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A tradition of change: the dynamic relationship between biodiversity and society in sector Muyuy, Peru

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Abstract

The theme of biodiversity and society provides an opportunity to look beyond skewed environmental ideologies that impel biodiversity researchers to ignore land "tarnished" by humans in search of "pristine" ecosystems. Data reported and analyzed in this paper test and draw conclusions based on a non-partisan stance that recognizes biodiversity as a product of complex natural and anthropogenic interactions. The data in this paper describes this process in the Amazon floodplain of sector Muyuy, Peru. A smallholder tradition of adaptive change in this highly precarious and unstable landscape provides a dynamic foundation upon which biodiversity is produced, managed and conserved. To examine this tradition of appropriate response to change, data was collected on land-cover dynamics using Landsat images and biodiversity inventories and household surveys of resource use technologies and conservation practices were carried out. Through complex agricultural technologies, sector Muyuy smallholders, known as ribereños, use a highly differentiated and dynamic environment to produce a great diversity of crops while creating habitats for endangered and over-exploited species of fish and river turtles, plants, and other species. Ribereños are smallholder farmers, fishermen and forest managers. They are the descendents of several indigenous groups as well as migrants from Europe, Asia and Africa. Most of the rural inhabitants of Peruvian Amazonia are ribereños. In Muyuy, we found that ribereños manage an average of 76 tree species per ha, including tropical cedar and other over-exploited timber species. We conclude that meaningful attempts at biodiversity conservation must begin at the interface between ecological and social processes and incorporate locally developed knowledge and practice. Published by Elsevier Science Ltd.

Keywords: Smallholders; Floodplain; Amazon; Biodiversity; Ribereños

1. Introduction

The theme of biodiversity and society provides an opportunity to look beyond skewed environmental ideologies that lead biodiversity researchers to ignore land "tarnished" by humans in search of "pristine" ecosystems. Many experts suggest that biodiversity is the result of natural processes (Terborgh, 1999) and relegate social processes to a category of "disturbances". In contrast, the anthropocentric point of view, proposed by many social scientists, argues that much biodiversity—including that in Amazonia—is largely the result of long-term human intervention and manipulation of natural processes (Raffles, 1998). The major objective of the data reported and analyzed in this paper is to test and draw practical conclusions, evaluating partisan positions in favor of a more balanced view that biodiversity is a part and product of complex and linked natural and anthropogenic interactions.

In response to the biodiversity crisis, many advances have been made in identifying endangered organisms, ecosystems, landscapes and environments. Most specialists agree, however, that the scientific community must seek more effective ways of mitigating these threats. Common approaches to this goal include the establishment of a multiplicity of protected areas, including UNESCO's Biosphere Reserves, as well as other forms of parks, community-based reserves and others. These efforts have produced limited results and it is clear that new approaches are required to conserve or restore species, ecosystems and landscapes on a regional and global scale. There are several reasons why the establishment of formal protected areas has failed to stem

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the rate of species extinction and damage to habitat-rich landscapes. In Amazonia, as in most areas around the world, considerable numbers of threatened species, habitats, ecosystems, landscapes and environments exist entirely outside the boundaries of parks, reserves and other conservation units. Most of these riches are located in areas used for the production of economic goods by human communities. In this paper, therefore, we seek to examine the crucial ecological and social processes associated with resource use and land-cover dynamics that influence changes in biodiversity levels over time and space in the floodplain region of Muyuy, a biodiversity-rich zone located outside protected areas in Peruvian Amazonia.

In looking beyond protected areas we are able to capture effective responses to a dramatic series of natural and social processes influencing biodiversity. Ribereños are smallholder farmers, fishermen, and forest managers. Most of the rural inhabitants of Peruvian Amazonia are Ribereños. Tradition in ribereño society is not one of homeostasis, but one of continuous interaction with a constant flux in social and physical landscapes. The ribereño tradition is a 'tradition of change' that demonstrates the production, maintenance and conservation of biodiversity by inhabitants of a highly dynamic floodplain.

Based on field observations, we argue that ribereño technologies and knowledge are valuable resources to be appreciated by conservation and development agencies. Smallholder technologies described in this case study can act as a foundation for sustainable resource use, thus reducing landscape and ecosystem destruction, as well as species loss. Numerous studies have shown that swidden-fallow or shifting cultivation systems maintained by smallholders contain much more biodiversity than do more "modern" land use systems such as cattle ranches, industrial plantations and others that are part of the current development models promoted in Amazonia (Brondizio and Siqueira, 1997; Pinedo-Vasquez, 1995; Anderson and Ioris, 1992). Solutions to the biodiversity dilemma will more readily come from studies that explore the multitude of social interactions with biodiversity and evaluate land use systems that conserve or damage Amazonian biodiversity. This goal cannot be reached by treating society as a unit that is either present or absent and biodiversity as an element that is either pristine or destroyed.

While most experts agree on the ecological value of biodiversity found in the landholdings of smallholders, there is little appreciation for its role in helping to improve living conditions. Smith (1996) has suggested that Amazonian peasants, particularly indigenous people, cannot benefit from the conservation of biodiversity. While the residents of Muyuy, as well as most indigenous and non-indigenous people in Amazonia, do not benefit from the biodiversity protected in parks and reserves, they do benefit from the biodiversity that they produce, manage and protect in their landholdings. Experts continue to argue these points largely because: (a) information on biodiversity managed by smallholders in Amazonia is incomplete and has yet to be presented in a consistent and accessible form; (b) most researchers do not understand the role of biodiversity in the livelihood of peasants; and (c) agrobiodiversity and other forms of biological diversity produced by residents of Muyuy and other regions are often not considered important biological resources.

