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The use of riparian environments in the rural Peruvian Amazon

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SUMMARY

River margins are valued for agriculture in the western Amazon because of their fertile soils and level surfaces. Riparian forests along river margins also provide valuable ecosystem services by protecting water quality and providing resources to aquatic organisms. Because inhabitants of the region rely on these aquatic resources, riparian deforestation may have unintended negative feedbacks on the health and well-being of rural communities. A survey of 79 households of mixed cultural background investigated how riparian environments were used, what mechanisms were in place for their conservation, and how local people valued them. Corn, beans and peanuts were cultivated preferentially in riparian areas, complementing the manioc and plantains grown on upland soils. People valued riparian areas for their ecosystem services and generally left a protective buffer of forest along rivers. Both the agricultural and ecological values of riparian areas may be preserved through proper management.

Keywords: agriculture, Andean Amazon, colonists, deforestation, indigenous people, land use, riparian zone, Peru

INTRODUCTION

Land-use change in the humid tropics exerts profound influences on surrounding land and aquatic ecosystems, and sometimes these influences have unintended negative impacts on the same humans converting the land. This is particularly true in frontier areas of the few remaining tracts of tropical rainforest, where human interventions may extend into surrounding ecosystems on which humans also depend. Certain ecological consequences of tropical forest conversion are well documented, such as the destruction of wildlife habitat (Skole & Tucker 1993; Laurance *et al.* 2000; Cochrane & Laurance 2002), the emission of greenhouse gases (Laurance *et al.* 1998; Potter *et al.* 2001) and the alteration of the hydrological cycle (Fearnside 1995; Costa & Foley 2000). A special case may also be developed for the conversion of the forests fringing rivers and lakes. Naturally vegetated riparian areas regulate flows of water, particulates and solutes from terrestrial to aquatic ecosystems. They shade streams and rivers, provide habitat and resources to aquatic and semi-aquatic organisms, and form corridors for the migration of terrestrial organisms (Naiman *et al.* 1993). Healthy riparian forests are essential to the maintenance of water quality and biological integrity in surface water systems, and their destruction often leads to subsequent degradation of adjoining aquatic ecosystems (Naiman & Décamps 1997; Jones *et al.* 1999).

Rural communities of the Peruvian Amazon are especially sensitive to degraded aquatic ecosystems because the health and well-being of people there are closely tied to the quality of nearby surface waters and the vitality of natural fisheries. More than 90% of households collect their drinking and domestic water from surface water sources (McClain *et al.* 2001). This water is consumed with little or no treatment, and waterborne diseases account for the majority of illnesses treated at local health clinics (McClain *et al.* 2001). From a nutritional standpoint, fish account for nearly half of the animal protein consumed by rural inhabitants (Pierret & Dourojeanni 1967; McClain *et al.* 2001). In light of the direct negative feedbacks that degraded aquatic resources may have on rural inhabitants of the Peruvian Amazon basin, conservation of riparian forests for the protection of river water quality and biological integrity is an urgent management goal.

At the same time, however, there is a strong impetus for the development of agriculture on riverside soils. In the rural Amazon Basin, certain agricultural activities have been focused along river margins since prehistoric times (Meggars 1984). Riparian areas and flood plains tend to have more fertile soils as a result of the occasional deposition of nutrient-rich sediments from flooding rivers, and agronomists encourage the development of agriculture along river margins (Sanchez *et al.* 1982). Especially important are proteinaceous crops like cereals and legumes, which are essential to the diet of local people but, in the absence of fertilization, do not grow well on upland soils (Shorr 2000). Other human activities such as logging and construction are also commonly focused in riparian areas to allow quick access to rivers, which serve as key transportation avenues in the region.

There are thus strong needs to both conserve and use riparian areas in the rural Amazon, and management plans must somehow reconcile these needs. Important considerations in the development of management plans will be current use, protection and perceptions of riparian areas. Here we report and discuss the results of a census of land use in riparian areas of two communities of differing cultural

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makeup in the Peruvian Amazon. We address the questions of what activities are focused in riparian areas, what community and extra-community rules regulate riparian area land use in different social groups, and to what extent inhabitants of the region recognize the importance of intact riparian vegetation for protecting adjacent aquatic ecosystems.

