FARMING AND PATTERNS OF AGROBIODIVERSITY ON THE AMAZON FLOODPLAIN IN THE VICINITY OF MAMIRAUÁ, AMAZONAS, BRAZIL

By

MORGAN J. SCHMIDT

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2003

ACKNOWLEDGMENTS

This research was supported by a Charles Wagley Research Fellowship through the Center for Latin American Studies and Tropical Conservation and Development Program at the University of Florida. Graduate studies were supported by a Graduate Alumni Fellowship from the University of Florida through the Department of Geography. The research was further supported by the Mamirauá Sustainable Development Institute.

I would especially like to thank Jomber Chota Inuma who introduced me to the Mamirauá reserve and contributed much encouragement, advice, and support during the research. I am grateful for the hospitality of Jomber's family, Dina and Ortila, who gave me a home in Tefé. I would also like to thank Niele Peralta Bezerra, José Márcio Ayres, Edila Moura, and Ana Claudeíse Nascimento for their support of the research; and José Elizon Rocha da Silva, for his tireless efforts in the field. I am grateful to all of the other assistants, informants, farmers, and families (too numerous to name) for their help, cooperation, and wonderful hospitality.

Finally, I would like to thank my family, whose support made my graduate career possible; and my committee members (Dr. Nigel Smith, Dr. Hugh Popenoe, and Dr. Michael Heckenberger) for their guidance, advice, and support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science

FARMING AND PATTERNS OF AGROBIODIVERSITY ON THE AMAZON FLOODPLAIN IN THE VICINITY OF MAMIRAUÁ, AMAZONAS, BRAZIL

By

Morgan J. Schmidt

December 2003

Chair: Nigel J. H. Smith
Major Department: Geography

An examination of agrobiodiversity on the flood plains and adjacent uplands along a stretch of the Amazon river (Middle Solimões) illustrates the enormous variability between different land use strategies. Farmers in the region use five principal habitat types for agriculture; beaches, mudflats, low levees, high levees, and uplands. High levees and uplands contain the greatest diversity in both land use types and useful plants. The research revealed 24 designations of land use by local residents when divided along lines of habitat, current status (field or fallow), and management. Home gardens are an important repository of agrobiodiversity because they contain almost the entire spectrum of useful species including many not found in other land use types and almost every home has one.

CHAPTER 1
AGRICULTURAL BIODIVERSITY AND SHIFTING CULTIVATION: THE RESEARCH IN CONTEXT

Introduction

Agricultural biodiversity is paramount in meeting the needs of Earth's growing human population. Wild relatives and traditional landraces of today's major crops hold the key to developing new, more robust, and better-adapted varieties that allow greater productivity in selected environments and better resistance to pests and diseases (Harlan 1975a, 1976; Vavilov 1987). Little-known crops are a major resource that can contribute new foods and other products with higher productive potential, greater efficiency, and increased nutritional value; or simply add welcome variation to our diet. A newly developed crop can strengthen local economies and create major industries. Maintaining diversity means keeping our options open to develop new crops and varieties or improve existing ones. This will help us meet the challenge of adapting agriculture to changing environments; and developing efficient, sustainable agricultural ecosystems. Hundreds of fruits, nuts, tubers, seeds, medicinals, ornamentals, timber, and other plants are virtually unknown outside of the regions where they are grown. These plants hold great untapped potential; and many are in danger of being lost to us forever with increased alteration of both natural environments and traditional agricultural ecosystems (National Research Council 1993).

In recent years, researchers and policy makers have increasingly called attention to the importance of studying the agricultural systems of traditional farmers (Posey 1981, 1985; Smith 1996a; Srivastava et al. 1999). It is thought that development plans can benefit from traditional farmers' intimate knowledge of the environment and time-tested farming techniques. Traditional systems of shifting cultivation in the tropics almost invariably contain high agricultural biodiversity; and are well-adapted to local environments. The farming methods of the caboclo population (mixed descendants of indigenous peoples and immigrants in the Amazon region) in the middle Solimões region of Amazonia are no exception. The Solimões river is the section of the Amazon river in Brazil stretching from the Peruvian border to the confluence of the Negro river. The middle Solimões region is approximately centered on the confluence with the Japurá river, a northern tributary coming from Colombia (Figure 1-1). Caboclos utilize a number of land-use systems and manage a myriad of useful plants in the diverse landscape along a stretch of the greatest river in the world. Our goal was to document the distribution and variability of agricultural biodiversity in the region as it relates to land management and habitat.

Chapter 1 gives a background on agricultural biodiversity and shifting cultivation and their significance. Chapter 2 describes practical aspects of studying traditional agriculture in the Amazon region; the research area (including its people, environment, and conservation reserves); data and methods; and life on the várzea (Amazon floodplain). Chapters 3 through 6 describe the results of the project. The chapters are organized by land-use and habitat. Chapter 3 describes the roça or manioc field and chapter 4, the capoeira or fallow, both on the várzea. Chapter 5 focuses on the diversity of home gardens in both the várzea and terra firme (uplands). Chapter 6 summarizes findings from the survey on terra firme agriculture. Chapter 7 summarizes what was learned and gives directions for future research.

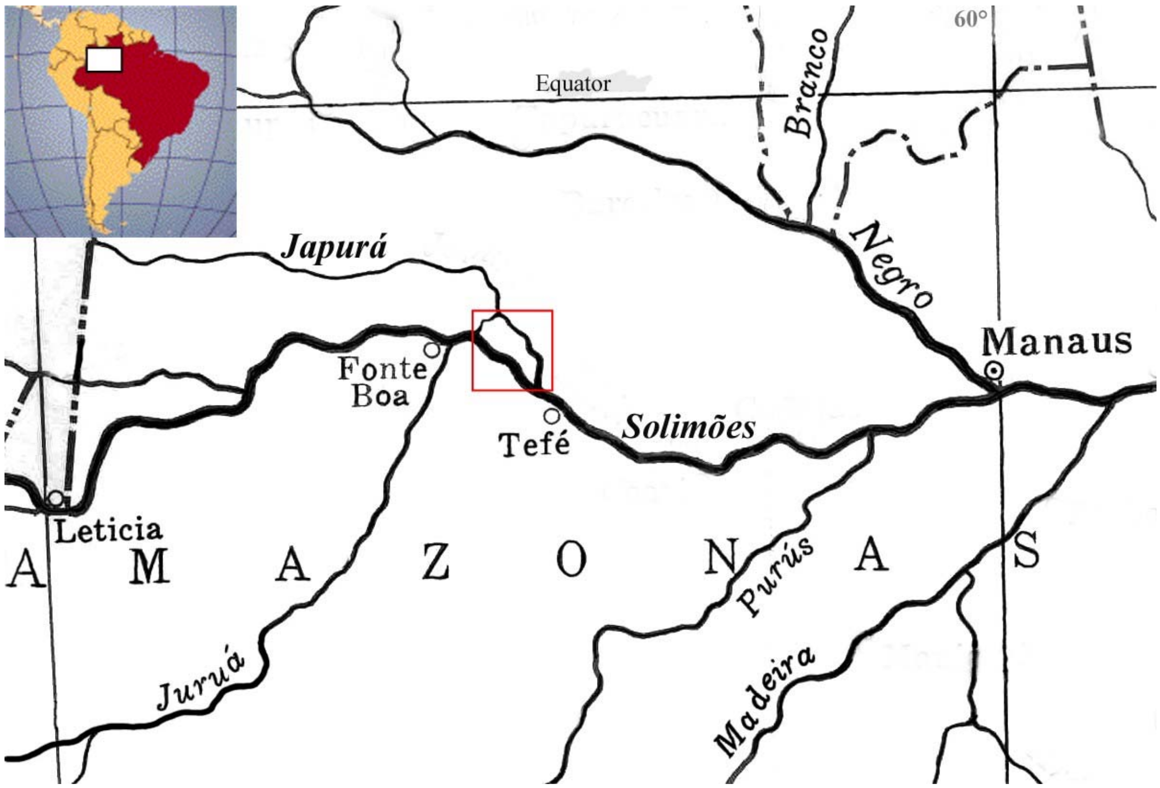

Figure 1-1. Map of the Brazilian Amazon centered on the middle Solimões region. The box delimits the study area.

Our Stake in Agricultural Biodiversity

Development of agriculture is arguably the most significant occurrence in human history. This major factor has allowed our population to rise at current rates and we now must increase food production to keep pace with population growth. Agricultural biodiversity (agrobiodiversity) is the biological resource that directly and indirectly contributes to crop and livestock production. It has been and will continue to be fundamental in our efforts to intensify agriculture (Srivastava et al. 1999).

For thousands of years, humans have been domesticating new crops and expanding the range of existing ones by borrowing from neighboring groups or taking them along when they migrate to new regions (Harlan 1975b). Repeatedly, crops that began in localized areas have proliferated around the globe to become staple foods or the basis of industry. Hundreds of little-known crops and varieties exist that could someday be grown on a much larger scale. Tropical agricultural ecosystems (agroecosystems) are especially diverse in both food and nonfood species; with current and potential uses including medicines, construction materials, industrial materials, and ornamentals (Alcorn 1984; Denevan and Padoch 1987; Smith et al. 1995). Agroecosystems often contain plants in the process of domestication (proto-domesticates) from which exciting new crops may be recruited (Smith 1996b).

Material for crop improvement is obtained from diverse landraces, wild crop relatives, and even unrelated species (Pimentel et al. 1997; Smith 1999; Smith et al. 1992). Plant breeders use these genetic resources to develop new varieties that are of greater quality, higher yielding, resistant to insects and disease, tolerable of stress, amenable to mechanical harvesting, and adapted to different environments (Harlan 1976; Plucknett et al. 1983). Traditional crops and varieties, proto-domesticates, and wild crop relatives, are a rapidly shrinking resource as modern agriculture advances, more farmers enter the market economy, cultural ecological knowledge is lost, and natural habitats are transformed (Altieri et al. 1987; Harlan 1975a; Nabhan 1985).

The expansion of green revolution technology can have a negative impact on genetic diversity. In the push for greater productivity, a handful of crops have gained importance and come to dominate world agricultural production, often resulting in the loss of traditional crops and varieties (Altieri et al. 1987; Harlan 1975a). For industrialized farms to be viable, farmers seek the highest yielding varieties available.

Commercial seed, developed to be compatible with agrochemicals, gives farmers limited choices as to which varieties will be planted (Clawson 1985). Mechanization requires that crops be of uniform size and shape; mechanization also makes intercropping of multiple species and varieties impractical (Chang 1977). The need for expensive technology and specialized knowledge has caused modern farms to focus on usually only one or two crops in order to compete successfully. Market forces dictate which crops will be grown as farmers cannot afford to spend time and energy on those that will not fetch the highest prices. The conversion of small, more diverse farms to large, mono-cropped farms and cattle ranches can eliminate traditional crops, varieties, and proto-domesticates (Smith 1999). In addition, the expansion of modern agriculture onto new lands puts populations of many wild crop relatives at risk of extinction, posing a threat to the crops that we rely on most (Damania 1994; Harlan 1976). All of these factors together have the effect of homogenizing agriculture around the world, by squeezing out crops and varieties that are less commercially important. These factors are critical, however, to the future development of agriculture and to human welfare.

Globalization brings rapid change to many cultures, often resulting in the disappearance of cultural knowledge of ecosystems, plant uses, and traditional agriculture (Altieri et al. 1987; Nabhan 1985; Steinberg 1998). This knowledge, acquired through many generations of experience and experimentation, is as important as genetic diversity for the development of sustainable agroecosystems (Altieri 1995; Gliessman et al. 1981). The passing away of traditional knowledge and management practices often goes hand in hand with vanishing crop diversity.

The loss of agrobiodiversity and traditional knowledge has grave implications for the safe and equitable future of the growing human population. As global food consumption increases, productive land is being lost by urbanization and degradation caused by unsustainable management. This necessitates the development of higher yielding varieties and more productive and sustainable agricultural systems. We must constantly contend with new pest and disease outbreaks that can devastate entire crops (Adams et al. 1971). Awareness is also increasing of the threat to agriculture posed by changing climates that may cause temperature and rainfall regimes to shift (Zandstra 1993). Our ability to expand food production and adjust to ecological and market changes stems largely upon the available genetic diversity.

Call for Conservation

During the 1960s, concern for the vulnerability of our major crops led to increasing efforts at collecting and preserving crop germplasm (Harlan 1975a; National Academy of Sciences 1972; Plucknett et al. 1983). A global network of gene banks was constructed with facilities for short, medium, and long term storage of seeds and limited maintenance of vegetatively propagated crops. The importance of preserving genetic diversity was emphasized by Harlan (1976), "In the future, the need for genetic variability and sources of resistance shall drive us to a much fuller exploitation of *all* the genetic resources we can assemble."

Although the practice of storing germplasm in ex situ gene banks is crucial for the future of agriculture, there are several recognized shortcomings in fully relying upon this method alone to conserve valuable genetic resources. First, there is insufficient representation of the full range of genetic diversity for many crops and a large number of less important crops are not represented at all (Harlan 1975a, 1976; Plucknett et al 1983).

Second, storage facilities may be vulnerable to natural disasters and political change. Third, the plants are taken out of the ecosystem where they have continuously co-evolved with animals, other plants, and environmental stress including rapidly evolving pests and diseases. For these reasons a number of researchers have argued for the importance of conserving genetic resources in situ (Altieri and Merrick 1987; Brush 1989). This can be accomplished if a way is found to preserve the agroecosystems in which they are found (Altieri 1989).

Tropical agroecosystems often contain a multitude of crops, varieties, proto-domesticates, and wild crop relatives including plants with a number of non-food uses. To conserve this resource we must understand where high genetic diversity is maintained and how management affects the abundance of crops and varieties (Alcorn 1984; Altieri and Merrick 1987; Smith 1996a). In tropical shifting cultivation (swidden) systems, it is pertinent to identify which processes of cultivation result in a secondary forest enriched with useful species, both planted and volunteer. Some useful plants may become more numerous when they are protected by the farmer during clearing, burning, and weeding or when they are favored by repeated cycles of cultivation (Baleé 1994). Enriched fallows and mixed orchards may result from the practice of swidden-fallow agroforestry where fields are not only left fallow but are planted to a diverse array of useful species (Colfer 1997; Coomes and Burt 1997; Denevan and Padoch 1987).

For traditional farmers, a diverse crop and variety repertoire has advantages in the field, on the farm, and in the region by providing security and greater efficiency (Clawson 1985). Maintaining a heterogeneous agricultural landscape of fields, fallows, natural areas, and extractive areas benefits families by providing game, fish, fruit, construction materials, medicines, and other products that contribute to subsistence and income (Altieri et al. 1987). When several crops and varieties are planted in a field or diverse landscape, they provide natural barriers that can act to slow the spread of pests and diseases (Adams et al. 1971) and can result in increased biological insect pest control (Altieri et al. 1987). However, one drawback is that the forest may act as a source of disease or pests for some native crops. Farmers are better able to cope with losses or plunging market prices if they are not dependent on a single crop. They can benefit by harvesting several crops that mature at different times, spreading their workload and income more effectively throughout the year and utilizing land more efficiently. A selection of crops and varieties also allows them to exploit small-scale environmental variation. A good example of this is the use of different crops by floodplain farmers according to micro-relief and soil texture (Denevan 1984). Studying the ways that traditional farmers interact with and manage their environments will enable us to merge the benefits of traditional agriculture with modern 'green revolution' technology, leading us down a path toward a sustainable agriculture.

The plant diversity of many traditional agroecosystems remains largely unexplored. There is a danger of losing the valuable genetic resources and sustainable management practices evolved over many generations as these agricultural landscapes are transformed. By documenting this diversity, plans may be devised to conserve it. It is certain that the more diversity we are able to maintain, the better equipped we will be to confront the challenges that await us. This research attempts to document the diversity of plants considered useful by the local population of the middle Solimões region. The focus is on the distribution of useful plants within the agricultural ecosystem of the Amazon várzea (floodplain) and adjacent terra firme (uplands). By understanding how agricultural practices influence the diversity of useful plants in the landscape, resource managers and local farmers can design management plans that more effectively conserve genetic resources.

Swidden Model

For many, the terms slash and burn, swidden, or shifting cultivation carry negative connotations and conjure images of poverty stricken peasants laying waste to large tracts of virgin rainforest. This type of farming has often been blamed for the current crisis of deforestation around the globe, particularly in the species diverse rainforest areas. It has been described as primitive, haphazard, simple, wasteful, and inefficient by scholars (Conklin 1954, 1961; Gregor 1977; World Bank 1992) and even outlawed by some governments (Finley and Churchill 1913; UNESCO 1983).

Finley exemplifies the dominant view of swidden agriculture during the first half of the twentieth century in his 1913 ethnographical and geographical sketch of the Subanu, an upland tribe on Mindanao in the Philippines, who practice this type of cultivation known locally as kaingin. He explains that “agricultural development is seriously retarded by want of proper methods” and “the lack of efficient labor” (Finley and Churchill 1913:15) Finley goes on to say, “The kaingin method of farming involves a great waste of labor and materials and must be eventually interdicted by appropriate laws, rigidly enforced.” Echoes of this pessimistic view of shifting cultivation can still be heard (Lavelle 1987).

Today, most swidden scholars agree that the system is not inherently unsustainable (Kleinman et al. 1995). In fact, it is a very effective adaptation to the environment, especially where soils are infertile. Swidden is a relatively efficient form of agriculture in terms of food production per unit of labor (Beckerman 1987; Carneiro 1968). The problems begin when human populations, market influences, or circumscription of territory exert too much pressure on the available land, causing farmers to shorten fallow periods (Boserup 1965; Carneiro 1970; Food and Agriculture Organization 1994; Pratap 2000; Steinberg 1998; Vasey 1979). Shorter fallows may result in lower yields, and soil degradation. Although interest has grown enormously since Harold Conklin (1954, 1961) brought these issues to the forefront in the middle of the twentieth century, researchers are only beginning to understand the intricacies of slash and burn.

This ancient form of agriculture is known by many names. In English, most commonly, the terms shifting, slash and burn, or swidden are combined with cultivation, agriculture, or horticulture to refer to the general model. In this thesis, I will use these names interchangeably. A widely accepted definition has been given by Harold Conklin (1961) as “any continuing agricultural system in which impermanent clearings are cropped for shorter periods in years than they are fallowed.”

The process is fundamentally the same worldwide independent of culture, climate, or ecosystem. A patch of forest is cut, allowed to dry, and then burned. The elements that were locked in the living vegetation are then released as ash providing a pulse of nutrients that are easily utilized by crops. The area is planted for one or more seasons becoming a productive field. During the cropping period nutrients are depleted from the system, weeds invade, crop yields and efficiency drop, and the field begins a metamorphosis back to a state of higher biomass. This transformation may be left to the hand of nature by simply abandoning the field and allowing the forest to regenerate itself, or the fallow may be carefully managed by farmers, effectively increasing the productivity and efficiency of the system (Denevan and Padoch 1987; Eden and Andrade 1987; Hammond et al. 1995). Although swidden systems are usually associated with the burning of cleared vegetation, there are exceptions in areas of high rainfall and certain floodplain habitats where fire is not always used (Beckerman 1987; Orejuela 1992; Pinedo-Vazquez et al. 1996).

The standard model of swidden farming hides infinite variation (Brookfield 2001; Denevan 1971). Differences include crop configuration, number of species and varieties, number of consecutive years planted, number of years left in fallow, whether or not it is burned, whether or not fallows are managed, amount of labor investment, and season of planting and harvest (Conklin 1954). The reasons behind this variation are also diverse. They include environmental, economic, demographic, and cultural factors that influence responses by farmers (Conklin 1954, 1961).

Environmental conditions such as climate, vegetation, soils, altitude, pests and diseases, and flooding regimes shape the management systems at local and regional scales. Tropical ecosystems, in particular, can exhibit significant small-scale heterogeneity that requires numerous adaptations for successful cropping. Economic considerations including access to land, labor, and capital, the degree of local and regional market integration, and available transport are extremely relevant to the decisions a farmer makes such as the amount of land cleared and planted, choice of crops, time in fallow, and degree of fallow management. Cultural factors control, to a great extent, the methods used in this agricultural system. Though farmers are often innovative, they tend to farm the way they are taught by their relatives, neighbors, or extension workers. Farming techniques may be lost or learned as cultures come into contact with one another, market opportunities arise, and new technologies and crops are introduced. Finally, individual preferences play a part in all of these variables. The knowledge and practices of individuals may vary significantly within a single community. The enormous diversity encountered in swidden systems around the world means that generalizations made in the past are becoming obsolete.

Why Study Swidden?

Research on swidden agriculture is valuable from both a theoretical and practical standpoint. From the theoretical angle, its study holds important clues for our understanding of agriculture's distant origins and development (Sauer 1952). Although the traditional forms of shifting cultivation we encounter today may not be a window into the past, examination of its myriad forms and techniques can provide insights and help form hypotheses to be tested with the analysis of empirical data. As human populations and market integration increase, swidden systems are transformed in numerous ways (Behrens et al. 1994; Henrich 1997; Serrão and Homma 1993). Information on these changes is valuable in providing us with a better understanding of the mechanisms and impacts of agricultural intensification (Boserup 1965; Turner et al. 1977; Vasey 1979).

From a practical standpoint, research on the sustainability of swidden systems is essential in our efforts at rainforest conservation in the twenty-first century (Serrão 1993). Destruction of tropical rainforests around the world is one of the most pressing environmental issues that we face today (Whitmore 1990). Impact on biodiversity and the global climate are two effects of deforestation that have relevance for everyone, regardless of where we live (National Research Council 1993). There are also various local and regional problems that may result from deforestation including, soil erosion and degradation, loss of habitat for fish and wildlife (Goulding 1999), rainfall reduction, and increased sedimentation of rivers and other water bodies.

Shifting cultivation has been cited as one of the main causes of tropical deforestation in many regions (Food and Agriculture Organization 1994). In a 1982 FAO study, this form of agriculture was identified as the most important reason for the loss of tropical forests (Lanley 1982). It was estimated to be responsible for 35 percent of deforestation in the American tropics, 49 percent in Asia, and 70 percent in Africa. Because of the species diversity of the rainforest, its threatened situation, and the fact that it is the environment where shifting cultivation dominates today, the question persists whether this form of agriculture is compatible with conservation. Can it be practiced in such a way as to benefit the natural environment by preserving biodiversity or even increasing it at the landscape scale? There is some indication that this might actually be the case.

William Balée (1989, 1994), in his work among the Ka'apor tribe that practice swidden gardening in the Eastern Amazon, found that old fallows contain significantly different species than old-growth forest suggesting an enhancement of biodiversity at regional scales. How can a system like the Ka'apor's be adapted to areas with higher population density and greater pressure on the land? Only a better understanding of contemporary swidden systems can begin to shed light on this question.

Slash and burn is a highly adaptive and sustainable agricultural system when cropping intensity is not so great as to preclude adequate fallow periods (Kleinman et al. 1995). However, when population increase or territorial circumscription necessitates raising the cropping intensity and shortening the fallow period, the ecologically sound system can break down, becoming unsustainable (World Bank 1992). By evaluating the many forms of shifting cultivation in different environments, we hope to find a way to use our rainforests rationally and intelligently, thus preserving them for future generations.

Swidden Agriculture in Time and Space

We do not know when the practice of swidden cultivation first came into use. We can be fairly confident, however, to suggest that it is among the oldest forms of agriculture in existence and it is, in that sense, a truly primitive form. Though conventional wisdom holds that agriculture began in the Fertile Crescent about 10,000 years ago, it is quite likely that it developed much earlier at various times and places rather than in one single origin event (Harlan 1975; Vavilov 1987). We must not rule out the tropical forest or tropical floodplain as possible settings for an early beginning of agriculture (Sauer 1952; Smith 1999).

Several conditions combine to make the tropical moist environment conducive to the development of plant domestication. The first is the climate, being very amenable to plant growth with abundant sunlight and rainfall. Second, there is a rich abundance of species with a large number of potential uses. A third characteristic that makes planting easier are the soft, friable soils of the forest floor and the annually renewed, nutrient rich floodplain soils. No matter what environment it was first initiated in, humans eventually learned that they could kill large trees by girdling to allow sunlight to reach the forest floor and burn vegetation to provide nutrients needed for plant growth.

Besides being one of the oldest forms of agriculture, swidden is one of the most widespread forms even today. It has been used on every continent except Antarctica and thousands of islands around the world. Although it is primitive in the spirit of its great age and continuity, swidden agriculture has evolved to a high level of diversity and sophistication in the multitude of cultures and environments where it is utilized. Innovative farmers from around the world have contributed to the evolutionary development of swidden giving it an abundance of forms. It is not a static and rigidly defined set of methods but rather, variations are determined by individual preferences and cultural history in addition to environmental factors.

Today we think of swidden as primarily a tropical agricultural system. In the past, however, it was practiced throughout the temperate zone as far north as present day Canada and Scandinavia (Clark 1952). During the Neolithic, shifting cultivation was used extensively in Europe and apparently resulted in immense ecological change by deforesting large areas.

Comparing the average fire interval over time, Lehtonen and Huttunen (1997) show that the slash-and-burn technique was commonly used for cereal production for about 2000 years in southern Finland, being the most important cultivation technique in the eastern part of the country until the 1900s. They point out that fires have a great influence on forest structure and swidden cultivation has greatly influenced the history of forest fires.

In another study in neighboring southern Sweden, Lageras (1996) examines the pollen record over the past 7000 years to document vegetation and land-use history. He determines that the first indication of human impact by forest clearance occurs around 6000 years ago. Pasture has been the principal agricultural land-use in the area beginning about 5000 years ago and slash-and-burn cultivation was probably introduced to the area around 1200 AD. In the last century the land has once again become covered by forest making it easy for us to forget that the landscape was once dominated by human activities, namely forest clearance and burning. This supports the idea that many areas, including parts of Amazonia, often considered pristine wilderness are, in fact, the product of human manipulation (Denevan 1992; Erickson 2000, 2001; Heckenberger 1996, 1998; Heckenberger et al. 1999, 2003; Raffles 1999; Smith 2002).

Swidden farming was a common practice by prehistoric Amerindians in many places throughout North America (Lopinot and Woods 1993; Woods 1987). Woods (1987) examined the ethnographic record to characterize prehistoric settlement patterns and concluded that many were determined largely by the reliance on maize agriculture. For native North Americans from the east coast to the Mississippi valley, corn was one of the most important crops and the ash from burned vegetation was an essential addition of nutrients to the soil. Because of corn's high demand on nutrients, all but alluvial soils, replenished annually by floods, had to eventually be put into fallow. Many settlements were located on high ground near rivers where fields could be planted on the floodplain as well as uplands. Many fallow fields were present and an infield-outfield system was often practiced with smaller gardens near homes and larger fields further away. In many cases, villages would relocate periodically at 10 to 30 year intervals due to exhaustion of agricultural land and lack of fuelwood. European colonists also used shifting cultivation up through the 1700s in the United States (Matlock 1997) and Southern Ontario (Clark 1952) resulting in the clearance of much of the eastern forests of North America.

The tropical moist forest is not an environment conducive to the preservation of ancient crop remains or human artifacts that were often made from wood and other perishable material (Harris 1972). Because of this fact, along with the paucity of archaeological research, relatively little is known about the origins of agriculture in the tropics as compared with Southwest Asia. However, evidence is mounting for the antiquity of agriculture in the tropics.

Recent research is firmly establishing Mesoamerica as one of the cultural regions that was an early center of crop domestication. In the lowlands of coastal Mexico, Pope et al. (2001) found evidence for extensive forest clearing and maize cultivation by 6,800 years ago. It is believed that the Maya civilization was based on some form of shifting cultivation that allowed a relatively dense population in a humid tropical region (Harris 1972).

Remains of domesticated manioc have been found in archaeological sites on the coast of Peru dating from 2,800 years ago (Ugent et al. 1986). This, together with recent phylogeography research that places the origin of cultivated manioc in the southern border region of the Amazon Basin, suggests that the crop was grown throughout the American tropics by 3000 years ago (Olsen and Schaal 1999). Swidden agriculture clearly has an immense history in tropical forest regions around the world.

CHAPTER 2
FOCUSING ON THE MIDDLE SOLIMÕES REGION

Prehistoric Agriculture and Settlement on the Amazon River

We know that human populations have been settled along the Amazon for many thousands of years. Paleoindian remains were found by Anna Roosevelt and colleagues at a site called Caverna de Pedra Pintada near Monte Alegre on the left bank of the Amazon downstream from Santarem (Roosevelt et al. 1996). It is a well dated cave site with cultural material from about 8,500 to 11,200 years ago and rock art thought to be from the same period because of paint specs found in the stratigraphy. The site is especially significant because of food remains of tropical forest species that were found including many edible tree fruits and a variety of fauna showing that the people subsisted on foods from the rainforest and river and not on big game like other paleoindian groups. Roosevelt suggests that the many species adapted to disturbance indicates there may have been some forest clearance by these early inhabitants, however, no remains of crop species have yet been found.

The river bluffs adjacent to the Amazon floodplain have yielded archaeological evidence for the earliest pottery yet known in the Americas and confirms specialized exploitation of river fauna by these early populations (Roosevelt et al. 1991, 1996). Caverna de Pedra Pintada and an Archaic shell-midden called Taperinha on the opposite side of the river from Monte Alegre excavated by Anna Roosevelt in 1987, both contain ceramics with dates over 7000 years ago.

Evidence for manioc agriculture is present in the archaeological record at Caverna de Pedra Pintada in the form of bowls and thick griddles like those used today for cooking manioc. The pottery relates to the lowland South American Formative period from about 4000 to 2000 years ago, thought to represent the diffusion of ceramics and root horticulture (Roosevelt 1980; Roosevelt et al. 1996). Evidence from various locations in northern South America indicates that manioc was a staple food for a number of groups by 3000 years ago (Lathrap 1970).

Ethnohistorical documents describe large populations densely settled along the main branch of the Amazon River when Europeans first arrived (Carvajal 1934; Porro 1994). Preliminary archaeological evidence lends credence to these reports (Heckenberger et al. 1999; Smith 1980). Most of the floodplain cultures were completely destroyed in the first 150 years of European contact. It is likely that these populations subsisted on a combination of aquatic resources and agriculture, both on the várzea and terra firme (Roosevelt 1980; Smith 1999). There is much uncertainty and debate as to the relative proportions of these resources in the subsistence economy of prehistoric riverine cultures.

Roosevelt (1980) theorized that the introduction of maize in the Orinoco and Amazon basins acted as a springboard for the development of dense populations. She reasons that manioc is ill-suited to the floodplain and makes inefficient use of the relatively fertile alluvial soils. Roosevelt claims that short maturing maize is a more appropriate crop for the unpredictable bottomlands and the high-protein grain makes optimal use of the nutrient-rich soils. The examination of contemporary agricultural systems, resource use, and ecological perceptions on the floodplains and adjacent uplands can help us to evaluate existing theories and provide insights into the subsistence economies of prehistoric riverine inhabitants.

Amerindian populations today are a vestige of what they once were (Denevan 1976a). In Amazonia, like elsewhere in the western hemisphere, the population has fallen drastically since first contact with Europeans in the sixteenth century due to disease, warfare, and slavery (Denevan 1976b; Heckenberger 1998; Meggers 1992). In pre-contact times, intensive agriculture, with significant transformation of the landscape, was well underway in several regions of the Amazon (Denevan 1970; Ericson 2000, 2001; Heckenberger 1996, 1998, 1999, Heckenberger et al. 2003). It is clear that Amerindian subsistence economies, including swidden cultivation, described in the ethnographic record are a remnant of their former range of variation (Beckerman 1987). Research on the swidden systems in use along the Amazon river today can add to our overall understanding of this subsistence activity in the region.

Practical Aspects of Swidden Research in Amazonia

National governments view the development of their Amazonian territories as imperative to the growth of their economies and modernization of their countries. Conservationists hope they will seek sustainable ways to develop natural resources. Conventional agricultural methods including mechanical clearing and tillage of the soil, large plantations, and mono-crops have so far not proven successful in Amazon rainforest areas (Fearnside 1987, 1988). These methods often cause soil erosion, degrade ecosystems, and deplete biodiversity (Gascon and Lovejoy 1998; Milliken 1992; Serrão et al. 1993). The search continues for forms of development that maintain the integrity of ecosystems and, at the same time, contribute to markets and raise the standard of living for local people.

Many researchers have emphasized that indigenous peoples have an important contribution to make to the question of how to develop the Amazon (Anderson and Posey 1989; Posey 1981,1985,1993; Schmink et al. 1992). Smith (1999) argues that native knowledge and modern science should be combined when trying to make rational use of the Amazon's resources. The National Research Council has urged that information on traditional agricultural systems of the humid tropics be researched and evaluated before this valuable knowledge is lost (National Research Council 1982).

Since the 1960s, the Brazilian government has implemented an aggressive development strategy for its Amazon territory. A perceived threat from other nations who "covet" the Amazon could be ameliorated by a clear Brazilian presence. Furthermore, the migration of large numbers of people to the vast, "unoccupied" frontier region was seen as a safety valve for social problems in the rest of the country. The opening up of Rondonia to colonist settlement brought thousands of landless people from Southern Brazil. In 1970, the Transamazon highway colonization scheme was begun with hopes that large numbers of migrants would come from the drought stricken northeast to settle in the Amazon and build a strong economy based upon agriculture, mining, and timber extraction (Moran 1984; Smith 1981). Rather than settling along the main rivers, the colonists inhabited upland areas along the new highways. They brought their notion of agriculture from the sub-tropical and temperate south and the dry northeast to a foreign environment. The colonization project made little effort at ecological zoning according to soil type or other indicators of fertility. The colonists were handed a piece of land that often lay on extremely poor soils. Many of the colonists failed and returned home while others found a livelihood in the growing urban centers. Some learned how to adapt their agricultural methods to the rainforest environment and were able to make a living.

The development of diverse agroforestry systems is seen by many as a viable option for Amazonian farmers (Smith 1996b). The maintenance of biodiversity and better preservation of ecosystem services are two potential advantages of agroforestry and some argue that the cutting of old growth forests would be slowed by having a more permanent system in place (Denevan 1980; Smith et al. 1995). Swidden agriculture frequently includes agroforestry as an integral part of forest management (Alcorn 1990; Coomes and Burt 1997; de Jong 1996; Denevan and Padoch 1987; Eden and Andrade 1987; Hammond et al. 1995; Unruh 1990). Indigenous peoples throughout the tropics often practice some form of fallow management that increases the productivity of a given field. In indigenous swiddens, cultivation is rarely stopped abruptly but instead, useful plants are harvested for many years after the field is "abandoned."

Denevan and Padoch (1987) and their colleagues studied what they aptly termed "swidden-fallow agroforestry" in a native Bora community of the Peruvian Amazon. In this particular case and many others, swidden fallow management is based on successive planting and harvesting of different crops. For example, a staple crop such as manioc may be interplanted with longer maturing crops like bananas and some fruit trees. As the crops are harvested, others may be planted in their place. Eventually, the field can become a secondary forest enriched with useful species or a fruit orchard. The advantage is that a farmer can return to his fallows to continue harvesting fruits, timber, medicines, and other products for years to come. Another benefit of having a diversity of crops growing in managed fallows is that farmers can spread production throughout the year.