Most quantitative studies on the biodiversity used, produced and managed by ribereños report only a small fraction of the total diversity found in their landholdings. For instance, many studies of species diversity conducted in estuarine floodplain environments only evaluate housegardens and not the many other land use stages or field types found in peasant landholdings (Anderson and Ioris, 1992). In this paper we incorporate and report the existing biodiversity produced and maintained by smallholders in the fields, fallows, housegardens and forests. In addition, we document the diversity of landforms and water bodies where ribereños produce, manage and collect resources.

2. The Muyuy floodplain

The Muyuy floodplain is located near Iquitos, the largest urban center in Peruvian Amazonia, and is populated by ribereños (Fig. 1). The population of Muyuy in 2000 was approximately 3740 persons distributed in 38 villages. Muyuy is one of the most densely populated rural floodplain regions in Amazonia with about 67 people/km^2. The age and gender composition of the sector Muyuy population is roughly similar to that of other Amazonian regions (Fig. 2). Muyuy's population is remarkably young. Pinedo-Vasquez (1995) found that more than half of the young population (62%) migrates to urban centers around the age of 15. This explains why, despite the population structure, the size of ribereño villages are relatively stable and resources are still available. Population growth in the rural area is not a major concern in the near future.

The total area of the floodplain known as sector Muyuy is approximately 292 km^2 of which approximately 223 km^2 is land and 69 km^2 is river during the season when river levels are at about an annual midpoint. Muyuy is an area dominated by a yearly flood cycle during which river levels rise and fall an average of over 9 m. When river levels are at their lowest annual level the total land surface area increases by about 30%; when they are at their highest level, virtually all land gets submerged. Due to its location within a highly dynamic floodplain, Muyuy includes a diversity of environments exposed to flooding of varying intensities and frequencies, riverbank erosion and deposition due to lateral migration, as well as other powerful fluviodynamic processes. The exact timing and height of floods varies from year to year.

The flood regime is not the only agent of change and instability in Muyuy. The sector also includes a great diversity of human settlements and production types that

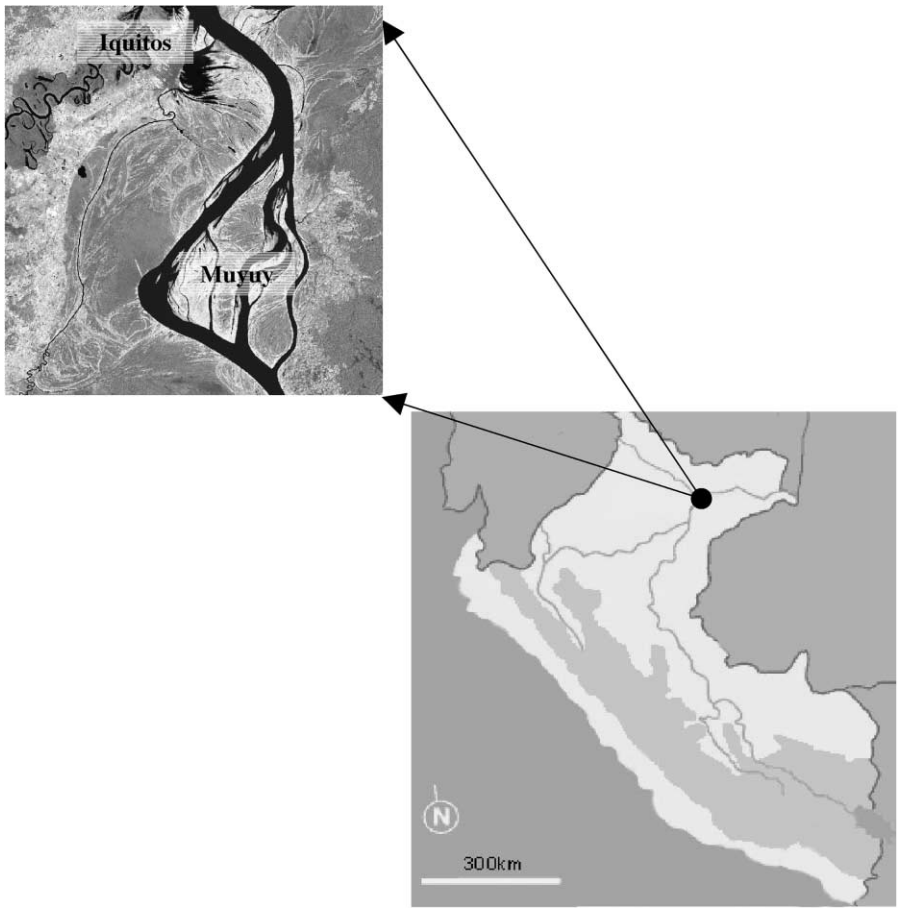

Fig. 1. The Muyuy floodplain is an island in the Peruvian Amazon.

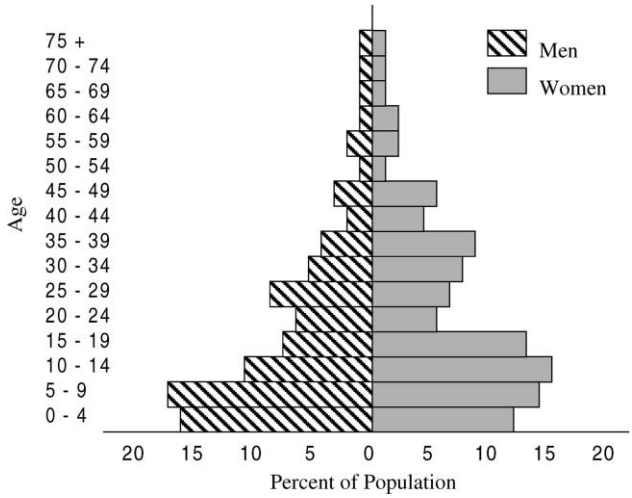

Fig. 2. Age distribution in Muyuy for the year 2000.

have created and altered landforms, water bodies and, particularly, vegetation. Virtually all of Muyuy's landscapes are constantly subject to complex and inter-linked natural and anthropogenic processes. These processes are highly variable and unpredictable in their frequency, intensity and spatial characteristics. In order to endure and prosper in this environment, historical data show that the residents of this region have developed technologies and strategies for managing and maintaining these processes.