METHODS

Study area

The study was conducted in the Palcazu river basin, which covers an area of 3041 km^2 and altitude of 300–3800 m above sea level (Fig. 1). The rugged Yanachaga range to the west and the lower San Matías range to the east delineate the Palcazu valley. Montane and sub-montane forests occur on the mountain slopes, while lowland tropical rainforest covers undeveloped portions of the valley bottom (Fig. 2). Rainfall is in excess of 2000 mm yr^{-1} and is concentrated in a rainy season from October to April (Servicio Nacional de Meteorología e Hidrología 1999). Annual average temperature varies with altitude, but in the lower portions of the basin where this study was located temperatures average 25°C.

Three different soil groups predominate in the Palcazu valley, namely (1) modern alluvial deposits along the present rivers, (2) ancient alluvial deposits no longer flooded parallel to but above the modern river levels, and (3) residual

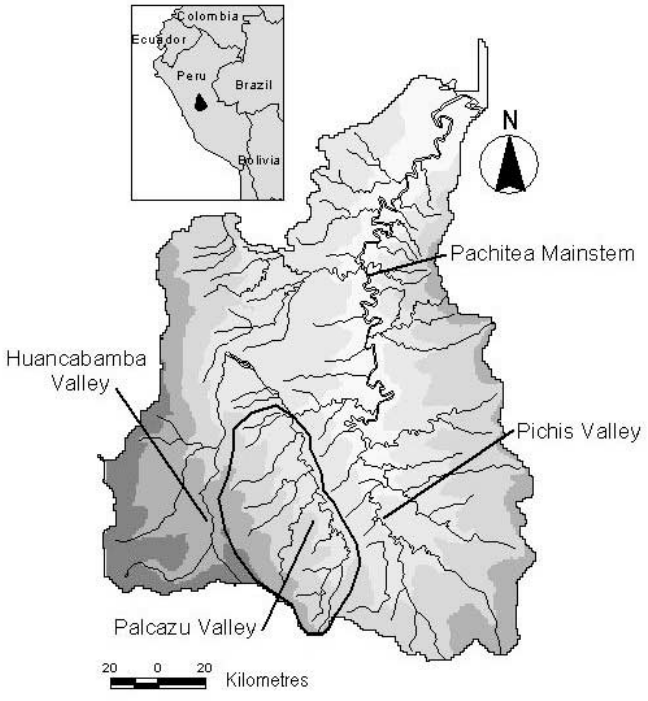

Figure 1 Map of the Pachitea Basin and its major tributary valleys. Shading reflects topography; darker shades indicate higher altitudes. The bold line enclosing the Palcazu Valley delineates the boundary of that catchment.

Figure 2 View of the Iscozacin river where it merges with the Palcazu. Exposed sand and gravel terraces are visible as well as riparian forest extending to the margin of the river. The river is approximately 10 m wide between the gravel bars.

materials on hill slopes and surrounding mountainsides (ONERN [Oficina Nacional de Evaluación de Recursos Naturales] 1982). Soils on the modern alluvial deposits are entisols and exhibit the greatest fertility, with neutral pHs, medium textures, and low levels of aluminium saturation. Soils of the ancient terraces are generally inceptisols; they are more acidic and contain higher levels of exchangeable aluminium, but when well drained they are also considered fertile (ONERN 1982). Soils of the surrounding hill slopes, however, tend to be highly acidic and low in phosphorus and exchangeable cations, making them generally infertile and not recommended for most agricultural uses (ONERN 1982). They consist of both inceptisols and ultisols. More than 75% of the total area within the Palcazu basin is underlain by infertile soils and is too steep for sustained agriculture.

In addition to differences in fertility, the differing disturbance regimes of modern versus ancient alluvial surfaces exert a strong control over their use for agriculture. Modern alluvial surfaces are subject to annual flooding, which can be quite unpredictable and intermittent in the Palcazu valley. Ancient alluvial surfaces, however, are elevated above the modern river channel and subject to flooding only under extreme conditions.

