BIODIVERSITY AS A PRODUCT OF SMALLHOLDERS' STRATEGIES FOR OVERCOMING CHANGES IN THEIR NATURAL AND SOCIAL LANDSCAPES: A REPORT PREPARED BY THE UNU/PLEC AMAZONIA CLUSTER

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Editorial Note

This paper is the text only of a larger paper which includes tables, diagrams and calculations. An edited text is printed here because of its value as a demonstration of methodology.

Background

The PLEC objective to measure biodiversity levels within the landholdings of smallholders emerges as an opportunity to look beyond the superficial environmental ideologies that impel many biodiversity researchers to ignore land 'tarnished' by humans and to search for 'pristine' ecosystems. In contrast, reporting the biodiversity that is produced, managed or conserved by smallholders, we aim to illustrate the valuable role of smallholders in the formation and transformation of biodiversity within the estuarine varzea floodplain. We argue that a considerable number of land-use systems in Amazonia enhance rather than reduce levels of biodiversity. We favour the promotion of smallholder agriculture, agroforestry and forest management practices within varzea floodplain environments as an alternative to cattle ranching, selective logging and other modern land-use practices currently threatening biodiversity in the region.

PLEC Amazonia aims to contribute the needed technical and scientific information for identifying alternatives to biodiversity destruction on regional and global scales. The biodiversity crisis, as a global event, is forcing countries to employ experts to measure and suggest actions that conserve, restore or improve species, ecosystem and landscape diversity (UNEP 1995). Results from biodiversity inventories are helping to identify regions and countries where levels of species and ecosystem extinction are critical (Vogt et al. 2000). Although species and ecosystem extinction are both biological problems, the solutions to these problems are also dependent on social components (Kalliola and Flores 1999). Experts recommend a thorough examination of the processes that change biodiversity levels over time and space (Brondizio 1996).

Research conducted in Amazonia provides two distinct opinions on the processes that control biodiversity levels. Ecologists suggest that biodiversity is the result of natural processes (Terborgh 1999). In contrast, the anthropocentric point of view, proposed by many social scientists, argues that biodiversity in Amazonia is the result of long-term human intervention and manipulation of natural processes (Raffles 1998). Both arguments limit our understanding of the combination of natural and anthropogenic processes that create high or low levels of biodiversity. As part of the PLEC project, the Amazonia Cluster tested the hypothesis that biodiversity is the result of complex interactions of natural and anthropogenic processes. We measured and monitored the levels of biodiversity produced, managed, maintained or conserved by smallholders within their landholdings in varzea environments. These residents take advantage of fluvio-dynamic and other natural processes to produce and conserve agro-biodiversity and biological diversity in their landholdings.

Several authors have reported that the landholdings of Amazonian smallholders contain high levels of species and ecosystem diversity (Brondizio and Siqueira 1997; Pinedo-Vasquez 1995). Studies that focus on swidden-fallow or shifting cultivation practices suggest that agroforestry and agricultural fields as well as forests managed 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 1997; Anderson 1992). These studies help to distinguish between the land-use systems that conserve and those that destroy Amazonian biodiversity.

While most experts agree on the ecological value of biodiversity found in the landholdings of smallholders, they also argue that biological diversity does not help farmers improve their living conditions (Smith 1996). In contrast, the conversion of forest land into pastures and the subsequent reduction of biodiversity produces high economic returns for cattle ranchers (Rabelo personal communication). The low economic value of biodiversity explains why in some tropical regions that are rich in biodiversity the majority of people are poor (Peluso 1995). Similarly, some researchers argue that Amazonian smallholders have little appreciation for biodiversity (Smith 1996). Experts continue to argue these points largely because: 1) what information exists on biodiversity managed by smallholders in Amazonia is incomplete and has yet to be presented in a consistent and accessible form and 2) most researchers do no understand the role of biodiversity in the livelihood of peasants.

Most of the studies that measure species diversity managed by smallholders in the Amazon estuary actually measure only a small fraction of the total diversity found in these landholdings. They often only evaluate house gardens and not the many other land-use stages or field types that are found in the landholdings (Anderson 1997). Here we report the existing biodiversity used and maintained by smallholders in all fields, fallows, house gardens and forests that contribute to economic activities in peasant landholdings or within community territories.

