers report that pastures inhabited by buffalo become less productive. Fishermen complain that buffalo trample floating vegetation mats, drive away fish, decrease available habitat for spawning, and tear their nets. Although these claims are largely anecdotal, they serve as the basis for conflicts and a growing antagonism against buffalo ranching.

An increasing herd coupled with the emerging resentment against buffalo is cause for concern. Are buffalo causing environmental and socio-economic problems on the floodplain, thus creating the need for special management when compared to cattle? Are buffalo especially problematic in the common property systems common throughout the floodplain? Our research is the first to broach these questions and to test for differences between cattle and buffalo productivity and management on the floodplain. Finding management differences between cattle and water buffalo may allow us to recommend alternative management options to ease the disquiet now associated with buffaloes. Drawing on the results of a survey of 84 ranchers, this study addresses these questions a sub-region of the Amazon Basin called the Lower Amazon. We compare production and management differences between cattle and buffalo, and examine conflict issues between buffalo ranching and other production alternatives. The results of this paper suggest that although buffalo have superior production figures and are popular among larger ranchers, they have serious production conflicts with smaller landowners and fishermen.

2. The floodplain ecosystem and farming systems

Known as the *várzea*, the floodplain of the Amazon River Basin is an area of about 300,000 km^2 that is periodically inundated, in an annual cycle, by the lateral overflow of the Amazon River (Junk and Piedade, 1997). Our study focuses on the floodplain of

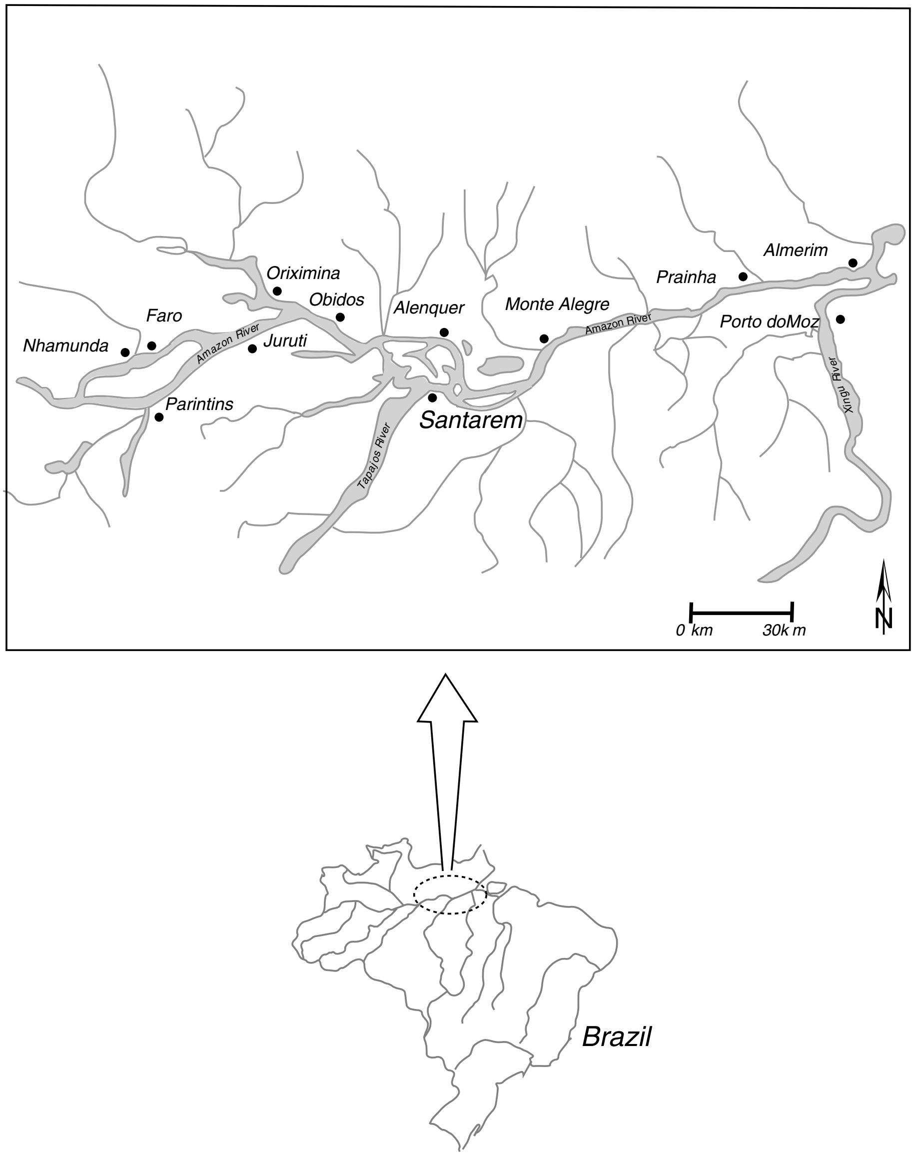

Fig. 2. The Lower Amazon Basin, Brazil.