This research will show that traditional caboclo farmers of the middle Solimões also practice various degrees of swidden-fallow agroforestry and forest enrichment.

Traditional systems could be adapted by colonists to develop a more viable agricultural system. Indeed, innovative colonists are already experimenting with various consortiums of crops on their own (Smith et al. 1995). The land use systems of traditional inhabitants can certainly provide some useful lessons for colonists to improve the way they utilize and conserve resources in Amazonia. This research examines the extent that traditional farmers on the middle Solimões utilize fallow management by documenting the distribution of useful plants in the agricultural landscape and the practices that result in that distribution.

In Brazil, while most of the nation's attention was focused on the terra firme as the main area of development in Amazonia, the várzea with its relatively small extent of about 2% of the basin, was largely ignored. The várzea is the floodplain of "white water" rivers that carry fertile sediment from the Andes Mountains. The realization that terra firme soils are generally poor in nutrients and do not support intensive cultivation of cereal crops without substantial external inputs has sparked a renewed interest in the várzea as a promising area for modern agricultural development (Junk 1982; Smith 1981). Because of the influx of nutrients brought by the flood, good prospects for irrigation, and ease of transport, some have advocated the development of arable farming or irrigated rice on the várzea. However, developers and policy makers generally do not know how to implement large-scale mechanized agriculture on land where massive, unpredictable floods are the norm.

Several attempts have been made to grow irrigated rice on the várzea with varying levels of success. A project at the mouth of the Jari River attempted to grow irrigated rice on a large scale in the 1970's. Their efforts were hampered by problems with soil fertility, pests, fungal diseases, and weeds (Fearnside and Rankin 1985). Junk et al. (2000) discourage large-scale arable farming on the várzea for environmental, economic, and social reasons. Instead, they support the integral management of aquatic and terrestrial resources through the zoning of economic activities and decentralized and participatory management by the local population.

There are four major economic activities on the várzea that vie for control over limited resources; fishing, forestry, agriculture, and ranching (Junk et al. 2000; Smith 1999). The conflicts of interest are exemplified by the possible adverse relation between fishing and the other three land uses that result in deforestation of the floodplain. Forest clearance for timber, agriculture, and pasture poses a threat to the productivity of aquatic resources by reducing their habitat and food sources (Fearnside 1990, 1995; Goulding et al. 1996; Goulding 1999). Deforestation is also a threat to the many endemic plants and animals of the várzea that are so far not adequately protected. In addition, the growth of ranches and large-scale agriculture can result in the loss of crops, varieties, proto-domesticates, and crop relatives that are vital for the future development of the várzea (Smith 1999). With the increasing interest in intensifying agriculture on the várzea, it is pertinent to examine the resource use and perceptions of the local inhabitants.

There are very few Amerindian groups that utilize várzea resources today. Having endured the first and longest sustained contact with their European conquerors, the Amerindians who lived along the Amazon River were virtually wiped out by disease, warfare, and slavery. Three Amerindian groups that currently practice agriculture on the floodplain are the Shipibo and Cocama who live in the Peruvian Amazon and the Tikuna (they have moved to the riverside from the uplands since the time of European contact) who live in the frontier region of Colombia and Brazil (Bergman 1980; Shorr 1999). However, they are relatively acculturated groups and are a small minority along the Amazon River. The caboclos of Brazil or ribereños of Peru comprise most of the inhabitants along the major rivers today. They are people of mixed Amerindian, European, and African ancestry (mestizo) who rely largely on subsistence techniques similar to those of indigenous Amazonians (Moran 1993; Sutlive et al. 1985; Wagley 1953). Indeed, there is a continuity of Amerindian culture and resource management in the caboclo way of life.

Relatively little attention has been paid to the living strategies of the mestizo riverine population (Padoch and de Jong 1991; Parker 1989). Hiraoka (1992) provides a brief review of the research on caboclo and ribereño resource management. Here, I will highlight some of the literature pertaining to caboclo/ribereño agriculture that is particularly relevant to this thesis. Denevan (1984) elaborated the concept of "horizontal" ecological zonation of agriculture on the floodplain, likening it to altitudinal zonation on mountain slopes. His article was inspired by Bergman's (1980) study of the Shipibo in Peru and work done by Judith Gunn who studied agricultural scheduling on the Ilha dos Purus in the Amazon above Manaus. Hiraoka (1985a, 1985b) described the ecological zonation of floodplain agriculture of a ribereño community near Iquitos in the Peruvian Amazon. Several studies have focused mainly on mestizo terra firme agriculture along the river near Iquitos (Chibnik 1994; de Jong 1996; Hiraoka 1986;

Padoch and de Jong 1992; Padoch et al. 1985). Frechione and colleagues (1989) examined caboclo's perceptions of biotopes and ecological zonation at Lake Coari on the Solimões. Anderson et al. (1995) studied resource management of caboclos in the Amazon estuary near the mouth of the Tocantins River. Swales (1999) compared land use dynamics and agriculture in the uplands and floodplain in the lower Amazon. Preliminary results of research on floodplain farming in the Brazilian state of Amapá are given by Padoch and Pinedo-Vasquez (1999). Some ongoing work is being done on agricultural systems and change on the várzea in the Mamirauá Sustainable Development Reserve where the data for this thesis was collected (Padoch et al. 1996; Pinedo-Vasquez et al. 1996, 1999). Finally, a comprehensive work edited by Junk et al. on actual use and options for sustainable management of the várzea includes information on current management practices by caboclos (Junk et al. 2000).

One way that caboclo agriculture can contribute to questions of várzea development are the many crops and varieties that they plant. Generations of farmers have selected varieties and individuals that are tolerant to flooding and resistant to pests and diseases. Development plans would be prudent to incorporate crops that are adapted to conditions on the várzea. Caboclo agricultural practices can also inform várzea development planners. We know that Amazon floodplain farmers utilize a number of habitats. What management strategies do they use to cope with the varying environmental conditions of those habitats? What crops do they plant in which habitats? The imperative of conserving várzea biodiversity and natural resources compels us to analyze the agroecosystems of caboclos in detail to determine which aspects of their management can contribute to the sustainable development of the Amazon floodplain.

Amazon Caboclo

The people who make their living along the middle Amazon today are known as caboclos, a designation whose significance has evolved and been modified during the history of colonial occupation (Lima-Ayres 1992). The term caboclo conveys different meanings to different people. An important distinction is made between the colloquial use of the word and its application in the academic literature. In the colloquial use, caboclo can be a racial category, economic class, or rural resident. In elementary school, Brazilian children learn that caboclo means a mixture of Amerindian and European ancestry. Caboclo also indicates a low social class, the rural or urban poor, and illiteracy. The term is generally derogatory and few people will refer to themselves as caboclo. It would be used by the urban upper class to refer to the urban poor, and by the urban poor for people from the "interior" or rural areas. Rural inhabitants, in turn, would not call themselves caboclos but use it to refer to Amerindians. In other words, it is always "the other" and rarely oneself (Lima-Ayres 1992).

In the academic literature, caboclo is not a racial category but rather, a social category, the indigenous Amazonian peasantry (Lima-Ayres 1992; Parker 1985; Ross 1978). A distinction is made between the caboclo and the other two major groups in the Amazon, Amerindians and recent migrants or colonists. Caboclos are made up of a mixture of people from three main regions; Amazonia, Europe, and Africa. Many caboclos are descendents of the indigenous inhabitants that lived along the Amazon when Francisco de Orellana first sailed down the river from Ecuador to the Atlantic in 1542. Amerindians were captured as slaves or enticed into missions and incorporated into the European colonial system. As time went on, Amerindians continued to migrate from tributary and headwater regions to fill the demographic void created by the depopulation of the vàrzea region. Miscegenation resulted in a population dominated by people of European (mainly Portuguese) and native Amazonian descent. Included in the mix are Africans who were originally brought to Brazil as slaves to work on plantations and also migrants who came to the Amazon from Northeast Brazil and other regions during the rubber boom from 1850 to 1920.

Wagley (1953) and Galvão (1952) made the first anthropological studies of the caboclo and characterized “caboclo culture” as a combination of Amerindian and Iberian cultural traits. Many aboriginal economic strategies have persisted in the caboclo population long after the tribal peoples were gone. Amerindian methods of agriculture, hunting, and fishing, as well as customs and religious beliefs are still practiced in order to make a living in the volatile, often unpredictable environment of the middle Amazon (Moran 1974; Parker 1985).

Middle Solimões Region

The Solimões River is the section of the Amazon River in Brazil stretching from the Peruvian border to the confluence of the Negro River near the city of Manaus. The middle Solimões region is approximately centered where the Japurá River joins the Solimões (Figure 1-1) (Lima-Ayres 1992). Tefé is the largest town and the commercial center of the region. According to the 1996 census, the municipality of Tefé had a population of 62,000 with 76% living in urban areas (IBGE 1998). The surrounding municipalities have a much lower urban population. In the nearby municipality of Uarini, with a 1996 population of 10,500, 20% are urban. The regional population is growing rapidly with a high rate of natural increase and rural to urban migration.

Two degrees south of the equator, the climate is tropical with little year long variation in average temperatures. Average monthly temperatures range from a daily minimum of between 21 and 23 degrees Celsius to a daily maximum of between 30 and 33 degrees Celsius (Ayres 1995). There is considerable variation in precipitation throughout the year and from one year to the next. December through March is the rainy season with about three times the amount of precipitation as during the dry season from July to October (Ayres 1995). Average yearly rainfall from 1977 to 1981 for the city of Tefé was 2,373 millimeters with the lowest and highest rainfall for those years being 2,190 and 2,632 millimeters.

Fishing, agriculture, and timber extraction are the predominant economic activities in the region. According to the Brazilian Institute of Geography and Statistics, manioc is the most important crop (IBGE 1998). In the municipality of Tefé (23,800 km^2), 2,238 out of 2,255 (99%) farms surveyed produce some manioc. Approximately 64,000 tons were harvested on 6000 hectares. However, only 33 tons were reportedly sold indicating that most manioc is grown for subsistence only. Bananas are the second most important crop in the region and, unlike manioc, most are sold on the market. Other crops that were included in the survey that are produced to a much lesser extent include corn, beans, sugarcane, oranges, tomatoes, and rice. Cattle ranching has not yet taken off in the region. A total of 5000 head of cattle were reported in the four municipalities of Tefé, Alvarães, Maraã, and Uariní with the majority in Alvarães and Tefé near the larger urban centers. Some hogs and poultry are also produced. Many rural families keep a few ducks or chickens around the home. Only a few of the households surveyed for this thesis owned cattle or hogs.

Virtually all settlements in the middle Solimões region are located near a river. Most rural inhabitants live in scattered settlements of fifteen houses on average and a few live in isolated homes. Many of the small settlements in the middle Solimões region began with the decline of the rubber era when rubber tappers moved in from more isolated extraction areas (Sociedade Civil Mamirauá 1996). The communities in the region are located either on the river bluffs surrounding the várzea, on the várzea itself, or on large lakes formed at the mouths of tributaries of the Solimões such as Lake Tefé, Lake Uarini, and Lake Amanã. Communities differ in their monetary wealth, degree of isolation, market connections, government support, and available habitats for agriculture and resource extraction. On the terra firme, the agricultural cycle follows the change in seasons from wet to dry. The cycle of activities on the várzea follow the pulse of the flood.

Connservation of the Várzea Ecosystem: The Mamirauá and Amanã Sustainable Development Reserves

The enormous productive potential and inumerable endemic species of the várzea have spurred researchers to underscore the importance of rationally managing floodplain resources (Goulding et al. 1996; Junk et al. 2000; Padoch et al. 1999; Smith 1999). The newly created Mamirauá Sustainable Development Reserve (MSDR) is the only conservation area specifically dedicated to the preservation of biodiversity and management of resources on the várzea in Brazil (Sociedade Civil Mamirauá 1996). Covering over one million hectares above the confluence of the Solimões and Japurá Rivers, the area was first established as an Ecological Station in 1990. The recognition that people live in and utilize the resources of Mamirauá prompted a new category of conservation unit to be created and the area was reclassified as a sustainable development reserve in 1996. In 1999, the Amanã SDR was created adjacent to Mamirauá to link up with Jaú National Park creating a central Amazon conservation corridor.

The goal of the Mamirauá project is to integrate conservation of biodiversity with the social development of local communities (Lima 1999; Howard et al. 1995; Sociedade Civil Mamirauá 1996). Scientists work with residents of the reserve to research, monitor, and protect natural resources and to develop a management plan that encompasses both conservation and development objectives. They must determine which activities threaten natural resources and seek new activities that are compatible with conservation goals.

Our study builds on others from the Mamirauá Reserve (Chota 1999; Padoch et al. 1996; Pinedo-Vasquez et al. 1996; Pinedo-Vasquez et al. 1999) to show the enormous resource of agrobiodiversity and management diversity used by small farmers within the conservation reserves. It is hoped that it will be valuable as a jumping off point for further research on agrobiodiversity in and outside the reserves and useful when considering new policies or projects that may affect agrobiodiversity in the region.

Data and Methods

To understand the spatial distribution of agrobiodiversity across different habitat types and management systems, the home gardens, fields, and fallows were visited in nineteen communities in the middle Solimões region (Table 2-1 and Figure 2-1). An inventory was conducted in each home garden that included all food, timber, and medicinal plants. The number of individuals of each species was recorded, the size of the home garden was estimated, and a position was taken with a GPS receiver.

Fields and fallows were visited and the following information was gathered.

- GPS position
- Type of work area (field, fallow, orchard, etc.)
- Estimated size
- Habitat (terra firme, high levee, low levee, mudflat, or beach)
- Useful species (including food, timber, medicinal, and other)
- Varieties of manioc and banana

- Name of owner
- Other information gathered for some fields and fallows including but not limited to: crop age, field age, number of consecutive seasons planted, number of previous fallows, age of last fallow, and status or use of the area before (fallow, old growth forest, etc.)

An attempt was made to visit all fields and fallows in each community. However, this was not always possible because of the great number of fallows in some communities, the logistics of reaching some of them, and the question of recruiting informants who were willing to take time out of their busy schedules to help us.

The objective of the study was to visit a large number of fields in communities located throughout the region, therefore, quick estimates of size were made rather than taking the time to carefully measure each field. Size was estimated by site and

Table 2-1. Number of home gardens, fields, and fallows visited in 19 communities on uplands and floodplains in the middle Solimões region

Community	Map id	Várzea/ terra firme	Num. home gardens visited	Num. fields visited	Num. fallows visited
Acari	9	várzea	0	1	0
Barroso	8	várzea	11	16	9
Bate Papo	10	várzea	0	2	3
Bela Vista do Manguary	11	várzea	2	5	9
Betania	15	várzea	16	35	16
Betel	16	várzea	10	26	13
Boa Esperança	19	terra firme	17	55	45
Jarauá	18	várzea	11	31	12
Jubará*	13	terra firme	5	15	8
Manacabi	17	várzea	7	14	12
Marirana	7	várzea	10	13	5
Nossa Senhora da Fátima	2	terra firme	8	16	22
Pentecostal	12	várzea	9	8	6
Porto Praia	4	várzea	15	7	12
São Francisco do Aiucá	5	várzea	15	48	25
São João	6	várzea	16	10	6
São Paulo do Coraçi	14	várzea	12	22	48
Sitio Fortaleza*	3	várzea	11	15	34
Vila Alencar	1	várzea	19	19	36

* In these two communities, fields were visited on both várzea and terra firme

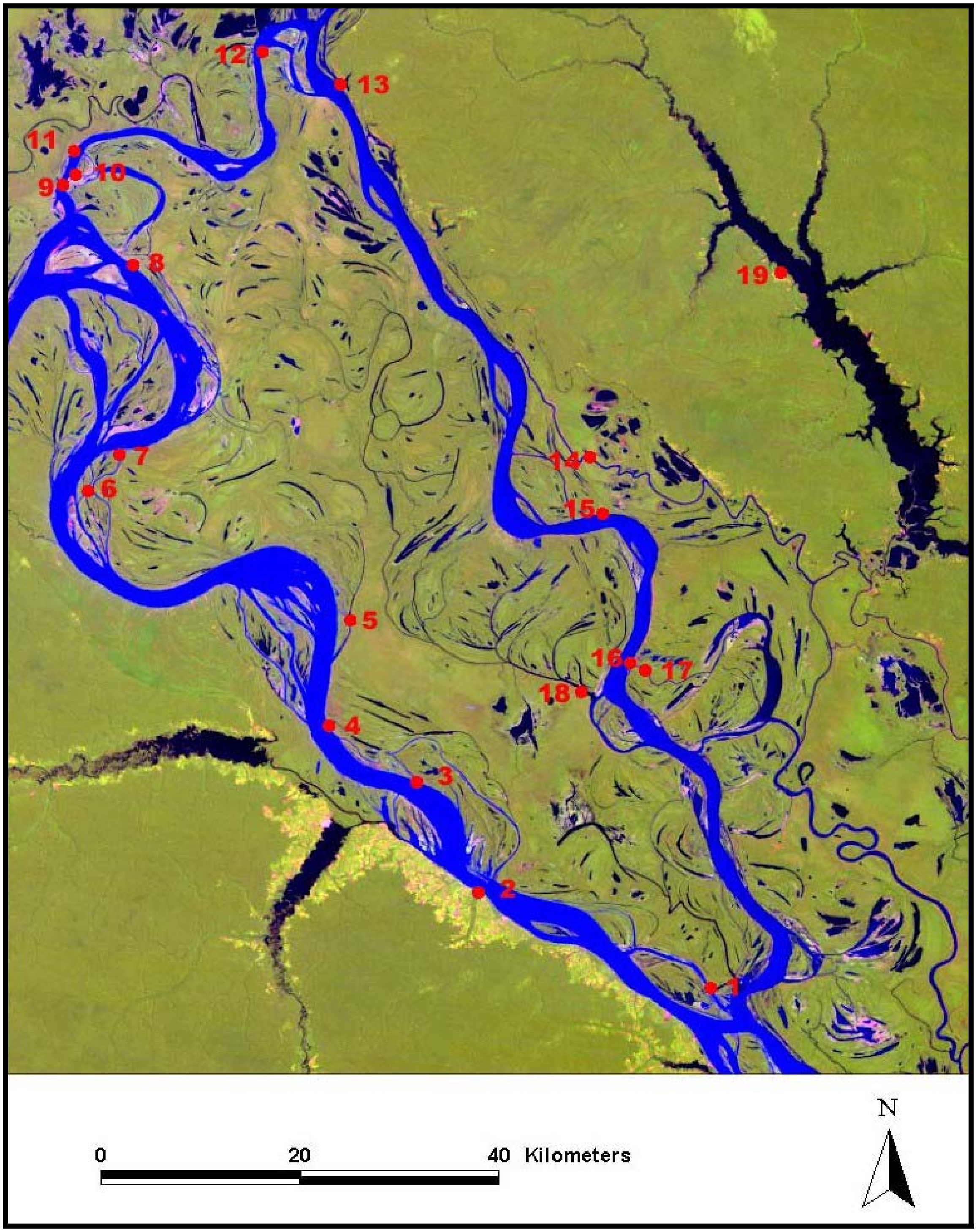

Figure 2-1. Landsat TM satellite image (bands 543) of the study region from 1999 with the locations of 19 communities included in the survey

occasionally checked by pacing. Estimates of the size of smaller fields should be accurate to within a couple of meters while the error may increase proportionately as the size of the field increases. In cases where it was impractical to measure the size by pacing and it could not be estimated by site because of thick canopy, the owner or informant gave his estimate of the size, leaving room for error. Therefore the size, especially for the larger fallows, should be considered rough estimates.

The distinction between habitats of terra firme and várzea is more clear than that between high and low levees and low levees and mudflats. It would have been possible to draw an arbitrary line between the habitat types based on the height of the land in relation to the high water level of the previous years flood but this would be possible only where there are trees with visible high water marks. In the interest of time this was not done. Instead, the decision was made to use the informant's classification of the habitat.

Local farmers classify habitats based on their observations of the depth of flooding and length of time underwater each season as well as the vegetation and soil types. They rely on their own experience from their particular local environment and so these classifications can be somewhat subjective. Farmers classify four major floodplain habitats used for agriculture; restinga alta (high levee), restinga baixa (low levee), lama (mudflat or silt bar), and praia (beach or sand bar). At the time of fieldwork, high levees were usually above water but some were flooded to a depth of usually not more than forty centimeters. The vegetation is well developed forest. Areas that farmers classified as low levees were flooded from one to several meters and vegetation is usually dominated by the imbaúba tree (*Cecropia* spp.). Mudflats are typically dominated by canarana grass (*Echinochloa* spp.) and beaches are devoid of vegetation.

The inventory of the fields and fallows recorded all species that were considered useful by the inhabitants. These included tubers, fruits, vegetables, nuts, timber, and medicinal plants. A few others with uses such as fishbait, latex, and thatch were also included. The inventories were made by walking around in the field or passing slowly along the riverbank in a boat. The informants were relied upon to name the useful species and much effort was made on our part to insist that all of them be recorded. The error here is most likely to consist of some species not being recorded for some fallows, especially the very large ones. Varieties of banana and manioc were recorded in many cases but not all. Sometimes the variety was unknown to the informant. Many of the fields that were visited had already been harvested and were often flooded. In this case the crops that had been harvested were reported.

The information on management was gathered, when possible, in informal interviews with the informant while visiting the field. Occasionally, details on yield, weeding, markets, or management were learned in this way.

Finally, an informal interview was conducted in the home after taking the home garden inventory. The residents were asked about the number and size of their fields and fallows, the crops they had harvested, and the produce they had sold to market. They were also asked about losses of crops and home garden plants due to the flood or pests and diseases. The information gathered in this way is supplementary only. The interviews were not structured and the same information was not given by every interviewee.

The data was put into a database and incorporated into a GIS using the geographical positions recorded in the field. To do this, a Landsat Thematic Mapper image was geo-referenced and the points were plotted. This has been given to the Mamiraua Sustainable Development Institute to be incorporated into their larger GIS database.

Areas that were designated as high levee or restinga alta were flooded to a maximum depth of one meter in the year 2000. Most of them were flooded less than 40 centimeters and the majority still had dry land, with many elevated up to 50 centimeters above the high water level for the year. In this survey the classification of habitat type was based on the informant's designation of the area. Therefore, it is assumed that some overlap exists between habitat type designations. In other words, areas that were called restinga alta in one community with one meter of water may be termed restinga baixa in another community. For example, in São Paulo do Coraçi located on a side channel (paraná) of the Japurá, some fields that had not flooded and were up to 50 cm. above the flood in 2000 were termed restinga baixa while in Betel, a community on the Japurá, restinga baixa fields were submerged in one meter of water. In the interest of time, the decision was made to rely on local designations of habitat types rather than attempting to measure the height of the land. Due to the extremely dynamic nature of the várzea landscape, the height of the land can change from year to year due to erosion and deposition of sediment. There is also the issue of differential flooding. Areas near the main channel of the Solimões probably receive higher floodwaters than areas near the Japurá or side channels.

Research Considerations of the Flood Season

Field research was conducted in the summer of 2000 (May to August) during the peak of the flood. Ideally, to study agricultural biodiversity on the várzea, it would be best to observe the agricultural fields through an entire cycle or, better yet, several cycles.

There would be no single part of the year on the floodplain in which all diversity could be captured. The agricultural calendar is complicated and dynamic with crops being planted and harvested during several seasons throughout the year.

At first consideration, it would seem that the flood season is the worst possible time to study agricultural diversity since the majority of the fields are harvested or even under water. But it is at precisely this season that we can get an idea of which species and varieties are retained in situ even during the flood. It is also significant that this research followed three consecutive years of high floods and the previous year, 1999, experienced an exceptionally high flood (Figure 2-2). The flood of 1999 was one of the five highest in the last century and caused substantial losses of seasonal crops, planting material, and perennials for residents of the Mamirauá and Amanã Reserves. This research is especially pertinent because it can indicate the level of agrobiodiversity that remains in the agricultural system after a period of several high floods. In addition, although the specific objective of this research was not to gather data on crop losses resulting from the high flood, a significant amount of information was collected during the inventories and interviews. It is enough to give a good, if not comprehensive, indication of which species are more susceptible to drowning and to what extent crops are damaged by high floods.

Crops including corn, beans, squash and others are probably somewhat underrepresented by this study since most of the areas where they are grown, mudflats (lamas) and beaches (praias), were under several meters of water at the time of the survey. Although the attempt was made to visit all of the areas where crops were planted, including those underwater, it is likely that some areas were missed in the survey due to the informants misunderstanding, forgetting, or downplaying the importance of these areas. Additionally, some of the non-harvested manioc fields that were visited may have contained additional crops that were harvested before the survey and went unreported by the informant. These factors combined generate substantial room for error. It is important to emphasize that the present study is simply a snapshot in time and a much more comprehensive, long-term study would be required to capture the full range of agrobiodiversity and its dynamic nature and resilience on the várzea.

Life on the Várzea

The stretch of floodplain in the middle Solimões region is among the widest along the entire length of the Amazon river. Inhabitants of the várzea must often travel many kilometers to reach the terra firme. The difference in level from low to high water is the highest in the Brazilian Amazon, exceeding fourteen meters in some years. Even the highest ground, the floodplain levees (restingas), may be inundated up to several months each year imposing special living conditions on residents who must cope with water covering their yards and fields for weeks on end.

The várzea landscape is one of the most dynamic on earth. The shifting river channels continually form and erode levees. High levees that are used for agriculture and settlements collapse into the river while elsewhere sandbars are colonized by pioneer vegetation and new islands and levees are formed. The time scales at which these morphological changes take place are extremely fast by geological standards with levees and islands potentially being molded or erased in less than a human lifetime. Agricultural fields concentrated in one area may shift to another area at intervals of several years in order to adjust to the rapid morphological changes in the landscape such as the closing off of channels as they become choked with vegetation and sediment and the building and destruction of levees.

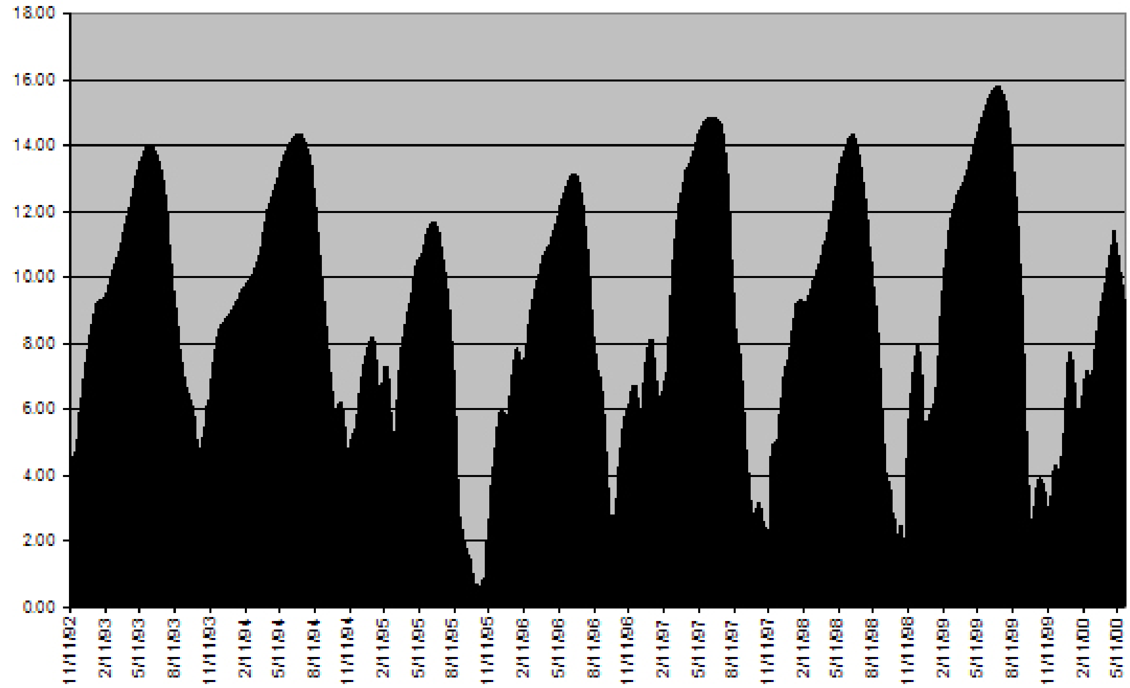

Figure 2-2. Seasonal fluctuation in water level on the middle Solimões, 1992-2000. Rise and fall (in meters) of the river near the town of Tefé. In 1999, there was approximately 14 meters difference between low and high water. Source: SDR Mamirauá 2000

Várzea dwellers have adapted their lifestyles to contend with the inevitable yearly flooding. Settlements on the floodplain are located on the high levees to avoid prolonged periods of inundation (Goulding et al. 1996). Most are along major river channels for access to river traders and collective transportation. Families on the floodplain usually build their homes on stilts to avoid being inundated by the rising waters. During the weeks or months with water under their homes people rely on their canoes for even a quick trip next door. Often the water is only several inches to knee deep and trudging through mud is commonplace. Children are frequently seen playing and splashing in the river right outside their front door. Animals must be kept in the house or on floating rafts if no dry ground is available.

The enchente or high water period is unanimously considered to be a time of hardship. Crops may not be grown on flooded land and fishing is less productive since fish are dispersed throughout the igapó or flooded forest. The greatest difficulty comes when they get a high flood like the flood of 1999 (Figure 2-2). They are accustomed to this ordeal and cope with it in a variety of ways. Many leave their homes and temporarily stay with relatives in towns on the river bluffs. Others stick it out and simply build a new floor above the water level, continuing to raise it when necessary to keep pace with the rising deluge. Residents along the main channels complained of huge wakes from passing boats. They would leave their doors open in order to diffuse the force of large waves breaking against the front of their homes. Instead, the powerful waves would sweep through their living room and crash into the back wall of the house. Some avoid the invading waters by living in a floating house with the added benefit of being more mobile, even able to tow their residence to a new location. People are very resilient and bounce back quickly from such events. They rely on friends, neighbors, and kinship networks to get them through these tough times.

The exceptional floods like the flood of 1953, the highest of the twentieth century, are remembered long afterwards. High floods can be quite a setback for residents. It is after one of these disruptions to their lives that families sometimes decide to make a move to terra firme. The people are highly mobile and the turnover rate for residents of the várzea is high (Sociedade Civil Mamirauá 1996).

Fishing and agriculture are the predominant economic activities for residents in this part of the Amazon floodplain. To earn an income, some devote all of their energy to fishing and others focus on agriculture but the majority depend on both activities for their livelihood. Other activities such as the extraction of timber, firewood, and fruit also serve to supplement their income but are generally only secondary in importance. The açai (*Euterpe* spp.) fruit, used to make a popular drink, is commonly collected and sold. Other fruits such as yellow mombim (*Spondia lutea*) and genipap (*Genipa americana*) are common on floodplain levees and are sometimes brought to market or sold to passing river traders. Honey from native stingless bees is occasionally harvested from the forest. Another possibility to earn extra money is hunting caiman and selling the meat dried or salted. Hunting of other animals may also be an important subsistence activity especially for the communities on or near terra firme. However, selling wild game products, including caiman, is illegal in Brazil so there is not a market for game meat as in some other regions of the Amazon, such as Peru. Turtles, turtle eggs, and manatee meat fetch a high price but those who try to sell them risk getting caught and fined by IBAMA, the federal environmental protection agency.

Working within or outside the community for a wage is an option for some individuals. Working as a day laborer for a neighbor is more common in terra firme communities where production of farinha or manioc flour is practiced on a relatively larger scale. Here, farmers sometimes hire day labor to weed their fields or they may contract someone with a chainsaw to clear some land. They typically pay a few dollars per day for this type of work. Some people also find temporary work in nearby towns.

Figure 2-3. Floodplain community during low water. The building in the foreground is a floating house and the high water mark from the previous flood is half way up the walls of the homes on the bank. Boca do Mamirauà, November 1999.

CHAPTER 3
STRATEGIES FOR FARMING ON THE FLOODPLAIN: THE ROÇA

Várzea farmers contend with unpredictable floods, relentless pests and diseases, and an extremely heterogeneous environment that is constantly changing. Crop losses are frequent and can cause significant setbacks. As a means of risk management, they employ numerous strategies and take advantage of the varied terrain by utilizing several different habitats for planting crops. Reliance on rapidly maturing varieties as well as crops that are able to withstand weeks or months in standing water help farmers cope with the inevitable yearly flood. They use their knowledge of the environment to select appropriate areas for planting crops. There is an element of risk as farmers attempt to predict the magnitude and timing of the coming deluge. Residents, therefore, rely on one another for assistance when losses occur.

The floodplain habitats used for agriculture are divided by farmers into four main types: beaches (praias), mudflats (lamas), low levees (restingas baixas), and high levees (restingas altas). The main factor that they use to differentiate them from one another is their altitude and, therefore, the degree to which they are subject to flooding. The distinction that is made between these habitat types can be rather arbitrary. Actually, a continuum exists between the habitat types and management depends on other factors as well such as predominant vegetation, sediment deposition, and individual preference.

Farmers who have access to land on terra firme often plant there as well. In the várzea community of Sitio Fortaleza, for example, several families have been planting on terra firme that is some distance away (one hour by motor boat or three hours rowing).

Figure 3-1. The bank of the Japurá River during low water. Shows a typical gradation from sandy beach to grassy mudflat to forested low levee (Nov. 1999).

Several members of the community expressed their opinion about the hardships of life on the floodplain and the relative security of farming on terra firme. They have decided to move their families to high ground and others in the community may soon follow. Jubará, a terra firme community on the bank of the Japurá river, also utilizes both várzea and terra firme for agriculture.

Fields, fallows, and home gardens are the three major categories of land use that farmers manage. All places where crops are planted or were planted in the past can be referred to as work areas (areas de trabalho). Annuals such as corn and beans or the semi-perennial crop manioc are planted in fields with the frequent inclusion of perennial fruit trees. Fallows range from a simple abandoned field with no useful species through a mono-cultural banana grove on up to a mixed fruit orchard. They harbor a large selection of useful plants and are a significant resource for subsistence and the market and often especially rich in construction materials. Home gardens contain a diverse range of fruit, vegetable, medicinal, and ornamental plants. They provide a range of foods and other useful products to the household.

When an area is selected for cultivation, farmers take advantage of pre-existing valuable plants by sparing them during field clearance. They also practice selective weeding to protect useful volunteer plants, some of which are favored by forest disturbance. These farming methods alter the mix of species in regenerating forests to create a heterogeneous forest environment on the floodplain, effectively increasing the occurrence of plants that are useful to humans and, in some cases, benefiting wildlife (Pinedo-Vasquez et al. 1999, Padoch et al. 1996). It is possible that overall diversity in the region is greater as a result of the variety of management strategies employed by vàrzea farmers (Balée 1994).