The inclusion of smallholders as principal stewards of biodiversity raises new questions and requires a detailed understanding of the factors that influence species diversity. Research must avoid the tendency to reduce studies to the simple quantification of biodiversity. To observe existing biodiversity beyond a simple summation of numbers, we incorporated both social and ecological methodologies and techniques into the design of our surveys. We included some ecological parameters to quantify biodiversity in different land uses and to calculate the standard indices recommended by members of the PLEC Biodiversity Advisory Group (BAG). We combined these methods with participant observation and other techniques used by social scientists to identify the technologies and local knowledge that maintain biodiversity in this dynamic social and natural environment.

Agro-biodiversity and other forms of biological diversity were measured within each land-use stage (LUS) and field type (FT) found within the landholdings of sampled smallholders located in the PLEC sites at Santarém-Ituqui and Mazagão-Ipixuna (Macapá). Data collected show that the two sites differ greatly in the number and kinds of plant species that are planted, managed or conserved by their inhabitants. Landscape analysis using historical and geographic information shows that the differences in levels of biodiversity between the two sites are due to the fact that each landscape is affected and controlled by different natural and social processes. Similarly, agrodiversity levels and other forms of production and management technologies differ between the two sites. Because the two sites are more different than they are similar in terms of the amount of biodiversity, the technologies used by farmers, and the processes they are subject to, were analysed and discussed in two separate documents. In this report we include data collected in the Mazagão-Ipixuna site and in a future report we will include data from Santarém-Ituqui.

The information collected from the Mazagão-Ipixuna site is reported in four separate sections. A brief discussion about the design and techniques used for gathering data on agro-biodiversity, biological diversity, production and management technologies, as well as conservation practices, is included in the methodology section. Methods used for collecting geographic and historical data on natural and social process are also described in this section. Data collected from biodiversity surveys, interviews and archival documents are included in the results section, which also gives data on agrodiversity and other forms of production and management technologies. Descriptive information about local conservation practices is also analysed and discussed in this part of the report. Biodiversity levels found in the site, the methodologies used in the surveys and the value of biodiversity indexes are also part of this final section. We end the report by stressing the need for re-constructing and interpreting biodiversity analyses in order to propose sound alternatives that can help to minimize the loss of biological diversity.

Methods

The physical changes in the landscape (including vegetation cover) are reported in a Master's thesis by a Brazilian student (Pereira 1998). Results from the interpretation of aerial photos and Landsat images, and information collected from land surveys, were used to identify important natural and social events that influenced the landscape in both sites. Data about the natural and anthropogenic origins of water bodies, land formations and type of vegetation cover were analysed by Raffles (1998), and used to help understand the role of people in modifying the landscape. Records on economic booms and busts, changes in land tenure and use over time were collected through interviews and by reviewing documents in archives located in Macapá and Belém.

The identification, quantification and classification of the existing land-use stages (LUS) and field types (FTs) used information collected from a sample of 60 landholdings; 36 were in Mazagão and 24 in Ipixuna. Data from each landholding were gathered during an average of two visits per year (at the beginning and the end of the agriculture season) for the last five years. We recorded the following information: the number, area and location of LUSs and FTs in relation to the river and house. With members of the families (men, women and children) we drafted maps for each landholding representing its location within the landscape.

The existing agro-biodiversity and other forms of plant diversity in the LUS and FTs were inventoried following the PLEC-BAG recommended methods and design. Plant diversity in forest areas was measured in 10 randomly selected samples (five in each site) from 27 ha of forest found in the 60 selected landholdings. All selected forests were managed at varying intensities for the harvest of timber and several other marketable resources. All trees greater than or equal to 5 cm DBH (diameter at breast height) were inventoried in 4 randomly selected plots of 25 m x 25 m in each of the sample forests. Individuals with a DBH less than 5 cm were inventoried in a sample of 80 (4 in each 25 m x 25 m plot) randomly selected sub-plots of 5 m x 5 m. In each inventoried plot and subplot we recorded the common name, height, DBH and location of each species. Because of the heterogeneity of the landscape we estimate ß-diversity in addition to the species richness and Shannon index recommended by BAG. Rank abundance per species was also calculated. Importance values for species and families were also estimated for all sample forests. The majority of the results and the estimated floristic and structural parameters of the inventoried forests are included in the Master's thesis of a Brazilian student and member of the Amazonia team (Rabelo 2000).