the Lower Amazon Basin, which stretches from the Pará-Amazonas State border east to the mouth of the Xingu River. It is an area of approximately 18,000 km^2, averaging 45 km in width along the banks of the Amazon (Fig. 2). Islands form throughout the floodplain by sedimentation of rich alluvial soils originating from the Andes and Andean zone (Fearnside, 2001; Furch, 1997; Sioli, 1984). During the high water phase of the Amazon River, these islands contain inland lakes 2–10 m deep (Irion et al., 1995), which are formed by the entrapment of water within the natural levees of higher ground at the edge of the islands. With the infusion of nutrients from the Amazon River and support of large fish populations the lakes play an important role in the productivity of the floodplains. The levees, meanwhile, are home to forest stands and human settlements (Goulding, 1980). When the waters recede, a sediment-rich lakebed is uncovered and natural grasslands exposed, which form the forage base for cattle and buffalo. The grasslands are considered common property, with property boundaries based only on river frontage, extending back to the lake edge (McGrath et al., 1993).

The richness of the system is also reflected in the complexity of the floodplain farm systems, which in addition to animal husbandry include fishing, market and subsistence gardens, and forestry. Crop–animal interactions (see, for example, Devendra and Thomas, 2002), however, such as animal traction, nutrient cycling, and the use of agricultural waste products are not very apparent. For example, although there are no specific constraints to animal traction, it is little used, but perhaps only for lack of custom. The animals graze on grasslands far from the production of market crops and in many cases are actively kept out of the crop area and so waste is excreted far from the crop site. Finally, other than poultry, there is little direct consumption of agricultural residue by animals. In fact, animal husbandry and other productive activities are often in conflict, the small farmer must allocate his time and land, when appropriate, between many activities depending on the season. This would appear to make cattle and buffalo difficult components of the farm systems on the floodplains, yet they have characteristics that ensure their integration. To the small farmer living in the Lower Amazon floodplain, cattle represent a means of diversifying farm income, of using non-arable land, and of maintaining a liquid but long-term investment – the proverbial walking banks. In addition, they infer a certain social standing and self worth to the smallholders.

Cattle and buffalo management in this ecosystem is governed by the annual rise and fall of the waters, and is a mixture between access to common property and private land management. When the floodwaters arrive, livestock are either transported to upland pastures or placed in raised corrals called *marombas*. Renting of upland pastures appears to be an attractive option, but is expensive in a cash-poor system (Merry et al., 2004). In addition, the pastures are often overstocked as upland landowners seek to maximize short-term profits. The cut-and-carry system of the penned animals, however, requires that the rancher cut the floating grass, a task that begins at approximately 4 a.m. and lasts until 9 or 10 in the morning. As the water recedes and floodplain forages emerge on inland lake fringes, livestock are driven to the floodplain grasslands. Here they are grazed in a common property.

Incentives for over use in common property resources – i.e., the dry season grazing on lakebed grasslands – are well documented (see Dietz et al., 2003 for an excellent discussion and reference list). Cattle owners on the floodplains, however, may have sufficient constraints on herd growth due to the need to take the animals to the high ground or by the cut-and-carry requirements of the wet season. This presents an interesting constraint on the over grazing of common resources.

2.1. Water buffalo ranching on the floodplains

The rapid growth of buffalo in the Amazon is partially due to the resilience of the animal and its production characteristics. With calving rates reported near 75% and calf mortality only 5–6% in the Lower Amazon (Camarão et al., 2002), a buffalo herd may grow quickly. Calving mortality rates for buffalo are low in the Amazon compared to other countries where rates range from 25% to 42% (Tulloch and Holmes, 1992). High calving mortality in other countries has been attributed to unsanitary corral conditions and poor management (Tulloch and Holmes, 1992).