Characteristics of the Roça

In the vernacular language of the region the term roça refers specifically to a manioc field. Plots dominated by a crop other than manioc are generally referred to by another name. For example, a field dominated by corn, watermelon, or banana would be called a milheral, melancial, or bananal, respectively. The manioc tuber is planted in habitats ranging from mudflats to high levees but never on low-lying sandy beaches that are the first to flood. A limited repertoire of crops is planted on beaches; mainly beans and watermelon. In this thesis, roças are designated as work areas used to plant any annual crop as well as the semi-perennial crop manioc. Roças may be monocultures with one or several varieties of a crop but are frequently polycultures containing a number of species and varieties. Perennial fruit trees (usually commercially valuable) are sometimes planted with the manioc crop to be left growing when cultivation is discontinued.

In a study of agricultural management systems in three communities in the Mamirauá Reserve, Pinedo-Vasquez et al. (1996) described two types of planting configurations that are primarily used. The first, called randomly planted (plantio mixturado), is a system under which two or more crops are interplanted. There is often one main crop and one or more secondary crops. In the second system, stratified planting (plantio dividido), roças are divided into sections where different crops are grown based on soils and topography. According to their research, the frequency with which each system is used is dependent upon the intensity of the flood in the previous year. Farmers tend to employ the stratified planting system more often after high floods as a means of risk management. They expect high floods two years in a row so they carefully choose the highest areas of the field to plant manioc and bananas and tend to increase production of fast growing crops like squash.

Roças may be cleared from forest (mata, sometimes referred to as mata bruta or mata virgem indicating its status as old-growth, mature, or virgin forest) or from any work area type included in the fallow category. Levees (restingas) are most often covered by closed canopy forest that necessitates burning in the first season. Once fields are established, burning is often unnecessary in the following seasons even when clearing young fallows.

In some cases, what is called forest (mata) may actually be old secondary regrowth. Residents usually do not have knowledge of a particular forest beyond about twenty years as many of the communities on the várzea of Mamirauá are less than twenty years old. It is quite possible that much of the forested levees have been cultivated at some time in the past (in historic or prehistoric times), effectively altering the natural mix of species in floodplain forests.

Valuable trees are sometimes, but not always, spared during forest clearance. Large timber or fruit trees can sometimes be found standing in the middle of a roça but this is fairly rare on the várzea. It is a more usual sight in terra firme roças that are typically much larger. Very large trees are sometimes left standing because of the danger or time it takes to cut them down. They often die when surrounding forest is removed but wood can still be exploited years afterward. A common way to preserve valuable trees in both ecosystems is to clear the forest just up to the useful tree and stop, leaving it just on the border of the field locally called the açero.

Farmers reported weeding levee fields up to four times during an eight-month growing season. This is done by crouching or sitting on the ground among the manioc stems and removing unwanted plants by hand or with a machete. Plants perceived of as valuable are often protected during this process. The three techniques; sparing trees during forest clearance, selective weeding, and the planting of perennials all contribute to the increased value of swidden fallows for the subsistence and income of farming families in the region.

Communities differ greatly in the distance to and amount of each habitat type available to them. In some communities forest on high levees is in short supply. Residents from the community of Manacabi reported that almost all of the high levees around the community has been cultivated and there are only a few small pieces of old forest left. Farmers in some communities travel great distances from their homes to clear fields from old forest on high levees.

Manioc is the principal staple crop of the region and the main commercial crop for many farmers who sell their surplus of processed manioc flour (farinha de mandioca). The crop is typically grown during a six to eight month season on the várzea. According to reports by farmers, some varieties of manioc that take one year to mature on terra firme take just six months in the fertile floodplain soils. The decision is usually made to harvest when the rising waters threaten to drown the crop. Farmers harvest the lowest lying roças first in order to keep pace with the rising flood. They also begin with the most flood prone areas within a roça. They hurry to pull the tubers from the ground before they are inundated and it is not uncommon for them to fall behind and harvest a crop that is already under a few inches of water. If flooded, a crop must be rescued quickly before it rots. This usually happens within about two days. If it is apparent that the river has stopped going up, the decision is often made to leave the crop in the ground for up to twelve months to thicken (engrossar). If farmers decide to continue planting a roça for another season, they frequently begin planting immediately after or during harvest as long as they believe that the river has stopped rising.

After manioc, banana is the most important crop for the majority of várzea farmers. Bananas are sold to market by many families and are a frequent contribution to the diet of local residents. A common strategy on the floodplain is to interplant a roça with manioc and banana for one or two years and then discontinue manioc production, leaving the field in some type of banana “fallow.” The density of this banana plantation can vary greatly. It might be only a few plants growing in a regenerating forest, simply termed “capoeira” or fallow by farmers. With a slightly greater density of planting and intensity of management including periodic weeding, it is called a “capoeira bananal” or banana fallow by the owner. The farmer refers to a dense, carefully weeded banana grove as a “bananal.” This example, which will be explored further in the next chapter, shows that there is no clear distinction between management types or the designations that farmers give them. Because of the diversity of management practices used in banana production, the bananal was not included in the roça category but instead was placed in the next major category, the capoeira.

Farming Praias and Lamas

The distinction between praias (beaches or sandbars) and lamas (mudflats or silt bars) is not always clear. Beaches and mudflats are often found together with the sandy beach grading upwards to the mudflat. The ground is uneven in most floodplain fields with high and low spots consisting of varying grades of sediment that can change on a yearly basis. Crops are segregated according to topography and soil texture.

The sandy beach, nearly devoid of vegetation at low water, is typically utilized to plant beans and watermelon. No preparation of the land is necessary. In one instance the informant took us to an immersed sandbar in the Solimões River. Though the land surface was several meters underwater in the middle of the huge, swiftly flowing river, he was able to show us the boundaries of the field where three families work together to cultivate watermelon and two varieties of beans, Manteiga and Comum (Preto). The size of the field is approximately 180 meters long by 40 meters wide divided into sections for each family. When the crop is nearing maturity, the families camp out on the beach to protect the crop from theft by passing boats. They take advantage of this time to collect turtles, turtle eggs, and to fish for catfish that are then salted and later sold. Farmers most often exploit the beaches and mudflats immediately in front of their village or on the opposite side of the river for convenience and protection from theft.

Where the sandy beach grades into silt or mud, farmers grow a variety of crops including beans, corn, bitter and sweet manioc, gherkin, and squash. Most areas that were classified as mudflats by residents were covered with canarana grass (*Echinochloa* spp.) and a few had low *Cecropia* trees. In these areas a thick layer of mud is deposited when the flood subsides.

Management of mudflats varies between communities and even among farmers of the same community. Of the nine fields where information on management was collected, only two were burned. For an additional two fields, it was reported that the farmers had wanted to burn but were unable to because of the weather. Of the two fields that were burned, one was burned before the flood leaving the area clean when the waters receded and the other was burned after the flood. In the second instance the canarana grass was burned both before and after slashing. In another field the grass was cut before the flood and the current carried the slash away leaving the area clean.

The remaining fields were cleared using the roça-tomba-junta method (Pinedo-Vasquez et al. 1999). This means that the field is not burned. At least 2 informants reported that the vegetation is cut and thrown into piles and then carried to the edge of the field and dumped. None reported that the slashed material was used as mulch (cobertura morta) used to control weed invasion as Pinedo-Vasquez and colleagues found but the question was not consistently asked in this survey. Their research also found that mulched fields should be left standing to dry out for 25 to 30 days before planting to avoid problems of insect attack and that farmers wait to plant their fields until they see that certain insects have emerged as adults. This fascinating aspect of floodplain agriculture warrants further investigation.

Fields on beaches and mudflats are often planted year after year without the need for fallow. For 5 fields on beaches, the average number of consecutive years planted was three with a minimum of two and a maximum of four. An additional field with beach and mudflat had been planted every year for 25 years according to residents. The average number of consecutive years planted for 15 fields on mudflats was five with a minimum of one and a maximum of twelve.

The species harvested were recorded for a total of 23 fields made on beaches and mudflats. The mean number of species harvested per field was two with a maximum of five. The most commonly planted crops in sand were beans and watermelon. On mudflats, the most common is manioc. Only two of the mudflat fields contained useful species after harvest; each had one samaumeira (*Ceiba pentandra*), a valuable and greatly exploited timber species in Amazonia.

Diversity and Management of Restinga Baixa Fields

The flood brings a thick layer of rich sediment that is deposited on restinga baixa or low levees each year. This allows farmers, in many cases, to plant their fields for a number of seasons with no reported decline in productivity due to soil fertility. More than twice as many fields were visited as fallows on low levees (106 fields and 50 fallows). This is the opposite of what was observed for high levees where there were many more fallows than fields (about 113 fields and 176 fallows). This could be a reflection of the fact that farmers do not need to clear new fields as often on low levees. Actual results from fallows for the number of years previously planted was about 3.75 years for low levees and 3.5 years for high levees. An alternative hypothesis for the greater number of fields on low levees is that, because fallows on low levees hold relatively few useful species, the location of these areas is quickly forgotten and they are, therefore, underrepresented in the survey. Out of ninety fields where the information was collected, the average number of consecutive years planted was 3.1 with a maximum of fifteen.

Management varies on low levee fields depending on location. Describing the specific factors that determine how the fields are managed is outside the scope of this research. However, it is likely to depend on influences such as depth of flood, sediment load and deposition, speed of current, vegetation, and weather. Other factors that are not determined by the environment may include available labor, available time, knowledge, custom, and personal preference.

The number of seasons that farmers cultivate low levee fields is apparently at least partially dependent on the maintenance of soil fertility through the annual deposition of sediment. In the community of Jubará on the Japurá River they are able to plant just two seasons before production begins to fall and the disease tuber rot (podre de batata) affects the manioc crop. According to one informant, they typically plant two years and leave the field fallow for seven years. This appears to corroborate what one farmer said from the village of Betania, also on the Japurá River. According to him, on the banks of the Japurá where the water carries a lower sediment load they typically plant three to five years and then leave the field fallow. However, on the side channel (parana) where the water carries more sediment, they can plant every year and the tuber does not rot.

The method of field preparation on low levees varies. Fire is used in some cases but usually only when opening a field for the first time. Jubará farmers reported that nobody burns low levee fields; they are only slashed and cleaned. In Betania and Marirana at least some low levee fields are burned after clearing only in the first season and it is not necessary the following seasons. In the village of São Paulo, it was observed that some farmers slash a field on low levees before the flood. Pinedo-Vasquez et al. (1996) found that a small proportion of fields were burned in 1993-94 in the three communities of Vila Alencar, Jaraua, and Barroso and those that were burned had been cleared too late in the dry season.

Most fields on low levees were made on land that had been fallow. Out of 82 fields, 55 (67%) were reportedly made on land that had previously been fallow and 27 (33%) were reportedly cut from virgin forest (mata) (Table 3-1). At least 11 of the fields cut from virgin forest had been imbaubais, stands consisting almost exclusively of *Cecropia* trees and canarana grass. For 17 of the fields that had previously been in fallow, the average length of time in fallow was 6.3 years with a minimum of two years and a maximum of twenty.

Crops harvested from low levee fields in 2000 include beans, corn, gherkin, bitter and sweet manioc, okra, squash, tobacco, and watermelon. The average number of species that were harvested from 58 fields was two with a minimum of one and a maximum of seven. It is not uncommon that farmers alternate crops, planting one crop one year and another crop the next.

There were 13 fields that had not yet been harvested. At least two of these were being harvested at the time of fieldwork. Although these fields were classified as low levees by informants, they fall on the high end of the spectrum since most low levee fields were flooded to a depth greater than one meter. All of them were planted with manioc and only four contained other species. These include two fields with mulateiro (*Calycophyllum spruceanum*), and one each with banana (*Musa* sp.), sugar cane (*Saccharum* sp.), and ingá (*Inga* sp.). Eight fields held from one to five manioc varieties with an average of 2.6.

Ninety-three of the fields visited on low levees had been harvested and only 16 of those (17%) had useful species remaining. Of these sixteen fields, there was an average of 2.4 species in each. The eight species that were found in at least two fields are shown in table 3-2. All of these are relatively flood tolerant except papaya (*Carica papaya*), a weedy species easily spread by birds. Only banana, guava (*Psidium guajava*), and cocoa (*Theobroma cacao*) were likely planted here. Açai preto (*Euterpe precatoria*), genipap (*Genipa Americana*), mulateiro, and the kapok tree (*Ceiba pentandra*) are volunteer species frequently encountered in fields and fallows. Other species that were found in only one field each include: cashew (*Anacardium occidentale*), sugarcane, cubiu (*Solanum sessiliflorum*), cuia (*Crescentia cujete*), feijão de praia (*Vigna unguiculata*), jauari (*Astrocaryum jauari*), jitó (*Guarea* sp.), corn (*Zea mays*), capsicum pepper (*Capsicum* sp.), pitomba (*Talisia esculenta*), and taxi (unknown). Three of these are volunteers; jitó and taxi are timber trees and jauari is a common várzea palm used for fish bait. One field also contained a small patch of manioc that the farmer had failed to harvest and one had already been replanted with manioc.

Table 3-1. Summary of statistics for low levee fields

	N	Mean	Min.	Max.	S
Consecutive Years Planted	90	3.1	1	15	2.6
Size (m^2)[1]	105	1643	100	6000	1247
Last Fallow Period (years)	17	6.3	2	20	4.6
Species Harvested	58	2.4	1	7	1
Manioc Varieties	24	2	1	5	2

1 the largest field (16,000 m^2 with four owners) was dropped

Table 3-2. The eight most common species remaining in sixteen harvested fields on low levees

Rank	Local name	English name	No. fields (16)	%
1	Banana	Banana	5	31
2	Goiaba	Guava	4	25
3	Açai	Açai	3	19
3	Cacau	Cocoa	3	19
3	Jenipapo	Genipap	3	19
3	Mulateiro	Mulato wood	3	19
3	Samauma	Kapok tree	3	19
4	Mamão	Papaya	2	13

Restinga Alta: The Preferred Habitat for Planting

Diversity of crops and management systems is greatest in the restinga alta or high levee. Several years can pass without flooding making them the most favorable environment for planting bananas and other perennials. Informants repeatedly voiced their opinion that high levees are the preferred areas for clearing fields. Local farmers designated eleven types of work areas on high levees (not including home gardens) with a range of crops and management strategies. There are two main types of fields on high levees, the roça and the corn field (milheral). These fields are predominately planted with manioc and/or corn but are often mixed with banana and other annuals and perennials. The other nine types of work areas will be discussed in chapter four on fallows. The generic designation of fallow is only for convenience as many are not simple abandoned fields. They range from having no management and no useful species to having intensive management and dozens of useful species.

Some high levee fields are planted year after year while others are planted just two or three seasons before being put in fallow. The number of consecutive years planted averaged 2.8 for 80 fields (Table 3-3). For comparison, some fields owned by residents of Betania had been planted up to 15 years in a row while in another area residents of

Jarauá reported that fields could only be planted two seasons before fallow was necessary. Both areas are high levees but by examining the location one difference is clear; the Betania fields are along the banks of the Japurá where a much greater amount of sediment is deposited while the Jarauá fields are on a paranà or side channel that carries little sediment.

Table 3-3. Summary of statistics for high levee fields

	N	Mean	Min.	Max.	S
Consecutive years planted	80	2.8	1	15	2.4
Size (m^2)	132	2573	150	20000	2490
Last fallow period (years)	18	6.9	4	20	3.9
Number of species (planted fields)	82	4.1	1	14	3.3
Number of species (harvested fields)	53	2.8	1	8	2.1
Number of manioc varieties	70	2.3	1	6	1.2
Number of banana varieties	72	1.4	1	4	0.7

According to the survey, high levee fields are cleared from forest (mata) about half the time. Out of 91 roças, 40 had been cleared from forest, 11 from banana groves (bananal), and 40 from fallows (capoeira). Available data for the age of 18 capoeiras that had been cleared for roças yielded an average of 6.9 years. The ages ranged from 4 to 20 years. Reports from informants indicate that, in general, roças are only burned in the first season after they are cleared from forest or old secondary forest (capoeira velha). In subsequent years, farmers generally use the roça-tomba-junta method for clearing the fields. The average size of 132 roças was 2,573 square meters. They ranged from 150 square meters to two hectares in size.

The 135 fields visited on high levees are divided into two groups for comparison; planted and harvested. The number of useful species in 82 planted fields ranged from 1 to 14 with an average of 4.1. Figures 3-2 and 3-3 show graphically the number of useful species encountered in planted and harvested roças. Planted fields with a single useful species are relatively infrequent, amounting to just 15 (18%). It is much more common for fields to be interplanted with two or more crops. A little more than half of the roças on high levees were found to still contain useful species after harvest. Out of 53 harvested roças, 31 (58%) of them held an average of 2.8 useful plants with a maximum of eight.

Manioc is the principle crop planted in high levee fields. The tuber was found growing in all but one of the planted fields. The crop is usually grown in association with banana. Fifty-six of the planted roças (68%) contained these two crops. Figure 3-3 shows that the majority of harvested fields are left with a single crop. This reflects the common practice of collecting the manioc, leaving only banana. Twenty out of the 31 harvested fields with useful plants contained banana, by far the most frequently encountered useful species left in fields after the manioc is collected.

Table 3-4 lists the 19 most common species found in planted fields on high levees with the corresponding number of harvested fields. It shows that the number of planted and harvested fields with bananas is relatively consistent at 70% and 65% respectively. The slightly lower number of harvested fields with bananas is probably a reflection of the fact that they are more likely to be on lower lying areas than planted fields. A greater proportion of planted perennials and non flood tolerant species such as açai, cocoa, lime (*Citrus aurantifolia*), and capsicum pepper are observed in planted fields, lending support to this idea.

Corn was often left in harvested fields because of ill-developed ears or attacks by pests. Occasionally, a small patch of manioc remained in the roça that had either not been harvested in time or was yet to be collected. A number of other useful species that had either been planted, protected, or had sprouted spontaneously remained in fields. Lime, sugarcane, cocoa, and possibly açai were planted.

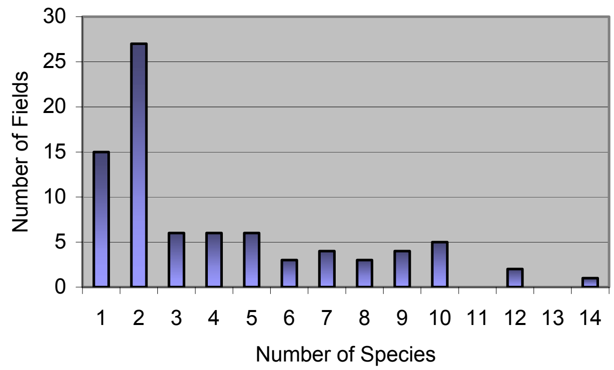

Figure 3-2. Number of species in 82 planted fields (roças) on high levees

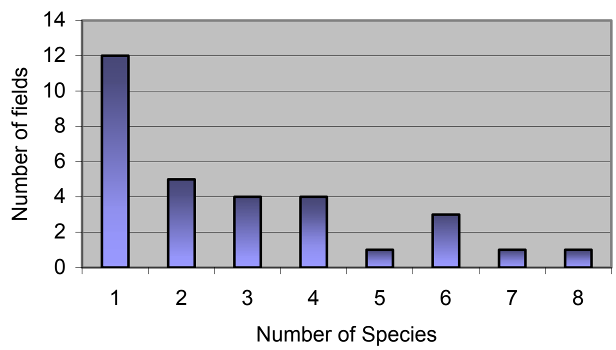

Figure 3-3. Number of species in 31 harvested fields (roças) on high levees

The 31 manioc varieties recorded growing in high levee roças are shown in table 3-5 and 3-6. Nine of these are sweet manioc (macaxeira) while the rest are bitter manioc (mandioca). Sweet manioc is typically grown in small patches within roças of bitter manioc or sometimes in home gardens. Out of 70 roças, 25 (36%) had only one variety of manioc while the majority had two or more varieties (Figure 3-4). The number of varieties ranged from one to six with an average of 2.3. By far, the two most common were the bitter varieties Pacu and Valdevina. At least one of these two were found in over 75% of all roças. Qualidades, as locals refer to varieties, may be called different names by different communities or individuals. In some cases more than one name may be given for the same variety. Further study is called for on the diversity of manioc varieties used by varzeà farmers.

Table 3-4. The 19 most common useful species found in planted fields on high levees with corresponding number of harvested fields

Rank	Local name	English name	Planted fields n=82	%	Harvested fields n=31	%
1	Mandioca	Manioc	81	99	6	19
2	Banana	Banana	57	70	20	65
3	Açai*	Açai	14	17	3	10
4	Cacau	Cocoa	13	16	2	6
5	Mulateiro	Mulato wood	12	15	5	16
6	Samauma	Kapok tree	11	13	3	10
7	Mamão	Papaya	10	12	2	6
8	Cana	Sugarcane	9	11	1	3
9	Jenipapo	Genipap	6	7	3	10
9	Limão comum	Lime	6	7	1	3
9	Taperebá	Yellow mombim	6	7	5	16
10	Cedro	Cedar	5	6	2	6
10	Jitó	Jitó	5	6	1	3
10	Ucuúba	Virola	5	6	1	3
11	Cará	New world yam	4	5	0	0
11	Jerimum	Squash	4	5	0	0
11	Milho	Corn	4	5	5	16
11	Muiratinga	Muiratinga	4	5	2	6
11	Pimenta	Capsicum pepper	4	5	0	0

* There are two species of açai but açai preto is most common on the várzea.

Nine varieties of banana were recorded in 74 fields on high levees (Table 3-7). In this case, just over half (56%) of the fields held only one variety of banana (Figure 3-5). The greatest banana diversity found in a single field was four types with an average of 1.5. The most common variety, banana prata, was encountered in 84% of all roças. The second most abundant type was banana comprida, a variety of plantain or cooking banana, found in 44% of roças. Certain varieties are more resistant to flooding, pests, and diseases.

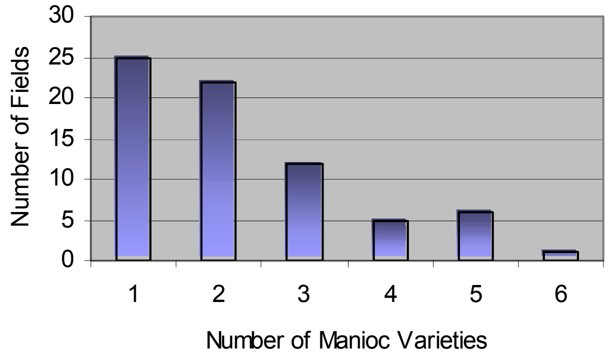

Figure 3-4. Number of manioc varieties in fields on high levees

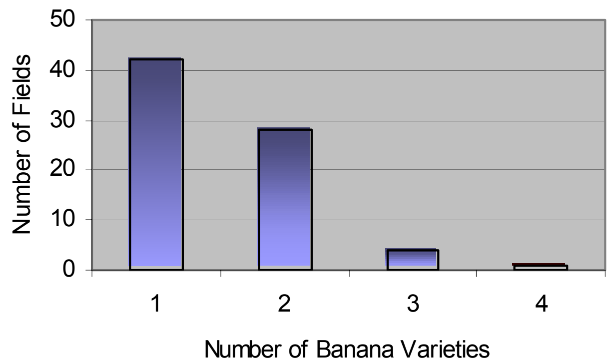

Figure 3-5. Number of banana varieties in fields on high levees

Table 3-5. Varieties of bitter manioc (mandioca) growing in 70 fields on high levees

Rank*	Variety	Num. Fields	%
1	Pacu	28	40
2	Valdevina	25	36
3	Olho roxo	8	11
4	Calai	7	10
5	Casca grossa	6	9
5	Ouro	6	9
6	Azulona	5	7
6	Pretona	5	7
6	Sisa	5	7
7	Antinha	4	6
7	Samauma	4	6
7	Tartarugão	4	6
7	Traira	4	6
8	Canjiru	3	4
9	Onça	2	3
10	Amendoem	1	1
10	Auraninha	1	1
10	Azulão	1	1
10	Colaia	1	1
10	Ourinho	1	1
10	Pelonia	1	1

* Rank is combined for varieties bitter and sweet manioc.

Table 3-6. Varieties of sweet manioc (macaxeira) growing in 70 fields on high levees

Rank*	Variety	Num. fields	%
4	Pão	7	10
5	Macaxeirão	6	9
7	Amarela	4	6
7	Branca	4	6
7	Pretinha	4	6
9	Preta	2	3
10	Cabral	1	1
10	Colombiana	1	1
10	Pagoa	1	1

* Rank is combined for varieties of bitter and sweet manioc.

Table 3-7. Varieties of banana growing in 70 fields on high levees

Rank	Variety	No. fields (N=70)	%
1	Prata	59	84
2	Comprida	31	44
3	Maçá	8	11
4	Nadja	4	6
4	Pacovão	4	6
4	Pacovinha	4	6
5	Guariba	2	3
6	Baiazinha	1	1
6	Urucuri	1	1

Crop Losses from Flooding, Pests, and Diseases

Locals view the yearly flood, especially the occasional high flood, as a major difficulty of surviving on the floodplain. Even in normal years, losses can occur when the erosive power of the current causes levees to collapse and fields are partially or entirely swept away. Farmers usually attempt to harvest their crops just ahead of the rising waters. The flood can be unpredictable, coming too fast or at the wrong time, leaving farmers with insufficient means to harvest their crops. They usually cultivate several fields in different locations and are sometimes faced with the decision of which fields will be sacrificed to the river and which ones will be saved. When manioc fields are drowned, the tubers quickly rot and farmers sustain additional losses when their planting stock for the following season is destroyed. Families must depend on relatives, friends, neighbors, and even neighboring villages to recover from these losses.

A number of families indicated that they had lost partial or entire crops during the high flood of 1999. Families were not comprehensively interviewed concerning the loss of crops but at least ten farmers reported that they had lost all or nearly all of their manioc roças to the flood the previous year. The example of one farmer in Vila Alencar may clarify the magnitude of the losses that can accrue in a high flood event. Anselmo lost a roça with the equivalent of about 200 kilograms of flour (farinha) because he didn't have time to collect it. He also lost 500 banana plants and a good many fruit trees that he had planted. In addition, at least 25 individuals of nine species were drowned in his home garden. His troubles carried over into the subsequent year because he lost most of his planting material with the loss of his crops and was only able to plant two small fields.

Although crop losses are potentially much greater during a high flood, farmers may still lose parts of their fields during normal years when they are unable to harvest them in time. At least two fields that were visited had small patches of un-harvested manioc standing in water. One farmer stated that he had lost his crop of beans when the water took it away.

At least two farmers from two different communities complained that corn they had planted failed to sprout. In the community of Manacabi, one informant reported that his family did not plant corn last season. He had planted some seed the year before that the Mamirauá project had given them and it had not sprouted. He also confirmed that corn could not be planted on the left bank of the channel because brown capuchin monkeys (macaco prego, *Cebus apella*) destroy it. They only plant it on the right bank (actually an island) where there are no monkeys. Another farmer explained that he normally sells a lot of squash but he could not plant it this year because of the large amount of sand deposited by the previous flood.

When a high flood occurs, farmers can suffer profound losses of perennial crops. Bananas, an important source of income for many families in the region, can be wiped out as many floodplain dwellers experienced in 1999. Bananas and plantains are a convenient crop for floodplain farmers because they can harvest them year after year.

When they are drowned, however, residents must replant large areas and it may take several seasons to build up their banana holdings once again. Young banana plants or suckers are sometimes destroyed along with the mature plants leaving planting material in short supply.

Banana losses depend on the length of time an area remains inundated and certain varieties are more resistant to flooding than others. According to one informant the Prata variety can resist up to three months, Maçá 2 months, and Comprida only 1 month. Another resident reported that the variety Peruana does not die in the flood. Suckers, locally called filhos (offspring), may stay under water more than three months and still escape the flood but this also probably depends on the variety. Several farmers reported that all of the banana suckers had been lost in the flood along with the crop.

During the interviews, at least 20 farmers reported that they had lost their banana plantations in the high flood the previous year. Antonio of Vila Alencar reported that out of 1000 banana plants, he was left with only 90 banana prata and 150 banana comprida. Francisco of Jarauá lost his banana crop and no suckers survived for replanting. In Sitio Forteleza, Antonio lost 110 of his 122 banana plants in a high levee plantation. He is one of several farmers in the community who has decided to give up agriculture on the várzea and move to terra firme. Francisco of Vila Alencar lost his entire crop of banana that he had planted on a low levee this season without harvesting any. He plans to replant the area again this year.

Perennial fruit trees that are not adapted to flooding are frequently killed in fields, fallows and home gardens. Recently planted seedlings are especially susceptible to drowning. Several villagers cited this reason for not planting fruit trees. They risk having all of their work wasted with the next year's flood. Table 3-8 lists the perennials that were drowned the previous season and the number of times they were reported. It does not reflect the number of individuals that were killed. Avocado (*Persea Americana*), lime (*Citrus aurantifolia*), and orange (*Citrus sinensis*) were the three most commonly cited fruit trees that had drowned in fields and fallows during the 1999 flood season.

An interesting comment was made by several informants concerning the survivability of fruit trees in flooded conditions. These residents have observed that many fruit trees can survive when flooded as long as they are not bumped by a passing canoe or floating log. Apparently, the shock caused by the hit is enough to kill a tree that would otherwise have survived a couple feet of water over its roots. Similarly, fruit trees in calm water are much more likely to survive than those exposed to a strong current especially since the current can carry floating objects that may bump the tree.

The economies of many communities have suffered from attacks on their crops by pests and diseases. According to local informants, communities along the lower Japurá River relied heavily on bananas and made a good income until about five years ago when mal (bad) struck. Mal is the generic term given to unknown pests or diseases that strike their crops. Reports indicated that many families had formerly derived the major part of their income from bananas before they were hit by disease in 1994. It is common for a family's main source of income to shift depending on the season and also year by year.

As Swales (1999) observed for the lower Amazon, there are no aid programs for farmers when crop losses occur and no extension workers to identify the diseases and teach how best to combat them. It is possible that the banana crop is suffering from black

Table 3-8. Perennials that were reported lost in fields and fallows

Local name	English name	Num. reported losses	Local name	English name	Num. reported losses
Abacate	Avacado	12	Ingá	Ingá	2
Limão	Lime	11	Manga	Mango	2
Laranja	Orange	10	Puxuri	Puxuri	2
Cupuaçu	Cupuaçu	7	Abacaxi	Pineapple	1
Abiu	Abiu	5	Açai	Açai	1
Cajú	Cashew	3	Cacão	Cocoa	1
Jambo	Malay apple	3	Camu camu	Camu camu	1
Lima	Lima	3	Carambola	Carambola	1
Pupunha	Peach palm	3	Seringa	Rubber	1
Andiroba	Andiroba	2			

sigatoka, a disease that had spread south from Central America to Colombia by 1981 (Smith et al. 1992) and may have continued spreading down the Japurá River. Another disease that affects banana in the region is Moko disease (febre da banana) (Pinedo-Vasquez et al. 1996). Infected planting material can be brought into várzea plantations when it is borrowed from the terra firme after a high flood leaves farmers in short supply. Farmers have discovered that certain varieties of banana have greater resistance to disease. Whether the bananas are grown in sun or shade also seems to make a difference. Several farmers reported that bananas grown in shade were less liable to contract a disease. Lemon is another important crop that has suffered from disease in the last several years.

The history of one roça on a high levee in the community of Manacabi can illustrate the impact of both flooding and disease particularly on banana production. The farmer cleared the roça from 6-year-old secondary regrowth, burned, and planted manioc and banana. He used the common strategy in which the field is left in banana after the manioc is harvested. The high flood of 1994 drowned his banana crop. The next year he planted it again with manioc and the Maçá variety of banana. Mal arrived and again his banana crop was killed. According to him, the disease dries the leaves, the bananas do not develop, and after about 3 months it dies. He replanted with a new variety, Prata, with a greater resistance to the disease. Last year's flood destroyed that crop. Now he says that the disease is beginning to affect the Prata variety.

Another example of the devastating effects of crop losses comes from the low-lying terra firme community of Boa Esperança located on the shore of Lake Amanã. Some residents reported earning a relatively prosperous living in previous years by selling banana, lemon, and avocado. They had money in the bank and the harvest and sale of fruit was comparatively easier work than growing manioc and processing manioc flour. Then, in the mid-nineties, a new disease struck the bananas and greatly curbed production. Shortly afterward, lemon trees were hit with a disease outbreak and most of the trees were lost. They were left with their avocado trees that still brought in a good income. A further blow was struck in 1999 when the community lost hundreds of trees from its fields and orchards along with a substantial part of the manioc crop during the unusually high flood. The high water killed most of the avocado trees and the community had no choice but to intensify manioc production in the year 2000, reportedly initiating an increase in forest clearing.

Storage and Loss of Planting Material

The semi-perennial crop manioc is reproduced vegetatively. On the várzea of the middle Solimões manioc is planted by cutting the stems into approximately 30 cm sections, making a shallow hole, and horizontally placing the sections in the ground. At harvest, leaves are stripped from some of the stems which are then saved for the following season. Depending on their method of storage, a high flood can cause crop loss not only for that year but also the following year. Planting material for the next season is typically stored in the field by setting bundles of stems upright on the ground (Figure 3-6). Any part that stays above water will be viable planting material but if submerged it is ruined. A safer strategy is to place the bundles of stems on a raised platform (Figure 3-7). In most years this method is successful, but the occasional high flood can submerge the platform and destroy the planting stock. The surest way to eliminate these losses is to store manioc stems on a floating raft but few people take the trouble to do this as it would entail either building a raft near the field or transporting the bulky bundles of stems to the village. Material for building the rafts, the lightweight assacu (*Hura crepitans*) trunks used for floats, are becoming scarce as timber extraction continues in the region (Albernaz and Ayres 1999).

When planting material is lost, people must turn to their relatives, friends and neighbors for help. Fortunately, most residents are willing to share and divide up their stock among those in need. Francisca explained that during the previous season there was a large deficit of planting stock in the community of Vila Alencar. Only a little of hers was lost and she was able to donate manioc stems to eight or nine families including some in a nearby community. It was still not enough for everyone and another farmer from the same village claimed that he had planted only part of one field and left another large field fallow because he lacked manioc and banana stock. A resident of Manacabi reported that he had planted manioc in less than half of his fields because he divided his planting material with others who had none.

If farmers have connections with villages on the terra firme, they may take a trip there to borrow some stock. One farmer from Barroso acquired stems from his church brothers (irmãos da igreja) on the upland banks of the Japurá River. He said that he was lucky not to have a problem with tuber rot (podre de batata) as often happens when terra firme varieties are planted on the floodplain. A farmer from Vila Alencar with a shortage of planting material said he could have obtained some in Alvarães, a nearby terra firme town, but he did not have available transport. A problem that was repeatedly voiced by várzea residents was the lack of adequate transport for situations like this and for getting their produce to market.

In the year 2000, just after the high flood of 1999, many farmers claimed that they were unable to plant all of the land that they would have normally cultivated because not enough planting stock was available. Often fields were planted to only a third or a half of their size. The survey documented 16 roças that had not been planted completely because the farmer lacked planting material. The average area not planted was approximately 1500 square meters per field.