Plant diversity in fallows was quantified in a sample of 18 ha (10 in Mazagão and 8 in Ipixuna) that was randomly selected from a total 52 ha of fallows. The selected 18 ha included fallows ranging from 5 to 8 years old that were managed to produce several products with market value, including the fruit of the açai (*Euterpe oleraceae*) palm. Inventories were carried out in a total of 90 plots (5 in each selected fallow) of 20 m x 20 m that were randomly selected from the selected fallows. Natural regeneration was also inventoried in each fallow plot using sub-plots of 2.5 m x 2.5 m. Data recorded for each inventoried species were the same as those used to record in the forest plots. All calculated biodiversity indices including ß-diversity paralleled the ones estimated for the forest samples.

The team selected a sample of 36 house gardens (20 in Mazagão and 16 in Ipixuna) to quantify plant diversity. The sample house gardens cover a total area of 94 ha. The average size of each garden was 2.3 ha. Each plant in these gardens was inventoried. Data recorded included common name and life form (tree, shrubs, vine, grass and herb). Species diversity was estimated using the indices recommended by BAG. We quantified species and varieties of planted or protected crops in 10 fields in Mazagão and 10 in Ipixuna, randomly selected from an average of 72 fields made by farmers at the beginning of the wet and dry seasons. Crop inventories were conducted twice a year (before harvesting in the wet and dry seasons). The average size of the selected fields was 1000 m2 (50 m long x 20 m wide). The fields were then divided into sub-plots of 10 m x 10 m. Plant inventories were conducted in a sample of 90 (5 in each of the 18 sampled fields) randomly selected plots. For all planted or protected species and varieties found, we recorded common name, life form and uses. The levels of agro-biodiversity found in each sampled field, as well as variations from one season to the other, are discussed based on absolute and relative abundance.

Agrodiversity and other production and management technologies, as well as conservation practices, were recorded using participant observation techniques. Team members followed the members of the selected households to their daily activities and observed and recorded production and management techniques used in the fields, house gardens, fallows and forests. Information collected from each household was cross-checked during group discussions and dialogue with the most knowledgeable members of each household and community.

Results

Dynamics of the natural environment

The Mazagão and Ipixuna sites are part of the estuarine varzea floodplain and are tidally-influenced environments. Both sites are composed of very heterogeneous landscapes that include a great diversity of human settlements, land formations, water bodies and vegetation cover. The iological and social components are subject to complex and dynamic natural and anthropogenic processes. Although these processes are highly variable and unpredictable in their frequency, intensity and spatial characteristics, the historical and landscape data show that the residents of both sites have developed technologies and strategies for managing and maintaining these processes.

Major changes in the direction of the river have taken place at both sites in the last fifty years. One of the major changes in landscape and river dynamics during this period was the formation of an island near of the city of Macapá. The residents of Mazagão reported an increase in sedimentation leading to the formation of new lands and an increase in the height of their levees. The residents of Ipixuna reported major changes in the size and number of streams, landforms and vegetation cover since the appearance of the island.

Our informants, as well as data collected from air photographs and Landsat images, record that three main fluvio-dynamic events have produced major changes in the social and natural landscape of Ipixuna. First, since the formation of the island, the river current is stronger and navigation is increasingly dangerous. Second, as the current of the Amazon river has become stronger, most of the sediments and other materials transported by the small and neighbouring Pedreira river are deposited at the mouth of the river. Third, since the current became stronger, the removal of vegetation along the stream has greatly increased lateral erosion by tidal pulse.

People from Ipixuna are managing these fluvio-dynamic and other natural processes to open new stream channels using water buffalo, to gain access to new land and resources (Raffles 1998). They have developed intricate technologies for raising planting surfaces above the level of tidal floods (Padoch and Pinedo-Vasquez 1999). These types of interventions exemplify how the mechanisms influencing landscape, ecosystem and species diversity cannot be identified by the study of either natural or social processes alone.

Social processes

Based on oral, historical and geographic information collected, the social processes characteristic of the two sites appear to be as complex and dynamic as the natural processes. The Ipixuna and Mazagão varzea floodplains were subject to different intensities and degrees of land and resource use, and of outside intervention, through the implementation of develop-ment and conservation projects. Resources have been commercially produced and extracted for varying periods encompassing several booms and busts. In Mazagão, commercial production of crops, such as rice, began in the middle of the 17th century. By contrast, commercial agricultural production in Pedreira-Ipixuna did not begin until the end of the 1940s (Raffles 1998).