Similar diseases affect buffalo and cattle worldwide (Ligda, 1997). In the Lower Amazon, however, ranchers reported that disease was less prevalent in buffalo than in cattle. In contrast, research has found no apparent differences between buffalo and cattle in other regions of the Amazon. For example, in the Central Amazon, buffalo were found to have less parasite infections and fewer incidences of brucellosis, but more tuberculosis and enzootic bovine leucosis than cattle (Hopf and Muchow, 2000). Regional experiences may explain these differences. However, a definitive answer to disease prevalence in buffalo and cattle on the floodplain would require further study.

In the flooded conditions of the Lower Amazon, cattle have difficulty swimming and are more susceptible to water-borne diseases and aquatic predators (i.e., snakes and piranha) than buffalo (Ligda, 1997). Buffalo, however, can navigate inundated areas and consume patches of floating vegetation during flooded conditions (Ohly and Hund, 2000). The ability to graze longer and more efficiently in flooded conditions may give buffaloes an economic advantage over cattle. Also, on the floodplain buffalo consume a greater variety of grass species than cattle (Ohly and Hund, 2000). This may be explained in part by a larger digestive tract and slower fermentation process, which enable buffalo to consume coarse forage not suitable for cattle (Sitwell, 1988). Buffalo, however, with fewer sweat glands (10 times less per cm^2) and hair follicles than cattle, find it difficult to transpire heat and cool down in hot conditions (Shafie, 1985). In environments with high temperatures (e.g., $\geqslant$34 °C), buffalo suffer from an increase in calf mortality, lower growth rate, and low milk production (Mahadevan, 1992). Air temperatures on the Amazon floodplain frequently pass 30 °C during the midday and can reach up to 45 °C, which may hinder buffalo. The floodplains, however, with large, accessible, bodies of water provide a solution to these problems.

3. Research methods

Buffalo and cattle production parameters, such as weight gain, reproduction, and dairy and meat production, were determined from results of a survey. Eighty-four ranchers from eight counties were interviewed. Ranchers raised buffalo, cattle, or a combination of both animals. Ranchers with holdings of all sizes (10 head to 1400 head) were selected for interviews from lists provided by local rancher associations or from visits by boat to floodplain communities. Interviews were administered in 1998 and supplemental economic data were updated in 2002. The first author with the support of field technicians administered all the survey interviews. The ranchers interviewed owned approximately 10% of buffalo and 5% of cattle ranched in the Lower Amazon Basin (IBGE, 2001).

The survey was designed to collect data on diverse issues such as: (a) methods of property acquisition and property size; (b) herd size and sex distribution; (c) ranch infrastructure and maintenance, including grassland management, costs, and methods for transporting livestock to and from the floodplain and the use of vaccines; (d) history of land-use conflicts (i.e., conflicts between farmers and ranchers because of crop destruction done by livestock); and (e) use of extension agents. To allow for quantitative analysis closed-form questions were used, but to capture opinions and views some qualitative open-ended questions were also included in the survey. Responses to open-ended questions were grouped into categories to explain some differences or used to discuss trends and formulate policy recommendations. Economic data were taken from ranchers and slaughter- houses.

To compare whether production and other descriptive values reported in the survey responses are statistically different for cattle and buffalo, the data are separated into the two categories (cattle and buffalo) and we use two-sample t-tests to test for significant differences between means. In all cases, normal distributions and equal variances are assumed. To permit the comparison of values in different years, all future values must be discounted to present values; in this manner we compare animal sales values in different years. The present value of a future sum is discounted using the following equation:

$$\mathrm{Pv} = \frac{\mathrm{Fv}}{(1+r)^{t}}, \tag{1}$$

where Pv is the present value in year 1, Fv is the future or sales value, r is the discount rate, and t is years. For a simple sensitivity analysis, the present value of an animal when discounted at either 5% or 10% and the production periods (the t) were 2.3 years for buffalo and 3.2 years for cattle.

Finally, we assume that with similar management there are no differences in costs of production and so compare monthly productivity through growth, price, and calving rate differences. Also, in some section of the analysis, economic data from 1998 were not available and it was only possible to do the economic comparison by coupling production data from 1998 with economic data (i.e., beef prices) from 2002. This methodology is considered adequate for the purpose of comparison between the two systems since the data are taken from similar sources for both.

4. Results

The results are presented in four sub-sections: a description of the regional buffalo and cattle herds and the ranches that house them; a description of the management practices on the floodplain; production values; and production constraints. Throughout the results section we compare buffalo and cattle.