Seeds of annual crops are dried and stored in bottles or cans for the following planting season. Corn is hung out to dry in the sun and may be stored hanging under the eves of the house where it can last for a year.

Bananas are planted from the suckers or young shoots that sprout next to mature plants. The suckers must be taken from an existing field and brought to a new area for planting. Once the suckers are taken out of the ground they must be kept shaded and moist until planting. As was mentioned in the previous section, the suckers may also be killed when a field is inundated for an extended period. They are usually able to survive for periods of up to three months while immersed in floodwater.

Figure 3-6. Bundles of manioc stems placed upright in restinga alta field. The water is approximately 0.5 meters deep. Community of Jarauà.

Figure 3-7. Storage of manioc stems on a raised platform in a high levee field. Bundles of planting material are sometimes seen stored on the side of a floating house or on a nearby raft. Community of Jarauà.

CHAPTER 4
CAPOEIRAS: ENRICHED FORESTS AND MANAGED FALLOWS

The popular perception that swidden agriculture entails two or three years of cultivation followed by an abrupt transition to a long fallow period is not supported by actual research. In many traditional swidden systems there is a gradual transition from field to managed fallow or orchard in which production continues for years beyond "abandonment" (Denevan and Padoch 1987; Eden and Andrade 1987; Hammond et al. 1995). There is often a steady progression of crops that in some ways mirror the natural regeneration of the forest through the development of vegetation strata. The rural population of the middle Solimões region manage the development of fallow fields to a great extent. Farmers also manage forests to enrich them with useful species including fruits and construction materials. This chapter documents the rich agrobiodiversity across a range of habitats and managed fallows in the middle Solimões várzea.

In the Brazilian Amazon, the term capoeira means fallow or secondary forest. Farmers in the middle Solimões refer to some areas as capoeiras even when they contain useful species and receive some form of management. When the concentration of useful plants and/or degree of management is greater, they use other descriptive terms such as bananal (banana grove) or frutal (fruit orchard) to refer to these work areas located principally on high levees where flooding is occasional and less intense.

Documenting the size and management history of fallows is often more difficult than gathering the same information for roças. The planted area of multiple ex-fields is sometimes lumped together by owners and informants as one capoeira that can have parts of different ages. In some cases a capoeira can be best thought of as a work area where different activities are taking place through time. A piece of the fallow may be occasionally used for a roça or bananal, or managed for other products. Small manioc patches on the order of 10x10 meters or less within a fallow are also sometimes planted. Partially as a result of this lumping together, the average size of capoeiras in table 4-4 is almost 6000 square meters compared to roças with an average of only 2600 square meters. Management practices of forest enrichment with bananas and fruits also use more extensive areas than a typical roça (some of these areas were not previously manioc fields according to the knowledge of the informant). Information on specific field divisions and management is forgotten over time and fallows can be left when residents move away or be created by farmers from other communities. With strong kinship ties in neighboring villages, farmers sometimes plant their fields in the territory of nearby communities (the territories of communities are generally not rigidly divided). Close relatives often plant their roças side by side to take advantage of the collective labor in clearing the forest and planting.

In the three Mamirauá communities studied by Inuma, Padoch, and Pinedo-Vasquez, fallow management or agroforestry is a specialized activity used only by a few households (Padoch et al. 1996, Pinedo-Vasquez et al. 1996). They reported that the number of managed fallows was about 40% of the total. Managed fallows were divided into two categories: 75% used the criação-da-mata (forest creation) agroforestry system which are developed from planted and protected volunteer species in a cleared field and 25% used the enriquecimento-da-mata (forest enrichment) system in which trees of useful species were protected during field clearance. The researchers stress the point that there is a tremendous variation in fallow management among individual farmers. They detail 12 techniques that are used in managing the stand, species, and the individual plant. These include thinning, girdling, selective cutting, removal of vines, leaving forest cover, removing forest, planting, seedling selection, pruning, weeding, insect nest removal, and bleeding.

Inuma, Padoch, and Pinedo-Vasquez (1996) also describe three classes of techniques for managing forest stands with a high density of a specific valuable species. Mata demarcada (demarcated forest) involves keeping a buffer of low shrubby vegetation around the managed forest, mudança de mata (changing of the forest) entails the creation of forest gaps to protect and encourage the growth of valuable trees and shrubs, and mata mantida (maintained forest) refers to the maintenance of dense stands of fruits such as bacurí-parí (*Rheedia* sp.) or camu-camu (*Myrciaria dubia*). The managed forest stands are named according to the dominant economic species and include bacabais (*Oenocarpus bacaba*), bacuriais (*Rheedia* sp.), camu-camuais (*Myrciaria dubia*), pau mulatais (*Calycophyllum spruceanum*), and urucuriais (*Attalea minor*). The three communities tend to specialize in one or two types of forest stands that they have within their territory.

Restinga Baixa

Capoeiras on low levees (restinga baixa) are generally not managed and contain few useful species because they are flooded frequently and for a relatively long duration. None of the more intensely managed land use classes were encountered on low levees. Table 4-1 summarizes the data for size of fallows, number of useful species, and the number of consecutive years that the area was cultivated before the current fallow period. With a mean average of about 2900 square meters, fallows on low levees tend to be

Table 4-1. Summary of statistics for fallows on low levees

	N	Mean	Min.	Max.	S	Median
Size	49	2894	200	17,500	3009	2000
Num. of useful species	17	2.8	1	7	1.7	3
Age of fallow (years)	50	2.8	1	6	1.47	3
Num. of consecutive years planted previously	12	3.75	1	8	2.2	3

smaller than those on high levees. This is probably because the more land extensive fallow management techniques are little used on low levees. The size reflects more accurately the smaller size of roças on low levees. Compared to the 2600 square meter average high levee roças, a low levee roça is about 1600 square meters or just over half the average capoeira size. This discrepancy between the size of roça and capoeira is most likely a result of sometimes lumping individual roça “parts” into one capoeira. The average age of fallows ranged from one to six with an average of just under three. The number of consecutive crops planted previously varied from one to eight years with an average of almost four. Only 34% of the fallows contained useful species. Seventeen out of 50 low levee capoeiras held from one to seven species with an average of three.

Table 4-2 shows the 25 useful species with nine uses encountered in low levee fallows. There is a large spread of useful species with low frequency counts. By making more observations the list of useful species would certainly continue to grow. The two most common, açaí (Euterpe oleracea), used for making a beverage, and the Kapok tree (Ceiba pentandra), a valuable timber, were each encountered in five out of 17 fallows. It is interesting to note that these two highly esteemed trees, occur in low levee fallows in only two communities each and tend to be found near one another. The different environments where each community plant their fields partially explains why some species tend to be found in higher concentrations in some communities and not others.

Table 4-2. The 25 useful species occurring in 17 capoeiras on low levees

Local name	English name	Use	Num. Capoeiras (17)	%
Açaí*	Açaí[2]	2	5	29
Samaúma	Kapok tree	3	5	29
Taperebá	Yellow mombim	1	4	24
Jenipapo	Genipap	1	3	18
Lauro inamuí	Lauro inamuí	3	3	18
Mulateiro (Pau mulato)	Mulato wood	3	3	18
Cacau	Cocoa	1,2	2	12
Castanha de macaco	Castanha de macaco	7	2	12
Inga	Ingá	1	2	12
Muiratinga	Muiratinga	3	2	12
Puruí	Puruí	1	2	12
Taxi	Taxi	3	2	12
Andiroba	Andiroba	3	1	6
Bacaba	Bacaba	2	1	6
Bacuri coroa	Bacuri coroa	1	1	6
Bacuri liso	Bacuri liso	1	1	6
Banana	Banana	1	1	6
Cedro	Cedar	3	1	6
Goiaba	Guava	1	1	6
Jacareuba	Jacareuba	3	1	6
Jauari	Jauari	5	1	6
Limão comum	Lime	1	1	6
Macacaricuia	Macacaricuia	3	1	6
Paricarana	Paricarana	3	1	6
Ucuúba	Virola	3	1	6

Use categories: 1 Fruit, 2 Beverage, 3 Timber, 5 Fish bait, 7 Nut, 9 Medicinal, 10 Latex, 11 Vegetable, 12 Livestock feed
* There are two possible species of açaí; açaí do Pará (*E. oleracea*), and açaí preto (*E. precatoria*).

Numbers three and four on the list, yellow mombim (*Spondias mombim*) and genipap (*Genipa Americana*), are two large fruit trees that seem to thrive in swidden fallows on the floodplain. They are rarely planted but often protected. In some cases however, they will be sacrificed in the interest of clearing a manioc roça. The next two on the list, lauro inamui (*Ocotea cymbarum*) and mulateiro (*Calycophyllum spruceanum*), found in three fallows each, are both valuable timber trees that sprout easily in manioc roças and are often protected and managed.

Restinga Alta

In contrast to low levee fallows that are flooded yearly for several months, fallows on high levees (restinga alta) are often managed and contain a much greater diversity of beneficial plants. Middle Solimões farmers use a variety of terms to designate work areas on high levees. The terms range from the fallow with no useful plants to the sitio (site), an area that is comparable to a home garden in the great diversity of useful species. A list of the work area designations and their descriptions is shown in table 4-3. The number of work areas visited gives an idea of the relative proportions in which they occur. The majority (70%) are simple fallows that have a lower average number of useful species than most of the other more intensively managed fallow types that made up 60 out of 202 (30%) non-roça work areas on high levees. Table 4-4 compares the size of non-roça work areas.

The complexity of management practices and diverse land use histories and the ambiguity of designations of land use types by different farmers makes it difficult to precisely divide the work areas into discrete categories, resulting in some overlap. Of all the areas <u>not</u> designated as roças, 75% contain useful species. The intensity of management and number of species vary widely across these work areas (Table 4-5). Some fallows contain only useful plants that were either spared when the roça was cleared or sprouted spontaneously while others are planted with a few dominant crops such as banana and açaí. Still others contain a diverse array of carefully tended fruits, vegetables, timber, or medicinal plants. Management techniques such as weeding and pruning vary in intensity from frequent to none.

The non-roça work areas can be split into two general groups; those that are considered capoeiras and those that are not. A capoeira may be specified further by local

Table 4-3. Local designations of work areas, number of areas visited, and their description

Local Term	English translation	Num. of areas visited	Description
Bananal	Banana Grove	17	Banana plantation or forest enriched with banana
Cacaual*	Cocoa Grove	0	Area planted with cocoa
Capoeira	Fallow	142	Fallow field
Capoeira bananal	Banana Fallow	22	Fallow enriched with banana or former bananal
Capoeira cacaual	Cocoa Fallow	2	Former cacaual
Capoeira fruteira	Fruit Fallow	12	Fallow enriched with fruit trees
Frutal	Fruit Orchard	2	Area enriched with a diversity of fruit trees
Sitio	Site	5	Area of intensive, long-term management and/or a high diversity of useful plants

* No cacaual areas were encountered during the survey but a few capoeiras were said to be former cocoa groves.

Table 4-4. Average size by type of capoeira

Type	N	Mean size (m^2)	Min. (m^2)	Max. (m^2)	S (m^2)
All Areas[1]	188	5978	600	50000	7899
Bananal	16	4222	400	10000	3420
Capoeira[2]	133	5901	500	50000	7924
Capoeira bananal	21	5362	400	40000	8362
Capoeira cacaual	2	2525	1050	4000	
Capoeira fruteira[3]	9	10856	1400	48000	16630
Frutal	2	36000	12000	60000	
Sitio	5	4760	2000	8000	2385

1 The five largest and smallest were dropped in calculating the average.
2 The two largest and smallest were dropped in calculating the average.
3 The largest and smallest were dropped in calculating the average.

residents as a capoeira bananal (banana fallow), capoeira cacaual (cocoa fallow), or capoeira fruteiras (fruit fallow) based on the relative amount of work that has gone into enriching them with valuable plants and the density of planted species. Three types of land use, bananal (banana grove), frutal (fruit orchard) and sitio (site) are not considered to be capoeiras by farmers. The owner has generally invested much more time and energy into these areas and the density of planted species is relatively higher.

Table 4-5. Average number of useful species by type of capoeira

Type	N	Mean num. species	Min.	Max.	S
Bananal	17	2.4	1	7	2.2
Capoeira*	88	3.5	1	18	3.1
Capoeira bananal	21	3.6	1	12	2.9
Capoeira cacaual	2	1.0	1	1	
Capoeira fruteira	12	10.2	5	19	4.3
Frutal	2	16.0	13	19	
Sitio	5	20.8	11	34	

* Only capoeiras that hold useful species are included.

Bananal

Banana is found growing in all types of work areas on high levees including home gardens. It is also planted on low levees where it is harvested after six months just before the flood (or just after) and completely replanted the next season. Although banana may still come in after manioc in importance as a regional staple, it was overall the most frequently observed species in the survey with 325 total observations compared to manioc which came in second with 210 observations. Its ubiquitousness across many types of habitats and management areas underscores its versatility and adaptability to the floodplain environment and its status as an important commercial and subsistence crop. Bananas are produced in a monocultural grove or intercropped with manioc. They are also found growing scattered here and there among roças, capoeiras, or home gardens.

The bananal is formed using one of three techniques. A common strategy is to interplant banana with manioc in the roça on high levees. When manioc cultivation is discontinued, the area is left as a bananal often for several years until a high flood destroys the bananas at which time it may be cleared to plant a roça once again or left as a capoeira. The second technique is to clear an area specifically for planting bananas. The area may be cleared from either forest (mata) or secondary forest of any age. It may or may not be burned. The third way is to clear only the undergrowth and select trees in a mature forest or secondary forest leaving large trees standing to provide shade for the crop. The area is often cleared strategically with undesirable trees removed and valuable ones left in place. Several informants told us that, by growing bananas in the shade, some disease can be avoided. In all three of these systems, various fruit trees may also be added creating a bananal with several economically valuable species in the mix.

Out of 10 banana groves (bananais plural) where the information was collected, half had been planted to roça at least one year at the beginning of the cropping sequence. In the other five, only banana was planted. At least three of these five areas were not completely cleared of trees. Instead, the underbrush was cut and the bananas were planted under shade.

A particularly interesting bananal was visited on a very wide high levee near the community of Vila Alencar. This area was referred to as mata bruta (mature forest or regrowth) and was apparently very old secondary forest. Only a few trees were cut and some trees were ringed but there was still sufficient canopy cover to shade out grasses. Weeds of only a few families (Musaceae, Piperaceae, and Solonaceae), soft-stemmed and easily weeded, are scattered throughout the field. According to the informant, after the bananas are grown and weeded, the weeds do not come back and some disease is avoided. In another field it was explained that roça was planted only the first year. After harvest, the secondary forest was allowed to grow back and provide shade for bananas and other fruit trees planted under the canopy. Besides banana, two other species (açaí and cocoa (*Theobroma cacau*) were planted and several timber species had been spared including muiratinga (*Maquira spruciana*), virola (*Virola surinamensis*), and the kapok tree. The area is occasionally weeded and other seedlings may be added. When bananas are killed by drowning like in the 1999 flood season, surviving suckers are gathered, the undergrowth is slashed, and the bananal is refurbished.

We visited 17 areas that were designated as bananal by informants. The average number of species and average size was slightly lower than the other capoeiras but the sample size is insufficient to conclude that there is a significant difference between the two types of land uses (Tables 4-4 and 4-5). The average age of 11 bananais was 3.4 years with a maximum of 7 years (Table 4-7).

High floods necessitate the periodic refurbishment of a bananal which may occur multiple times during the period of cultivation. Farmers sometimes change the location of the bananal when disease arrives in the hopes of achieving a disease free crop for a couple of seasons. Leaving a bananal fallow for a time can also help in controlling disease.

Bananais contained the lowest average number of species of any capoeira type except the capoeira cacaual. The planted species include açaí, banana, cocoa, sugarcane, cupuaçu (*Theobroma grandiflorum*), breadfruit (*Artocarpus altilis*), and manioc (Table 4-6). Other species were either protected during forest clearance or sprouted (or resprouted) spontaneously. One farmer informed us that he spared castanha de macaco (*Couroupita guianensis*), cedar (*Cedrella fissilis*), and muiratinga (*Maquira spruciana*) in his bananal at the time of clearing. A number of naturally occurring trees are economically valuable timber species that are harvested in the region. These include cedar, muiratinga, mulateiro, kapok, taxi, and virola (Albernaz and Ayres 1999). Ingá and yellow mombim (*Spondius mombim*) are two fruit trees that also occur spontaneously on the floodplain. Ituá (*Gnetum nodiflorum*) is a vine which bears fruit that can be roasted and eaten and is also utilized as fish bait.

Varietal diversity was not found to be very great in bananais (Table 4-8). The average number of banana varieties in 10 fields was 1.3 with seven containing only a single variety. Only three varieties of banana were registered in these areas. The Prata variety has replaced Maçá as the most popular variety in the region due to its elevated resistance to disease. It was found in eight out of ten bananais. The Comprida variety was second, occurring in four bananais while Maçá was found in only one.

Bananais were greatly affected by the previous flood season possibly lowering the average number of varieties found in the fields but this may not be the primary reason why there exists a relative dominance of a few select varieties. In his study of agricultural intensification by a Tikuna Amerindian community in the Upper Solimões, Shorr (1999) revealed the increasing dominance of a few varieties of manioc and banana in recent decades. According to his research, it was increasing market participation that caused the shift in their crop repertoire. The Comprida variety was more frequently planted due to its durability in transport, greater marketability, and higher price. It is likely that a similar process has been occurring in the Middle Solimões as farmers have become increasingly integrated into local markets.

Table 4-6. The 22 useful species occurring in 17 banana groves (bananais)

Local name	English name	Use	Num. Bananais	%
Banana	Banana	1	17	100
Açaí*	Açaí[2]	2	3	18
Cacau	Cocoa	1, 2	2	12
Cedro	Cedar	3	2	12
Muiratinga	Muiratinga	3	2	12
Cana	Sugarcane	2	1	6
Carapanaúba	Carapanaúba	3, 9	1	6
Castanha de macaco	Castanha de macaco	7	1	6
Cupuaçu	Cupuaçu	1	1	6
Fruta pãu	Breadfruit	1	1	6
Ingá	Inga	1	1	6
Ituá	Ituá	1, 5	1	6
Mandioca	Manioc	8	1	6
Mulateiro	Mulato wood	3	1	6
Murumuru	Murumuru palm	5	1	6
Namuirana	Namuirana	3	1	6
Pau ferro	Pau ferro	3	1	6
Samaúma	Kapok tree	3	1	6
Tanibuca	Tanibuca	3	1	6
Taperebá	Yellow mombim	1	1	6
Taxi	Taxi	3	1	6
Ucuúba	Virola	3	1	6

Use categories: 1 Fruit, 2 Beverage, 3 Timber, 4 Bowl, 5 Fish bait, 6 Thatch, 7 Nut, 8 Tuber, 9 Medicine

* There are two possible species of açaí; açaí do Pará (*E. oleracea*), and açaí preto (*E. precatoria*).

Table 4-7. Summary of statistics for banana groves (bananais)

	N	Mean	Min.	Max.	S	Median
Age of bananal	11	3.4	1	7	2.0	3
Num. of species	17	2.41	1	7	2.24	1
Num. of banana varieties	10	1.3	1	2	0.48	1

Table 4-8. Banana varieties occurring in 10 banana groves (bananais)

Variety	No. Bananais	%
Prata	8	80
Comprida	4	40
Maçá	1	10

Capoeira

Farmers distinguish between two classes of secondary regrowth, old secondary regrowth (capoeira velha) and young secondary regrowth (capoeira nova) but age stipulations can vary by community or individual. For example, one informant may designate a 1 to 3-year-old fallow as "young" and anything older than 3 "old" while an informant from another community may consider fallows up to 5 or even 8 years "old." There is never a sharp distinction between the two designations.

In the areas designated as capoeira, 88 of 142 (62%) were found to contain an average of 3.5 useful species. Maintenance of swidden fallows consists of occasional weeding around bananas and fruit trees by slashing encroaching vegetation with a machete.

The capoeiras can be divided into two distinct types; those that were formerly roças and those that were formerly bananais. Information on previous land use was collected for 111 fallows. Most of the areas designated as former bananais were not planted with manioc at the start, agreeing with the information on management history of bananais presented above. A few of the areas were planted with roça the first year and then planted to banana (and sometimes other fruits) in the following years.

It is useful to compare these two types of fallows to see which form of management may lead to a greater diversity of useful plants and the nature of the beneficial species that are retained. Table 4-9 shows data on the number of useful species found, age, and number of consecutive years formerly under cultivation for the two types of capoeiras. Fifty-two of 79 (82%) former roças contained an average of 3.5 species. Less of the former bananais were found to contain useful species, only 20 out of 32 (60%). The average number of species in the former bananais were slightly higher with 4.4 species.

Table 4-9. Summary of statistics for fallows (capoeiras) on high levees

		N	Mean	Min.	Max.	S	Median
Former roça	Useful Species	52	3.52	1	18	3.33	3
	Banana Varieties	20	1.3	1	3	0.57	1
	Age of Fallow (years)	77	3.4	1	13	2.5	3
	Years Planted Before	53	3.4	1	15	3.2	2
	Size[1] (m^2)	72	5196	800	18000	4770	4000
Former bananal	Useful Species	20	4.35	1	13	3.25	4
	Banana Varieties	9	1.1	1	2	0.33	1
	Age of Fallow (years)	31	3.4	1	15	3.3	2
	Years Planted Before	22	3.6	1	12	2.7	2
	Size[2] (m^2)	30	6891	1000	28000	7615	3950

1 Two largest and smallest values were dropped in calculating the mean.
2 Largest and smallest values were dropped in calculating the mean.

Table 4-10. Banana varieties occurring in fallows (capoeiras) on high levees

Variety	Num. capoeiras (41)	%	Num. former roças (23)	%	Num. former bananais (13)	%
Prata	31	76	17	74	10	77%
Maçá	8	20	4	17	4	31%
Comprida	5	12	3	13	2	15%
Nadja	3	7	1	4	2	15%
Pacovinha	1	2	1	4	0	0%

Table 4-11. Twenty-five most frequently encountered species and their use in capoeiras on high levees with a comparison of former roças and former bananais

Local name	English name	Use[1]	Capoeiras (88)	%	Former roças (52)	%	Former bananal (20)	%
Banana	Banana	1	41	47	23	44	13	65
Açaí*	Açaí[2]	2	26	30	15	29	9	45
Cacau	Cocoa	1	24	27	13	25	6	30
Mulateiro	Mulato wood	3	14	16	10	19	3	15
Taperebá	Yellow mombim	1	14	16	7	13	5	25
Lauro inamui	Lauro inamui	3	12	14	5	10	6	30
Ucuúba	Virola	3	11	13	7	13	4	20
Tacaca	Tacaca	3	10	11	5	10	4	20
Assacu	Assacu	3	8	9	6	12	1	5
Bacaba	Bacaba	2	8	9	4	8	4	20
Limão comum	Lime	1	8	9	6	12	1	5
Manga	Mango	1	8	9	4	8	3	15
Muiratinga	Muiratinga	3	7	8	4	8	1	5
Cedro	Cedar	3	6	7	4	8	2	10
Cuia	Calabash goard	4	6	7	3	6	0	0
Cupuaçu	Cupuaçu	1	5	6	3	6	2	10
Jitó	Jitó	3	5	6	3	6	2	10
Cana de açucar	Sugarcane	2	4	5	1	2	0	0
Fruta pão	Breadfruit	1	4	5	3	6	0	0
Ingá	Inga	1	4	5	3	6	1	5
Jambo	Malay apple	1	4	5	3	6	1	5
Jauari	Jauari	5	4	5	3	6	1	5
Jenipapo	Genipap	1	4	5	2	4	0	0
Mamão	Papaya	1	4	5	2	4	0	0
Urucuri	Urucuri palm	6	4	5	1	2	2	10

Use categories: 1 Fruit, 2 Beverage, 3 Timber, 4 Bowl, 5 Fishbait, 6 Thatch

* There are two possible species of açaí; açaí do Pará (*E. oleracea*), and açaí preto (*E. precatoria*).

The results for both the average age of the fallow and the average number of years formerly under cultivation were three and a half years; virtually the same for both land use types.

A total of 68 useful species were recorded in 88 capoeiras on high levees. Table 4-11 shows the 25 most frequently encountered and gives an indication of their relative dominance in former roças and former bananais. Although the sample of former bananais is small, it can give us an indication of possible differences between the two land use types. Banana is the most common valuable plant growing in fallow areas. The percentage of former bananais containing banana was higher with 65% compared to former roças with 44%. Açaí also occurred 16% more frequently in former bananais. The fact that yellow mombim occurs 12% more frequently in former bananais would makes sense since it is a tree that would more likely be sacrificed when clearing land for a roça because of the need for full sunlight in manioc production. It is more convenient to spare fruit trees like yellow mombim and genipap or valuable timber in a bananal where large trees are often preserved to provide some shade and the banana plants are often scattered over a wide area. Of the 25 most frequently encountered useful plants in capoeiras, the majority (11) are fruit trees, eight are timber trees, three are used for beverages, and one each are used for fish bait, thatch, or bowls.

Five varieties of banana were found growing in capoeiras on high levees (Table 4-10). In 29 capoeiras, the average number of varieties was 1.2. Only six capoeiras (21%) had more than one variety; five had two varieties, and one had three. Five of these are former roças and one is a former bananal. Again, prata is the variety that dominates in these areas. This variety was found in 76% of the 41 capoeiras where information on variety was collected. It occurred in almost the same percentage of former roças and former bananais. Maçá is the second most common variety, found in 20% of 41 capoeiras. Comprida is third with 12 percent. Two relatively uncommon varieties, Nadja and Pacovinha, were also found.

Capoeira Bananal

Local residents sometimes distinguish the capoeira bananal (banana fallow) from a regular capoeira. It is relatively enriched with bananas and often with other fruits. It can result from several possible origins. After a high flood kills much of a crop in a more densely planted bananal the status of the work area is "downgraded" to capoeira bananal. The area is often replanted to renew its status as a bananal. The capoeira bananal can also result from a harvested roça that was interplanted with bananas. It may be only partially planted with bananas. In that case it is more like a small bananal within a larger capoeira. It can also be capoeira of any age that is enriched with scattered banana plants. Out of 13 capoeira bananais (plural) surveyed, six were formerly roças, four were mata (forest), two were bananais, and one was capoeira.

The ages of capoeira bananais range from 2 to 18 years with an average of almost four (Table 4-12). The number of years capoeira bananais was previously planted with crops, reported in only three cases, was two.

The capoeira bananal is a range along a continuum of plant diversity in the agricultural ecosystem of the middle Solimões várzea. They contained from 1 to 12 useful species with an average of over three. The most frequently encountered species are those that commonly sprout spontaneously in restinga alta fields and fallows (Table 4-13). These include açaí, genipap, papaya, mulatto wood, and yellow mombim.

Table 4-12. Summary of statistics for banana fallows (capoeira bananal)

	N	Mean	Min.	Max.	S	Median
Age of capoeira bananal	16	3.88	2	18	4.00	3
Num. of species	21	3.57	1	12	2.87	2.5
Num. of banana varieties	17	2	1	4	1.06	2

Table 4-13. The 30 useful species found in 21 banana fallows (capoeira bananal)

Local name	English name	Use	Num. capoeira bananal (21)	%
Banana	Banana	1	20	91
Mulateiro	Mulato wood	3	6	27
Açaí*	Açaí[2]	2	5	23
Mamão	Papaya	1	5	23
Taperebá	Yellow mombim	1	5	23
Cuia	Calabash gourd	4	3	14
Jenipapo	Genipap	1	3	14
Goiaba	Guava	1	2	9
Manga	Mango	1	2	9
Muiratinga	Muiratinga	3	2	9
Samaúma	Kapok tree	3	2	9
Alfavaca	Alfavaca	9	1	5
Assacú	Assacú	3	1	5
Bacaba	Bacaba	2	1	5
Bacuri coroa	Bacuri coroa	1	1	5
Cacau	Cocoa	1	1	5
Cajú	Cashew	1	1	5
Capim santo	Lemon grass	9	1	5
Cubiu	Cubiu	1	1	5
Goiaba araça	Goiaba araça	1	1	5
Graviola	Soursop	1	1	5
Ingá	Inga	1	1	5
Jacareúba	Jacareúba	3	1	5
Jambo	Malay apple	3	1	5
Jauari	Jauari	5	1	5
Jitó	Jitó	3	1	5
Lauro abacate	Lauro abacate	3	1	5
Limão comum	Lime	1	1	5
Majirição	Majirição	9	1	5
Mandioca	Manioc	8	1	5

Use categories: 1 Fruit, 2 Beverage, 3 Timber, 4 Bowl, 5 Fishbait, 6 Thatch, 7 Nut, 8 Tuber, 9 Medicine

* There are two possible species of açaí; açaí do Pará (*E. oleracea*), and açaí preto (*E. precatoria*).

Table 4-14. Banana varieties in banana fallows (capoeira bananal)

Variety	Num. banana fallows (17)	%
Prata	16	94
Comprida	9	53
Maçá	5	29
Guariba	2	12
Peruana	2	12

Figure 4-1. Banana fallow on a high levee on the Solimões River. Banana, açai and several other fruits are growing in partial shade in an area about ten meters wide extending 200 meters.

Cuia, a planted and carefully tended shrub whose giant gourd fruits are used as bowls, cups, and ladles was found in three of 21 capoeira bananais.

Of course, a capoeira bananal should have bananas. It is the presence and density of bananas that determine the areas classification. They occur with up to four varieties in all but one of the 21 surveyed with an average of two. Of five varieties, banana prata is the most prolific, occurring in 94% of the fallows surveyed, Comprida (plantain) was found in half, and Maçá, Guariba, and Peruana were found in a few (Table 4-14). The single capoeira bananal with no bananas had been planted with bananas until the previous years flood killed them all.

Capoeira Cacaual

The designation of cocoa fallow (capoeira cacaual) is relatively rare among land use types on the várzea. Only two areas of this type were encountered. One of the sites was apparently an old cocoa plantation that had been planted about 20 years ago. It was reported to be a very large area, about 2000 meters long and 500 meters wide, and the only planted species it contains is cocoa. No information on additional species, management, or number of individuals was collected but there is almost certainly at least some other useful species in such a large area. The other site is an eight year old cocoa fallow that was cleared from mature forest 10 years ago and planted to manioc and banana for two consecutive seasons before being planted to cocoa and left fallow. The area is about 100 by 40 meters and cocoa is the only useful species.

Capoeira Fruteira

A fruit fallow (capoeira fruteira) is created when a farmer decides to invest a significant amount of energy in forming a swidden fallow replete with fruits and other useful species. These areas are typically located conveniently close to the village to facilitate care and protection of crops and easy transport of bulky fruits back to the home. The development of the fruit fallow begins in the roça phase. Fruit trees are planted among the manioc crop offering excellent protection for the developing seedlings by providing a moist, shady environment. Seedlings may be planted during the first or second crop of manioc or at any time throughout the life of the capoeira. During the fallow phase, optimal conditions are maintained for the production of fruits by managing secondary forest trees to provide the right amount of sun or shade for each crop. By manipulating the species composition of the regenerating forest in favor of valuable subsistence and market crops, a farmer creates a fallow rich in fruits and other useful plants and increases land-use efficiency by significantly boosting production over the fallow cycle. The agroforestry system thus installed acts the same as the naturally regenerating forest in functioning to restore the fertility of the soil for a future cropping sequence.

Table 4-15. Summary of statistics for fruit fallows (capoeira fruteiras)

	N	Mean	Min.	Max.	S	Median
Age of capoeira fruteira	9	7.78	1	30	8.66	5
Num. of species	12	10.17	5	19	4.28	9.5
Num. of banana varieties	6	2.17	1	3	0.98	2.5

Table 4-16. Banana varieties in six fruit fallows (capoeira fruteiras)

Variety	Num. capoeiras fruteiras (6)	%
Prata	6	100
Comprida	2	33
Maçá	2	33
Peruana	2	33
Guariba	1	17

If the density of valuable fruits reaches a high level, the area may stay in “fallow” indefininately. A small sample revealed a mean age of eight years and a median of five years with one fallow 30 years old (Table 4-15). The farmer may continue to enrich the fruit fallow over time with the addition of seedlings, vegetables, and medicinal plants and trotection of naturally occuring plants. Reaching a certain density of valuable plants, a famer may begin to refer to the fruit fallow as a sitio. When trees are old, a farmer can decide to clear the land (or certain portions of it) again for manioc production. Also, a high flood may kill many of the trees making roça production advantageous once again.

Table 4-17. The 29 useful species most frequently encountered in 12 fruit fallows

Local name	English name	Use	Num. capoeira fruteiras (12)	%
Banana	Banana	1	8	67
Açaí*	Açaí[2]	2	6	50
Fruta pão	Breadfruit	1	6	50
Taperebá	Yellow mombim	1	6	50
Cacau	Cocoa	1	5	42
Jenipapo	Genipap	1	5	42
Cuia	Calabash gourd	4	4	33
Cupuaçu	Cupuaçu	1	4	33
Goiaba	Guava	1	4	33
Inga	Ingá	1	4	33
Limão comum	Lime	1	4	33
Mamão	Papaya	1	4	33
Manga	Mango	1	4	33
Araça boi	Araça boi	1	3	25
Buriti	Buriti palm	2	3	25
Cajú	Cashew	1	3	25
Laranja	Orange	1	3	25
Muiratinga	Muiratinga	3	3	25
Mulateiro	Mulato wood	3	3	25
Pupunha	Peach palm	1	3	25
Seringa	Rubber	10	3	25
Abiu	Abiu	1	2	17
Bacuri liso	Bacuri liso	1	2	17
Cacau jacaré	Cacau jacaré	1	2	17
Jambo	Malay apple	1	2	17
Lima	Lima	1	2	17
Limão caiana	Limão caiana	1	2	17
Ucuúba	Virola	3	2	17
Urucu	Annatto	11	2	17

Use categories: 1 Fruit, 2 Beverage, 3 Timber, 4 Bowl, 5 Fishbait, 6 Thatch, 7 Nut, 8 Tuber, 9 Medicine, 10 Latex, 11 Colorant
* There are two possible species of açaí; açaí do Pará (*E. oleracea*), and açaí preto (*E. precatoria*).

Twelve fruit fallows were encountered in 6 communities. Five of these belong to the residents of Vila Alencar. The encouragement of researchers from the Mamiraua project, who contributed technical support and seedlings of fruit trees, resulted in several of these areas especially rich in fruits (Table 4-17). Banana was most frequent with up to three varieties in eight of twelve (67%) capoeira fruteiras and a total of five varieties present (Table 4-16). Approximately twenty out of the 29 most frequently observed species in the fruit fallows were planted. Others such as papaya and ingá may be planted or protected.