Residents of Muyuy take advantage of fluviodynamic and other natural processes to produce, transform, and conserve agrobiodiversity and other forms of biological diversity in their landholdings and surrounding environments. Smallholders intervene in natural processes through complex agriculture, agroforestry and other types of production and management technologies as well as conservation practices. As ribereños interact with natural processes, socioeconomic factors are also constantly altering the availability of resources and their value. Political change, including variation in regional, national, and international economic development and credit policies are yet other sources of change and instability that have long affected the biodiversity of Muyuy's environments.

Several development and conservation initiatives have been and continue to be tested by governmental and non-governmental agencies in the villages of Muyuy. Abandoned buildings, machines and other evidence of development projects are scattered over the Muyuy landscape. Despite numerous projects produced by decades of political

and economic pressures to promote "improved" and "modern" production systems developed elsewhere and to reduce landscape and crop diversity, most of the production systems and techniques used by smallholders in Muyuy are based on locally developed technologies.

The ribereños of Muyuy and neighboring communities typically engage in multiple production and management activities. Their landholdings contain an immense diversity of species, ecosystems, landscapes and environments. In Muyuy, the ribereños' knowledge of diversified resource use and their dependence on a large number of produced, managed and collected resources have enabled them to resist large-scale clearing of their forests for sugar cane plantations, pastures or other single use systems promoted by development projects. This contrasts with other Amazonian floodplain regions, for instance near urban centers such as Manaus and Santarem, where the rate of land conversion to cattle ranches and other single use systems is very high. Consequently, those areas have greatly impoverished biodiversity (Junk et al., 2000).

The livelihoods of all Muyuy households integrate complex agriculture, agroforestry and other types of conservation, production, and management technologies. Local histories as well as our recent data show that these locally developed technologies and conservation practices are dynamic and change to adjust to social and ecological processes. They have also resulted in a notably patchy landscape.

Within this diverse and patchy landscape are small populations of several threatened species. Proponents of limited access conservation strategies incorrectly attribute the species loss to the patchy "non-pristine" landscape. In Muyuy, however, most species listed as over-exploited and endangered are the victims of regional and global market forces. Currently, the over-exploited forest species are found only in the landholdings of smallholders. Likewise, populations of paiche (*Arapaima gigas*) can be found only in lakes that are protected by the Muyuy residents in village or inter-village reserves.

3. Research methods

Data reported in this paper were gathered over a 5-year period (1996–2000). Most information on physical changes in the landscape (including vegetation cover) was obtained using a series of Landsat images from 1987, 1995 and 2000. Information collected from these images was checked in the field and compared with data collected using land surveys and from archives in Iquitos.

Two demographic censuses (collected in 1997 and 2000) provided data on the resident and itinerant populations of the area. Information on natural and political-economic processes was also collected through interviews with selected informants. Interviews as well as land surveys were used to identify the origin and age of landforms, water bodies, and vegetation that form the Muyuy landscape. Records on economic booms and busts, as well as changes in land tenure and use were also collected in interviews with the oldest residents of Muyuy and by reviewing documents in archives located in public offices in Iquitos.

The number and area of village or inter-village lake reserves, family-protected forests and other conservation areas were recorded during land surveys. Information on local rules and means of enforcement was collected for each protected area. The names of threatened species and environments at risk of being converted to simplified resource uses were also recorded. Data on the number and size of fields, forests and housegardens made and maintained, were collected annually during the 5 year study. The sample includes 84 landholdings in 14 of the 38 villages in Muyuy (six landholdings per village). The size of the household sample was the result of a self-selection process that occurred during the first 2 years of the study period. Information for each sample property includes the number and area of fields, fallows, forests and housegardens as well as the type of landform in which they were located. Together with family members (men, women and children), hand-drafted maps were drawn for each landholding, representing its location within the landscape and the spatial distribution of the fields, fallows, forests and housegardens.

The diversity of agricultural and other production and management technologies practiced by members of 84 households was investigated using participant observation techniques. We accompanied members of the selected households in their daily activities and observed and recorded production and management techniques. Information collected from each household was crosschecked during group discussions and dialogues with the most knowledgeable members of each household and community.

The planted, protected, managed or conserved agrobiodiversity and other forms of plant diversity within fields, fallows, forests and housegardens of each sampled landholding were inventoried three times over the 5 years. Plant diversity in forest areas was measured in 1 ha randomly selected plots for each of the 84 sampled landholdings. Individual plants with a diameter at breast height (DBH) equal or more than 5 cm were inventoried in a sample of 168 (2 in each 1 ha sampled forest) randomly selected sub-plots of 25 m × 25 m. Plant diversity in fallows was quantified for a sample of 252 plots of 20 m × 20 m that were randomly selected in the 84 sampled landholdings. Fallows where plots were established ranged from 5 to 8 years old and are managed for several products. We selected a sample of 120 housegardens to record plant diversity. The average size of each garden was 1.8 ha. In each inventoried plot and sub-plot established in forests, fallows and housegardens we recorded the common name, height, DBH, life form (tree, shrub, vine, grass or herb) and location of each species. We also quantified species and varieties of planted or protected crops three times during the 5-year study in 150 fields that were made by the 84 sample families at the beginning of the

high water and low-water seasons. Due to the heterogeneity of the landscape we estimated β-diversity in addition to the species richness and Shannon index.