Despite decades of political and economic pressures to adapt modern production systems and reduce crop diversity, most of the production systems and techniques used by smallholders in both sites are based on indigenous technologies. Swidden fallows are the predominant production system practised, which allows smallholders to maintain high levels of agro-biodiversity and other forms of biological diversity in their fields, fallows, house gardens and forests. This in turn helps farmers in both sites to access cash income by harvesting or extracting several resources.

Commercial extraction from both sites has followed patterns similar to other areas of the estuarine varzea. Commercial logging started in both locations at the beginning of this century (Pinedo-Vasquez 1999). Extraction of seeds of *murumuru* (*Astrocaryum murumuru*), *andiroba* (*Carapa guianensis*) and *pracaxi* (*Parkia* spp.) was carried out commercially from 1940 until about 1970. Commercial fishing of catfish and shrimp became an important cash source for the inhabitants in both regions after 1950 (Raffles 1998). Extraction of the fruits and the heart of the açai palm (*Euterpe oleraceae*) has had a significant economic impact in both sites since 1960. Currently, heart of palm, fruits of açai, several species of timber and shrimp are the most important products extracted for sale.

The increase in demand for açai fruit and timber in the market, and the decline in prices for agricultural products, have changed the role of agriculture, agroforestry and forest extraction in the household economy. In the past, crop production was mainly for the market and was the main source of cash income for smallholders in both sites, and agroforestry and forest products were mainly for their subsistence. Currently, agricultural activities are mainly for the production of subsistence products while agroforestry and forest management have become the main activities for income generation. Emphasis on agroforestry and forest products explains why smallholders are reducing the size and number of agricultural fields.

Agricultural fields

Although quantitative data were collected for only two years, we can clearly see a trend in the number and size of land-use stages in both sites. In 1998 within the landholdings from Ipixuna and Mazagão there were 25 and 23 fields respectively. The data from 1999 show the number of fields declined to 12 and 18. In both cases fields were left to become fallows for the production of several agroforestry and forest products such as açai fruit and *pau mulato* (*Calycophyllum spruceanum*), a valuable fast growing timber species.

While the number of fields declined, the average field size remained at 0.6 ha for both years. Results show that the decline in the number of fields did not affect the levels of agro-biodiversity in fields at both sites. Farmers are not only planting crops, but are also protecting the seedlings and saplings of several forest and agroforest species. While a similar number of species and varieties were planted at both sites, smallholders from Mazagão protected more than twice the number of species and varieties than did the farmers of Ipixuna. Numbers of species and varieties planted or protected by smallholders in their fields, including the naturally regenerated seedlings of forest and agroforest species, were very high.

There were important differences between the two sites. Farmers in Mazagão tend to focus on protecting rather than planting species: in Ipixuna the converse is true. Species and their varieties observed in fields included grains, tubers, fruit, medicinal and timber species. The average number of species and varieties of crops found in the sampled fields was higher than those reported in fields owned by smallholders within colonization projects and areas owned by cattle ranchers (Anderson 1992). A considerable number of species inventoried are perennials. The farming of tree, shrub and other perennial seedlings shows how smallholders are responding to the drop in prices and market instability of the typical annuals.

Agricultural products are produced in large industrial plantations in the south of Brazil and are generally cheap and of high quality. As markets in urban Amazonia are flooded with staple crops from southern Brazil, smallholders find they cannot compete with the falling prices for rice, beans and other crops. Based on these and other socio-economic pressures, we found that household income in both sites is in a transitional phase, shifting from a dependence on agricultural products to agroforestry and forest products.

The protection or planting of timber, fruit and other forest or agroforestry species in the fields is changing agrodiversity and other farming technologies used by smallholders. Although fields are still made using swidden techniques, we observed that most farmers are opting not to burn the slash. They believe that seeds of valuable agroforestry species such as *maracuja do mato* and forest species such as tropical cedar are destroyed by fire, preventing natural regeneration. Similarly, weeding operations tend to be more selective and less intensive. For instance, when growing corn, beans and other annual crops the majority of farmers do not weed their fields.