Frutal

A fruit orchard (frutal) can be thought of as a well developed fruit fallow with a relatively dense planting of fruit trees and a high diversity of species. Two areas designated as fruit orchards were visited on two long high levees behind the community of Sitio Forteleza. Both are owned by the same family. One is approximately 300 meters long and the other is 2000 meters long. The width varies from 20 to 40 meters. The first is three years old. It was previously forest (mata) with many valuable species. Thirteen useful species were inventoried in this fruit orchard (Table 4-18). They spared all trees with a use. These include açaí preto used for making a beverage, the bacuri coroa (*Rheedia* sp.) fruit, and the timber trees envira vassourinha (*Xylopia calophyllum*), jacareúba (*Calophyllum brasiliense*), manixi (*Brosimopsis oblongifolia*), marirana (*Coepia* sp.), virola (*Virola surinamensis*) (also a good fish bait), and others. The method used here is to clean underneath the trees and plant fruits. Some of the fruits that were planted include araçá boi (*Eugenia stipitata*), bacuri liso (*Rheedia macrophylla*), breadfruit, cocoa, cupuaçu, ingá, Malay apple (*Eugenia malaccensis*), and mango (*Mangifera indica*). At the time of my visit they were clearing undergrowth to plant bananas and had already planted some. They will not plant roça here.

The second, much larger fruit orchard begins directly behind the community at the back of the home gardens and stretches along a high levee beside the natural canal (paraná) for approximately 2000 meters. It is several years old and contains 19 useful species (age was not obtained). The village’s two small herds of cattle and water buffalo have free reign in this area. The owner, Francisco, claims that roça has never been planted here. A number of banana and orange trees were lost in last year's flood.

Table 4-18. The 25 useful species found in two fruit orchards (frutal)

Local name	English name	Use	Num. frutals (2)
Açaí*	Açaí[2]	2	2
Araçá boi	Araçá boi	1	2
Bacuri coroa	Bacuri coroa	1	2
Cacau	Cocoa	1	2
Limão comum	Lime	1	2
Samaúma	Kapok tree	3	2
Ucuúba	Virola	3	2
Andiroba	Andiroba	3, 9	1
Bacuri liso	Bacuri liso	1	1
Cedro	Cedar	3	1
Cupuaçu	Cupuaçu	1	1
Envira vassourinha	Envira vassourinha	3	1
Fruta pão	Breadfruit	1	1
Ingá	Inga	1	1
Jacareúba	Jacareúba	3	1
Jambo	Malay apple	1	1
Jitó	Jitó	3	1
Manixi	Manixi		1
Manga	Mango	1	1
Marirana	Marirana	3	1
Muiratinga	Muiratinga	3	1
Mulateiro	Mulato wood	3	1
Puruí	Puruí	1	1
Seringa	Rubber	10	1
Taperebá	Yellow mombim	1	1

Use categories: 1 Fruit, 2 Beverage, 3 Timber, 4 Bowl, 5 Fishbait, 6 Thatch, 7 Nut, 8 Tuber, 9 Medicine, 10 Latex, 11 Colorant
* There are two possible species of açaí; açaí do Pará (*E. oleracea*), and açaí preto (*E. precatoria*).

Sitio

When a farmer proudly proclaims a place "my sitio" it carries with it an intimate meaning of a site that receives special care and attention. It may even be a secluded retreat where the family can go to take a break from the tediousness of village life. A diverse orchard of mature fruit trees is the core vegetative component of the sitio. This cultural forest has been carved out of the surrounding mata bruta (old forest) through years of patient investment in time and energy. In addition to the fruit orchard, a small roça or maize patch, or a garden of vegetables and medicinal herbs is sometimes planted in an area with adequate sunlight. Other useful timber, medicinal, or fish bait trees may be protected or planted in the sitio.

The designation of sitio implies something of permanence. As much as any location on the ever changing várzea can be considered permanent, the sitio is quite possibly the longest lasting cultural feature of the floodplain forest. It can stay in the family, passed on from father to son. It is also one of the few areas with enough invested to give the land monetary value. The sitio may be bought and sold.

The sitio can be formed in a number of ways. It sometimes begins as a roça that is continually enriched with valuable plants until it eventually becomes a mature, productive orchard. At some point there is a conscious decision by the farmer that this is where he will concentrate a portion of his energy; this will be his sitio. The energy invested in management can be reduced when the orchard is mature and forms a thick canopy that blocks out the sun. A sitio may also start out as a vacant resident's home garden. When people change residences on the várzea they often dismantle their homes to take advantage of the lumber and reassemble them in a new location. The former home garden may then be kept as a sitio, passed to a family member, or sold to a neighbor.

The sitios visited on the várzea had several different origins and management regimes. A brief description of four of them can provide a picture of the diversity of land use on the várzea even in this single type. The first sitio, located in the community of

Betel on a very high levee along the bank of the Japurá River, started out as someone's home garden. The current owner purchased it from the previous owner who took his house with him when he left. This impressive orchard had 17 species of fruit packed into an area about 10 meters wide and 300 meters long. There was a large number of cocoa, cupuaçu, citrus, and guava (*Psidium guajava*) trees, thriving among many other species. The owner earns some income from the sitio by selling cupuaçu and cocoa. I could hardly take notes as my guide repeatedly broke open cocoa fruits and shoved them into my hands, a welcome refreshment in the hot equatorial sun. There were bundles of manioc stored here that had started to take root and hundreds of small fruit tree seedlings scattered around that had sprouted on their own.

This is an important source area of seedlings for enriching fields and fallows. Many of the seedlings drowned in the 1999 flood including avacado (*Persea Americana*), abiu (*Pouteria caimito*), banana, cupuaçu, lima (*Citrus* spp.), and peach palm (*Bactris gasipaes*). Some seedlings of cupuaçu and pupunha survived. These are two terra firme species that normally do not resist flooding very well. By continuously selecting more resistant seedlings for replanting, varieties might evolve over time that are better adapted to conditions on the várzea.

The second sitio is located along a side channel of the Japurá. The owner also purchased this area from another owner. He paid $RS400 or approximately US$235 for this 120 by 40 meter site. It now has 11 species after three were lost during last year's flood. All of the abiu, avacado, and banana were lost along with some orange trees.

A third sitio in the community of São Paulo has a manioc processing house (casa de farinha) on the site. It sits on a high levee that did not flood in the year 2000. They have started some watermelon seedlings to plant on the mudflat in front as soon as the flood recedes. Besides the twenty odd species of fruits, vegetables, and medicinal plants they have planted, several valuable trees have been spared during forest clearance including castanha de macaco (*Couroupita guianensis*), macacarecuia (*Couroupita* sp.), muiratinga, and the kapok tree. Interestingly, they also planted catoré (*Crataeva benthami*), a favorite fruit of the prized tambaqui fish (*Colossoma macropomum*)(Araujo-Lima and Goulding 1997). There is a harvested manioc field at the site located conveniently close to the manioc processing house.

At a forth site, named "Sitio Isaias" near the village of Sitio Forteleza, the family constructed a small house, not a manioc processing house, but an elevated shelter from the midday sun or a weekend retreat. The family told me they like to come here occasionally and stay for a few days just to get away from the village. It is a place of rest and relaxation where they enjoy roasting fish or harvesting and eating any fruit that is in season. They can keep busy working in the nearby fields or in one of two small vegetable and herb gardens at the site. When I visited they were making the delicious beverage from the açaí palm. Often mixed with manioc flour or tapioca, it is a hearty snack that is greatly revered by people of the region and provides a welcome break in the days activities when friends and neighbors are invited to share the refreshing treat. This sitio is about 20 years old and was developed from a former cocoa grove (cacaual). There is a banana fallow on one side that extends for approximately 100 meters. The large size (8000 m2) and heterogeneity of the site with the addition of two small vegetable and herb gardens gives this sitio the greatest number of useful plants of any work area that was visited with 34 species.

The five sitios that were encountered in the survey contained an average of 20.8 species. This is a significant jump in useful plant diversity over the other types of land use, more comparable with home gardens than fields or fallows. Actually, the diversity is higher than the average várzea home garden probably due to the greater size of the sitio and because some homeowners do not take an interest in developing home gardens. The average sitio is more than four times larger than the average home garden. The sitio with the lowest number of species held 11 while that with the highest held 34.

A total of 61 species were logged in the five sitios. Table 4-19 shows all species that were found in at least two sitios. The most common were cocoa and Malay apple, occurring in all five sitios, and açaí occurring in four. Fruit trees account for most of the diversity in sitios. Out of the 24 most common species, 13 are fruits, three are edible palms used for making beverages (açaí, bacaba (*Oenocarpus bacaba*), and buriti (*Mauritia flexuosa*)), three have medicinal uses (andiroba (*Carapa guianensis*), boldo (*Pneumus boldus*), guava), two are timber trees (andiroba, kapok), one is a latex (rubber (*Hevea brasiliense*)), one is a vegetable (tomato (*Lycopersicum esculentum*)), one is a tuber (manioc), and one is used as a bowl (calabash gourd (*Crescentia cujete*)). Other species that were found in only one of the five sitios also include fruit, nuts, timber, condiments, and medicinal plants.

Table 4-19. The twenty-four most frequently encountered species and their use in five sitios

Local name	English name	Use	Num. sitios (5)	%
Cacau	Cocoa	1	5	100
Jambo	Malay apple	1	5	100
Açaí*	Açaí[2]	2	4	80
Bacaba	Bacaba	2	3	60
Banana	Banana	1	3	60
Buriti	Buriti palm	1, 2	3	60
Cuia	Calabash gourd	4	3	60
Cupuaçu	Cupuaçu	1	3	60
Fruta pão	Breadfruit	1	3	60
Laranja	Orange	1	3	60
Lima	Lima	1	3	60
Limão comum	Lime	1	3	60
Manga	Mango	1	3	60
Puruí	Puruí	1	3	60
Andiroba	Andiroba	3, 9	2	40
Araçá goiaba	Araçá goiaba	1	2	40
Boldo	Boldo	9	2	40
Goiaba	Guava	1	2	40
Mamão	Papaya	1	2	40
Mandioca	Manioc	8	2	40
Pupunha	Peach palm	1	2	40
Samaúma	Kapok tree	3	2	40
Seringa	Rubber	10	2	40
Tomate	Tomato	11	2	40

Use categories: 1 Fruit, 2 Beverage, 3 Timber, 4 Bowl, 5 Fish bait, 6 Thatch, 7 Nut, 8 Tuber, 9 Medicine, 10 latex, 11 vegetable
* There are two possible species of açaí; açaí do Pará (E. oleracea), and açaí preto (E. precatoria).

CHAPTER 5
DIVERSITY IN HOME GARDENS

An examination of agrobiodiversity in agricultural ecosystems of Amazonia would be sorely deficient if it did not include a serious look at home gardens. These resource islands packed with useful plants are found almost ubiquitously around homes in the region. Padoch and Jong (1991) emphasized that most studies of home gardens had focused on world regions with high population density and Amazonia, with its extensive available land, did not seem a likely area to find this complex and intensively managed system. Their work in the Peruvian community of Santa Rosa, however, illustrated that home gardens of the Amazon basin contain a high level of diversity even among the non-tribal riverine population whom, it was sometimes felt, had lost the intimate plant knowledge of tribal Amerindians. Smith (1996b) points out that even recently arrived colonists are quick to develop diverse backyard collections of plants.

Recent interest in tropical home gardens has been driven by the enormous diversity of plants they contain, their importance for family subsistence and household income, and their promise for agroforestry. Smith and colleagues stressed the value of home gardens as a largely untapped resource for agroforestry development in the Amazon and their role in crop domestication (Smith 1996b, 1999; Smith et al. 1995, 1996). They note that several crops such as Barbados cherry (*Malpighia glabra*) and cupuaçu, previously grown only in the backyard for subsistence, are now successful commercial crops. Chota (1999) describes the rise of the native backyard tree, umarí (*Poraqueiba cericeae*) to principal crop in the village of Tamshiyacu, 30 kilometers from the city of Iquitos, Peru.

Varieties of the tree were carefully selected from home garden stock to plant on a commercial scale. Today there are approximately 4,000 hectares of umarì growing in Tamshiyacu. Padoch et al. (1985) found that more than 60% of the $5,000 average annual family income comes from the sale of umarì. There is clearly an enormous potential for developing new crops from the immense diversity of plants grown in home gardens.

Home gardens are an important venue for plant domestication. Plants are sometimes recruited from the forest and carefully tended for their medicinal, ornamental, or food producing qualities. Pre-existing and spontaneous plants are commonly protected. Many exotic species from the African and Asian tropics are also introduced. Once established in the home garden, the process of farmer selection and propagation can begin.

Seedlings were observed growing in home gardens on many occasions in the study area and elsewhere in the Amazon. Seeds from especially good quality fruits are saved and planted. They may be found growing in planters or seedbeds with vegetables and medicinal plants. Spontaneous volunteers are found at the base of mature home garden trees where they have sprouted from fallen seeds. There is often an abundance of young plants that provide farmers with a large selection for replanting in other areas. Farmers select especially vigorous specimens for replanting. A natural selection process also takes place in home gardens as more resistant seedlings survive flooding while others perish. Seedlings are stored in the home garden where they can be closely watched until they are transferred to a roça or capoeira, usually at the beginning of the rainy season.

Tropical home gardens are noted to have an intimate relation with the family and residents affirm that the home is not complete without one (Jose and Shanmugaratnam 1993). They are often among the most well tended components of the agricultural system. Plants are kept nearby where they can be easily looked after and protected. Many receive special attention that includes watering, soil amendments, protection from animals, and the use of planters or pots. Charcoal or other organic materials are commonly mixed with soil to enhance fertility. Especially rich soil is selected for use in planters and pots. A section of the garden used for growing vegetables and medicinal plants is often protected from chickens and other animals with wire or netting. Home gardens furnish shade and protection from the wind for people, domestic livestock, and pets. Activities such as the processing of manioc and other foods and the production of charcoal are often performed in the comfort of the home garden.

Children especially benefit by the diverse foods grown in the home garden and by the knowledge developed from close proximity and observation of the many species and varieties of plants. Whenever there is something to be had, kids climb the trees or reach up with long poles to dislodge fruits, ripe or unripe. Home gardens often make a large contribution to family subsistence by providing many foods in season at various times throughout the year or at critical times when other sources of food are scarce, notably during the flood season.

Home gardens are important areas for leisure as well as meeting places for neighbors (Lima 1994). The shaded area provides welcome relief from the hot afternoon sun and wooden benches are sometimes placed to enjoy the view of the river and passing boats. A sizeable area around the house is often kept weeded and swept clean. The usual method of dealing with grass or weeds is to remove them with a hoe or machete, scraping the ground smooth and clean. Frequent sweeping with a broom made of palm fronds keeps the ground free of forest litter which is then swept into piles and burned. In a study on Careiro Island near Manaus, Lima (1994) found that the fires can be intentionally used to disperse pests from trees. Other areas are kept in grass and leaves may be left in place to provide mulch, conserving moisture and adding organic material to the soil. Many yards on the várzea are kept in grass and several communities in the study area had cattle, buffalo, or goats that kept it nicely trimmed.

Figure 5-1. Yard in the várzea located on a paraná connecting the Japurá River to the Solimões. On the floodplain, home garden plants are often kept principally in the area behind the house while the front of the home is kept in grass. Cattle affect the way that plants can be grown in the village. They often destroy young trees and other plants that are left unprotected. The levee here was about one meter above the high water mark for 2000. Community of São Paulo do Coraçi.

Diversity in Middle Solimões Várzea Home Gardens

Contrary to a popular perception that the floodplain is not amenable to growing perennial crops, recent research has shown that home gardens on the Amazon vàrzea contain levels of diversity comparable to those on terra firme (uplands) (Lima 1994; Lima and Saragoussi 2000; Chota 1999; Smith 1996b). Smith directly compared home gardens on the uplands with those on the middle Amazon várzea and found a greater number of perennial species in a smaller sample of floodplain gardens.

In the middle Solimões várzea, an area with the highest range in river level from low to high water for the entire length of the Brazilian Amazon (sometimes more than 16 meters), it appears that in terms of average number of species, floodplain home gardens are somewhat less diverse than upland gardens. A total of 176 useful species (excluding ornamentals) were recorded in 163 home gardens on the várzea with an average of 12 species per household. This compares to 135 useful species found in 30 terra firme home gardens in the same region with an average of 21 plant species per garden. There were 99 species common to both the várzea and terra firme out of 212 total home garden species. Average diversity is lower in home gardens on the floodplain because of environmental variation within communities and the difficulties of planting perennials in areas subject to annual flooding. Differences in socio-economic situation (more fishermen with less interest in planting?) or higher mobility of residents could also be factors that lead to less diverse home gardens on the floodplain.

Although várzea home gardens are slightly less diverse than their counterparts on terra firme, a large number of useful species on the várzea are found exclusively in home gardens illustrating their value as a repository of agrobiodiversity. Out of 204 total species recorded on the várzea, 87 were found exclusively in home gardens. By comparison, there were just 29 species not found in home gardens. This indicates that almost the complete repertoire of useful plants in the agroecosystem of the middle Solimões is represented to some extent in home gardens, an important fact to remember when considering the conservation of agrobiodiversity in the region.

The wide range of uses for home garden plants underscores its importance for family subsistence and well-being. Approximately 20 different uses were reported for plants in the middle Solimões. The use was recorded only when reported by residents or in the scientific literature. Home gardens were inventoried in 14 vàrzea communities. The average number of homes in each village is 12. Of the 171 homes visited, only 8 did not keep any useful plants. The most common use is fruit (including nut) or beverage with 62 species (44%). All except 16 várzea gardens had at least one fruit tree growing. Home gardens contained an average of 4.8 species and 14.6 individual trees in the fruit and beverage category (Table 5-1). Medicinal is the second largest use category with 39 species (28%) and timber is third with 19 species (14%). At least 19 species have more than one use. Other uses are vegetable (11 species), fishbait (6 species), condiment (4 species), calking (3 species), latex (2 species), livestock feed (2 species), snack (2 species, includes chocolate and sugarcane), tuber (2 species), and 1 species each used for a bowl, dye, fiber, food colorant, grain, and mulch. Firewood is also gathered from the home garden.

The number of useful species in floodplain home gardens varies widely. Figure 5-2, shows the frequency that a given number of species occurred. The number of useful species ranges from one to 29 and the average vàrzea home garden contains 12 species.

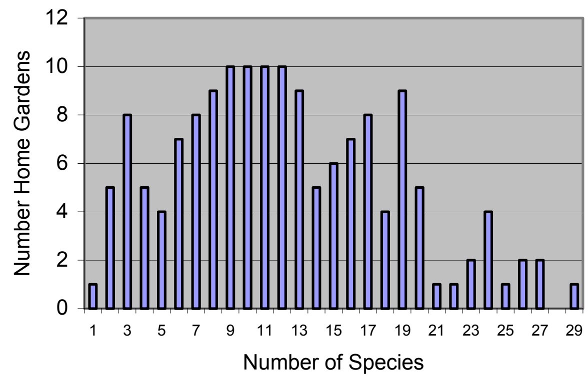

Figure 5-2. The number of species in 163 home gardens on the várzea

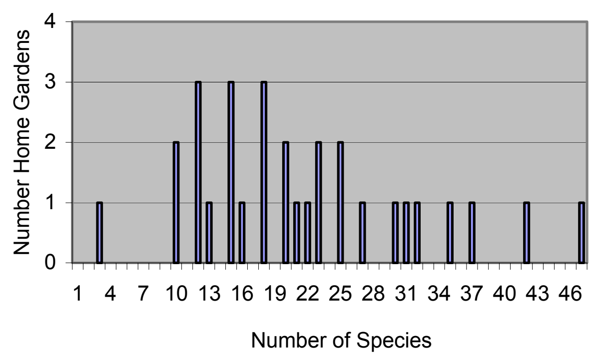

Figure 5-3. The number of species in 30 home gardens on terra firme

There are several possible reasons for homes that do not have gardens or have only a few species. Like fields, many villages lie on uneven ground. Some residents have low-lying yards and strong currents can kill all except the most adapted of floodplain plants. Home gardens within communities usually lie adjacent to one another but it is not unusual for groups of homes to be separated by larger distances when divided by low lying areas.

A home garden is very personalized and each member of the family can contribute to its development. Exceptionally diverse gardens are usually managed by avid plant collectors. Padoch and Jong (1991) studied upland home gardens in the village of Santa Rosa in the Peruvian Amazon and found that plant assemblages varied according to the special needs and interests of families. Some individuals do not have much interest in raising home gardens. This is also true in the middle Solimões region. Several homeowners claimed they were primarily fisherman and not interested in agriculture.

In the Mamirauá reserve, a small proportion of families in some villages live on floating houses. They have no yard (quintal) but frequently care for several types of medicinal plants or vegetables in planter boxes on the side of the house or on separate floating rafts. New homes had few plants and young couples or single men can often rely on mature home gardens of their family, friends and neighbors. In a large family there are more individuals to contribute to the maintenance of the garden and long-term residents have had more time to acquire diverse collections of plants. However, there is no proven correlation between homeowner age and species richness in home gardens (Padoch and Jong 1991).

People with undeveloped gardens usually expressed their desire of planting more trees but many also explained their frustration with raising perennials on the várzea. Some considered it a waste of time. Seedlings can be less tolerant to flooding than mature trees and are often killed during the first few years after planting. Some of the gardens visited had fruit seedlings underwater and it was unknown which ones would come out of the flood alive. A number of residents reported that older trees, ordinarily able to survive a few feet of water, can be killed from the impact of a floating log or canoe. This effect was also reported by floodplain farmers on Careiro Island near Manaus (Lima 1994). A process of natural selection is likely operating here if, frequently, only the most tolerant individuals survive. The assumption follows that várzea home gardens would be promising places to search for crop plants that are more tolerant to flooding for the expansion of agroforestry on the floodplain.

A large variation in home garden diversity was found among communities, ranging from 7.4 to 17.3 average species. Table 5-1 shows the average number of species broken down by community. Minimum numbers of species by community range from 1 to 12 and maximums range from 17 to 29. The variation may be due in a large part to differences between communities in terms of impact from flooding (depth and speed of current), socio-economic situation, age of households, and personal preference. The two communities with the lowest average number of species are Barroso, a low-lying community on the Solimões, and Jarauà, another village with a relatively greater impact from flooding where residents have developed a fishing cooperative. The four communities with the highest average diversity, Betel, Manacabi, Marirana, and Porto Praia are all on relatively higher levees and were completely dry at the time of the survey. More research is needed to learn how the location, environment, economy, and social factors influence diversity in home gardens.

Table 5-1. Average number of useful species in 163 várzea home gardens by community

Community	N*	Mean	Min.	Max.	S	Median
All communities	163	12.0	1	29	6.3	11
Betel	11	17.3	12	27	5.1	17
Manacabi	8	16.9	12	26	4.2	17
Marirana	6	16.5	8	24	5.7	17
Porto Praia	16	14.9	3	24	6.7	13
São Francisco do Aiucá	17	13.0	4	27	6.1	12
Betania	15	12.3	6	24	5.5	12
Bela Vista do Manguary	2	12.0	5	19		
São Paulo do Coraçi	12	11.5	3	29	7.0	10.5
São João	11	11.3	3	22	6.1	9
Sitio Fortaleza	11	10.3	2	17	4.4	11
Vila Alencar	21	10.1	3	23	5.6	9
Pentecostal	10	9.4	6	17	3.4	9
Barroso	11	8.4	2	19	5.7	9
Jarauá	12	7.4	1	21	6.4	6.5

*Homes without a home garden were omitted (8 homes surveyed had no useful species).

Table 5-2. Fruit, nut, and beverage species in várzea home gardens

Local name		Várzea home gardens Num. of indiv.	Num. of home gardens (n=163)	Ave. indiv. per garden observed	Terra firme home gardens Num. of indiv.	Num. of home gardens (n=30)	Ave. indiv. per garden observed
Goiaba	Guava	566	107	5.3	91	21	4.3
Cacau	Cocoa	261	52	5.0	32	17	1.9
Banana	Banana	257	56	4.6	73	21	3.5
Açaí[1]	Açaí[1]	186	46	4.0	120	20	6.0
Cana de açucar	Sugarcane	162	29	5.6	5	4	1.3
Ingá açu	Ingá açu	118	63	1.9	15	6	2.5
Graviola	Soursop	80	46	1.7	11	9	1.2
Camu camu	Camu camu	71	28	2.5	4	1	4.0
Bacaba	Bacaba	69	24	2.9	38	17	2.2
Cubiu	Cubiu	68	29	2.3	13	5	2.6
Mamão	Papaya	62	17	3.6	60	18	3.3
Ingá cipó[2]	Ingá cipó[2]	60	29	2.1	31	11	2.8
Limão comum	Lime	55	28	2.0	19	8	2.4
Côco	Coconut	45	33	1.4	18	12	1.5
Cajú	Cashew	45	23	2.0	28	13	2.2
Manga	Mango	41	23	1.8	56	16	3.5
Taperebá	Yellow mombim	40	27	1.5	4	3	1.3
Jambo	Malay apple	40	23	1.7	26	17	1.5
Araçá goiaba	Araçá goiaba	31	20	1.6	4	3	1.3
Buriti	Buriti	30	19	1.6	17	11	1.5
Castanha sapucaia	Castanha sapucaia	30	11	2.7	0	0	0
Cupuaçu	Cupuaçu	28	11	2.5	54	16	3.4
Bacuri liso	Bacuri liso	25	14	1.8	0	0	0
Jenipapo	Genipap	22	16	1.4	4	3	1.3

Table 5-2. Continued

		Várzea home gardens			Terra firme home gardens		
Local name		Num. of indiv.	Num. of home gardens (n=163)	Ave. indiv. per garden observed	Num. of indiv.	Num. of home gardens (n=30)	Ave. indiv. per garden observed
Puruí	Puruí	21	16	1.3	5	3	1.7
Maracujá	Passionfruit	20	17	1.2	8	6	1.3
Lima	Lima	20	13	1.5	8	5	1.6
Ingá	Inga	20	12	1.7	5	1	5.0
Azeitona	Olive	17	11	1.5	2	2	1.0
Marirana	Marirana	17	10	1.7	9	6	1.5
Pupunha	Peach palm	15	10	1.5	41	15	2.7
Laranja	Orange	14	10	1.4	54	8	6.8
Limão tangerina[3]	Limão tangerina[3]	13	10	1.3	12	6	2.0
Fruta pão	Breadfruit	13	7	1.9	0	0	0
Bacuri liso	Bacuri liso	12	9	1.3	0	0	0
Mutamba	Mutamba	12	8	1.5	0	0	0
Goiaba araçá	Goiaba araçá	11	8	1.4	0	0	0
Abiu	Abiu	10	6	1.7	35	9	3.9
Castanha de macaco	Castanha de macaco	9	6	1.5	0	0	0
Castanholeira	Castanholeira	8	8	1.0	0	0	0
Bacuri coroa	Bacuri coroa	7	5	1.4	2	2	1.0
Abacaxi	Pineapple	7	2	3.5	31	6	5.2
Araçá boi	Araçá boi	5	4	1.3	16	4	4.0
Cacau jacaré	Cacau jacaré	5	4	1.3	3	3	1.0
Cacaurana	Cacaurana	4	3	1.3	1	1	1.0
Pitomba	Pitomba	3	2	1.5	2	1	2.0
Araçá do igapo	Araçá do igapo	2	2	1.0	0	0	0

Table 5-2. Continued

Local name		Várzea home gardens: Num. of indiv.	Várzea home gardens: Num. of home gardens (n=163)	Várzea home gardens: Ave. indiv. per garden observed	Terra firme home gardens: Num. of indiv.	Terra firme home gardens: Num. of home gardens (n=30)	Terra firme home gardens: Ave. indiv. per garden observed
Carambola	Carambola	2	2	1.0	1	1	1.0
Ingá igapó	Ingá igapó	2	2	1.0	0	0	0
Ingá sapo	Ingá sapo	2	2	1.0	0	0	0
Ingásinho	Ingásinho	2	2	1.0	0	0	0
Marimari	Marimari	2	2	1.0	7	3	2.3
Abacate	Avocado	1	1	1.0	31	9	3.4
Açerola	Barbados cherry	1	1	1.0	0	0	0
Apuí	Apuí	1	1	1.0	0	0	0
Bacabinha	Bacabinha	1	1	1.0	3	2	1.5
Biribá	Biribá	1	1	1.0	8	5	1.6
Cajurana	Cajurana	1	1	1.0	0	0	0
Ingá curta	Ingá curta	1	1	1.0	0	0	0
Limão cida	Limão cida	1	1	1.0	0	0	0
Tangerina	Tangerina	1	1	1.0	6	4	1.5

Note : The frequency (number of home gardens) and abundance (number of individuals) of 61 fruit, nut, or beverage species in 171 home gardens on the várzea and their corresponding number in terra firme home gardens. (See appendix 2 for the complete list of home garden species with their scientific name, frequency, and use)

1 There are two possible species of açaí; açaí do Pará (*E. oleracea*), and açaí preto (*E. precatoria*).

2 also called ingá comprida

3 also called limão de suco

Counting the number of individuals of each species gives an accurate picture of crop abundance (Table 5-2). There appears to be some positive correlation (r=0.7) between the frequency a species is encountered in home gardens and its abundance (the number of individuals). The 5 most frequently encountered perennials in the fruit, nut or beverage category (guava, cocoa, banana, açai, and sugarcane) were also the most abundant with 4 to 5 individuals per garden.

The list of fruit, nut, or beverage species in table 5-2 is a mix of native and exotic species. The top ten most abundantly occurring species include two exotics from the Asian tropics, banana and sugarcane. Of the 61 species listed, 48 are native to tropical America and 13 come from tropical Asia.

The occurrence of species in home gardens is clearly influenced by economic and environmental reasons as well as personal preferences. Guava, occurring in 66% of home gardens, is tolerant to flooding and is a favorite, vitamin rich, snack fruit and also medicinal plant. Although guava is a relatively unimportant commercial crop in the area, it is both more than twice as frequent and abundant as cocoa, the second most abundant crop. Cocoa is commercially valuable, flood tolerant, and, besides being made into chocolate, is a delicious fruit or juice.

Bananas, the third most abundant fruit, are found in 34% of várzea home gardens. Table 5-3 shows that there is significant variation among communities in the extent that bananas are grown in home gardens. Bananas are a refreshing treat, a frequent food at mealtime, and are also readily sold. In addition, bananas are somewhat tolerant to flooding. Many banana plants can survive one to three months in saturated ground. They usually produce before being drowned by the flood and it is not uncommon for them to be harvested by canoe in several feet of water. Suckers can usually survive longer when immersed and will continue growing the following season.

Table 5-3. Number of banana varieties in várzea home gardens

Community	N	Gardens with banana present	% gardens with banana	Average num. of varieties *	Average num. of individuals **
All Communities	163	43	26	1.2	6.0
Betel	11	5	45	1.2	4.2
Manacabi	8	4	50	1.5	8.3
Marirana	6	6	100	1.0	10.2
Porto Praia	16	3	19	1.0	2.0
São Francisco do Aiucá	17	2	12	2.0	3.0
Betania	15	4	27	1.0	3.0
Bela Vista do Manguary	2	0	0		
São Paulo	12	0	0		
São João	11	3	27	1.0	6.3
Sitio Fortaleza	11	0	0		
Vila Alencar	22	3	14	1.0	3.0
Pentecostal	10	7	70	1.9	7.6
Barroso	11	6	55	1.2	6.2
Jarauá	12	0	0		

*Average calculated only for home gardens with banana present.
**Average number of *torceiras* calculated only for home gardens with banana present.

Table 5-4. Banana varieties in várzea home gardens

Variety	Num. individuals	Num. home gardens	Avg. num. of individuals per home garden observed
Comprida	107	23	4.7
Prata	107	19	5.6
Urucuri (sapo)	14	5	2.8
Peruana	9	1	9.0
Paco vão	7	2	3.5
Japurá	3	1	3.0
Baié	2	1	2.0
Maçá	2	2	1.0
Inajá	2	1	2.0

The nine varieties of banana reported in várzea home gardens are given in table 5-4. Two of these dominated home gardens on the floodplain. The Comprida variety, a plantain, and Prata, a common commercial variety, were both found in about 20 gardens with a total of 107 individuals each. Urucuri, also known as sapo or frog, came in third with 14 individuals in 5 home gardens. The other six varieties were found in only one or two home gardens each with very few individuals. Home gardens on the várzea should also be a promising place to search for new crop germplasm to be used in the development of varieties with greater resistance to flooding.

Losses from Flooding

Losses in home gardens resulting from high floods primarily consist of species that are intolerant to flooding and seedlings (Table 5-5). Species that are adapted to terra firme such as cashew, cupuaçu, and peach palm are high on the list of drownings.

Table 5-5. Home garden plants that were killed during the 1999 high flood on the várzea

Local name	English name	Num. gardens	Local name	English name	Num. gardens
Cajú	Cajú	10	Pimentão	Green pepper	2
Limão comum	Lime	9	Urucu	Annatto	2
Abiu	Abiu	6	Alfavaca	Alfavaca	1
Cupuaçu	Cupuaçu	6	Araçá boi	Araçá boi	1
Jambo	Malay apple	6	Araticum	Araticum	1
Laranja	Orange	6	Azeitona	Olive	1
Pimenta	Capsicum pepper	6	Bacaba	Bacaba	1
Açai	Açai	5	Bau bau	Bau bau	1
Ingá	Inga	4	Cacau	Cocoa	1
Manga	Mango	4	Cubiu	Cubiu	1
Pupunha	Peach palm	4	Goiaba	Guava	1
Abacate	Avocado	3	Limão caiana	Limão caiana	1
Graviola	Soursop	3	Limão de suco	Limão de suco	1
Maracujá	Passion fruit	3	Mastruez	Mastruez	1
Tomate	Tomato	3	Namui	Namui	1
Banana	Banana	2	Pimenta doce	Pimenta doce	1
Carambola	Carambola	2	Seringa	Rubber	1

Note: not all families were interviewed about losses in home gardens

Fruits from the Asian tropics including citrus, Malay apple, and mango are also frequently lost when high floods occur. Species that are usually flood tolerant such as açai and ingá are easily drowned when young seedlings are completely immersed in water for extended periods during high floods.

Size of Home Gardens

The size of home gardens on the floodplain range from a mere 50 square meters to greater than half a hectare (Table 5-6). The average size is about 900 square meters. When broken down by community, the average size varies widely. The village Pentecostal had the smallest average size. Its gardens are consistently small with an average size for the community of only 261 square meters. On the other end of the spectrum lies Marirana with gardens ranging in size from 800 to 6000 square meters and an average of over 2800.

There is slight positive correlation between size and number of species in várzea home gardens (r=0.31). The scatter diagram in figure 5-4 shows number of species in 163 várzea home gardens plotted against the size given in square meters. It is obvious that a larger home garden does not necessarily mean more species. In Inuma's (1999) study of home gardens in the three villages of Vila Alencar, Jarauá, and Barroso, it was found that the size, as well as the sale of products, is inversely proportional to the distance from markets. It was also observed that larger home gardens held greater numbers of livestock.