4. An overview of natural processes and responses

Sector Muyuy is part of the highly dynamic central Amazonian floodplain (Kalliola et al., 1993). The region comprises heterogeneous landscapes that include a great diversity of human settlements, land formations, water bodies and vegetation cover. Based on examination of three sets of Landsat images, major changes in the direction of the river and the location of structural features have taken place from 1987 to 2000. One of the major changes in the landscape was the formation of an oxbow lake at the north end of Muyuy (Fig. 3a). The formation of this oxbow lake was the product of sedimentation of a secondary channel near Iquitos and the lateral migration of the Amazon river. The formation of the lake and the closure of the secondary channel left Iquitos disconnected from the main river channel for a considerable part of the year. This change creates an obstacle for ribereños bringing their products to the city markets. Riverbank erosion has significantly reduced the size of the large and populated island of Padre. Two of the five villages located on this island were abandoned because of severe erosion during the flooded period and their inhabitants moved to the other side of the river and founded two new villages. This type of adaptation is common in the region. Padoch and de Jong (1992) report that a village

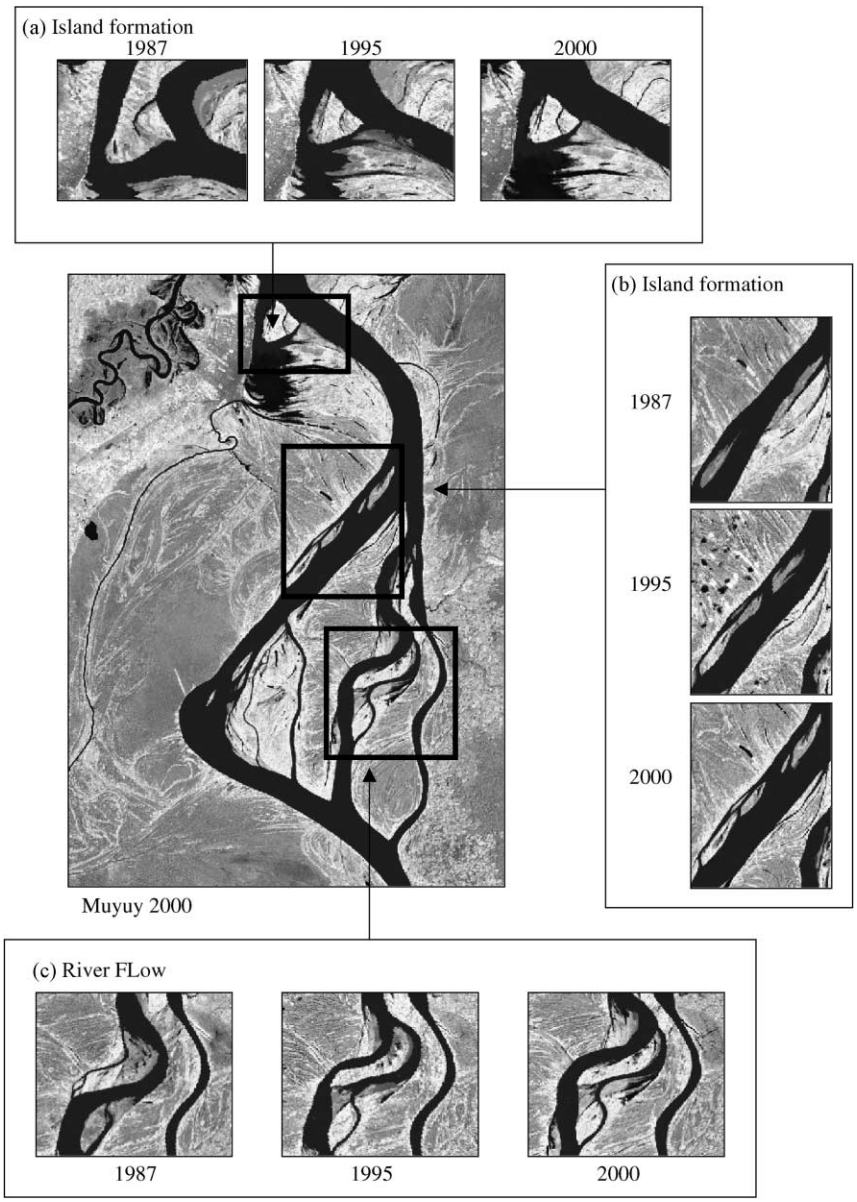

Fig. 3. Landscape changes in three regions of Muyuy from 1987 to 2000.

located in the Ucayali floodplain switched from one bank to the other more than five times in the last 50 years.

Another important change in Muyuy has been the formation of several small islands near a large island in the center of Muyuy (Fig. 3b). Residents of the large island reported an increase in sedimentation and an increase in the height of levees near the community. Villagers also reported major changes in the size and number of streams, landforms and vegetation cover since the appearance of the small islands. The change in area and number of landforms and streams caused several important economic shifts. These include an increase in fish populations, an expansion of silt bars available during the dry season for planting annual crops, and of high levees for planting perennial crops and making agroforests.

The formation of secondary channels at the south end of Muyuy is perceived to be the most important change since 1987 (Fig. 3c). Since the formation of the secondary channel, the river current at this section of Muyuy is stronger and navigation is increasingly dangerous. As the current of the river became stronger, the five oxbow lakes became shallow due to sedimentation, and currently all three dry out when the river level is low. Villagers plant rice and other annual crops in the dry lakes. In addition, a strong current is removing the vegetation along the new stream forming a number of small new stream channels that facilitate access to forest resources at the interior of the large island. Enhanced access to this area has led to an increase in the extraction of catahua (*Hura crepitans*) and other timber species. This in turn has prompted the villagers to control access to the resources and their extraction. For instance, community rules were established to prohibit outsiders from extracting timber within the community territory, while residents limited their extraction to four adult trees (DBH greater than 55 cm) per year. Such shifts in village control illustrate how ribereños effectively use and vary conservation actions in response to changes resulting from fluviodynamic processes and market modifications.