4.1. Herd and ranch characteristics

With 78% of the total buffalo population in herds between 300 and 3000 head, the results from Table 1 suggest that the buffalo herd is concentrated on larger ranches and not on small ranches nor in small herds. The mean herd size for the larger ranches with buffalo was 788 (sd = 690, n = 14). Only 5% of the buffalo population is in herds of less than 100 head. Cattle herd population follows a similar pattern (Table 1) with 80% of the population held on what are considered large farms (300–3000 head). In the case of cattle ranches, the herd average was 891 (sd = 594, n = 25). In a direct comparison of ranches with, and without, buffalo, the average size of the herd with buffalo was significantly larger at 635 head (sd = 94, n = 58) whereas those ranches without buffalo had an average of 178 head (sd = 39, n = 26). Similar results can be seen for ranch size (Table 2), where ranches with buffalo are on average 1101 ha and those without only average 293 ha.

These results, however, do not suggest that buffalo are exclusively ranched in large herds. Of the ranches that raised buffalo in this survey, 32% had less than 100 animals, 42% had between 100 and 300 animals, 25% had between 300 and 3000 animals, and one had over 3000 animals.

In an analysis of ranch size, the average farm with buffalo is shown to be 1101 ha (sd = 230) whereas those with only cattle had an average of only 293 ha (sd = 73). In addition, only 7% of the buffalo herds are on ranches of less than 100 ha and 25% are on ranches between 100 and 300 ha; whereas, 68% are on ranches greater than 300 ha. These estimates are for the area of upland ranches only, because floodplain land is used as a commons area and therefore not parceled as properties. The results from herd size and ranch size analyses suggest that ranchers with small landholdings seem less inclined to raise buffalo than compared in other countries where buffalo are raised. Larger ranchers, however, appear to favor buffalo and maintain an average ratio of 81 buffaloes for every 100 beef animals.

On average, buffalo herds surveyed in this study were started in 1982 (sd = 8.6, n = 60), approximately 6 years later than cattle herds (1976, sd = 17.1, n = 84). When asked why they started to raise buffalo, ranchers responded with one or more of five general responses (n = 60 ranchers who gave a total of 73 responses): (1) buffalo had greater productivity than cattle (34% of the responses); (2) buffalo were better adapted to floodplain environmental conditions compared to cattle (33% of the responses); (3) buffalo were more profitable than cattle (18% of the responses); (4) buffalo were easier to manage than cattle (10% of the responses); (5) buffalo were inherited (5% of the responses).

Table 1
Herd populations and distribution of ranches studied in the Lower Amazon, Brazil

	Herd size	Total head	Percent of total herd sampled	Percent of farms	Mean	sd	*n*
Buffalo							
Small herd	<100	1341	5	32	58	30	18
Medium herd	100–300	4119	17	42	196	63	24
Large herd	300–3000	11,025	45	25	788	690	14
Very large[a]	>3000	8000	33	2	8000		1
Cattle							
Small herd	<100	1151	4	43	52	32	34
Medium herd	100–300	4329	16	26	206	52	21
Large herd	300–3000	21,380	80	31	891	594	25

[a] This outlier was removed from all statistical analysis.

Table 2
Comparisons of buffalo and cattle ranch and herd size on upland ranches

Description	Unit	Mean	sd	*n*
Ranch size				
Ranches with buffalo	ha	1101	230	40
Ranches with only cattle	ha	293	73	16
Herd size				
Herds with buffalo	head	635	94	58
Herds with only cattle	head	178	39	26
		Ranch size	Percent	
Buffalo ranch size distribution	ha	<100	7	
	ha	100–300	25	
	ha	>300	68	

Most ranchers who raised buffalo reported that their herds had increased or remained the same size from 1993 to 1998 (Table 3). Forty-one percent of buffalo herds increased during this period, 28% decreased and 31% of the herds remained the same size ($n = 60$ responses). For cattle herds, estimates were similar: 48% of the herds

Table 3
Herd initiation, herd size history, and future expectations for buffalo and cattle herds on floodplain ranches in the Lower Amazon, Brazil

	Year started			Herd size from 1996–2001 (% of farms)			Future expectations of herd size (% of farms)		
	Mean	sd	*n*	Increased	Decreased	Same	Increase	Decrease	Same
Buffalo	1982[*]	8.6	61	41	28	33	64	17	17
Cattle	1976	17.1	50	48	20	28	76	12	8

[*] Significant difference between means at $p = <0.05$.

increased, 20% decreased, and 32% remained the same ($n = 67$). Most ranchers expected their buffalo and cattle herds to increase (64% and 76%, respectively); however, twice as many ranchers expected declines in their buffalo herds compared to declines in cattle herds during this time (17% and 8%, respectively).