The average size of terra firme home gardens in table 5-7 is only slightly greater than those on the várzea at 971 square meters. Nossa Senhora da Fatima, a community established on the high bluff of the Solimoes river, has the largest gardens and the greatest average species diversity. The average size of home gardens in the relatively

Table 5-6. Average size of 155 varzeá home gardens in 14 communities

Community	N	Mean size (m^2)	Min.	Max.	S	Median
All Communities	155	898	50	6400	962	600
Marirana	10	2833	800	6000	1586	2450
São Francisco do Aiucá	15	2047	600	6400	1530	1625
Bela Vista do Manguary	2	1500	1000	2000		
Porto Praia	15	1242	225	3200	684	1250
São João	16	910	200	2400	794	500
Vila Alencar	19	815	250	2800	712	600
Sitio Fortaleza	11	759	200	1500	433	600
Jarauá	11	572	50	1750	481	600
Barroso	11	550	100	1250	337	600
Betel	10	505	225	1000	249	425
Manacabi	7	489	225	750	220	500
Betania	16	470	105	2400	557	300
São Paulo do Coraçi	12	348	150	500	116	338
Pentecostal	9	261	100	450	125	225

Table 5-7. Average size of 30 terra firme home gardens in 3 communities

Community	N	Mean size (m^2)	Min.	Max.	S	Median
All Communities	30	971	25	5400	1367	300
Nossa Senhora da Fátima	8	2316	300	5400	1926	1800
Jubará	5	944	240	1600	580	1000
Boa Esperança	17	333	25	2500	584	150

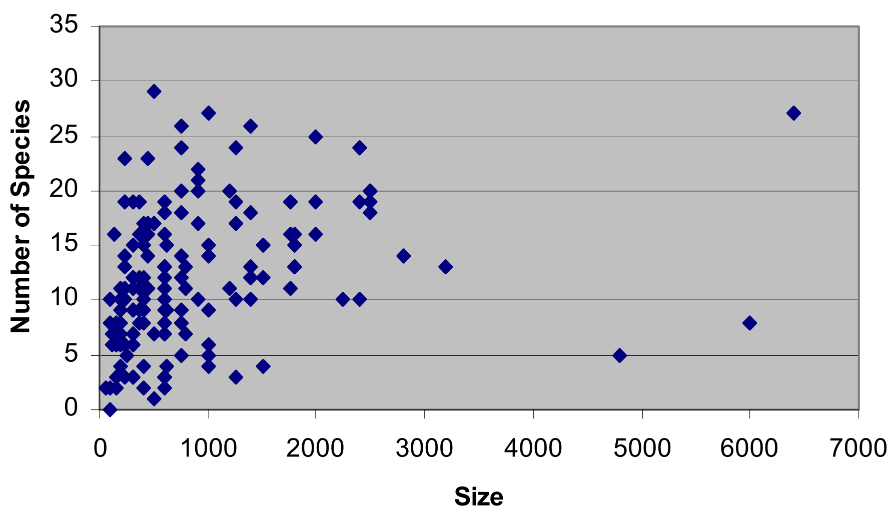

Figure 5-4. Scatter diagram showing number of species in 163 várzea home gardens in relation to size in square meters. There is a slight positive correlation between the size of home gardens and number of useful species (r=0.31).

large upland community of Boa Esperanca is much lower. However, back yards in this village commonly grade into diverse fruit orchards or capoeira fruteiras. There is sometimes a fuzzy division between the end of the backyard and the start of a fruit fallow or orchard. In cases where the border of the home garden was not obvious, the division was drawn according to the opinion of the homeowner.

Livestock in Home Gardens

There is often an animal component to home gardens on the floodplain. Many families raise livestock and pets (Figure 5-5). According to Inuma (1999), the principal animal component in the three communities studied is poultry. Chickens (*Gallus* sp.) make up the largest part. They are also the home garden product that is most frequently sold. Ducks are less common because they are frequent victims of attacks by predators including piranhas which bite their feet while they swim. According to one family in Marirana that raises a higher than average number of ducks and chickens in a fenced in area of the yard, they lose a few animals per year to anacondas and caiman, the main predators. The family plants corn to feed the livestock. Chickens and other animals also forage on kitchen scraps, fallen fruits, insects, weeds and often roost in low home garden trees and bushes.

Inuma found that in Vila Alencar, in 1999, three families were raising sheep and four were raising cattle. Floating platforms like the one pictured in figure 5-6 called marombas are constructed to shelter livestock during the flood and they are fed the floating canarana grass pictured in figure 5-7. They are sometimes transported to the nearby town of Alvarães on the river bluffs to wait for the water to recede. Five out of the 14 villages surveyed had households that raised cattle. Some of the communities voted that cattle would not be allowed because of the disruption caused to crops and home gardens. Cultivation was discontinued in some areas because of the destruction caused by roaming cattle and water buffalo. Planters were forced to move their fields to the opposite side of the river. Water buffalo are especially adept at swimming across streams or around fences.

Terra Firme Home Gardens

Thirty-four home gardens were inventoried in three widely separated terra firme communities set in different environments. Nossa Senhora da Fátima is a river bluff community located on the right bank of the Solimões, a sediment laden “white water” river, upstream from Tefé. Jubará sits low on the left bank of the Japurá, a brown water river with a lower sediment load. Boa Esperança is a relatively isolated low lying village on the shore of Lake Amanã, one of the large lakes formed near the mouths of tributaries when sea level was lower. The latter two communities are not immune from the effects of an abnormally high flood. Substantial areas of the village and agricultural fields were engulfed during the previous season causing large crop losses in both Jubará and Boa Esperança. It is not known what losses may have accrued in the home gardens of these two communities as residents were not interviewed. This leads to the realization that these communities, lying on the edge of the várzea, are set in a transitional zone where they must still contend with the effects of the flood.

The majority of terra firme home gardens are consistently diverse with a mean average of 21.4 species. All of the 34 home gardens surveyed contained at least ten useful species with five exceptions. One yard in Boa Esperança owned by a young man held just three individuals of three species. Four homes in Jubará did not have gardens. These houses are built on stilts in low areas that are seasonally flooded. When households do not have a home garden they typically share produce with a nearby family member or neighbor.

It makes sense that Nossa Senhora da Fátima would have the greatest number of species since it lies on the high bluff and is unaffected by flooding. On the other hand, a number of home gardens in the other two communities are occasionally impacted by exceptionally high floods.

In the survey, a total of 135 species were found in terra firme home gardens. Ninety-nine (73%) of these were also encountered in várzea gardens leaving 36 species that were exclusive to the terra firme. The ten most abundant fruit and beverage species were açai (includes two species *E. oleracea* and *E. precatoria*), guava, banana, papaya, mango, cupuaçu, orange, peach palm, bacaba, and abiu. From table 5-2, we see that species with a low tolerance to flooding were much more common in terra firme home gardens such as avocado, pineapple (*Ananas comosus*), abiu, cupuaçu, orange, and peach palm.

Banana was a frequent member of terra firme gardens as the third most abundant fruit and beverage species. Overall, half of the gardens contained banana with an average of 1.5 varieties and 5.1 individuals (Table 5-9). The most abundant types are two varieties of plantains (Table 5-10). Out of nine varieties recorded, five are plantains.

Table 5-8. Average number of species in 30 terra firme home gardens

Community	N*	Mean	Min.	Max.	S	Median
All communities	30	21.4	3	47	10.1	20
Nossa Senhora da Fatima	8	28.3	16	42	8.8	30.5
Boa Esperança	17	18.9	3	47	10.8	15
Jubará	5	18.6	12	22	4.0	20

* Homes without a home garden were omitted. (4 homes surveyed did not have useful species).

Table 5-9. Number of banana varieties in terra firme home gardens

Community	Num. of samples	Gardens with banana present	% gardens with banana	Avg. num. varieties*	Avg. num. individuals**
All communities	30	15	50	1.5	5.1
Nossa Senhora da Fátima	8	3	38	1.7	5.3
Boa Esperança	17	11	65	1.5	5.3
Jubará	5	1	20	1.0	2.0

* Average calculated only for home gardens with banana present.
** Average number of *torceiras* calculated only for home gardens with banana present.

Table 5-10. Banana varieties in terra firme home gardens

Variety	Num. individuals	Num. home gardens	Avg. num. individuals per home garden observed
Paco vão*	33	5	6.6
Comprida*	17	4	4.3
Prata	15	4	3.8
Comprida 3 palmas*	4	2	2.0
Baié	1	1	1.0
Comprida pão*	1	1	1.0
Comprida rabo de bandeira*	1	1	1.0
Guariba	1	1	1.0
Maçá	1	1	1.0

* Variety of plantain or cooking banana.

Figure 5-5. Backyard with animals in a Solimões River community. The village was inundated with up to one meter of water and divided by a swift flowing furo or canal. This quintal was the only patch of dry ground left in the village for animals to seek shelter. Note that there is an obvious lack of plant diversity in this home garden with many animals. Several families also maintain a small herd of cattle and water buffalo. Community of Sitio Fortaleza.

Figure 5-6. Maromba constructed to provide shelter for animals during the flood. Bela Vista do Manguari; two isolated homes on the Japurá River.

Figure 5-7. Cattle being fed the floating canarana grass during the flood season. Bela Vista do Manguari.

Figure 5-8. Terra firme home garden. Raised planters are used to grow vegetables and herbs and netting is used to protect sensitive plants from animals. Numerous species and varieties of useful plants are densely planted in a small area around the house. Boa Esperança, Lake Amanã.

Figure 5-9. Well developed home gardens grade into diverse fruit orchards. Boa Esperança, Lake Amanã.

CHAPTER 6
A MORE STABLE ENVIRONMENT: TERRA FIRME

Data was gathered on land-use management and agrobiodiversity in four communities on the uplands or terra firme. This is useful as a comparison in order to help resolve academic issues concerning the nature of agricultural systems on the várzea as well as practical problems that can contribute to the development of agroforestry in the region. It also shows that we must consider not only the floodplain but also the surrounding terra firme if our goal is to protect and conserve agrobiodiversity in the region.

The terra firme or uplands can be can be defined as all land that is not subject to flooding. This is contrasted with the várzea or floodplain that is subject to the powerful forces of Amazonian rivers that persistently act to reshape the landscape. There are advantages for agriculture on both landforms. The principal benefit for agriculture on the floodplain is the seasonal or occasional replenishment of soil fertility in the form of fresh sediment deposited by the Solimões and Japurá Rivers. This may allow for repeated cropping on the same location many times in succession. The terra firme field, on the other hand, often has low, quickly declining soil fertility and rapid weed invasion. As a consequence, it is usually only planted with one or two consecutive crops before production drops and a fallow period is initiated.

The great advantage of the terra firme, as was often voiced by local residents, is its stability. Although more land may be required for a sustainable swidden rotation, farmers need not contend with the unpredictability of the flood and the disruption to their lives it can cause. They may still lose production due to weed invasion, pests and diseases, and declining soil fertility but one of the major variables determining a good harvest on the várzea, the flood, is taken out of the equation for terra firme farmers.

Upland farmers have the option of building more permanent orchards or agroforestry systems that include crops intolerant to flooding. These are often ones that have a ready market and a high value as fruit or in the pulp industry. They include such crops as avocado, Barbados cherry, cupuaçu, lime, orange, papaya, pineapple, and soursop (Annona muricata).

Local farmers often aspire to raise cattle and the uplands is perceived as an environment much more amenable to this purpose than the floodplain where there is the ever present problem of what to do with the herd during the flood. Cattle farmers on the river bluffs have the advantage of utilizing both upland and floodplain habitats for grazing.

Unlike some relatively ephemeral floodplain communities, sometimes obliged to shift location due to the changing landscape of the várzea, terra firme villages stay in a fixed location. With the relative permanence of the uplands comes stability for the family. There is often easier access to better schools with more regular schedules and higher quality health care.

The data on fields, fallows, and home gardens on uplands was collected in four communities at dispersed locations throughout the study area. These communities differ dramatically with respect to the environment and access to markets, the habitats used for agriculture, and the relative emphasis on fruit or manioc production.

Nossa Senhora da Fátima is located on a high bluff on the right bank of the Solimões upstream from the municipal center of Tefé and slightly downstream from the town of Uarini. It is at the mouth of a small stream (igarapé) that greatly facilitates access to fields during the high water season. Residents of Nossa Senhora da Fatima do not sustain damage from the flood but it greatly controls the ease of access to their fields. They typically travel by boat during high water to reach their "port" where they walk the remaining distance to the field. It is not uncommon to travel 30 minutes by boat and up to one hour on foot to reach the roça. Families in this area focus heavily on the production of manioc flour (farinha de mandioca) for the market. Many farmers cultivate several large fields totaling several hectares annually. They often rely on credit to purchase equipment like motors and chainsaws and hire labor for weeding and forest clearance.

Boa Esperança is a relatively isolated community on the shores of Lake Amanã. Although this village is at a much greater distance from markets than Nossa Senhora da Fatima, their access to the market is similar. There seemed to be a difference however, in the relative importance of manioc and fruit between the two communities. Residents of Boa Esperança had a greater reliance on fruits (avocado, banana, and lemon) until disease and flooding drastically cut the production of these crops. It is noteworthy that this community, although considered terra firme, suffered substantial losses due to flooding during the 2000 season. The lakeshore does not have high bluffs and low-lying areas are subject to flooding as the lake is connected to the Japurá River by paranás or natural canals.

Jubará is on the left bank of the Japurá River. There are no high bluffs in this area and residents reported that a number of upland fields were flooded with some loss of crops in 1999. Several homes in low-lying areas are built on stilts to avoid flooding and have no home garden plants. Farmers can cultivate both the várzea and terra firme giving them greater options for choosing field locations.

Finally, the community of Sitio Fortaleza lies on the floodplain a good distance from the river bluffs (one hour by motorboat or three hours rowing). Several households from this village regularly make fields on the bluffs in the territory of another community where they have relatives. Some of them are planning to permanently move to the terra firme in order to avoid the disruption to their lives caused by the flood.

Like the farmers of the várzea, cultivators of terra firme lands use a variety of descriptive terms to refer to land-use zones in different stages of the cropping cycle and with different crop compositions. The land-use designations used by farmers of the terra firme are summarized in table 6-1. Farmers' conception of land-use on terra firme is essentially the same as on the high levees of the várzea. Roça is a synonym for manioc field and it usually contains several additional minor crops. If a roça is interplanted with a significant amount of banana is may be referred to as "manioc with banana" (roça com banana), otherwise, there are no special designations for different types of roças.

Non-roça work areas or fallows are divided into several types depending on the relative amount of investment in the site or the dominant planted species. A capoeira bananal or capoeira fruteira is a fallow that has been enriched with banana or other fruit trees to a greater density than a simple capoeira. Going one degree further, the designation of abacatal, açaízal, bananal, or frutal imply an even denser planting of

Table 6-1. Summary of local land-use designations by terra firme farmers

Land-use designation	English translation	Num. visited	Description
Abacatal	Avocado Grove	3	Area enriched primarily with avocado
Açaízal	Açaí Grove	1	Area enriched primarily with açaí
Bananal	Banana Grove	3	Area enriched primarily with banana
Capoeira	Fallow	70	Fallow area
Capoeira Bananal	Banana Fallow	1	Fallow enriched primarily with banana
Capoeira Fruteira	Fruit Fallow	11	Fallow enriched with a variety of fruit trees
Frutal	Fruit Orchard	1	Area enriched with a variety of fruit trees
Roça	Manioc Field	87	Field planted to manioc and other crops.
Sitio	Site	4	Area of intensive, long-term management and/or a high diversity of useful plants

avocado, açaí, banana, or fruit trees, respectively. The sitio on terra firme is usually a mature fruit orchard surrounding the casa de farinha or manioc processing house when it is located away from the home site.

Field and Fallow Management on Terra Firme

Some of the most obvious differences one notices between roças on the várzea and terra firme are their size, shape, and configuration. A typical roça on the várzea is ten meters wide and 50 to 100 meters long while a typical roça on terra firme is much larger, measuring 100 by 100 meters or one hectare. The average size of terra firme roças is 6738 square meters (0.67 ha.) compared to only 2573 square meters (0.26 ha.) for roças on high levees. Whereas várzea roças are long, narrow, and sometimes irregularly shaped following the contour of the levees, terra firme roças are typically rectangular with straight edges and distances measured in arm spans (braços).

The average size of capoeiras is more than double that of roças because of the lumping together of fields into a single fallow, discussed in chapter four. The mean size of fallows is 1.4 hectares while the median is one hectare. There are some very large fallows of seven or eight hectares that presumably contain parts of different ages. The most that any one family would have in production at a time would be about four hectares.

Most várzea roças are confined to levees that are accessible by fluvial transport, usually along the major rivers or well-traveled side channels. Terra Firme roças may also be located on lakeshores or streams where they are accessible by boat. However, they are more commonly reached on foot along an array of trails carved from the forest. Trails are formed in roças while they are in production and are extended outward as new fields are cleared further from the village.

Like the várzea, most of the terra firme roças surveyed had been cleared from secondary forest as opposed to so-called mata virgem or virgin rainforest. Out of 68 roças, 44 (65%) were cleared from fallow and 24 (35%) were forged from old-growth forest. The age of fallows cleared for roças, reported in 39 cases, ranged from one to 15 years (Figure 6-1). Fields were left in fallow a mean of 5.1 years with a median of four. The length of the fallow period from the previous cropping cycle, also recorded for eight fallows, is consistent with this. The average was 5.8 years with a range from four to ten years. We can compare this to available data for high levees on the floodplain. The ages of 15 high levee fallows at the time of clearance ranged from four to 20 years with a mean of 7.9. Although it is a small sample, this indicates a possibility that fields are left fallow for longer periods on the várzea, a question that warrants further research.

The actual age was recorded for 63 fallows. They ranged from one to 20 years old with a mean average of almost four years and a median of three. From the histogram in figure 6-2, we see that the majority of fallows surveyed were one or two years old. There are two possible explanations for the propensity of young fallows on the uplands. One is that older fallows are larger, consisting of smaller fallows lumped together. There is a slight positive correlation (r=0.27) between the size of fallows and their age. The other possibility is that manioc agriculture is expanding in the communities surveyed. This second hypothesis is supported by preliminary satellite image processing work on manioc agriculture in the area of Nossa Senhora da Fatima and by interviews with farmers. It is likely a combination of both.

Once forest is cleared, farmers usually plant one or two crops of manioc before the next fallow period. The average number of consecutive crops planted in roças is 1.6 (Figure 6-3). However, these roças are still in production. To determine the actual average number of consecutive crops planted we must look at the data for capoeiras and the number of previous crops planted (Figure 6-4). This data was reported for 25 fields and yielded a mean of 2.24 with a range of one to six crops and a median of two. This is less than the results for várzea high levees. The number of previous crops planted on high levees ranged from one to 15 with a mean of 3.4 and median of two. Várzea farmers are able to plant more crops, on average, than terra firme farmers. This is presumably due to differences in soil fertility and/or weed invasion.

Farmers were asked about the number of cropping cycles on a particular piece of land. This refers to the number of times that the land has gone through a complete cycle from field to fallow and back to field again. The information was gathered for 33 terra firme fields (Table 6-2). The maximum number of cropping cycles recorded in the survey was five and the average was about two. Figure 6-5 shows the number of previous fallows for 66 terra firme roças. Adding one to the number of previous fallows would indicate the current cropping cycle. Figure 6-6 shows the number of cropping cycles for 35 capoeiras. Most of the current roças are in their second cropping cycle while most capoeiras are in their first cropping cycle.

A common scenario is the clearance of old-growth forest for one or two consecutive manioc crops followed by a short fallow period of one to five years and another crop of manioc. Farmers decide if another crop will be planted based on growth and yield of the previous crop and the degree of weed invasion as well as field history, soil quality, and the presence of pests or disease. The field would then be allowed to rest in fallow for a longer period, on the order of eight to ten years or more. Farmers usually judge when a fallow is ready to enter a new cropping cycle by the height and thickness of the regenerating forest. Secondary forests accumulate living biomass at different rates depending on the soil quality.

The number of consecutive crops and length of the fallow period also depends on available labor. In one instance, when asked why a particular field had been planted five times in a row, the woman replied that she was a widow and did not have the means to clear a new field from forest. The yield was greatly reduced because the land was not given time to recuperate.

Crops typically take longer to grow on terra firme because of generally lower soil fertility. Bananas often take 12 months to produce as opposed to just eight months on the floodplain. An advantage of farming manioc on the terra firme is that it can be left in the ground until the farmer is ready to harvest rather than being forced to harvest before the flood. The longer it is left in the ground, the larger the tubers will be. Crops are normally left in the ground for one to two years. Fields can be partially harvested according to need and availability of time for processing. The average age of the upland manioc crop was almost eight months. The oldest crop that was recorded had been growing for 22 months.

Losses of both manioc and other perennials in terra firme fields and fallows were sometimes reported. Farmers in both Boa Esperança and Jubará lost crops in low-lying areas in 1999. Some were forced to harvest their crop early and at least one field was totally lost. For example, a 0.24-hectare roça with 5,800 stems planted (covas) harvested early at seven months yielded seven sacks of tubers. Had the crop been left to grow for 12 months, an estimated 40 sacks would have been harvested. Several farmers in Nossa Senhora da Fatima reported significantly lower yields due to tuber rot (podre de batata). Crops also suffer occasional damage from peccaries and other wild animals such as deer and agouti.

Table 6-2. Summary of statistics for roças on terra firme

	N	Mean	Min.	Max.	S	Median
Size (square meters)	79	6738	300	60000	9753	3500
Num. of species	87	4.17	1	15	2.85	4
Manioc varieties	84	2.76	1	12	1.86	2
Banana varieties	46	1.59	1	5	0.93	1
Crop age (months)	65	7.57	1	22	3.43	8
Consecutive crops	51	1.61	1	5	0.78	1
Num. cropping cycles	33	2.21	1	5	0.96	2
Last fallow (years)	39	5.12	1	15	3.05	4

Table 6-3. Summary of statistics for capoeiras on terra firme

	N	Mean	Min.	Max.	S	Median
Size (square meters)	56	14,105	300	80,000	16,908	10,000
Num. of species*	43	3.93	1	10	2.35	3
Num. of banana varieties	17	1.76	1	5	1.25	1
Age of fallow (years)	63	3.8	1	20	3.3	3
Consecutive crops planted previously	25	2.24	1	6	1.23	2
Num. cropping cycles	35	1.77	1	5	1.14	1
Last fallow (years)	8	5.8	4	10	2.14	5

*Only capoeiras with useful species are included.

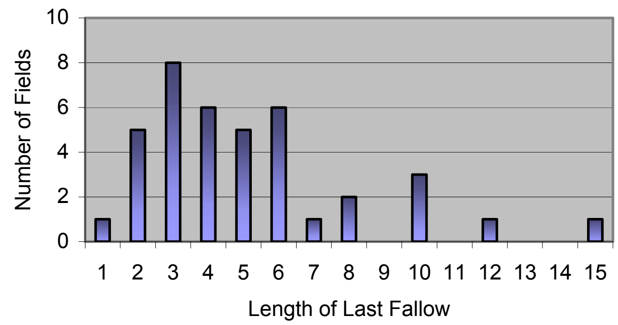

Figure 6-1. Length of the previous fallow for 39 fields (roças) on terra firme

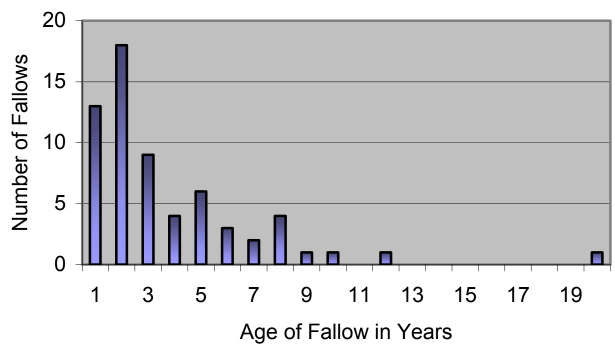

Figure 6-2. Age of 63 fallows (capoeiras)

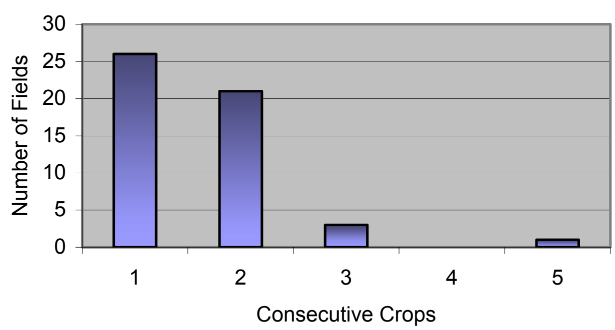

Figure 6-3. Number of consecutive crops planted in 51 fields (roças) on terra firme

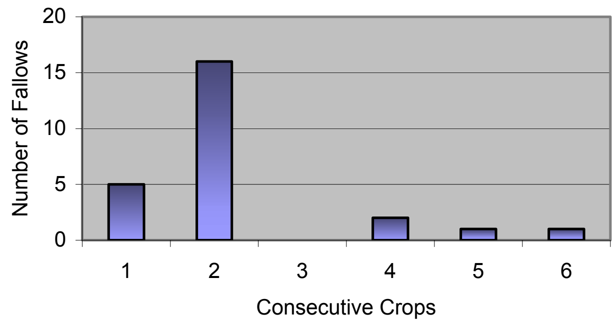

Figure 6-4. Number of consecutive crops previously planted in 25 fallows (capoeiras) on terra firme

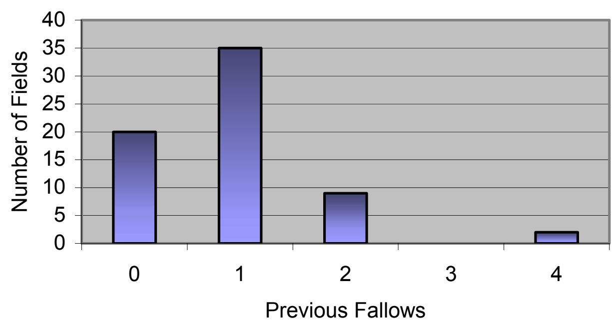

Figure 6-5. Number of previous fallows for 66 fields (roças). Adding one to the number of previous fallows indicates the number of planting cycles.

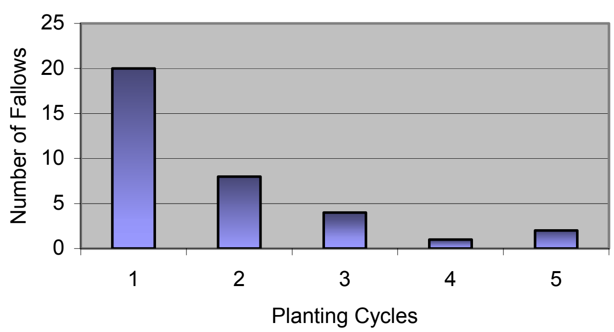

Figure 6-6. Number of cropping cycles for 35 fallows (capoeiras) on terra firme

Figure 6-7. Eight-month-old terra firme field (roça) cleared from old-growth forest. Manioc is planted among fallen tree trunks. Community of Boa Esperança, Lake Amanã.

Figure 6-8. Roça developing into fruit fallow (capoeira fruteira). Boa Esperança, Lake Amanã.

Agrobiodiversity in Terra Firme Roças

The dominant crops on the terra firme differ from those found on the várzea but the pattern of diversity across land-use types is similar. Roças in both environments hold an average of four species. The histogram in figure 6-9 showing the number of species occurring in terra firme roças is comparable to the one for planted roças on várzea high levees (Figure 3-2). The great majority of fields have two or more species with two being the most common. Just 14 out of 87 roças (16%) contained only a single species (manioc). The number of species in each upland field ranged up to 15 compared with 14 in restinga alta fields.

Terra firme fields include many species common to the várzea and several more that are relatively rare on the flood affected lowlands. A total of 51 useful species were documented in terra firme roças (Table 6-4). Crops that are grown principally in the uplands include pineapple, new world yam (*Dioscoria trifida*), Brazil nut, cupuaçu, and peach palm. Banana and the new world yam (cará, a tuber similar to a potato) are the most frequently occurring secondary crops inter-planted in the manioc field. These two crops are encountered in half of all roças. They are followed by açaí and pineapple, found in 24% and 21% of roças, respectively. Two valuable crops, Brazil nut and cupuaçu are both found in 15% of roças. Two palms, peach palm and tucumã (*Astrocaryum vulgare*) are represented in 10% of roças. Peach palm is usually planted while tucumã is often dispersed by animals. Various other fruits and, to a lesser extent, timber trees are also planted or protected in fields. Nineteen of the 50 useful species recorded in table 6-4 were encountered only once.

A total of 31 varieties of bitter manioc (mandioca) and 5 varieties of sweet manioc (macaxeira) were found in 84 terra firme roças. Table 6-5 and 6-6 list the name, rank, and the number of fields where each variety occurred. The number of varieties in each field, shown graphically in the histogram in figure 6-10, ranged from one to 12. Most fields were planted with three, two, or one variety, respectively. The average was nearly three.

The most common variety of manioc was Leonsa, found in 52% of roças, and second was Sete anos, found in 33% of roças. The repertoire includes five varieties of sweet manioc. The sweet varieties have a high risk of being destroyed by peccaries and agoutis so farmers avoid planting a large amount. It must be noted that the two most common varieties were found only in Boa Esperança, the largest community visited (63% of the terra firme roças surveyed were in this community). They were absent from the other three communities. It must be remembered that the same variety could be known by a different name in another community. It is imperative to initiate comprehensive research to document the diversity of manioc in the region in order to protect this valuable resource.

Eleven banana varieties were recorded in 46 terra firme roças. Table 6-7 lists the varieties and their frequency of occurrence. Like fields and home gardens on the várzea, the crop is represented by a few dominant varieties with others occurring at a low proportion. As with terra firme home gardens, plantains are the most common. Two varieties of plantain, Comprida and Pacovão, are the most frequently planted. They are found in 52% and 37% of fields, respectively. The number of varieties in each field ranged from one to five with an average of 1.6 (Figure 6-11).

Table 6-4. The 51 useful species encountered in 87 terra firme roças

Local name	English name	Num. roças	%	Local name	English name	Num. roças	%
Mandioca	Manioc	87	100	Cupuí	Cupuí	2	2
Banana	Banana	48	55	Gangelim	Gangelim	2	2
Cará	New world yam	44	51	Mamão	Papaya	2	2
Açaí (2 species)	Açaí	21	24	Manga	Mango	2	2
Abacaxi	Pineapple	18	21	Muiratinga	Muiratinga	2	2
Abacate	Avacado	14	16	Sova	Sova	2	2
Castanha do Pará	Brazil nut	13	15	Alfavaca	Alfavaca	1	1
Cupuaçu	Cupuaçu	13	15	Andiroba	Andiroba	1	1
Pupunha	Peach palm	9	10	Angelim	Angelim	1	1
Tucumã	Tucumã	9	10	Araruta	Araruta	1	1
Cajú	Cashew	8	9	Bacabão	Bacabão	1	1
Bacaba	Bacaba	6	7	Capitiu	Capitiu	1	1
Goiaba	Guava	5	6	Carapanaúba	Carapanaúba	1	1
Jambo	Malay apple	4	5	Envira	Envira	1	1
Limão comum	Lime	4	5	Gingibre	Ginger	1	1
Piquiá	Piquiá	4	5	Maná	Maná	1	1
Cana de açucar	Sugarcane	3	3	Marimari	Marimari	1	1
Cedro	Cedar	3	3	Maúba	Maúba	1	1
Ingá	Inga	3	3	Pimenta	Capsicum pepper	1	1
Jerimum	Squash	3	3	Pimentão	Green pepper	1	1
Laranja	Orange	3	3	Seringa	Rubber	1	1
Milho	Corn	3	3	Sucupeira	Sucupeira	1	1
Puná	Puná	3	3	Toari	Toari	1	1
Tanimbuco	Tanimbuco	3	3	Tucupi de arara	Tucupi de arara	1	1
Cacau	Cocoa	2	2	Uxi liso	Uxi liso	1	1

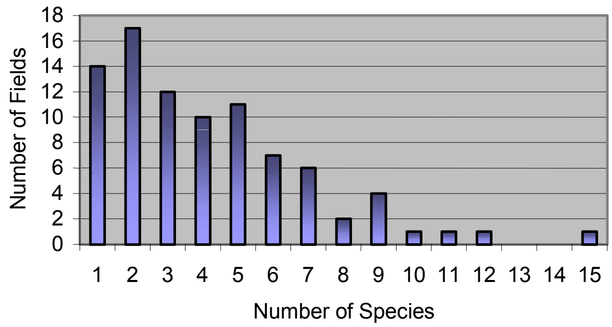

Figure 6-9. Number of useful species in 87 fields (roças) on terra firme

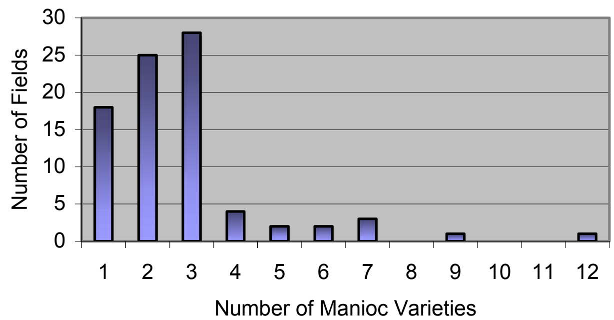

Figure 6-10. Number of manioc varieties in 84 fields (roças) on terra firme

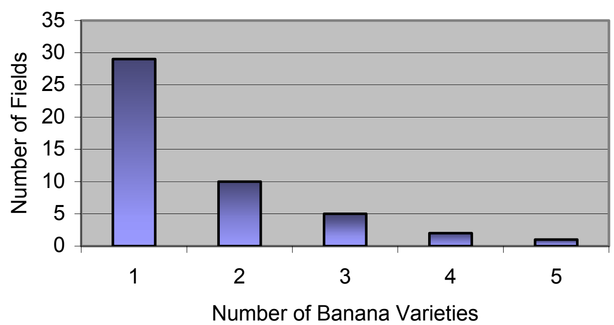

Figure 6-11. Number of banana varieties in 46 fields (roças) on terra firme

Table 6-5. The 31 varieties of bitter manioc (mandioca) found in 84 terra firme roças

Rank	Variety	Num. roças	%
1	Leonsa	44	52
2	Sete anos	28	33
3	Baiana	23	27
3	Tartaruga	23	27
4	João Gonzalo	14	17
5	Ará	12	14
6	Azulão	9	11
7	Parauá	8	10
8	Antinha	7	8
8	Lira	7	8
9	Amarelinha	5	6
9	vila nova	5	6
10	Pe de lopes	4	5
11	Pretinha	3	4
12	Bodó	2	2
12	Castanha	2	2
12	Farauá	2	2
12	Pelonia	2	2
12	Seis meses amarela	2	2
12	Seis meses branca	2	2
12	Tucumã	2	2
13	Aauria	1	1
13	Ajurí	1	1
13	Amarela	1	1
13	Castinha	1	1
13	Coraçi	1	1
13	Geralda	1	1
13	Gonzalão	1	1
13	Maguari	1	1
13	Moura	1	1
13	Sacaí	1	1

Table 6-6. The 5 varieties of sweet manioc (macaxeira) found in 84 terra firme roças

Rank*	Variety	Num. roças	%
7	Caboquinha	8	10
11	Preta	4	3
12	Amarela	2	2
13	Africana	1	1
13	Roxa	1	1

* rank is based on all varieties of bitter and sweet manioc

Table 6-7. The 11 banana varieties found in 46 terra firme roças

Rank	Variety	Num. roças	%
1	Comprida*	24	52
2	Pacovão*	17	37
3	Prata	8	17
4	Tres palmas*	7	15
5	Maçá	6	13
6	Baia	2	4
6	Guariba	2	4
6	Guariba branca	2	4
6	Nadjá	2	4
6	São Tomé	2	4
7	Guariba vermelha	1	2

* variety of plantain

Agrobiodiversity in Terra Firme Capoeiras

Ninety-six non-roça areas were surveyed on terra firme. Out of these, 70 were called simple capoeiras by their owners. The remaining areas were referred to by other descriptive terms depending on crop diversity and management. Refer back to table 6-1 for a summary of the land-use types and their explanations. This section will cover the results of the survey for simple capoeiras. The next section will describe the other land-use types referred to by terra firme farmers.