5. A history of economic booms and busts

Oral histories, as well as historical and geographic information reveal that the social and economic processes that lead to change in Muyuy have been no less complex and dynamic than the natural ones. Over the last century the Muyuy floodplain has been subject to different intensities and forms of land and resource use. Many of these were generated locally although others resulted from changes in far-off markets as well as from more direct outside interventions in the form of development and conservation projects.

In Muyuy patterns of commercial production and extraction have varied greatly in response to recurring but ephemeral economic booms and busts. Although the Rubber Boom has been widely discussed, many other such economic fluctuations have affected Muyuy. One of the early booms of the 20th century was based on the extraction of firewood for fueling steamboats as well as on the cutting of high-grade timbers such as tropical cedar and mahogany for export to international markets. The main impact of this boom was the virtual depletion of populations of the four most valuable timber species: tropical cedar (*Cedrela odorata*), mahogany (*Swietenia macrophylla*), lupuna (*Ceiba pentandra*) and capinuri (*Maquira coreaceae*).

Muyuy residents also witnessed and participated in the extraction of river and land resources for international markets several times in recent history. A major boom occurred during the Second World War. Turtle eggs were intensively collected and processed to fill the industrial demand for lubricants, supplies of which had been disrupted during the war. One of the negative results of this boom was the drastic decline of the population of charapa (*Podocnemis expansa*), the giant river turtle, which is now considered to be one of the most endangered species in Amazonia.

The disruption of the supply of leather in international markets produced by the Second World War also had considerable repercussions on the populations and current situation of wildlife in Muyuy. The residents of Muyuy were engaged in hunting jaguars, black caimans, peccaries, river otters and other large game for their skins to supply world markets with leather. During this time populations of most large game animals suffered and in cases such as the black caiman and jaguars, they were totally exterminated from the region. Similarly, the increased demand in regional and national markets have greatly reduced the population of paiche (*A. gigas*) fish in the lakes of Muyuy and other regions.

A third major disruption affecting the residents and resources of Muyuy came as a result of a series of economic shifts, the most important one of which was petroleum exploration in Amazonia in the 1970s. While ongoing oil production employs few local residents now, the era of exploration and construction of an oil pipeline provided opportunities to many rural men to escape traditional forms of labor and production in the region and to earn substantial cash incomes for the first time. One of the eventual impacts of this boom was the migration of a considerable part of Muyuy's population to the city of Iquitos. Many of the families that remained in the villages had the means to purchase a house or land in the shantytowns of Iquitos during this period. Another important impact of the oil boom was the collapse of a number of family-run enterprises in the sector Muyuy known as *fundos*. The *fundos* of Muyuy had largely produced sugar cane for processing into a rough cane alcohol. Since the 1950s *fundos* had been losing their regional economic importance due to complex shifts in local society and in marketing patterns (Santos-Granero and Barclay, 2000). During the petroleum boom *fundos* lost their source of cheap rural labor and finally collapsed. They also lost out because they could not compete with the low-priced sugar cane alcohol imported from Brazil. With these shifts the production of sugar cane on a relatively large scale in Muyuy came to an end.

The fourth economic change in Muyuy that we will mention was largely an attempt to revive sugar cane production and the commercial production of alcohol. This time, however, the financing and implementation came in the guise of an internationally funded development project. From 1977 to 1983, the government of Italy provided capital for large-scale planting of sugar cane on the former fundo lands. The scheme, which involved cane cultivation on a larger scale than had been seen before, as well as the provision of agricultural credit, formation of growers' cooperatives, and the building of a sugar mill, met with failure within a few years.

The reluctance of smallholders to convert their land into larger-scale sugar cane plantations as was required for accessing the agricultural loans, and the low prices of alcohol in the markets, led to the collapse of the Italian development efforts. Several other schemes followed, including a loan program for the production of rice (particularly on silt bars) and *Urena lobata* (particularly on low levees) for smallholders. These programs, that lasted until the end of 1980s, are remembered by the majority of Muyuy residents as *la bella epoca*. This period was a "golden age" for the area's smallholder producers because the loan programs had provided them with capital during the time of the year when some supplementary funds were needed to produce annual and other crops after floods.

6. Ribereño responses to resource depletion

The periods of booms and busts profoundly affected important biological resources of the region. At various times and places timber, animal, and land resources of Muyuy appeared to have been depleted. Each time, however, ribereño villagers responded to these changes with mitigating actions. During and after the firewood and timber booms, for instance, ribereños actively engaged in planting, managing and protecting individuals of these species, and they continue to do so. As a result of their little-recognized conservation efforts over many years the landholdings of ribereños again contain healthy populations of the four formerly severely over-exploited timber species (Table 1). Throughout these woodland areas one finds evidence of how these species are being managed. One indication that trees of valuable species are being deliberately propagated is that individual adult trees that farmers selected and maintained as seed producer trees to maintain reproduction of the species are found throughout Muyuy forests (Table 1). Despite the obvious conservation value of keeping productive trees that help to produce seeds and seedlings for the restoration of the four over-exploited timber species, conservation experts have regularly ignored such contributions of ribereños and their management methods (Vasquez and Gentry, 1989).