4.2. Ranch management

Of all the ranches surveyed, 92% were involved in a breeding program whereby the main objectives were breeding for heifers to increase the herd or sell, and for production of bulls for market. In addition, 42% of the ranches had dairy production for city markets as an objective, and 38% made cheese. Twenty-seven percent had dairy production for in-house consumption, and only 15% of the farms did any fattening. Fattening was described as buying bulls at two years old to fatten for market.

Ranchers on both the floodplain and upland send their animals out to graze during the day, and then bring them back to the corral at night. This activity is done to reduce theft of animals. This represents a grazing pressure component and a management choice. Longer grazing schedules result in greater pressure on the pasture resource and a management regime could vary times on the pasture for cattle and buffalo. When comparing this activity between the floodplain and upland, (i.e., are all animals left out longer in either site), it was found that there is no significant difference between the two. On a daily basis, ranchers left cattle on the floodplain an average of 9.3 h a day (sd = 1.4, $n = 27$) and buffalo 8.7 h a day (sd = 2.9, $n = 45$) Other comparisons are reported in Table 4.

Closely related to the issue of daily grazing hours, is the length of time the animals stay on the floodplain. The survey results suggest that buffalo stay on the floodplain significantly longer than cattle ($p = <0.006$). Buffalo spend an average of 7.7 months

Table 4
Comparison of buffalo and cattle meat and dairy characteristics on floodplains in Brazil

Characteristics	Buffalo	Cattle	Unit	Source
Meat production				
Time to market	28.0	38.0	Months	This study
Market weight (carcass)	208.0	178.0	Kilograms	This study
Growth rate	14.6	9.4	kg/month	This study
Market price	1.2	1.4	$/kilogram	This study
Calving percentage	75.0	60.0	Percent	This study
Calf mortality	7.0	11–15.0	Percent	Ohly and Hund (2000)
Female lifespan	9.0	7.0	Years	Ohly and Hund (2000)
Dairy production				
Milk output	1000–1400.0	800–1200.0	kg/year	Costa et al. (2000)
Milk on natural pasture	4.0	N/A	Liters/cow/day	Carvalho (1993)
Milk on cultivated pasture	7.0	5.0	Liters/cow/day	Carvalho (1993)
Percent fat in milk	7.6	3.9	Percent	Vale et al. (1996)
Percent protein in milk	4.4	3.5	Percent	Vale et al. (1996)
Milk to produce 1 kg cheese	8.0	12.0	Liters	Carvalho (1993)
Milk to produce 1 kg butter	14.0	20.0	Liters	Carvalho (1993)

on the floodplain (sd = 2.1, n = 58), whereas cattle stay for only 6.7 months (sd = 1.7, n = 61). The more time livestock spend grazing on the floodplain translates into less time ranchers need to rent upland pastures for livestock.

Because it was difficult to distinguish whether on farms with mixed herds the buffalo are treated differently, we cannot say with any confidence that buffalo receive different medical attention. In general, many of the ranchers claim to protect against hoof and mouth disease (81%), external parasites (81%), and internal parasites (74%). There is less attention paid to Brucelosis (42%) and Black leg (36%). But, given the fact that it is mandatory to vaccinate against Hoof and Mouth, the interpretation of this result must be considered with care, since it is likely that ranchers will not admit to not following strict vaccination schedules.

4.3. Production values

Buffalo and cattle are primarily sold in markets close to the ranches between January and March. Ranchers sell their livestock during this time to lower transport costs to upland pastures and to keep fewer livestock on upland pasture. Other ranchers sell their livestock on a need-only basis and have smaller herds (mean = 200 head, sd = 41, n = 28).