Three social groups can be identified in the Palcazu valley, namely Amuesha native communities, descendants of German Swiss and Austrians who began to colonize the basin in the 1850s, and more recent *mestizo* (of mixed indigenous and European decent) colonists from other parts of Peru. The Peruvian government estimated the 2002 population of the Palcazu valley to be just over 8000 inhabitants, of whom 90% live in rural areas (INEI [Peruvian National Institute for Statistics and Information] 2002). People take their water primarily from rivers and streams of the basin and consume it directly or after boiling (Aparicio 1999). Most households

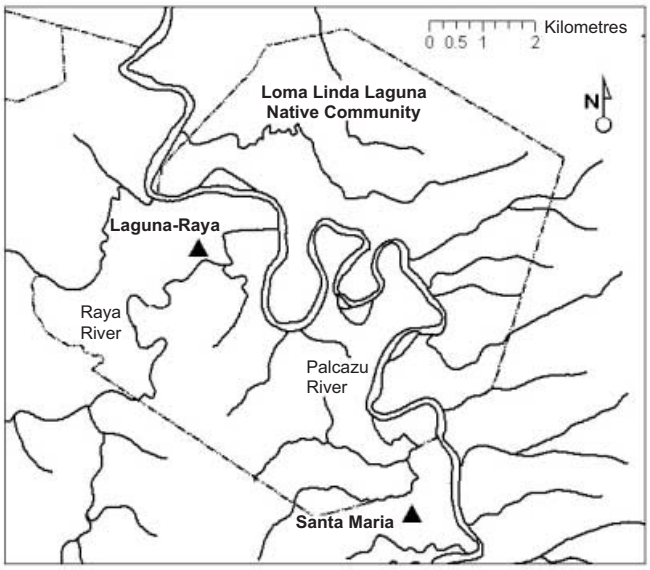

Figure 3 Base map of study sites showing Laguna-Raya within the Loma Linda Laguna native community (demarcated by the dashed line) and the town of Santa María in the south.

also supplement their diet with fish from rivers and streams (Aparicio 1999).

We conducted our interviews in two small communities of the Palcazu valley, Laguna-Raya and Santa María (Fig. 3). Laguna-Raya is an Amuesha native community located along the Raya River at an altitude of 300 m. There is one unique title for the entire community (communal land); however, each community household has a parcel of land. An internal statute governs the community and is amended by communal assemblies of variable frequency. Santa María is a colonist settlement a little higher in the valley (400 m above sea level) and topographically more rugged than Laguna-Raya. The Palcazu River, which runs past Santa María, serves as a major source of water and fish to the community. The community is composed mainly of individual family small farms (*chacras*), the majority of which lie along the river. In Santa María, each colonist family has an individual piece of land, and most families hold titles to their land. The economies of both Laguna-Raya and Santa María are largely subsistence based and centred on the cultivation of crops, the raising of animals, and the complementary activities of fishing and hunting (Cossío 2001).

Survey techniques

Data were gathered in a survey of 79 households and an ethnographic study in both communities between 18 May and 17 July 2001. The entire populations of Laguna-Raya and Santa María were interviewed, with the exception of two households that declined interviews. The ethnographic study consisted of observations, informal conversations and unstructured interviews with householders about their conceptions, classification, use of riparian areas and their activities in general.

The survey was based on structured interviews in which householders were interviewed about their use of riparian areas, economic activities and factors affecting these activities. Because of the travel distances between interviews, we were able to interview on average five households per day in Laguna-Raya and three per day in Santa María.