Table 1
Average number of seed producer trees found on forest holdings owned by 64 sample families in Muyuy (average holding size 15 ha)

Species	No. of individuals	Average DBH (cm)
S. macrophylla	18	48
C. odorata	42	64
C. pentandra	12	112
Maquira coreaceae	58	75

Responses to the depletion of wildlife to supply oil and skins for the war effort are also evident. Despite the allegations of some conservation experts, ribereños have not been passively allowing their wildlife to disappear, reacting only when outsiders show them how to save their animals and other precious resources from extinction. They have long employed a diversity of strategies to protect and restore the populations of over-hunted and over-fished resources. Muyuy residents have established several village and inter-village reserves to protect and restore populations of paiche, river turtles, black caimans and other lake resources. As a result of such efforts, some of the protected lakes contain healthy populations of these animals (Table 2).

Although the adult populations of threatened species in the three lakes are still very low, they are playing an important role in the restoration of populations in and around Muyuy. In addition, the much maligned swidden agricultural system practiced by smallholders and the ways in which individual families control hunting, collection of fruits and other forest resources is helping to restore populations of wildlife. Results of wildlife surveys conducted in a sample of 15 forests owned by families shows a great diversity of wildlife species including the over-hunted paca, locally known as *majaz* (*Dasyprocta paca*), agouti, known as *añuje* (*Dasyprocta agouti*) and others. Hiraoka (1992), also found that villagers of San Jorge (a village near Muyuy) maintain considerable populations of deer, paca and other small game. They have continued to hunt these species but at a

Table 2
Average number of adult paiche (*A. gigas*) more than 1 m long, giant river turtle (*P. expansa*), taricaya (*Podocnemis* spp.) and black caiman (*Melanosuchus niger*) of more than 1 m long, that were inventoried in three inter-village lake reserves in Muyuy

Threatened species	Lake 1	Lake 2	Lake 3
Paiche (*A. gigas*)[a]	12	27	8
Giant river turtle (*P. expansa*)[b]	9	4	6
Taricaya (*Podocnemis* spp.)[b]	52	76	48
Black caiman (*M. niger*)[a]	13	18	7

All censuses were conducted following the methods and techniques recommended by expert fishermen and hunters of turtles and caimans from the villages. We are reporting average number of individuals per lake. An estimated size of each lake is 27 ha for lake 1, 19 ha for lake 2 and 23 ha for lake 3.

[a] The population of black caimans and paiche were recorded combining capture and observations in the lake and surrounding areas during the lowest level of the river.

[b] Adult taricaya and giant river turtle were inventoried in the lakes and the surrounding areas by sight and by counting the number of tracks and nests.

rate that does not lead to precipitous declines in their populations. These and other data show that ribereños and their conservation practices can help restore populations of valuable and threatened terrestrial and aquatic resources that were over-exploited during the Second World War and later.

7. Ribereño technologies and conservation practices

Ribereño resource use systems and production technologies have evolved to take advantage of the environmental heterogeneity produced by natural, including fluviodynamic, processes. The farmers of Muyuy do not plough, level or drastically change the topography and soils of the diverse biotopes that compose the three main land formations of the floodplain. Ribereño families produce and collect resources from all the 39 "planting environments" that compose the main land formations (Fig. 4). Ribereños employ diverse and complex production and management technologies to inter-crop several species and varieties of annual and perennial crops in each of the land forms that compose the varzea landscape. Using the tremendous diversity of terrain, soils, temporal qualities and other subtle differences as a resource, Muyuy's small farmers plant an average of 13 species differentiated into 40 varieties of annual crops on ephemeral sandbars. Another 22 species and 74 varieties are planted on silt bars. The average number of species and varieties of agricultural, agroforestry and forest crops planted by ribereños on levees is much higher than in silt and sand bar environments, with 82 species and more than 260 varieties of plants in all their production spaces (Fig. 4).

Ribereños' diverse resource use systems optimize the use of local and environmental heterogeneity. Their landholdings are a complex mosaic and together form a patchy landscape. The average size of a ribereño household's landholdings is 25 ha., comprising an average of five patches or plots of forest, nine patches of fallow, three distinct patches of agricultural field and one house garden (Table 3).

Table 3
Average number of patches and area (ha) of forests, fallows, fields and housegardens that composed a typical property owned by a ribereño household

	Average no. of patches	Average total area (ha)
Forests	5	15
Fallows	9	8
Fields	3	0.8
Housegardens	1	1.2

Averages were estimated from land surveys conducted in 84 sampled households in 1997 and 2000.

Although data have been collected for only 5 years, we can clearly see a pattern in the number and sizes of forests, fallows, fields and housegardens where ribereño households produce, manage and conserve floodplain resources. The data show that the number and area of agricultural fields are very small in comparison to the extent of managed forests and fallows. The relatively small size of fields made by ribereños and the large areas of fallows and forests found on their properties have led some to conclude that ribereños are more extractors than producers (Kalliola and Flores Paitan, 1998; Brondizio and Siqueira, 1997; Anderson and Ioris, 1992). Based on this and other misleading generalizations, development agencies designed their agricultural projects to increase the size of agricultural fields. Their agricultural credit aims to promote the planting of one or a very few selected crops. These programs hope to make the ribereño a farmer rather than forest extractor.

The goals of many conservation projects are largely similar to those promoting agriculture. Their most salient difference is that they tend to focus on the promotion of agroforestry. Such programs are also meant to reduce ribereño dependence on the extraction of forest and river products.