Under the environmental and management conditions of the Lower Amazon, buffalo are significantly more productive than cattle (Table 5). Buffalo can be ready for market in 28 months, whereas cattle take an average of 38 months. In addition, buffalo weigh approximately 30 kg more (208 kg vs. 178 kg) at slaughter (Table 5). Mitigating some of these large productivity differences is the fact that buffalo meat is less expensive than cattle beef. At the time of the survey, buffalo meat was reported to be selling at about $1.06/kg, and beef at $1.24/kg at slaughterhouses (both prices are in 1997 dollars for carcass meat). This leads to a monthly productivity difference of 36% ($7.88 for buffalo vs. $5.80 for cattle). Furthermore, the calving percentages (percent of cows giving birth per year) for buffalo and cattle are different in ranches of the Lower Amazon; buffalo have an average calving percentage of 75%, while for cattle it is 60%. Greater calving rates will increase the value of the herd by producing more calves. Incorporating calving percentages into calculations of monthly productivity

Table 5
A comparison of financial returns from buffalo and cattle production in the Lower Amazon

Animal	Weight[a] (kg)	Age[b] (month)	Price [c] ($/kg)	Total value ($/head)	Discounted total value ($)		Monthly value ($)	Calving rate (%)	Adjusted value ($)
					5%[d]	10%[d]			
Buffalo	208	28	1.06	221	197	177	7.89	75	5.92
Cattle	178	38	1.24	220	189	164	5.80	60	3.48

[a] Carcass weight at slaughter.
[b] Age at slaughter.
[c] Average price (converted to US$) in meat markets in Santarém, Pará for 1997.
[d] Discount rate.

increases the profitability difference between cattle and buffalo from 36% to 70% ($5.91 for buffalo vs. $3.48 for cattle).

4.4. Production constraints

Perceptions given by ranchers as possible reasons why buffalo may not be raised by ranchers with smallholdings in the Lower Amazon are as follows: buffalo ranching (1) has a larger financial risk than cattle ranching; (2) is not traditional; and (3) may lead to conflicts with neighboring landowners. The stability of buffalo and cattle meat prices was cited as an important decision of what animal to ranch. Many of these ranchers expressed concerned about the price stability of buffalo prices. Small landowners also expressed that they did not want to break with the tradition of cattle ranching to experiment with buffalo; and that they were reluctant to raise buffalo because they were uncertain about buffalo management. Information is scarce, and in fact, few ranchers with smallholdings sought advice from agricultural extension agencies (e.g., no ranchers with holdings of less than 100 animals had instruction or advice on how to manage buffalo; $n = 18$). Lastly, 57% of ranchers with buffalo experienced conflicts with other landowners while only 19% of the ranchers without buffalo experienced conflicts. Indeed, some small landowners, who primarily resided in floodplain communities, explained that their communities were in the process of or had drawn up accords prohibiting buffalo ranching. These ranchers felt disinclined to invest in buffalo for fear of reprisals by neighbors.

5. Discussion

5.1. The role of buffalo in conflicts

If buffalo perform better than cattle under the conditions of floodplain ranching, then why is there anecdotal evidence of increasing bias against their production? The answer may lie hidden in issues such as cultural norms, tradition, and handling requirements, but the results from this survey suggest that conflicts with other floodplain users are the main problems associated with buffalo ranching. Fig. 3 depicts the main sources of conflict for the buffalo ranchers showing the main antagonists in almost half of all conflicts, to be fishermen. Wading out in chest deep water, buffalo utilize canals, stream channels and inundated trenches to navigate between vegetation mats. Line nets placed by fishermen also occupy these areas. Buffalo easily trample and tear nets when they are passing through, resulting in economic losses for fishermen. The presence of buffalo in fishing areas convinces fishermen that buffalo are driving fish away to other lake systems. Fishermen have reported that the introduction of buffalo in their lake systems has resulted in lower fish catches.

The most productive months for fishing are the rising and falling water months. During these months, buffalo will have more contact with fishermen because they are able to stay longer and return earlier to the floodplain than cattle. In a separate survey of only community members in the Lower Amazon, buffalo were the reason for

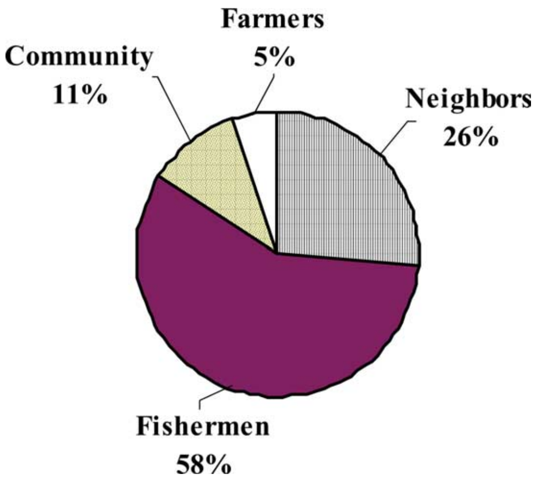

Fig. 3. Sources of conflict for buffalo ranchers on the floodplains of the Lower Amazon, Brazil.