The histogram in figure 6-12 shows that, out of 70 capoeiras, 43 (61%) held useful species. Most of them contained between one and six. If we look at the 21 most commonly occurring species in table 6-9, those found in five or more fallows, we see that 18 are in the fruit, beverage, and nut categories. The three most common fruits are açaí, avocado, and banana. There is a strong market for açaí in urban centers. Although two species are grown on terra firme, açaí preto and açaí do Pará, the latter is preferred for planting and marketing. Avocado is easily collected and transported and is sold at a high price in towns.

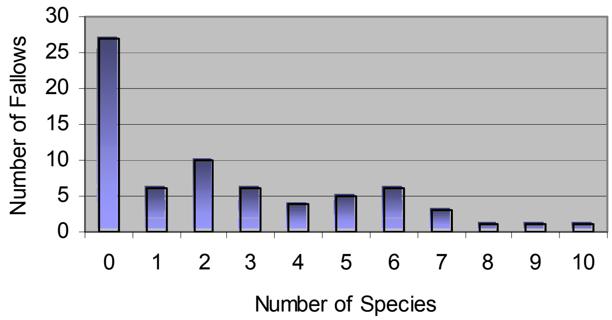

Figure 6-12. Number of useful species in 43 fallows (capoeiras) on terra firme

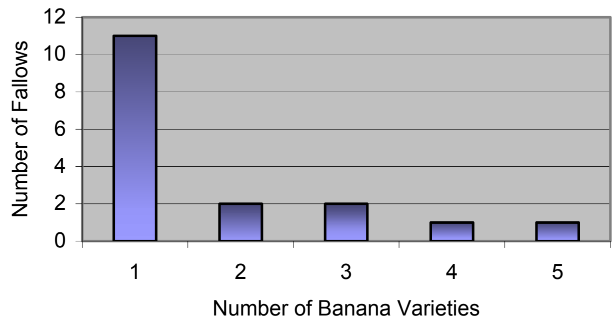

Figure 6-13. Number of banana varieties in 17 fallows (capoeiras) on terra firme

Banana was found in nearly half of the capoeiras. Most contain only one variety (Figure 6-13). Fourteen varieties of banana were documented (Table 6-8). Several of the fallows are managed for Brazil nut (castanha do Pará), a valuable nut that fetches a good price at market. One farmer reportedly sells about 60 boxes of nuts per year for $RS 12 per box. Many of the other fruits on the list are also marketable and often contribute to a family's income.

Other useful species common in terra firme fallows include such products as New World yam (cará), a tuber commonly planted in roças that looks like a purple potato. It continues to grow in fallows long after the roça phase has ended. According to one informant, "Cará never dies." It can even be found growing in a 15-year-old fallow. Manioc also spouts again after harvest and is commonly found in terra firme fallows for some time after cultivation is discontinued. Unlike the várzea, there is no flood to kill the plant and farmers sometimes take advantage of spontaneously sprouting manioc. Cacau jacaré (*Theobroma mariae*) (caiman cocoa), a species of wild cacau, ingá, a sweet leguminous fruit, and tucumã, an oily palm fruit, are common volunteer trees in capoeiras. Seringa, the rubber tree, can be used to extract latex and is also a good fish bait.

Like the várzea, some terra firme fallows are reportedly managed for timber. Although we must go to number 25 on the list before we reach the first timber species (samauma), there are at least 20 species that are exploited for construction materials. The last, ubim (*Geonoma* sp.), is a palm whose fronds are utilized for roofing material. There is a wide variety of timber species with a low frequency of occurrence.

Table 6-8. The 16 banana varieties documented in non-roça areas on terra firme and the frequency in each land-use type

Local name	All non-roça n=67	Capoeira n=43	Capoeira fruteira n=11	Bananal n=3	Frutal n=1	Sitio n=4
All varieties	30	18	3	3	1	3
Prata	12	5	2	3	1	1
Maçá	10	5	2	2		
Pacovão*	9	4		3		2
Comprida*	8	5			1	
Tres palmas*	6	1		2		2
São Tomé	4	3			1	
Baia	3	1	1		1	
Costela de vaca*	2	1				
Guariba	2	2				
Rabo de bandeira	2			2		1
Baia grande	1			1		
Duas palmas	1	1				
Guariba vermelha	1	1				
Nadja	1	1				

* variety of plantain

Table 6-9. The 68 useful species encountered in fallows on terra firme and the frequency they were recorded in each land-use type

Local name	English name	All non-roça n=67	Capoeira n=43	Capoeira fruteira n=11	Bananal n=3	Frutal n=1	Sitio n=4
Açaí (2 species)	Açaí	34	19	5	3	1	4
Abacate	Avocado	30	13	9	3	1	1
Banana	Banana	30	18	3	3	1	3
Pupunha	Peach palm	25	9	8	2	1	4
Castanha do Pará	Brazil nut	23	13	3	2	1	3
Cupuaçu	Cupuaçu	21	5	9		1	4
Limão comum	Lime	18	8	5		1	3
Ingá	Inga	14	6	3		1	3
Abacaxi	Pineapple	13	8	3		1	
Cará	New world yam	13	8	3	1		1
Bacaba	Bacaba	12	4	4	1		3
Tucumã	Tucumã	12	9	1			1
Manga	Mango	11	1	4	1	1	3
Cacau	Cocoa	10		3	2	1	4
Cajú	Cashew	9	5	1			3
Goiaba	Guava	8	2	1	2	1	1
Seringa	Rubber	8	2	3		1	2
Mandioca	Manioc	7	3		1	1	1
Cacau jacaré	Cacau jacaré	5		2		1	2
Jambo	Malay apple	5		3			2
Lima	Lima	5		1		1	2
Cana de açucar	Sugarcane	4	2		1		
Laranja	Orange	4		1	1		2
Piquiá	Piquiá	4	2	1			1
Samaúma	Kapok tree	4	1			1	2
Abiu	Abiu	3	1	2			
Beribá	Beribá	3		1	1		1
Cupui	Cupui	3	1	2			
Graviola	Soursop	3	1	1	1		
Marimari	Marimari	3	2				1
Puruí	Puruí	3		1			2
Azeitona	Olive	2		1		1	
Cajú açú	Cajú açú	2	1				1
Cedro	Cedar	2				1	1
Mamão	Papaya	2	1				1
Murucututu	Murucututu	2	2				

Table 6-9. Continued

Local name	English name	All non-roça n=67	Capoeira n=43	Capoeira fruteira n=11	Bananal n=3	Frutal n=1	Sitio n=4
Pará pará	Pará pará	2	2				
Pimenta	Capsicum pepper	2			1	1	
Sucuúba	Sucuúba	2	2				
Tangerina	Tangerina	2		1			1
Taperebá	Yellow mombim	2					2
Angelim	Angelim	1	1				
Anoirá	Anoirá	1	1				
Apui	Apui	1		1			
Araçá	Araçá	1		1			
Araçá goiaba	Araçá goiaba	1					1
Aracá pel	Aracá pel	1				1	
Assacú	Assacú	1					1
Bacabão	Bacabão	1	1				
Capú	Capú	1	1				
Carambola	Carambola	1				1	
Cedrorana	Cedrorana	1	1				
Lacre	Lacre	1	1				
Lauro abacate	Lauro abacate	1	1				
Lauro amarelo	Lauro amarelo	1	1				
Leitaúba	Leitaúba	1	1				
Limão cida	Limão cida	1					1
Manga maçá	Manga maçá	1					1
Maracujá	Passion fruit	1					1
Maxixi	Maxixi	1	1				
Muirataua	Muirataua	1	1				
Pachiuba	Pachiuba	1	1				
Perereca	Perereca	1	1				
Tacana	Tacana	1	1				
Tanimbuco	Tanimbuco	1	1				
Taxi	Taxi	1	1				
Tinta arana	Tinta arena	1	1				
Ubim	Ubim	1	1				

Other Non-Roças

Farmers on the terra firme, like those on those on the várzea, use descriptive terms to distinguish special work areas from simple capoeiras. These are areas where they have invested a relatively greater amount of time and energy in planting fruits and other crops (Table 6-8) and usually receive some degree of continuing management such as weeding and additional enrichment planting. They make up one-quarter of all non-roça work areas. Because of the considerable investment necessary for the production of tree crops and the high concentration of useful plants, they are often taken out of the roça cycle for an indefinite period. Old trees may be cut down and replaced but the area is rarely destroyed completely in order to plant a roça.

Farmers sometimes plant orchards consisting of one principal crop. When a single species dominates, the land-use area is named for that crop. For example, an area especially rich in avocado, acai, or banana is referred to as an abacatal, acaizal, or bananal. Three avocado groves and one açaí grove were documented in the community of Boa Esperança. The avocado groves are not densely planted orchards but avocado trees interspersed in a capoeira matrix. They are small areas containing up to four other perennial fruit crops. The açaí grove is an area 50 x 30 meters recently planted (2 years) with 1000 açaí, 50 cupuaçu seedlings, and several plantains.

The bananal is rare on terra firme. Farmers tend to combine cultivation of banana with the roça rather than clearing an area solely for that purpose, a common practice on the várzea. Only three were encountered in the terra firme survey, all in Boa Esperança. Unlike banana groves on the várzea that are primarily monocultures, these were interplanted with a number of other crops. Two of them held more than ten species each while the third contained four. The more diverse banana groves were formed during an earlier roça phase. One of these was planted with banana and lemon. The lemon was wiped out by disease. The third was created in five-year-old capoeira using an interesting system. The undergrowth is cleared first and suckers are planted. After planting, the larger trees are chopped down and the area is later burned.

It is much more common for farmers to plant a diverse mix of crops than a single species. Besides the roça and capoeira, the most frequent land-use designation used by farmers on the terra firme is fruit fallow (capoeira fruteiras). Eleven were visited; ten in Boa Esperança and one in Nossa Senhora da Fatima. The number of species ranged from three to 17 with an average of eight. Most of the capoeira fruteiras were developed from roças, either interplanted with manioc or enriched with fruits after a short fallow period. A number of lemon, avocado, and banana plants were lost in these areas from flooding and disease. One particularly diverse area, designated as a fruit orchard (frutal), contained 22 species including, according to the owner, 800 açaí seedlings. It was cleared from forest eight years previously and, during that time, partially planted to manioc twice.

There were four areas visited on terra firme that the owner was proud to call, “my sitio.” Three of them are in Boa Esperança and one is in Nossa Senhora da Fatima. They are located near the home and, in the case of Nossa Senhora, at the boat landing on the way to the fields. The latter consists of a diverse array of fruit trees growing around the manioc processing house. The ages range from six to 14 years and all of them were planted with one or two crops of manioc at the start. These mature fruit orchards are consistently diverse, with the number of species ranging from 13 to 21. A few valuable timber species are also included in the mix.

CHAPTER 7
LESSONS FOR CONSERVATION OF AGROBIODIVERSITY IN THE MIDDLE SOLIMÕES

In the coming decades, humans will continue to develop and intensify agriculture in order to feed our rapidly growing population. Farmers and scientists will strive to improve agricultural systems, making them more sustainable and better adapted to shifting markets and environments. Agrobiodiversity is crucial in this endeavor.

Researchers and policy makers have singled out the Amazon várzea as an area of great potential for increased arable farming and the development of agroforestry systems. To do this, we must take stock of the agrobiodiversity in existing farming systems and how it relates to management and habitat. Ultimately, we will want to protect this diversity. One way to do this is to initiate policies that encourage the conservation of biological diversity in the agricultural landscape and avoid policies that affect the loss of this valuable resource.

If we wish to protect and conserve agrobiodiversity in the middle Solimões region, we must first understand its distribution across the agroecosystem. The objective of this research is to answer the question, "Which systems of management and which environments are repositories of agrobiodiversity?" This knowledge will help those concerned develop policies that lead to conservation of the diverse useful plant repertoire and the continuation of management practices that maintain high levels of plant diversity.

Distribution of Agrobiodiversity

What have we learned about the distribution of agrobiodiversity in the Middle Solimões region? It comes as no surprise that there is a great diversity of useful plants in the tropical agroecosystem of the Middle Solimões. Studies in other regions of the tropics, including Amazonia, have yielded similar results. This survey documented a total of 263 species used by local residents excluding ornamentals.

The wide range of habitats that are utilized by farmers in the Middle Solimões is impressive. Farmers conceive of five principal habitats used for agriculture; beaches (praias), mudflats (lamas), low levees (restingas baixas), high levees (restingas altas), and uplands (terra firme). It must be emphasized that these categories are not rigidly divided, but instead form a continuum. Furthermore, there exist widely varying environmental characteristics between areas in the same category in terms of soils, vegetation, sediment deposition, impact from flooding, pests and diseases, and accessibility.

The habitat determines the diversity of useful species to a great extent. This can be couched in terms of impact from flooding. The highest areas on the floodplain, the high levees, are flooded for a relatively short duration and many do not flood at all in normal years. This allows farmers to build up holdings of perennials, even those that are exotic to the várzea and intolerant to flooding. For this reason work areas on floodplain high levees contain levels of diversity comparable to those on uplands.

There is a myriad of management strategies within habitat types. The research revealed 24 designations of land use by local residents when divided along lines of habitat, current status (field or fallow), and management. The most diverse floodplain habitat in terms of land use types is the high levee with nine types recorded. Several additional classifications of managed capoeiras were described by Pinedo-Vasquez et al.

(1996) that were not dealt with in this survey. The most species diverse land use types are also on high levees resulting in the bulk of agrobiodiversity on the varzea being found here. Ten land use categories were distinguished on terra firme. Again it must be stressed that, like habitat types, land use categories are anything but rigid and unchanging. Roças and capoeiries are extremely varied in management and dynamic in form.

Table 7-1 helps to conceptualize the agroecosystem as a whole in terms of agrobiodiversity as it relates to habitat and land use. The number of work areas visited gives us a good idea of the proportions that each land use type is found. Combining this with the total number and average number of species gives a useful quick measure of the value of each land use type as a storehouse for agrobiodiversity. The number and percent with useful species indicate the proportion of each land use type that houses useful plants. By definition most of the land use types must contain useful species but this statistic is particularly useful for examining the number of fields and simple capoeiras that house economically valuable plants during the fallow period.

Home gardens are the heavyweight champions of agrobiodiversity on both the várzea and terra firme. Almost the complete repertoire of useful plants in the agroecosystem of the Middle Solimões is represented to some extent in home gardens, an important fact to remember when considering the conservation of agrobiodiversity in the region. Out of 204 total species with 19 possible uses documented on the várzea, 176 (86%) of them were observed growing in home gardens. Of these, 87 species were found exclusively in home gardens. Likewise on terra firme, 135 out of 176 total species (77%) were present in home gardens with 92 species found only there. It is abundantly clear

Table 7-1. Summary of species diversity by land use type on the várzea and terra firme of the Middle Solimões Region

	Land use type	Num. visited	Total num. species	Avg.* num. species	Num. with useful species	% with useful species
Várzea	Roça low levee harvested	93	23	2.4	16	17
	Roça high levee planted	82	64	4.1	82	100
	Roça high levee harvested	53	37	2.8	31	58
	Roçado high levee**	7	22	6.6	5	71
	Capoeira low levee	50	25	2.8	17	34
	Bananal	17	22	2.4	17	100
	Capoeira high levee	141	68	3.5	88	62
	Banana fallow	21	30	3.6	21	100
	Cocoa fallow	1	1	1.0	1	100
	Fruit fallow	12	41	10.2	12	100
	Fruit orchard	2	25	16.0	2	100
	Sitio	5	61	20.8	5	100
	Home garden	171	176	12.0	163	95
	All várzea	655	204		460	70
Terra Firme	Home garden	34	135	21.4	30	88
	Roça	87	51	4.2	87	100
	Fallow	70	47	3.9	43	61
	Avocado grove	3	10	4.0	3	100
	Açai grove	1	3	3.0	1	100
	Bananal	3	16	8.7	3	100
	Banana fallow	1	5	5.0	1	100
	Fruit fallow	11	29	7.9	11	100
	Fruit orchard	1	18	18.0	1	100
	Sitio	4	34	17.5	4	100
	All terra firme	215	176		184	86
	All work areas	872	263		644	74

* Averages are calculated only for work areas containing useful species.
** Roçado is a cleared field before planting. The useful species in a roçado consist of those that are spared at the time of forest clearance. Unfortunately the sample size is small because the season of clearing fields was just beginning at the time of the research.
Note: The habitats praia (beach) and lama (mudflat) are not included in the table since they rarely contain useful species after harvest.

that home gardens represent a critical repository of agrobiodiversity in the Middle Solimões Region and a crucial resource for in situ conservation.

Several other land use types boast levels of diversity comparable to home gardens. These areas include the fruit fallow (capoeira fruteiras), fruit orchard (frutal), and sitio. They are rarely developed by farmers. Only a few with sufficient knowledge and experience are willing to invest the time and energy necessary to create a diverse fruit orchard or sitio. Unlike home gardens they are located off the home site and often cover extensive areas.

Fields contain multiple useful species more frequently than a single species. It was found that 82% of planted roças on high levees hold two or more species with an average of 4.1. They consist of a mix of planted and protected species. Farmers tend to plant polycultures even in low-lying beaches and mudflats where the land is flooded for many months each year, although these areas rarely contain useful species after harvest. On high levees, however, it is a common practice to interplant the manioc roça with banana and other perennial fruit trees that are left after manioc cultivation is discontinued.

Even after harvest, high levee roças contained an average of 2.8 useful species. Fallows are also sometimes further enriched with fruits. In this way secondary forests are itinerantly enriched from cyclical planting and fallow periods when economically valuable species are spared, protected and planted in fields and fallows. This process could have the net effect of increasing overall biodiversity across the landscape.

Results indicated a rich selection of manioc and banana varieties in the Middle Solimões. Approximately 65 varieties of manioc and 20 varieties of banana were reported. However, a few varieties of manioc and banana typically dominate while others are represented in only a small proportion of fields and gardens. The average number of varieties planted across all work areas is approximately 2.3 for manioc and 1.5 for banana.

With the exception of the former cocoa grove (cacaual), the bananal is the land use type with the lowest average number of useful species. It is also not particularly diverse in varieties. Are we seeing, in these two land use types, the effects of streamlining production for the market? The bananal is typically a mono-cultural, mono-varietal planting that produces a product with a high demand in the marketplace. However, the management technique of selectively clearing forest (primarily undergrowth) and planting across an extensive area in partial shade could hold promise as a low impact form of agriculture on the floodplain.

For effective conservation of agrobiodiversity in the Middle Solimões Region it is necessary to consider not only the várzea but also the surrounding terra firme. Out of the 263 total species recorded in the survey 86 are exclusive to the várzea and 59 are exclusive to the terra firme. Some plants that were given the same common name in the survey could also actually be separate species, adding to the list. It is common in the tropics for the same name to be given to a number of closely related species.

Theoretical Implications

The results of this research raise questions concerning some current theories about the nature of prehistoric agriculture and settlement on the Amazon river. According to Roosevelt (1980), fast growing annuals such as corn and beans were the principal crops grown on the várzea in prehistoric times. She theorized that maize cultivation on fertile várzea soil was the mechanism that propelled the development of dense populations and complex chiefdoms. Manioc is seldom mentioned as having been an important crop on the várzea. In fact, Roosevelt claims it is ill-suited for floodplain agriculture and makes inefficient use of the fertile soils.

Several lines of indirect evidence call into question Roosevelt's ideas on the importance of manioc for prehistoric várzea farmers. Through interviews with informants we learned of várzea varieties that are clearly distinct from those of the terra firme. They are faster growing varieties adapted to the shorter growing season on the floodplain. The great number of varieties that are grown lends support to the idea of a deep history of manioc agriculture on the várzea. Furthermore, when terra firme varieties are brought to they várzea they frequently develop diseases, namely podre de batata or tuber rot. Research is needed to understand the diversity of manioc on the várzea.

A second point for consideration is that current practices seem to refute claims of manioc as an inappropriate crop for the várzea. Local farmers have shown that manioc agriculture is viable on the várzea by growing the crop in a range of habitats including mudflats, low levees, and high levees. When one sees the prevalence of manioc production on the middle Solimões várzea today and the relatively unimportant role of maize, one wonders at the possibility of maize having once been the dominant crop.

Further arguments against manioc as an important crop on the várzea can also be refuted. The idea that manioc is a poor source of protein and corn, with its greater nutrient content, uses floodplain soils more efficiently and is more appropriate for sustaining dense populations is negated by the super abundance of animal protein on the várzea. Some have also argued that manioc is not an appropriate crop for the production of surplus which is seen as a prerequisite for the development of complex societies. However, ethnohistorical accounts report that manioc tubers were buried in the ground on the floodplain and preserved for extended periods during the flood (Acuña 1641). Clear ethnographic examples demonstrate that processed manioc can be stored for months. In the upper Xingu region of southern Amazonia, Amerindians store dried, processed manioc in large silos inside the home (Carneiro 1983). Manioc is also an ideal crop to store in the field since it does not need to be harvested until the farmer is ready. When flood waters stop rising, manioc fields on high levees are often left for several extra months to increase production by harvesting larger tubers.

This research has shown the wide range of fruits that can be grown on the várzea. Some of them may have been important crops for Amerindian populations that provided variation to the diet, food at different seasons, and rations for animals such as turtles. Most fruits on the floodplain ripen during the high water period to be dispersed by fish; at precisely the time when manioc production stops and fishing is least productive because fish are dispersed throughout a wide area. Fruits may have been an important food source during this time of scarcity.

It is true that the dynamic várzea is not a promising place to find evidence for the economies of prehistoric societies but, aside from Lathrap (1968) in the upper Amazon of Peru, there has been virtually no archaeological work done on the floodplain above Marajó Island. Intensive management of natural resources such as is evidenced in other regions of Amazonia (Ericson 2000, 2001; Heckenberger 1996; Heckenberger et al. 2003), and in the Solimões region itself from ethnohistorical documents (Carvajal 1934; Porro 1994), could have supported a much larger population on the várzea than there is today. Further research on the living strategies of the local population along with archaeological and botanical studies must be undertaken in order to learn how prehistoric Amerindians exploited the várzea environment.

Directions for further research

The conservation of agricultural biodiversity should be a priority in the Amazon Region and particularly on the várzea. Local caboclo farming systems should be recognized as a research and conservation priority within the Mamirauá project. Policies should be devised that strive to conserve agrobiodiversity in situ and care should be taken not to implement projects that result in its loss on a large-scale. While the principal concern of the Mamirauá and Amanã Sustainable Development Reserves is to conserve plant and animal diversity and not necessarily crop diversity, they are in an excellent position to consider conservation of agrobiodiversity. An infrastructure is in place for research, education, and extension work. Communities are sufficiently organized to discuss possibilities for resolving the problems of preservation and there is a growing sensitivity to issues concerning the conservation of natural resources especially if it concerns their livelihood.

The Mamirauá Institute has encouraged the cultivation of annual crops on less biodiverse beaches and non-forested levees as a way of taking pressure of the species-rich floodplain forests on high levees. They have also initiated programs to promote the planting of commercially valuable fruits and timber. Further research on agrobiodiversity could help in this effort. Questions about agricultural sustainability and compatibility with goals of biodiversity conservation should also be asked.

Information on the abundance of useful species in fields and fallows is of critical importance. Except in the case of home gardens, this research has simply recorded the presence or absence of useful species in fields and fallows. More information is needed on the density of these species to more precisely estimate their actual abundance or scarcity in the agroecosystem.

More work needs to be done concerning the origin of useful species in fields and fallows. Which species are planted and which are protected? Preliminary work has been done by Inuma (1999) in home gardens but much more research needs to be done concerning the management of useful species.

Preliminary work in three communities by researchers at the Mamirauá Institute has shown that fallow management and diverse agroforestry systems are only developed by a select few farmers with specialized knowledge and experience (Padoch et al. 1996; Pinedo-Vasquez et al. 1996). The research should be expanded to include a larger sample of communities. How many families actually practice agroforestry and fallow management? What reasons are given for not doing it?

Floodplain farmers could greatly benefit by the development of agroforestry systems using flood tolerant crops or those that are native to the várzea. Several questions need to be asked: Which crops with an existing market are most suitable for growing on the várzea? Which crops have potential for developing and expanding markets? What is the potential for communities to create a value added product from their production? Possibilities for the manufacture of frozen fruit pulp, jams, and other products are already being discussed by residents of Mamirauá.

Critical research needs to be done on crop varieties. How many varieties are out there and what is their distribution? This research has barely touched on this problem but results have indicated that production consists of a few dominant varieties and other varieties are much less common. Are these heirloom varieties being lost in the interest of streamlining production? What can be done to conserve them in the field?

If we want to further understand the spatial distribution of agrobiodiversity and the dynamics and sustainability of the agricultural system it is necessary to examine individual communities more closely. A combination of field data, interviews and satellite data can be used to answer some important questions:

- How do communities vary in their distance to, availability, and use of different habitat types?
- What is the distribution of agrobiodiversity among communities?
- How do families differ in the amount of land they use for agriculture and the amount of forest cleared annually? How do communities differ?
- What is the potential for expansion of annual crop production on low-lying areas?
- Are there fallows that were missed in the survey because they are old and forgotten or in areas difficult to reach?
- Is agriculture expanding on the floodplain?
- How much old growth forest is left?
- Fields are usually cleared close to major rivers and channels. Are there species endemic to these areas that are at risk of extinction?
- How do agriculture and forest dynamics differ on terra firme?

An example of further work that can be done is shown here for the community of Betania. Figure 7-1 shows the resulting map of the territory of Betania with GPS positions of fields and home gardens. Thirty-four roças were visited in Betania for a total area of 80,500 m^2 (8.05 ha.) among 17 owners. The average size of the roças is 2368 m^2. The smallest is just 600m^2 while the largest is one hectare (10,000m^2). A total of 45 capoeiras were visited with a total area of 293,570 m^2 (29.36 ha.) among 19 owners. The average size of the capoeiras is 6827 m^2. The smallest is 480 m^2 and the largest is 50,000

m^2. No useful species were encountered in 10 capoeiras. The other 35 have a mean of 4.4 useful species with a maximum of 16. The average age is 3.8 years with a maximum age of 13 years. We also know which habitats these fields and fallows are found. By classifying satellite images we can estimate the amount of land available for agriculture in each habitat type (Figure 7-2). Putting these together, we have an idea of the proportion of land used for agriculture and natural areas.

Further progress could be made by doing more detailed participatory mapping of agriculture and resource use in individual communities (Figures 7-3 and 7-4). Improved GPS technology and the removal of selective availability allow accurate maps of agricultural fields, fallows, and resource extraction areas.

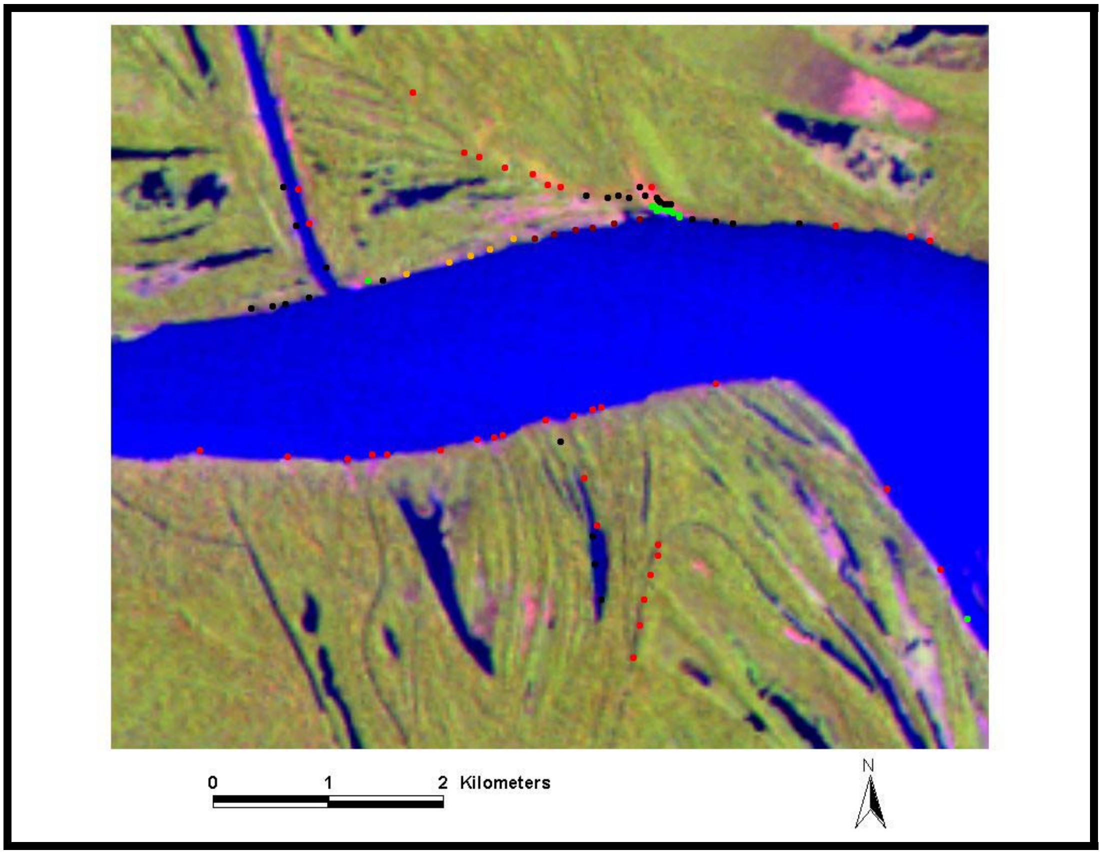

Figure 7-1. Map of fields and home gardens of Betania. GPS positions are overlain on Landsat TM image, bands 5,4,3, August 1999. Color code for points as follows: green = home garden, red = restinga alta roça, black = restinga baixa roça, gold = lama, burgundy = praia.

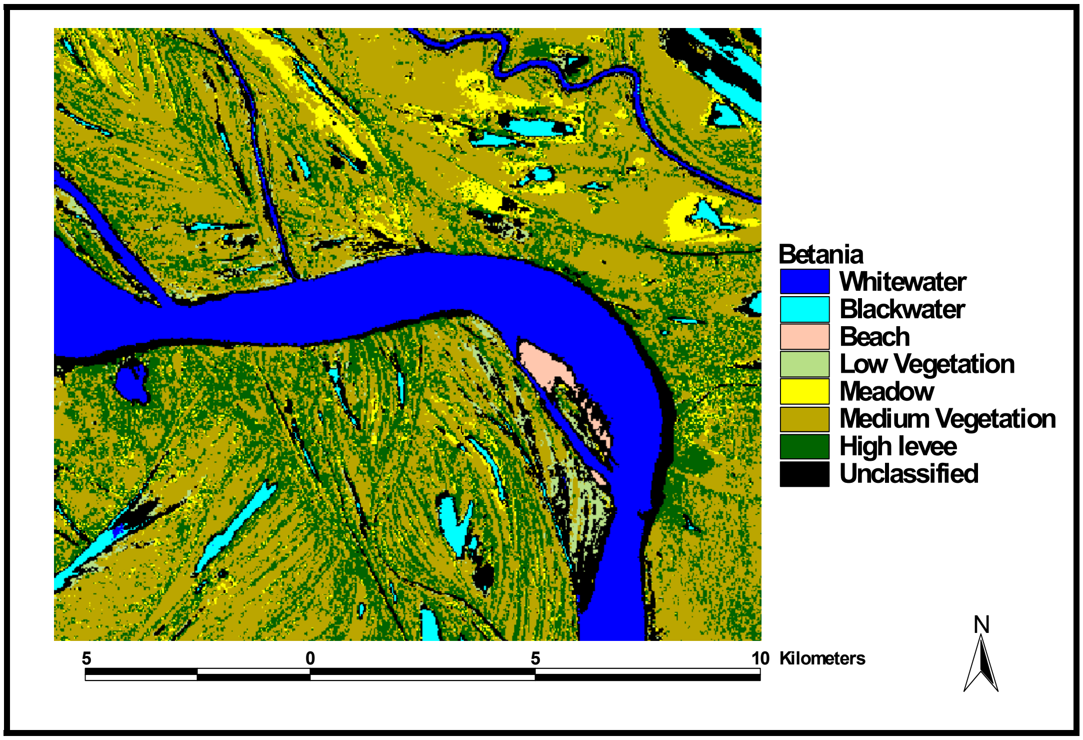

Figure 7-2. Preliminary classification of satellite image in the vicinity of Betania from figure 7-1. High levees can be seen somewhat clearly but more work needs to be done to differentiate habitat types and land use using satellite image processing. New sensors with higher resolution will help in this effort.