Fallows

Changes in farming operations and technologies are helping smallholders to manage seedlings and saplings of tree and shrub species in their fields. In agricultural fields it is common to find protected agroforestry and forest species naturally regenerating both randomly and in clusters. Most farmers explain that they are protecting the seedlings of timber species, açai palm and other valuable species to enrich their future fallows and forests. Based on the performance of the protected seedlings in fields, farmers have two main fallow types: 1) wild fallows (*capoeiras com mato*), where vegetation is low in valuable species and 2) enriched fallows (*capoeiras contaminadas*), where vegetation is dominated by valuable species. Smallholders use the wild fallows for making fields and manage the enriched fallows for the production of agroforestry and forest products.

Despite the assumption that human intervention in fallows lowers the species richness (Anderson 1992), we found that the enriched fallows contained levels of plant diversity similar to the wild fallows. The general trend is that smallholders tend to maintain or in some cases increase levels of biodiversity as part of a strategy to increase the number of outputs available in the fallows. Of the eight sampled households, six maintained more species in their enriched fallows than in their wild fallows and only two had less.

While the difference in the average species richness between enriched (25) and wild (22) fallows was just 3 species, differences in species composition among enriched fallows are greater than among wild fallows. Biodiversity levels vary considerably with the intensity and frequency of the owners' interventions. For instance, Alvino maintained more than twice the number of species (39) than did Juracy in the same size (0.3 ha) of fallow, while in their wild fallows they maintained similar numbers of species.

There was a difference in the density of individual plants per area and species richness. Smallholders maintained more individuals of species in enriched fallows (average 557 in 0.26 ha) than in wild fallows (average 347 in 0.26 ha). Differences among the sampled enriched fallows were greater than among the sampled wild fallows. For instance, Alvino maintained more than three times more individuals (1120) per species than Juracy in the same size (0.3 ha) of fallow. Such differences are present also in fallows owned by a single family. For example Tomé maintained varying densities of individuals in his three sampled enriched fallows.

Plant diversity and density of individuals and species were clearly influenced by the intensity and frequency of management operations as well as the way in which the seedlings and saplings of valuable species were managed in the field stage. Results from the floristic and structural analysis were consistent with field observations. Vegetation of wild fallows that were not managed was clearly dominated by individuals of *imbauba* (*Cecropia membraneaceae*) and other early colonizing pioneer species. The majority of enriched fallows contained several agroforestry species including bananas and several species and varieties of citrus. This report focuses on enriched fallows because they are under intensive management and they have considerable economic and ecological importance.

Field observations showed that farmers maintained individuals of economic species at different stages of growth in the same fallows and fields. There were adult *pau mulato* trees near other individuals of the same species in the sapling and seedling stages. These uneven-aged stands created a multiplicity of habitats for other species in the landscape.

Of the eight sampled enriched fallows only two (Tomé 2 and Tomé 3) had an estimated species richness index (Dmn = 0.93 and 0.89) of less than one, while only one fallow (Nonato) showed an estimated Shannon's index (H' = 0.84) of less than one. The proximity of the estimated indices to one indicates that there was a correlation (r = 0.94) between the distribution of individuals and species in the enriched fallows.

The rates of abundance and dominance of species in fallows reflects the smallholders' intensive use and management of fallows.

Species richness in the enriched fallows showed a strong correlation (r = 0.88) between number of species and number of individuals. The number of trees per area increased when the number of species increased in the fallows.

Although thinning and removal of vines are the main management operations applied to fallows, smallholders are adapting or developing new management techniques. This transformation and innovation is facilitated by the increased value of forest and fallow products in the markets. In both sites farmers are making small openings (*clareras*) in their fallows for planting semi-annual species such as bananas, and for transplanting seedlings of desirable species. They collect seeds of several species, such as tropical cedar and açai palm, to broadcast in their fallows. The frequency and intensity of termite nest removal and other operations to control pests are also increasing as a result of farmers' economic dependence on fallow products. Decisions to convert fallows into fields or forests are based on several factors, including how well production of agroforestry products, such as bananas, is faring, and on whether forest species, such as açai palm, are dominating the vegetation.

Forests

In both sites we found that the forest areas of smallholders were the results of successive management operations that began in the field stage and continued into the fallow and forest stages. Inventories conducted in a sample of 10 hectares (5 in Mazagão and 5 in Ipixuna) showed a great diversity of species.