75% of all land-use conflicts involving livestock reported (n = 55 conflicts). From the community member's perspective, the dominant reasons for conflict were the presence of buffalo in lakes where fishing occurred, and the trampling of crops by buffalo (Azevêdo et al., 1999a,b).

Fig. 4 is a schematic of the four periods of water level, fishing activity, animal presence, and conflict potential on the floodplain during the year. Period I is the high water period, when all the animals are all on the Upland, and there is little chance of conflict. In period II the waters begin to recede, and fishing productivity is at its highest. Buffalo and cattle are both brought on at roughly the same time, somewhere towards the end of August, and the potential for conflict is high. In period III, the

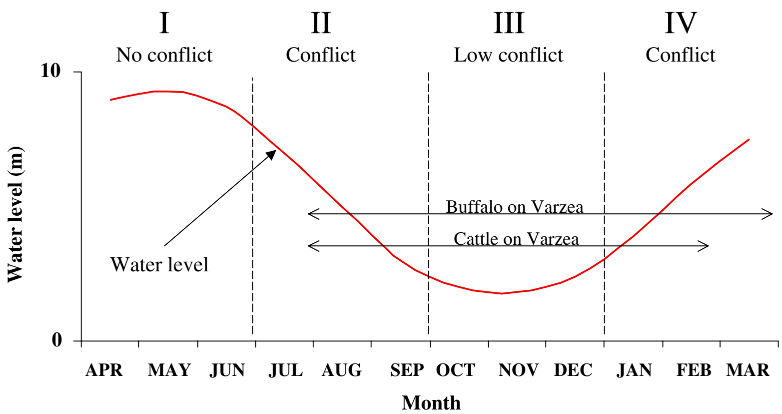

Fig. 4. Periods when buffalo and cattle have the greatest possibility of interacting with fishermen on the floodplain, Lower Amazon, Brazil.

water has receded to such an extent that the lakebed in the island may be dry and, even if not, there will be less conflict. Period IV is the period of rising water and here again conflicts are likely. If periods I and III are exempted from conflict analysis, and we compare the months on the floodplain during conflict periods, the extra month that buffalo remain on the floodplain suddenly becomes more important. Instead of comparing 7.7 months to 6.7 months, we now compare 4.7 months to 3.7 months and, as a result, see buffalo staying on the floodplain 27% longer than cattle in the conflict months. If the dry season is longer (i.e., period II is four months) then buffalo can be on the floodplain for an even greater percentage of time (37%) during the conflict months.

Other conflicts are apparent between the buffalo ranchers and their neighbors, nearby farmers, and the community. The source of these conflicts is not as distinguishable, but the primary, land-based, complaint lodged against buffalo is that they break fences and consume crops. These crops are vitally important in the subsistence of the small farmers, and so it is likely that if buffalo are destroying the crops, they will enter into conflict. Some floodplain communities have responded to conflicts caused by buffalo by creating accords prohibiting buffalo ranching in their proximity.

5.2. Accords

Accords are largely unofficial regulations adopted by community members in local meetings (McGrath et al., 1993). They originally served to provide collective action against outsider fishing in community lakes, and later they were expanded to include rules about other resource uses on the floodplain (Castro, 2000). Large ranchers usually ignore community accords because of their success in overturning accords in courts of law. In the last few years, this trend is beginning to reverse; accords have recently been ratified by federal agencies and defended in local courts. Further, the implementation of accords is receiving institutional backing from federal agencies such as EMBRAPA, as well as non-governmental and community organizations that interact with floodplain communities.

Accords generally prohibit the ranching of buffalo as opposed to regulating their production. Recent accords have begun to diversify and some reflect the special conditions in the communities where they are adopted. For example, an accord for a floodplain community was implemented with specific provisions to prevent the entry of buffalo into a stream that is used for bathing and water supplies by the community. The accord further directs ranchers to direct their herds to the floodplain grasslands to avoid interactions with agricultural fields and floodplain forests (Federal, 2002b). In another community, an accord requires that ranchers may have a maximum of 15 head of either cattle or buffalo on marombas, in order to prevent overgrazing of aquatic macrophytes, which potentially could reduce forage availability during the dry season (Federal, 2002a).