While the argument among experts on exactly what constitutes an extracted and what a produced resource will doubtless continue, data collected in Muyuy show that it is very difficult (and probably pointless) to identify which products

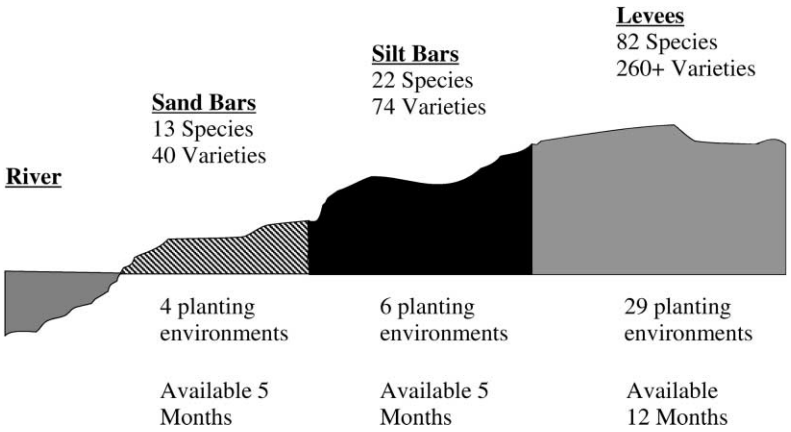

Fig. 4. Vertical representation of three main land formations in the Muyuy floodplain. The number of environments and the species and varieties of crops that are planted and protected by ribereños are given for each formation.

are extracted and which are produced by ribereños. However, there is much evidence that shows that ribereños use highly diverse, complex and sophisticated technologies for producing, managing and protecting floodplain resources. Muyuy households have small farms not because they are lazy, ignorant, or are "forest people". The farmers of the area are industrious and productive farmers and agroforesters, but they are not conventional farmers and agroforesters. Sector Muyuy is not a conventional place for farming and agroforestry. The dynamism and uncertainty that has long characterized both the natural and socio-economic environments of floodplain Amazonia have led to the development of resource management patterns that emphasize diversity, adaptation, and flexibility. Such technological knowledge is rarely found among groups such as timber companies or large-scale commercial fishing concerns, nor is it often found in externally planned and financed development projects.

As research done in other parts of Amazonia shows, many complex and "indirect" local resource management patterns are easily misunderstood and ignored (Pinedo-Vasquez et al., 2001). For instance, ribereño residents of Muyuy maintain large stocks of fish in their lakes by protecting the floating grass meadows and riparian vegetation surrounding the lakes. Similarly, populations of rodents and other forager species are managed by protecting fruit species that were planted or protected. Stocks of commercial volume of timber species found in Muyuy are also the products of long processes of management that originated with the protection of spontaneously occurring seedlings and seed producer trees in the fields and fallows. These and other systems of resource use can be lost if experts persist in categorizing ribereño resource uses as pure extractivism and promoting conventional approaches to production and conservation. Perhaps the greatest risk in this situation is that of inadvertently causing the disappearance of management and production techniques and methods that could be used for developing effective actions to confront the biodiversity crisis.

A close evaluation of ribereño landholdings shows that Muyuy farmers maintain high levels of biodiversity in their production spaces. Under the widely employed swidden-fallow system the diversity of plants increases from field to fallow and from fallow to forest (Fig. 5). Such practices explain why the residents of Muyuy not only plant crops, but also protect the seedlings and saplings of forest and agroforest species that appear in their agricultural fields. The average number of species and varieties of crops found in each of the fields sampled in Muyuy is higher than those reported in fields owned by smallholders within colonization projects (Anderson and Ioris, 1992). Although fields are still made using swidden techniques, we observed that most farmers are opting not to burn the slash. Plant diversity is also encouraged by the selective way swidden fields are weeded.

Those fields that eventually mature into fallows rich in economically valuable plant species are known as *purmas cuidadas* or enriched fallows; where few seedlings protected in fields survived the process of aging, farmers have "wild fallows" or *purmas remontadas*. Ribereños use these wild fallows to make new fields and manage the enriched fallows for the continuing production of agroforestry and forest products. The general pattern observed in Muyuy and reflected in the biodiversity inventory data is that smallholders tend to maintain or in some cases increase levels of biodiversity as fields age in order to increase the number of products available in the fallows (Fig. 6). The range of Shannon index values ($H' = 2$–3.5) shows that while ribereños maintain biodiversity-rich fallows, differences in Shannon index values among fallows clearly demonstrate that biodiversity levels vary considerably with the intensity and frequency of the owners' interventions (Fig. 6). Farmers who were interviewed corroborated the estimated Shannon index values, by mentioning that vegetation in fallows where no management operation were conducted tend to be dominated by individuals of cetico (*Cecropia membraneaceae*).

Thinning and removal of vines are the main management operations applied to fallows. Muyuy farmers are, however continually experimenting and adapting or developing new management techniques. This transformation and innovation of technologies may be driven by recently increasing prices for some agroforest and forest resources. For instance, field observations indicated that the residents of Muyuy make

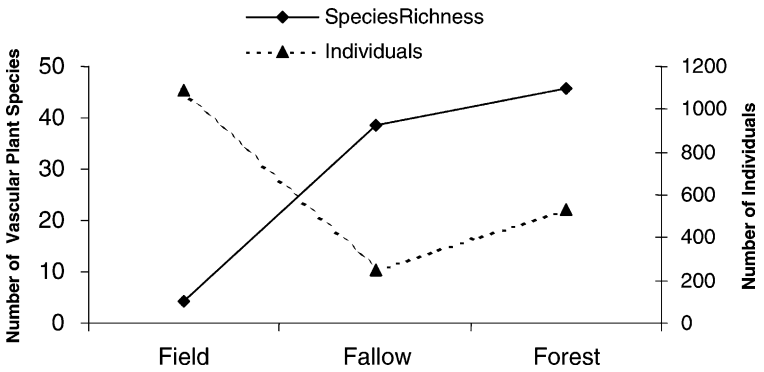

Fig. 5. Succession of biodiversity in phases of swidden-fallow systems practiced by the residents of Muyuy.