In both sites the forests contained high levels of species richness and evenness. The average number of species (51) found in the Mazagão forests was higher than the average (36) found in Ipixuna. In contrast, the sampled forests of Ipixuna had more trees (average 1117) than those sampled (average 1041) in Mazagão. These results reflect the histories of management and resource. extraction. In Mazagão people are more dedicated to forest activities and they tend to continually enrich their forest with desirable species of timber, medicinal plants, and fruits. Farmers in Ipixuna practise more agroforestry and the collection of fruits and medicinal products, with some timber extraction.

Despite the differences in forest uses and management practised by the two groups, forests in both sites showed very high diversity on Shannon's Index. Based on the estimated diversity indices, forests in Mazagão had higher values (average H' = 2.59) than do forests in Ipixuna (average H' = 1.77). These results were very similar to the reported estimated Shannon's Index for forest areas in other regions of the estuarine varzea floodplain (Anderson 1992).

While forests in Mazagão were richer in species than are those in Ipixuna, the two most commercially valued species (*Euterpe oleraceae* and *Calycophyllum spruceanum*) were some of most dominant and abundant species in both sites. This abundance indicates that people are encouraging the establishment and growth of these and other valuable species. Similarly, the presence of a high number of timber, fruit and medicinal species suggests the intensity of management by local people in both sites. Data show that the people also maintain low numbers of individuals of several non-commercial species. Among these are pioneer species such as *C. palmata* and *Croton* spp. that play an important role in attracting game animals.

The estimated Importance Value Index (IVI) shows that eight of the ten most important species found in the forests of Mazagão and Ipixuna produced commercial products.

As in the case of managing fallows, people are adapting and developing innovative management technologies that correspond to specific environmental and economic conditions. The abundance and dominance of economically important species is maintained through manage-ment that promotes the regeneration of species under different light and environmental conditions. For instance, the majority of farmers conduct pre-harvest operations to avoid excessive damage to the forests, thus optimizing production. Some innovative farmers broadcast seeds or plant seedlings of valuable species before cutting timber. Most seedlings are collected from other parts of the forests, but the seedlings of *andiroba* (*Carapa guianensis*) are mainly produced in house gardens.

House gardens

Within their house gardens the inhabitants of Mazagão and Ipixuna include orchards, nurseries, medicinal plants, vegetables, ornamentals, spices, grasses and vines, and areas for raising domestic animals. The sampled house gardens include most of these categories and all vegetation in them was inventoried. The species and varieties of domestic and semi-domestic animals are currently being recorded and will be included in a later report.

House gardens in Mazagão and Ipixuna were rich in species and produced a large variety of products. There was little variation between sites in numbers of species and individuals maintained. Variation becomes apparent when individual house gardens are compared. Based on these observations, the biodiversity analysis of the sampled house gardens from both sites was pooled.

Although results showed that house gardens contain high biodiversity, there was a significant difference (CV = -0.02) in the number of species and individuals found in each sampled house garden. The average number of species found among the 16 sample house gardens was 17; the maximum, 26, belonged to Nicolau da Silva and the minimum, 11, to Rudinaldo. Similarly, results show that the number of individuals found in the house gardens varied from 136 (Pedro D) to 815 (Alziro). Most of the species found in Alziro's house gardens were herbs, grasses or vines that he planted for medicinal, ornamental, spice and food uses. The majority of species inventoried in Pedro D's house garden were palms and trees.

The estimated species richness index shows that people are maintaining high levels of biodiversity in their house gardens. Among the 16 sampled areas only one house garden had a low species richness index (Dmn = 0.45). However, the estimated diversity and Shannon indices indicate that all sampled house gardens featured high species diversity. Two house gardens, Nicolau (H' = 2.83) and Hernandes (H' = 2.05) contained the highest diversity of species.

While the levels of biodiversity in fields, fallows and forests are strongly dependent on the intensity and frequency of production and management technologies, the number of species in house gardens depends more on their uses. House gardens that are composed of orchards, nurseries and gardens have a greater number of species than those with only one field type.

Conclusion

We expect to continue collecting more data on the biological composition of the different land-use stages and field types found in the landholdings on the PLEC sites. Results from the biodiversity surveys conducted in Mazagão and Ipixuna discussed in this report are only a fraction of the data collected by the Amazonia Cluster. Upcoming reports from the sub-Clusters in Santarém-Ituqui and Iquitos-Peru will add useful biological data that can help to clarify further the complex and diverse operations and technologies used by smallholders who produce and maintain Amazonian biodiversity.

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