Accords that regulate livestock production on the floodplain provide an opportunity for incorporating the results of this study into management regimes or regulations for buffalo and cattle production. There are three management recommendations that could be considered for implementation: (1) preventing herds from entering the floodplain during periods of high fishing activity in floodplain lakes; (2) monitor herds while they are grazing; and (3) corral herds during the night. Bringing buffalo herds on the floodplain after periods of high fishing activity should reduce interactions with fishermen and reduce conflicts. This practice, however, has costs. Less time spent grazing on floodplain grasses may result in less productivity for buffalo. According to ranchers interviewed in this study, the consumption of floodplain grasses yields higher rates of weight gain than the consumption of grass on upland pastures. Furthermore, time on upland pastures will increase costs for ranchers who rent pastures during the flood season. Monitoring herds during grazing periods is expected to lower buffalo interactions with fishermen and agricultural areas, and can prevent the entry of buffalo into sensitive areas (e.g., stream channels). Monitoring can also lead to the implementation of rotational grazing, which can reduce impacts to forage species on the floodplain. Yet, some ranchers argue that the extra labor cost associated with monitoring herds may not make this option viable. Corralling herds overnight is practiced in some floodplain communities to protect livestock from being stolen. Corralling herds is also expected to lower interactions with agricultural plots and other sensitive areas. There are few costs associated with corralling since most ranches have corrals built. Lost opportunities to graze overnight when temperatures are cooler and extra labor needed to gather buffalo would be the primary costs for this practice.

The effectiveness of accords in managing livestock on the floodplain will greatly depend on enforcement. Few practices to enforce accords in communities exist; the only method employed has been litigation against ranchers in regional courts. Non-governmental organizations and community groups have attempted to create community watch groups to monitor accord provisions, but it is too early to determine if this practice is working.

6. Conclusion

Large ruminants are an important component of small farm systems on the floodplains of the Lower Amazon and although their interaction with other production activities may seem destructive rather than constructive, their place as flexible storage of capital value – walking banks – and their benefits to social worth is confirmed. To fill this role, the small farmer is faced with a choice of animal, cattle or water buffalo. Historically, cattle have been the ruminants of choice in these systems, but recently buffalo have become more popular – it is estimated that the population of buffalo in the Lower Amazon alone stands at 160,000 head – although the herd is still small when compared to cattle. Superior production figures, for both meat and dairy, have earned the buffalo increasing "market share" with ever more farmers choosing them over cattle. Indeed, 64% of ranchers expected their buffalo herds to increase. But, as the range and popularity of buffalo grows so does their reputation as a potential threat to the Amazon ecosystem and to traditional land use practices (Smith et al., 1995).

This dichotomy is a potential threat to the continued expansion of buffalo ranching in the Lower Amazon. It is possible that buffalo, although well suited to the environment, are unable to exist in harmony within the farm systems of the floodplain. On the islands within the floodplain of the Amazon River, land ownership is based meters of river frontage extending back into variable common property depending on the season. The systems incorporate agriculture and fishing as well and as animal husbandry, and while cattle have existed in this systems for decades with relative ease, buffalo have been more problematic because they are said to destroy pastures and to wreak havoc with agricultural production – many agricultural areas are unfenced, but even where fenced are easily overcome by buffalo. Buffalo have the additional complication that they can interfere with fishing. Fishing is at its most productive on the floodplain during the annual rising and falling water seasons; at full water and the height of the dry season fish are dispersed or in the main body of the river, respectively. Buffalo are able to withstand deeper water than cattle and wade well into the lake to feed on floating mats of vegetation. These floating mats house fish populations and the fishing nets for their capture. Some floodplain communities have responded to conflicts caused by buffalo by creating accords prohibiting buffalo ranching in their proximity.

Conclusions drawn from this survey suggest that buffalo in the Lower Amazon are a desirable animal (from a rancher's perspective) for animal husbandry systems, and out-produce cattle in terms of meat and dairy production. The positive attributes of buffalo, however, are tempered by their environmental impacts, and their role in conflicts between ranchers and other floodplain land users. With current rates of herd growth in the Lower Amazon, it is expected that the growth of buffalo ranching will parallel the growth of livestock ranching on the Amazon floodplain, and if buffalo can be managed in such a way as to reduce their role in conflicts and increase their participation in draft and dairy production among ranchers with small holdings, their production should outpace cattle production on the floodplains of the Amazon Basin. Management recommendation emerging from this work is that, in order to reduce access to peak conflict periods, buffalo be removed from the floodplains at the same time as cattle and also that herds, if possible, be monitored more closely.

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