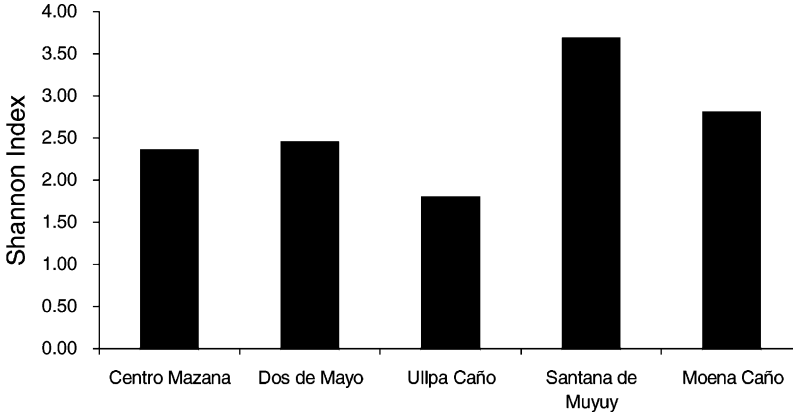

Fig. 6. Variation in fallow diversity ($n = 5$; area $= 900\,m^2$).

small openings (or *clareras*) in their fallows to plant or transplant lemon and several species of medicinal plants. Small farmers collect the seeds of several forest species, such as tropical cedar (*C. odorata*) and species of the *Musaceae* family locally known as bijao, to broadcast in their fallows. The frequency and intensity of removing termite nests, along with other operations to control pests, is also increasing as a result of the economic importance of fallow products. Farmers' decisions to convert fallows into fields or forests are largely based on how well the production of agroforestry products is faring, and on whether forest species, such as of timber are dominating the vegetation.

The majority of forest areas that are part of the landholdings of ribereños are the results of successive management operations that began at the field stage and continued into the fallow and forest stages. Inventories conducted in a sample of seven plots of forest (each $900\,m^2$ in size) of multiple ages show that the forests in ribereño landholdings contain high levels of species richness. The mean average number of plant species per hectare (76), estimated using data collected in the five plots, is greater than richness (52) found in forests that were not reported to be managed (Kalliola and Flores Paitan, 1998). There were dramatic contrasts in species composition between sites. These differences reflect the histories of management and resource extraction practiced by their owners. Field observation and interviews suggest that some ribereños are more dedicated to enriching their forests with timber species, while others are more interested in fruit and medicinal species. Despite the abundance of commercially valuable plant species, inventory data show that ribereños also maintain small numbers of individuals of some non-commercial species. Among these are pioneer species such as *C. membraneaceae* that play an important role in attracting game animals and fish during floods.

As in the case of managing fallows, the residents of Muyuy use complex forest management technologies to produce economic products while maintaining important ecosystem functions. The abundance and dominance of economically important species is maintained through the application of management operations that promote the regeneration of species under varying light and environmental conditions. Ribereños conduct pre-harvest operations to avoid excessive damage to the forests, thus improving production. Among the most recent and innovative operations is the broadcasting of seeds or planting of seedlings of valuable species before cutting timber. Most seedlings are collected from other parts of the forests; the seedlings of the four over-exploited species mentioned above are, however, produced in housegardens. Within the housegarden category the Muyuy residents maintain orchards, nurseries as well as areas for raising domestic animals. Housegardens are also rich in species and produce a large variety of products.

Results of the biodiversity surveys presented in this paper show that a great diversity of resources are produced, managed and protected by ribereños in their landholdings. The reported levels of agrobiodiversity and other forms of biodiversity should add useful biological data and further clarify the complex and diverse operations and technologies used by smallholders that produce and maintain Amazonian biodiversity outside formally protected areas.

8. Conclusions

The Muyuy case shows that ribereños do not separate conservation from production as is done by experts engaged in the promotion of conventional development and conservation programs. The dynamic nature of the floodplain, with a high local turnover of habitats and species, creates ecological conditions for resource use systems embedded in both conservation and production practices. Residents of Muyuy are producing to conserve and are conserving to produce as part of a long tradition of making their livelihoods in a rich but highly risky environment characterized by extreme natural and social dynamism. Such a "tradition of change" has allowed ribereños to profit economically while enhancing the conservation of floodplain biodiversity. Data presented in this case study also show that ribereño traditions of

resource use produce patchy landscapes and avoid the wholesale conversion of species- and habitat-rich environments and landscapes into cattle ranches, sugar cane plantations and other forms of simplified, conventional land use.

The diversity of resource use systems and other cultural practices, as well as the capacity of ribereños to adapt to natural and social changes, are rural realities that are still only rarely taken into account in the design of conservation and development schemes. The Muyuy case calls for a new and unconventional understanding of both conservation and resource management. Setting aside large areas where no one but armed guards and scientists can tread does not fit into the ribereño way of conservation. The Muyuy vision of a balanced world includes landscapes that are clearly Amazonian because they were shaped not only by a distinctive conjoining of physical and biological processes but also by the work of human hands and minds. In community lake reserves and family forest reserves, the farmers of Muyuy offer a distinctly local and rural approach to conservation and production. Conservation measures like these, established and maintained by local communities, may prove more efficient in protecting a large share of biodiversity than do the traditional parks and reserves established by conservation groups. Community lake reserves and family forest reserves. So far these peasant practices have not only been ignored but have often been denigrated and threatened by urban experts in both conservation and development.

Finally, we argue that the biodiversity crisis must be seen as not only the loss of species and habitats, but also the loss of locally developed resource use systems and technologies that have formed the landscapes in which many of those species and habitats exist. Muyuy residents offer not only a set of techniques and technologies that work, but also an alternative vision of what needs to be preserved. Without the knowledge and experience of ribereños and other Amazonians, the parks, reserves and other protected areas will go but a very short way toward alleviating the biodiversity crisis.

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