RESULTS

Access to riparian areas

In the native community of Laguna-Raya, 55% of households had access to riparian areas at the time of the interview (Table 1). Households with no riparian areas within their allotted parcels of land could request access to communal riparian areas. In the colonist community of Santa María 76% of households reported that they had access to riparian areas. Ninety-four per cent of households with direct access to riparian areas in Laguna-Raya, and 88% in Santa María, reported that these riparian areas had had abundant vegetation when they acquired the land. Households in Laguna-Raya reported that they had a mean length of river in their properties of 315 m, while in Santa María, the mean length was 489 m. The reported mean for Santa María excludes an outlier of 3000 m reported by one household. Eighty-eight per cent of people in Laguna-Raya and 75% in Santa María, left a fringe of trees as protection of their lands in riparian areas (Table 2). This fringe was similar between these two communities, the mean being 22.1 m in Laguna-Raya and 27.5 m in Santa María. A large percentage of the

Table 1 Number of households with access to and using riparian areas.

	Laguna-Raya		*Santa María*	
	Number	*%*	*Number*	*%*
Access	33	57	16	76
Using	32	96	16	100

Table 2 Characteristics of riparian areas in each community. ± = standard deviation.

Riparian variables	*Laguna-Raya*	*Santa María*
Mean length of river on property (m)	315 (±279) (n = 31)	489 (±269) (n = 14)
Number of households that leave a protection fringe in riparian area	29 (87.9%) (n = 33)	12 (75.0%) (n = 16)
Mean width of protection fringe (m) in riparian area	22 (±21) (n = 29)	27 (±=27) (n = 12)
Mean protection fringe in riparian area that is forested (%)	99 (±3) (n = 30)	82 (±24) (n = 12)
Mean riparian area under cultivation (ha) per household	1.1 (±0.8) (n = 30)	1.9 (±1.5) (n = 15)

protection fringe was forested in both communities (99% in Laguna-Raya, and 82% in Santa María).

Use of upland and riparian areas

Respondents reported that agriculture was the main activity in both communities and was developed in both upland and riparian environments, although crops planted in the two environments differed. Households in Laguna-Raya cultivated a mean area of 9.4 ha, while in Santa María the mean was 17.3 ha. Most households in both communities cultivated in upland areas (80% in Laguna-Raya and 76% in Santa María). The general system of cultivation in uplands was similar between the two communities. Farmers cut the vegetation in an area, sowed it, and moved to another area after approximately 1.5 years. Fields were left fallow for 3–4 years between plantings. The main crops planted in uplands were manioc (95% in Laguna-Raya and 75% in Santa María) and plantain (56% in Laguna-Raya, and 94% in Santa María). Other reported crops planted in uplands were *pituca*, citrus and coffee.

Agricultural plots in riparian areas were generally small in both communities and the riparian crops were more diverse (Table 3). Households in Laguna-Raya reported cultivating a mean area of 1.1 ha in the riparian area. For households in Santa María the area of cultivation in riparian areas averaged 1.9 ha (Table 2). Manioc and plantains were cultivated within the riparian area (Table 3), but this was generally on non-flooding terraces or further inland from the riverbanks. Corn was a crop planted almost exclusively in riparian areas by both communities. In the only pronounced difference between the two communities, a higher proportion of households in Laguna-Raya reported cultivating peanuts and beans in riparian areas (Table 3).

Table 3 Principal crops in riparian areas.

Crops	*Laguna-Raya producers*		*Santa María producers*	
	Number	*%*	*Number*	*%*
Corn	23	72	9	56
Peanut	15	47	1	6
Bean	13	41	1	6
Manioc	17	53	9	56
Plantain	24	75	8	50
Pituca	7	22	3	19
Citrus	1	3	2	12
Rice	1	3	3	19
Coffee	0	0	1	6
Other	6	19	6	37

Perceptions of importance of riparian areas and rules for their protection

One hundred per cent of Laguna-Raya householders recognized riparian areas as important, with 60% emphasizing the importance of riparian areas for soil protection, 30% emphasizing the fertility of riparian soils, 6% emphasizing the riparian area's role in supporting flora and fauna, and 3% emphasizing the aesthetics of intact riparian areas (Table 4). In Santa María, 81% of householders responded that riparian areas are important for protection of soil (62%) and soil fertility (19%); 19% of those interviewed said that riparian areas were not important and instead posed risks for their crops and property.

Table 4 Perceptions regarding the importance of riparian areas.

Reason for importance	*Laguna-Raya*		*Santa María*	
	Number	*%*	*Number*	*%*
Soil protection	20	60	10	62
Fertile soil	10	30	3	19
Biota	2	6	0	0
Aesthetic	1	3	0	0
Not important	0	0	3	19

In Laguna-Raya, 88% of households reported that they leave a forested buffer between their riparian agricultural plots and adjacent rivers and the average width of buffers was reported to be 22 m. In Santa María, 75% of households reported that they leave a forested buffer and that these buffers average 27 m in width (Table 2).

DISCUSSION

Importance and use of riversides in the Amazon

Archaeologists and anthropologists have long emphasized the importance of rivers and their fertile flood plains in supporting prehistoric and modern human communities of the Amazon (Meggars 1971), and although upland resources are not as scarce as some have proposed (Roosevelt 1999; Smith 1999), there is little argument about the relative richness of floodplain environments (Moran 1995). It is important, however, to distinguish between the flood plains of the Amazon's large tributaries (where most research has been focused) and the riparian areas featured in our study. True flood plains develop along the downstream reaches of rivers, are subject to regular flooding of varying depths, and are characterized by distinctive features such as natural levees, abandoned oxbow lakes, palm swamps, and floodplain forests. Along the large rivers of the Amazon, flood plains may be many kilometres in width (Junk 1993).

Riparian areas, by contrast, lie between non-floodplain rivers and adjoining terrestrial systems and may be flooded, but the frequency of flooding is irregular. Riparian areas develop unique plant and animal communities that are adapted to occasionally saturated soils and high disturbance regimes (Naiman & Décamps 1997). In the Amazon and all river basins, riparian areas border a much larger percentage of total river and stream length than flood plains simply because a majority of any river system's total length is accounted for by smaller rivers and streams. Riparian soils share similarities with floodplain soils by virtue of the occasional flooding that enhances their fertility. Riparian areas are distinct, however, in the degree to which they

directly buffer streams and rivers against inputs of sediments and contaminants from adjoining uplands.

Our results indicated clear similarities between Laguna-Raya and Santa María in the partitioning of specific crops between uplands and riparian areas, with manioc and plantains cultivated preferentially in uplands and corn cultivated preferentially in riparian areas. Differences existed as well, however, in that peanuts and beans were cultivated only in Laguna-Raya. We believe that the absence of these crops in the riparian fields of Santa María is because riparian areas near the community are elevated ancient terraces containing the soils of intermediate fertility. Previous investigators in the Palcazu valley (Smith 1982; Salick 1989; Staver 1989) have also noticed differences in the riparian and upland crops reported here.

While recognizing differences, it is informative to note the similarities between our findings and those from studies of Amazon floodplain environments. In north-eastern Peru, Hiraoka (1986) investigated the agricultural practices of mestizo households in the community of Tamshiyacu, along the Amazon river. There, crops such as corn, beans and rice were grown on annually exposed floodplain soils, and these crops served to complement the manioc that is cultivated on upland soils. Similar patterns of floodplain cultivation have been reported further upstream along the Ucayali river (Padoch & de Jong 1992), and in the Ecuadorian Amazon among Quichua and Shuar indigenous peoples (Danish Environmental Research Programme 1998). Shorr (2000) emphasized the nutritional importance of planting proteinaceous cereals and legumes on floodplain soils to complement the carbohydrates derived from upland plots. His study of the Tikuna community on the Upper Solimões river of Brazil found that corn and melons were cultivated preferentially on floodplain soils. Shorr (2000) was surprised, however, to find none of the 165 households he sampled to be cultivating peanuts or rice on floodplain soils and only one household to be cultivating beans on floodplain soils. Agronomists have recommended for decades that more nutritious and intensive crops be preferentially cultivated on alluvial soils, both as a means of improving the health of basin inhabitants and of lessening pressures to slash-and-burn high-biodiversity upland forests (Sanchez *et al.* 1982; Nicholaides *et al.* 1984).

Our study showed that inhabitants of the Palcazu valley value riparian forest for the ecological services they provide, namely protection and fertility of soil. In a study of a floodplain environment in the upper Rio Negro basin, Chernela (1989) found that Tukano indigenous groups conserve floodplain forests because they know these forests to be important in supporting natural fisheries. In contrast to the fertile alluvial soils of whitewater rivers, the alluvial soils of the blackwater Rio Negro are extremely infertile and their agricultural potential is low. Consequently the Tukano have adopted a management strategy that prohibits the cutting of floodplain forests and emphasizes the maintenance of healthy fisheries, which supply a greater amount of protein to the Tukano diet than could crops planted on the same alluvial soils. Hiraoka (1986) mentioned that the community of Tamshiyacu left forest corridors between agricultural fields and along streams, and he indicated that these corridors served as firebreaks and refuges for flora and fauna. He did not, however, specify whether these corridors were conserved for cultural or legal reasons; neither did he make clear whether the interpretation of their services was his own or whether members of the community expressed it.

To our knowledge, our study is the first to address the perspectives of Amazon people toward riparian forest and degree to which they comply with rules that govern their use. A greater percentage of Amuesha households in Laguna-Raya, as compared to colonist households in Santa María, reported leaving forested buffers along rivers, although the mean width of these buffers was less than that in Santa María. We suspect that the stronger communal structure in the native community results in a greater respect for buffer areas and awareness of their ecological value. Householders in both communities are subject to rules requiring that riparian forests be protected, although the source of these rules differs. Protection of riparian areas in the communal system of Laguna-Raya is required by the community's own General Assembly, which, according to informants, specified that a buffer of forest 50 m wide should be maintained along all rivers. Some householders in Laguna-Raya indicated that the impetus for this rule was the advice of parents and grandparents who had discovered the need for preserving riparian areas through personal experiences, while other householders indicated that the rule was implemented in response to advice given by agronomists visiting the community. In Santa María, the legal titles to land held by householders stipulate that landowners are to leave a 50 m wide buffer of forest along rivers. This figure comes from the Peruvian *Ley Forestal y de Fauna* (law concerning forests and wildlife), which specifies that this buffer be maintained along all rivers and lakes.

Relevance to watershed management efforts

The results of our study hold implications for efforts to develop viable watershed management programmes in the Peruvian Amazon. We found that agriculture in riparian environments is important for the cultivation of crops that do not grow well on less fertile upland soils. These crops are important to the dietary health and economic potential of local people and should be encouraged. At the same time, however, the conservation of riparian forests is important to protect adjacent water quality and aquatic resources on which local inhabitants also depend. The challenge is therefore to exploit the arable properties of riparian areas without compromising the services they provide in preventing water contamination and providing habitat and resources for living resources in rivers.

McClain and Llerena Pinto (1998) stressed the need to implement watershed management activities in the Peruvian Amazon that protect river water quality and quantity *in situ*. In Peru, watershed management (*manejo de cuencas*) focuses

primarily on the reduction of soil erosion (Vasquez Villanueva 1997), and water management is concerned primarily with the equitable distribution of water among users for irrigation and consumption purposes (Intermediate Technology Development Group 1997). These perspectives reflect a strong bias in the country toward the high mountain and coastal desert environments where the majority of the population lives and where in-stream aquatic resources are of less importance to local people. A new, Amazon-centred, approach to watershed management is needed, with emphasis placed on the management of water and aquatic resources at their source.

Financial resources are scarce in the Peruvian Amazon and heavily engineered water management systems are unfeasible. Water management must therefore employ natural tools for water quality management; riparian areas represent one of the most effective natural tools to combat contamination while at the same time supporting aquatic organisms (McClain 2002). This study has shown that both indigenous and colonist inhabitants of the Pachitea basin recognize the values of riparian areas for conservation purposes and generally leave continuous forest buffers along rivers. Resource management efforts should move quickly to implement programmes that reinforce the current good practices of local people, further educate local people on the ecosystem services provided by riparian areas, and strengthen the institutional framework for maintaining these practices into the future.

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