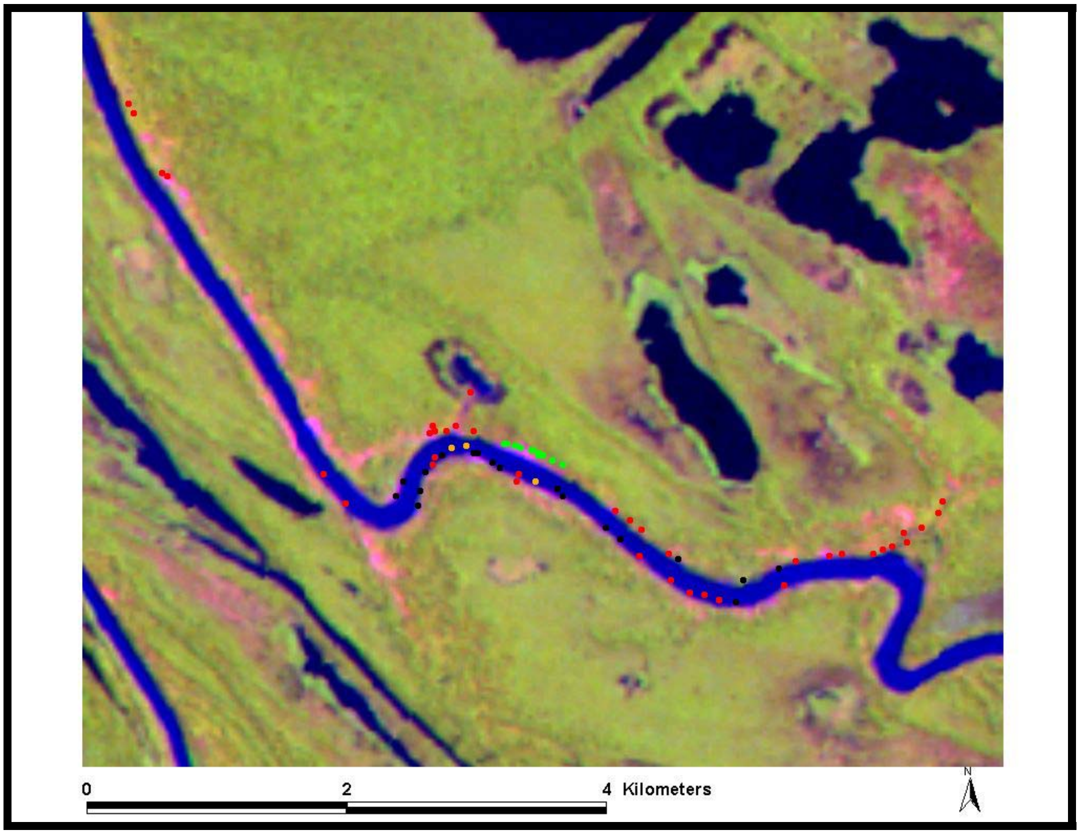

Figure 7-3. Map of fields and home gardens of São Paulo do Coraçi. Color code for GPS points is the same as figure 7-1.

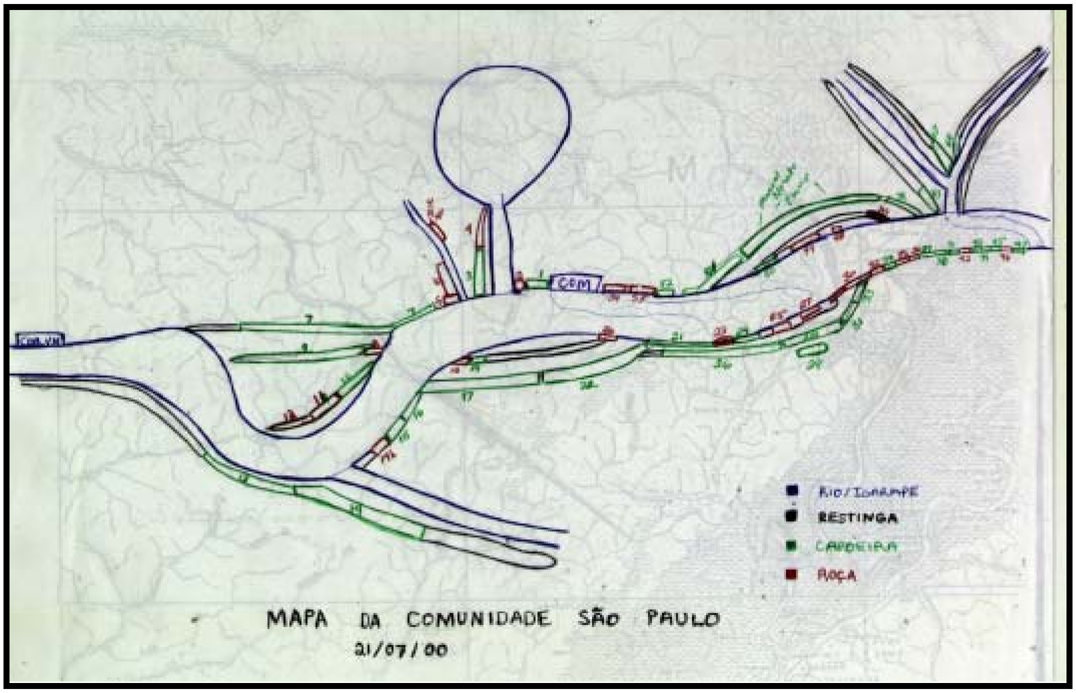

Figure 7-4. Participatory mapping of levees with fields and fallows in São Paulo do Coraçi. The community is in the center. Roças are in red and capoeiras are in green. Compare to satellite and GPS map in figure 7-3.

APPENDIX A
USEFUL SPECIES OCCURRING IN FIELDS AND FALLOWS

Table A-1. Useful species occurring in fields and fallows

Local name	Scientific name	Family	Use
Abacate	*Persea americana*	Lauraceae	Fruit
Abacaxi	*Ananas comosus*	Bromeliaeae	Fruit
Abiu	*Pouteria caimito*	Sapotaceae	Fruit
Acasou	?	?	
Açaí do Pará	*Euterpe oleracea*	Arecaceae	Beverage
Açaí preto	*Euterpe precatoria*	Arecaceae	Beverage
Alfavaca	*Ocimum micrathum*	Lamiaceae	Medicine
Algodão	*Gossypium* sp.	Malvaceae	Caulking
Amacaca	?	?	
Amor crescido	*Portulaca* sp.	Portulacaceae	Medicine
Andiroba	*Carapa guianensis*	Meliaceae	Medicine, timber
Angelim	*Hymenolobium* sp.	Leguminosae	Medicine, timber
Anoirá	?	?	Timber
Apuí	*Clusia* sp.	?	Fruit
Apurui	?	?	
Araçá	*Eugenia* sp.	Myrtaceae	Fruit, fish bait
Araçá boi	*Eugenia stipitata*	Myrtaceae	Fruit, fish bait
Araçá do igapo	*Eugenia* sp.	Myrtaceae	Fruit, fish bait
Araçá goiaba	*Eugenia* sp. *Psidium* sp.	Myrtaceae	Fruit, fish bait
Araçá pel	*Eugenia* sp. *Psidium* sp.	Myrtaceae	Fruit, fish bait
Araruta	*Marantha arundinacea*	Marantacea	Tuber, medicinal
Assacú	*Hura crepitans*	Euphorbiaceae	Timber, rafts
Azeitona	*Eugenia cuminii*	Myrtaceae	Fruit
Bacaba	*Oenocarpus distichus, O. bacaba, O. multicaulis*	Arecaceae	Beverage
Bacabão	*Oenocarpus* sp.	Arecaceae	Beverage
Bacabinha	*Oenocarpus mapora, O. minor*	Arecaceae	Beverage

Table A-1. Continued

Local name	Scientific name	Family	Use
Bacuri	*Rheedia* sp., *Platonia insignis, Moronobea canoida*	Gutiferacea	Fruit
Bacuri coroa	*Rheedia* sp.	Gutiferacea	Fruit
Bacuri liso	*Rheedia macrophylla, R. brasiliensis*	Gutiferacea	Fruit
Banana	*Musa* sp.	Musaceae	Fruit
Biribá	*Rollinia deliciosa*	Annonaceae	Fruit
Boldo	*Pneumus boldus*	Monimiacea	Medicinal
Bolaxeira	*Apeiba* sp.	?	
Buriti	*Mauritia flexuosa*	Arecaceae	Fruit, beverage
Cacau	*Theobroma cacao*	Sterculiaceae	Fruit, chocolate
Cacau jacaré	*Theobroma mariae*	Sterculiaceae	Fruit
Cacaurana	*Theobroma speciosum, T. mariae*	Sterculiaceae	
Cajú	*Anacardium occidentale*	Anacardiaceae	Fruit
Cajú açú	*Anacardium giganteum*	Anacardiaceae	Fruit
Cajurana	*Pouteria* aff. *elegans*	Sapotaceae	
Camapu	*Physalis angulata*	Solanaceae	Vegetable
Camu camu	*Myrciaria dubia*	Myrtaceae	Fruit
Cana de açucar	*Saccharum* sp.	Graminea	Snack, beverage, medicinal
Capim santo	*Cymbopogon citratus*	Poaceae	Beverage, medicinal
Capitiu, caá-pitiú, (caapitiu?)	*Siparuna guianensis*, (*Renealmia occidentalis*?)	Siparunacea, (Zingerberacea)	Medicinal
Capú, (capuchina?)	(*Tropaeslum majus*?)	(Trepaeolacea?)	Timber
Cará	*Dioscorea trifida*	Dioscoriaceae	Tuber
Carambola	*Aberrhoa caranbola*	Oxalidaceae	Fruit
Carapanaúba	*Aspidosperma nitidum*	Apocynaceae	Timber
Castanha de macaco	*Couroupita guianensis (Lecythis usitata?)*	Lecythidaceae	Nut
Castanha do Pará	*Bertholletia excelsa*	Lecythidaceae	Nut
Castanha sapucaia	*Lecythis pisonis*	Lecythidaceae	Nut

Table A-1. Continued

Local name	Scientific name	Family	Use
Castanha de tracajá	?	?	Nut
Castanholeira	*Terminalia catappa*	Combretaceae	Nut
Catoré	*Crataeva benthami*	Capparidaceae	fFsh bait
Cebolinha	*Allium fistulosum*	Liliaceae	Condiment
Cedro	*Cedrella fissilis*	Meliaceae	Timber
Cedrorana	*Cedrelinga catenaeformis*	Leguminosae: Mimosoideae	
Côco	*Cocos nucifera*	Arecaceae	Nut
Coentro	*Coriandrum sativum*	Umbelliferae	Condiment
Copaíba	*Copaifera* sp.	Leguminosae	Medicinal
Couve	*Brassica oleraceae*	Brassicaceae	Vegetable
Cravo	*Dianthus* sp.	Cariofilaceae	
Cubiu	*Solanum sessiliflorum*	Solanaceae	Fruit
Cuia	*Crescentia cujete*	Bignonaceae	Bowl
Cupuaçu	*Theobroma grandiflorum*	Sterculiaceae	Fruit
Cupuí	*Theobroma subincanum*	Sterculiaceae	Fruit
Envira	*Rollinia* sp.	Annonaceae	Timber
Envira cacau	*Rollinia* sp.	Annonaceae	Timber
Envira vassourinha	*Xylopia* cf. *calophyllum*	Annonaceae	Timber, broom
Envira torrada	?	Annonaceae	Timber
Feijão de praia (manteiginho)	*Vigna unguiculata*	Fabaceae	Vegetable
Fruta pão	*Artocarpus altilis*	Moraceae	Fruit
Gergelim	*Sesamum indicum*	Pedaliacea	Condiment
Gingibre	*Gingiber officinale*	Zingiberaceae	Condiment
Goiaba	*Psidium guajava*	Mirtaceae	Fruit
Goiaba araçá	*Psidium acutangulum*	Mytaceae	Fruit
Graviola	*Annona muricata*	Annonaceae	Fruit

Table A-1. Continued

Local name	Scientific name	Family	Use
Hortelã	*Mentha* sp.	Lamiaceae, Labiatae	Medicinal
Hortelãzinho	*Mentha piperita*	Lamiaceae, Labiatae	Medicinal
Hortelã roxa	Mentha sp.	Lamiaceae, Labiatae	Medicinal
Ingá	*Inga* sp.	Mimosaceae	Fruit
Ituá	*Gnetum nodiflorum*	Gnetaceae	Medicinal, food
Jacareúba	*Calophyllum brasiliense, C. angulare*	Clusiaceae, Gutiferacea	Timber
Jambo	*Eugenia malaccensis, E. jambos*	Myrtaceae	Fruit
Jauari	*Astrocaryum jauari*	Arecaceae	Fish bait
Jenipapo	*Genipa americana*	Rubiaceae	Fruit
Jerimum	*Cucurbita* sp.	Cucurbitaceae	Vegetable
Jitó	*Guarea* sp.	?	Timber
Lacre	*Vismia* sp.	Guttiferae	
Laranja	*Citrus sinensis*	Rutaceae	Fruit
Lauro abacate	*Aniba* sp.	?	Timber
Lauro amarelo	*Nectandra* sp.	?	Timber
Lauro chumbo	?	?	Timber
Lauro jacaré	?	Lauraceae	Timber
Louro inamuí	*Ocotea cymbarum*	Lauraceae	Timber, medicinal
Leitaúba	?	?	
Lima	*Citrus* spp.	Rutaceae	Fruit
Limão comum	*Citrus aurantifolia*	Rutaceae	Fruit
Limão de Caiena	*Averrhoa bilimbi*	Oxalidaceae	Fruit
Limão caipirinha	?	Rutaceae	Fruit
Limão cida (cidra?)	(*Citrus medica*?)	Rutaceae	Fruit
Limão tangerina, Limão de suco	*Citrus* sp.	Rutaceae	Fruit
Macacaricuia	*Couroupita* sp., *Eschweilera* sp.	?	

Table A-1. Continued

Local name	Scientific name	Family	Use
Macacaúba	*Platymiscium ulei, P. duckei*	Leguminosae: Papilionoideae	Timber
Majirição	*Ocimum* sp.	Lamiaceae	Medicinal
Mamão	*Carica papaya*	Caricaceae	Fruit
Maná	*Fraxinus ornus*	Oleaceae	Medicinal
Mandioca	*Manihot esculenta*	Euphorbiaceae	Tuber
Manixi	*Brosimopsis oblongifolia*	Moraceae	
Manga	*Mangifera indica*	Anacardiaceae	Fruit
Manga maça	*Mangifera* sp.	Anacardiaceae	Fruit
Mapati	*Pourouma cecropitolia*	Moraceae	Medicinal
Maracujá	*Passiflora edulis*	Passifloraceae	Fruit
Maracujá do igapó	?	?	Fruit
Marimari	*Cassia leiandra, C. spruceana, C. grandis*	Leguminosae: Caesalpinioideae	Fruit, medicinal
Marirana	*Coepia* sp.	Chrysobalanaceae	
Mastruz	*Chenopodium ambrosioides*	Chenopodiaceae	Medicinal
Maúba	*Clinostemon mahuba (Licaria mahuba)*	Lauraceae	Timber
Maxixe	*Cucumis anguaria*	Cucurbitaceae	Vegetable
Melancia	*Citrullus vulgaris*	Cucurbitaceae	Fruit
Milho	*Zea mays*	Poaceae	Food
Mucura caá	*Petiveria alliacea*	Phytolacaceae	Medicinal
Mucuúba	?	?	
Muirataua, Muirajuba	*Apuleia molaris*	Leguminosae: Caesalpinioideae	Timber
Muiratinga	*Maquira spruciana (M. coriaceae?)*	Moraceae	Timber
Mulateiro	*Calycophyllum spruceanum*	Rubiaceae	Timber
Murucututu	?	?	
Murumuru	*Astrocaryum murumuru*	Arecaceae	
Murupi	?	?	

Table A-1. Continued

Local name	Scientific name	Family	Use
Namuirana	?	?	
Pachiuba	?	?	Timber
Pará pará	*Jacaranda copaia, Cordia umbraculifera*	Bignonaceae	Medicinal, timber
Paricarana	*Pithecellobium corymbosum*	?	Timber
Pau ferro	?	?	Timber
Perereca	?	?	Timber
Pimenta (5 varieties)	*Capsicum* sp.	Solanaceae	Condiment
Pimentão	*Capsicum annum*	Solanaceae	Condiment
Piquiá	*Caryocar villosum*	Caryocaraceae	Fruit, timber
Pitomba	*Talisia esculenta*	Sapindaceae	Fruit
Puná	?	?	Timber
Pupunha	*Bactris gasipaes*	Arecaceae	Fruit
Puruí	*Boroja sorbilis*	Rubiaceae	Fruit
Samauma	*Ceiba pentandra*	Bombacaceae	Timber
Seringa	*Hevea brasiliense*	Euphorbiaceae	Latex
Seringa barriguda	*Hevea spruceana*	Euphorbiaceae	Latex
Seringa murupita	?	?	Latex
Sorva	*Couma utilis*	Apocynaceae	Latex
Sucupira	*Andira micrantha*	Leguminosae: Papilionoideae	Timber
Sucuúba	*Himatanthus tarapotensis, H. sucuuba*	Apocynaceae	Timber
Tacaca	*Sterculia* sp.	Sterculiaceae	Timber
Tacana	?	?	
Tangerina	*Citrus nobilis* var. deliciosa	Rutaceae	Fruit
Tanibuca	*Terminalia tanibouca*	Combretaceae	Timber
Taperebá	*Spondias mombim*	Anacardiaceae	Fruit
Taxi	?	?	Timber

Table A-1. Continued

Local name	Scientific name	Family	Use
Tinta arana	?	?	
Toari	?	?	Timber
Tomate	*Lycopersicum esculentum*	Solanaceae	
Tucumã	*Astrocaryum vulgare, A. tucuma, A. aculeatum*	Palmacea, Arecaceae	Fruit
Tucupi de arara	?	?	
Ubim	*Geonoma* sp.	Arecaceae	
Ucuúba	*Virola surinamensis*	Myristicaceae	Timber, fishbait
Uruá	*Cordia nodosa*	Boraginaceae	Fish bait, livestock feed
Urucu	*Bixa orellana*	Bixaceae	Food colorant
Urucuri	*Attalea minor*	Arecaceae	Roofing material
Uxi liso	*Endopleura uchi*	Humiriaceae	Fruit

Sources: Araujo-Lima and Goulding 1997; Brucher 1989; Cavalcante 1974; Cid 1978; Cointe 1947; Fernandes et al. 1952; Gentry 1993; Inuma 1999; Lima 1994; Popenoe 1920; Purseglove 1968a, 1968b, 1972a, 1972b; Ribeiro 1999; Smith 1999; Smith et al. 1992, 1995; Stasi 1989.

Note: Scientific names and families are a "best guess" as no samples were collected in the field. The objective of this research was to document the spatial distribution of agrobiodiversity in the middle Solimões region rather than to identify and name each plant. This list includes all plants found in várzea and terra firme home gardens considered useful by residents except ornamentals.

APPENDIX B
USEFUL SPECIES OCCURRING IN HOME GARDENS

Table B-1. Useful species occurring in home gardens

Local Name	Scientific Name	Family	Use	Num. varzea gardens (163)	%	Num. terra firme gardens (30)	%
Abacate	*Persea americana*	Lauraceae	fruit	1	1	9	30
Abacaxi	*Ananas comosus*	Bromeliaeae	fruit	2	1	6	20
Abiu	*Pouteria caimito*	Sapotaceae	fruit	6	4	9	30
Açaí do Pará, Açaí preto (2 species)	*Euterpe oleracea, E. precatoria*	Arecaceae	beverage	46	28	20	67
Acerola	*Malpighia glabra*	Malpighiaceae	fruit	1	1	0	0
Alface	*Lactuca sativa*	Asteraceae	vegetable	3	2	0	0
Alfavaca	*Ocimum micrathum*	Lamiaceae	medicinal	34	21	10	33
Algodão	*Gossypium* sp.	Malvaceae	caulking	5	3	1	3
Algodão branco	*Gossypium barbadense*	Malvaceae	caulking	2	1	0	0
Algodão roxo	*Gossypium* sp.	Malvaceae	caulking	16	10	1	3
Alho	*Allium sativum*	Liliaceae	condiment, medicinal	0	0	1	3
Amor crescido	*Portulaca* sp.	Portulacaceae	medicinal	6	4	2	7
Anador planta	?	?	medicinal	4	2	0	0
Andiroba	*Carapa guianensis*	Meliaceae	medicinal, timber	2	1	3	10
Apuí	*Clusia* sp.	Moraceae	fruit	1	1	0	0
Araçá boi	*Eugenia stipitata*	Myrtaceae	fruit, fishbait	4	2	4	13
Araçá do igapó	*Eugenia* sp.	Myrtaceae	fruit, fishbait	2	1	0	0
Araçá goiaba	*Eugenia* sp. *Psidium* sp.	Myrtaceae	fruit, fishbait	20	12	3	10
Araçá pel	*Eugenia* sp. *Psidium* sp.	Myrtaceae	fruit, fishbait	0	0	4	13
Araçá pera	*Eugenia estipitata*	Myrtaceae	fruit, fishbait	0	0	1	3
Arati	?	?		3	2	0	0
Araticum	*Annona* sp.	Annonaceae	medicinal	0	0	2	7
Arruda	*Ruta graveolens*	Rutaceae	medicinal	3	2	2	7
Assacú	*Hura crepitans*	Euphorbiaceae	medicinal, timber	5	3	0	0

Table B-1. Continued

Local Name	Scientific Name	Family	Use	Num. varzea gardens (163)	%	Num. terra firme gardens (30)	%
Assacui	*Euphorbia cotinoides*	Euphorbiaceae	timber	0	0	1	3
Azeitona, Ameixa	*Szyzgium cumini*	Myrtaceae	fruit	11	7	2	7
Bacaba	*Oenocarpus distichus, O. bacaba*	Arecaceae	beverage	24	15	17	57
Bacabinha	*Oenocarpus mapora, O. minor*	Arecaceae	beverage	1	1	2	7
Bacuri	*Rheedia* sp., *Platonia insignis, Moronobea canoida*	Gutiferacea	fruit	9	6	0	0
Bacuri coroa	*Rheedia* sp.	Gutiferacea	fruit	5	3	2	7
Bacuri liso	*Reedia macrophylla, R. brasiliensis*	Gutiferacea	fruit	14	9	0	0
Banana (13 varieties)	*Musa* sp.	Musaceae	fruit	56	34	21	70
Batata doce (3 varieties)	*Ipomea batatas*	Convulvulaceae	tuber	1	1	5	17
Bau Bau	?	?	medicinal	1	1	0	0
Biribá	*Rollinia deliciosa*	Annonaceae	fruit	1	1	5	17
Boldo	*Pneumus boldus*	Monimiacea	medicinal	10	6	3	10
Boldo folha grauda	?	?	medicinal	1	1	0	0
Boieira	*Apeiba* sp.	?		5	3	0	0
Buriti	*Mauritia flexuosa*	Arecaceae	fruit, beverage	19	12	11	37
Cacamo	?	?		1	1	0	0
Cacau	*Theobroma cacao*	Sterculiaceae	fruit, chocolate, medicinal	52	32	17	57
Cacaui	*Theobroma speciosum, T. sylvestre*	Sterculiaceae	fruit	0	0	1	3
Cacau jacaré	*Theobroma mariae*	Sterculiaceae	fruit	4	2	3	10

Table B-1. Continued

Local Name	Scientific Name	Family	Use	Num. varzea gardens (163)	%	Num. terra firme gardens (30)	%
Cacaurana	*Theobroma speciosum, T. sylvestre*	Sterculiaceae	fruit	3	2	1	3
Café	*Coffea arabica*	Rubiaceae	beverage	0	0	3	10
Cajú	*Anacardium occidentale*	Anacardiaceae	fruit	23	14	13	43
Cajú açú	*Anacardium giganteum*	Anacardiaceae	fruit	0	0	1	3
Cajurana	*Pouteria* aff. *elegans*	Sapotaceae	fruit	1	1	0	0
Calipi	?	?		0	0	1	3
Camu camu	*Myrciaria dubia*	Myrtaceae	fruit	28	17	1	3
Cana de açucar	*Saccharum* sp.	Graminea	snack, beverage	29	18	4	13
Capeba	*Pothomorphe sidaefolia*	Piperacea		0	0	1	3
Capim santo	*Cymbopogon citratus*	Poaceae	beverage, medicinal	45	28	6	20
Cará	*Dioscorea trifida*	Dioscoreaceae	tuber	0	0	2	7
Carajuru	*Arrabidea chica*	Bignonaceae	medicinal	0	0	4	13
Carambola	*Averrhoa caranbola*	Oxalidaceae	fruit	2	1	1	3
Carapanaúba	*Aspidosperma nitidum*	Apocynaceae	timber	1	1	0	0
Caraucu	?	?		1	1	0	0
Cariru, Caruru	*Amaranthus flavus*	Amarantaceae	vegetable	13	8	6	20
Carrapateira	?	?	medicinal	0	0	1	3
Castanha eletaca	?	?	nut	0	0	1	3
Castanha de macaco	*Couroupita guianensis, Lecythis usitata*	Lecythidaceae	nut	6	4	0	0
Castanha do Pará	*Bertholletia excelsa*	Lecythidaceae	nut	0	0	3	10
Castanha sapucaia	*Lecythis pisonis*	Lecythidaceae	nut	11	7	0	0
Castanholeira	*Terminalia catappa*	Combretaceae	nut	8	5	0	0
Catoré	*Crataeva benthami*	Capparidaceae	fish bait	2	1	0	0

Table B-1. Continued

Local Name	Scientific Name	Family	Use	Num. varzea gardens (163)	%	Num. terra firme gardens (30)	%
Catinga de mulata	*Leucas martinicensis*	Labiatae	medicinal	6	4	5	17
Cauacu	?	?		0	0	1	3
Caximguba	*Ficus* sp.	Moraceae	mulch, fishbait	12	7	1	3
Cebolinha	*Allium fistulosum*	Liliaceae	condiment	90	55	20	67
Cedro	*Cedrella fissilis*	Meliaceae	timber	10	6	0	0
Cheiro verde	?	?	condiment	2	1	2	7
Chicória	*Eryngium ekmanii, Cichorium intybus*	Umbelliferae, Composta	condiment	15	9	8	27
Chifre de corno	?	?	medicinal	0	0	2	7
Cibalena	?	Zingiberaceae	medicinal	1	1	0	0
Cidreira	*Melissa officinalis*	Lamiaceae	medicinal	15	9	2	7
Cidrela	*Lippa alba*	Verbenaceae		0	0	2	7
Cipó-alho	*Mansoa alliacea*	Bignoniaceae		2	1	3	10
Coco	*Cocos nucifera*	Arecaceae	beverage, nut	33	20	12	40
Coentro	*Coriandrum sativum*	Umbelliferae		8	5	2	7
Corama	*Bryophyllum pinnatum, B. calycimum*	Crassulaceae	medicinal	0	0	1	3
Corisa	?	?		2	1	0	0
Couve	*Brassica oleraceae*	Brassicaceae	vegetable	16	10	9	30
Cravo	*Dianthus* sp.	Cariofilaceae		7	4	4	13
Cravo-de-defunto	*Tagetes erecta, T. patula*	Asteraceae		4	2	0	0
Cubiu	*Solanum sessiliflorum*	Solanaceae	fruit	29	18	5	17
Cuia	*Crescentia cujete*	Bignonaceae	bowl	93	57	12	40
Cuiamanza	*Polyscias* sp.	Araliaceae		3	2	2	7
Cuminho (Cuminho bravo)	(Pectis elongata)	(Composta)	condiment	3	2	1	3

Table B-1. Continued

Local Name	Scientific Name	Family	Use	Num. varzea gardens (163)	%	Num. terra firme gardens (30)	%
Cupuaçu	*Theobroma grandiflorum*	Sterculiaceae	fruit	11	7	16	53
Envira	*Rollinia* sp.	Annonaceae		1	1	0	0
Envira cacau	*Rollinia* sp.	Annonaceae		2	1	0	0
Envira-vassorinha	*Xylopia* cf. *calophyllum*	Annonaceae		2	1	0	0
Envirinha	?	Annonaceae		1	1	0	0
Erva doce	*Pimpinella anisum*	?	medicinal	0	0	4	13
Eucalypto (arbusto)	?	?	medicinal	1	1	0	0
Feijão de corda	*Vigna sinensis*	Fabaceae	vegetable	1	1	0	0
Fruta-pão	*Artocarpus altilis*	Moraceae	fruit	7	4	0	0
Gergelim	*Sesamum indicum*	Pedaliacea	medicinal	3	2	0	0
Goiaba	*Psidium guajava*	Mirtaceae	fruit	107	66	21	70
Goiaba araçá	*Psidium acutangulum*	Mytaceae	fruit	8	5	0	0
Graviola	*Annona muricata*	Annonaceae	fruit	46	28	9	30
Hortelã	*Mentha* sp.	Lamiaceae, Labiatae	medicinal	8	5	6	20
Hortelã folha graúda	*Plectramthus amboicus, Mentha viridis*	Lamiaceae, Labiatae	medicinal	14	9	3	10
Hortelã folha miúda	*Mentha* sp., *Mentha villosa*	Lamiaceae, Labiatae	medicinal	4	2	0	0
Hortelãzinho	*Mentha piperita*	Lamiaceae, Labiatae	medicinal	6	4	5	17
Ingá açu	*Inga cinnamoea*	Mimosaceae	fruit	63	39	6	20
Ingá cipó / comprida	*Inga edulis*	Mimosaceae	fruit	29	18	11	37
Ingá curta	*Inga* sp.	Mimosaceae	fruit	1	1	0	0
Ingá do igapó	*Inga* sp.	Mimosaceae	fruit	2	1	0	0
Ingá sapo	*Inga* sp.	Mimosaceae	fruit	2	1	0	0

Table B-1. Continued

Local Name	Scientific Name	Family	Use	Num. varzea gardens (163)	%	Num. terra firme gardens (30)	%
Ingá sp.	*Inga* sp.	Mimosaceae	fruit	12	7	1	3
Ingásinho	*Inga* sp.	Mimosaceae	fruit	2	1	0	0
Jacareúba	*Calophyllum brasiliense, C. angulare*	Clusiaceae, Gutiferacea	timber	2	1	0	0
Jaismia de gato (Jasmim?)	?	?		1	1	0	0
Jambo	*Eugenia malaccensis, E. jambos*	Myrtaceae	fruit	23	14	17	57
Jambu	*Spilanthes acmella*	Compositae	medicinal	12	7	1	3
Japana	*Eupatorium ayapana*	Compositae	medicinal	1	1	1	3
Jauari	*Astrocaryum jauari*	Palmae	fish bait	2	1	1	3
Jenipapo	*Genipa americana*	Rubiaceae	fruit	16	10	3	10
Jerimum	*Cucurbita* sp.	Cucurbitaceae	vegetable	4	2	0	0
Jitó	*Guarea* sp.	?	timber	1	1	0	0
Jucá	*Caesalpinia ferrea*	Luguminosae	medicinal	0	0	1	3
Lacre	*Vismia* sp.	Guttiferae		1	1	0	0
Laranja	*Citrus sinensis*	Rutaceae	fruit	10	6	8	27
Louro	*Varium*	Lauraceae	medicinal, timber	5	3	0	0
Louro-inamuí	*Ocotea cymbarum*	Lauraceae	medicinal, timber	4	2	0	0
Lima	*Citrus* spp.	Rutaceae	fruit	13	8	5	17
Limão comum	*Citrus aurantifolia*	Rutaceae	fruit, condiment	28	17	8	27
Limão cida (cidra?)	(Citrus medica?)	Rutaceae	fruit	1	1	0	0
Limão tangerina, Limão de suco	*Citrus* sp.	Rutaceae	fruit	10	6	6	20
Macucu	*Aldina heterophylla, Ilex macoucoua*	Leguminosae: Papilionoideaa	medicinal, dye	1	1	0	0

Table B-1. Continued

Local Name	Scientific Name	Family	Use	Num. varzea gardens (163)	%	Num. terra firme gardens (30)	%
Majirição	Ocimum sp.	Lamiaceae	medicinal	27	17	1	3
Malvaísco, Caá peba	*Piper peltatum*	Malvacea	medicinal	4	2	1	3
Mamão	*Carica papaya*	Caricaceae	fruit	17	10	18	60
Mandioca, Macaxeira	*Manihot esculenta*	Euphorbiaceae	tuber	3	2	7	23
Manga	*Mangifera indica*	Anacardiaceae	fruit	23	14	16	53
Mangarataia	*Zingiber officinalis*	Zingiberaceae	condiment, medicinal	10	6	4	13
Manixi	*Brosimopsis oblongifolia*	Moraceae		1	1	0	0
Maracujá	*Passiflora edulis*	Passifloraceae	fruit	17	10	6	20
Marcela	*Pluchea quitoc*	Compositae	medicinal	0	0	1	3
Mari-mari	*Cassia leiandra, C. spruceana, C. grandis*	Leguminosae: Caesalpinioideae	fruit, medicinal	2	1	3	10
Marirana	*Coepia* sp.	Chrysobalanaceae	fruit	10	6	6	20
Mastruz	*Chenopodium ambrosioides*	Chenopodiaceae	medicinal	19	12	6	20
Maxixe	*Cucumis anguaria*	Cucurbitaceae	vegetable	11	7	0	0
Melancia	*Citrullus vulgaris*	Cucurbitaceae	fruit	0	0	1	3
Melhoral	*Piper cavalcantei*	Piperacea	medicinal	0	0	1	3
Menta	?	?		1	1	0	0
Milho	*Zea mays*	Poaceae	food, livestock feed	1	1	0	0
Mucura caá	*Petiveria alliacea*	Phytolacaceae	medicinal	8	5	7	23
Muiratinga	*Maquira spruciana, M. coriaceae*	Moraceae	timber	22	13	0	0
Mulateiro	*Calycophyllum spruceanum*	Rubiaceae	timber	10	6	0	0
Munguba	*Pseudobombax munguba*	Bombacaceae	mulch	11	7	0	0

Table B-1. Continued

Local Name	Scientific Name	Family	Use	Num. varzea gardens (163)	%	Num. terra firme gardens (30)	%
Mungubarana	*Pachira* sp., *Bombax paraense*	Bombacaceae		0	0	1	3
Murucuri	?	?		1	1	0	0
Murupita	*Sapium hippomane, Sapium* sp.	Euphorbiaceae		3	2	0	0
Mutamba	*Guazuma unifolia*	Esterculiacea	medicinal, fruit, fiber, livestock feed	8	5	0	0
Mututi	*Paramachaerium ormosioides*	Leguminosae		1	1	0	0
Orelho de porco	?	?		3	2	0	0
Palheteira	*Clitoria racemosa*	Leguminosae	timber	8	5	2	7
Palmaceiteira	?	?		0	0	1	3
Panquilé	?	?	medicinal	1	1	0	0
Paricá	*Virola theiodora, Peptadenia peregrina*	Myristicaceae, Numosacea		3	2	0	0
Parigorico	?	?		1	1	1	3
Patchouli	Pogostemon patchouly	Labiatae	medicinal	0	0	1	3
Pau ferro	*Acacia catehu*	?	timber	1	1	0	0
Pau de ralo	?	?		1	1	0	0
Peão branco	*Jatropha curcas*	Euphorbiaceae	medicinal	37	23	6	20
Peão roxo	*Jatropha gossyfiifolia*	Euphorbiaceae	medicinal	39	24	14	47
Pepino	*Cucumis sativus*	Cucurbitaceae	vegetable	2	1	0	0
Picão	*Bidens bipinnatus*	Compositae		0	0	1	3
Pimenta ardosa (6 varieties)	*Capsicum frutescens*	Solanaceae	condiment	89	55	24	80
Pimenta doce (2 varieties)	*Pimenta docia*	Myrtaceae	condiment	5	3	8	27

Table B-1. Continued

Local Name	Scientific Name	Family	Use	Num. varzea gardens (163)	%	Num. terra firme gardens (30)	%
Pimentão	*Capsicum annum*	Solanaceae	vegetable	17	10	5	17
Piquiá	*Caryocar villosum*	Caryocaraceae	fruit	0	0	3	10
Pirarucu caá	*Kalanchoe pinnata*	Crassulaceae	medicinal	13	8	3	10
Pitomba	*Talisia esculenta*	Sapindaceae	fruit	2	1	1	3
Pupunha	*Bactris gasipaes*	Arecaceae	fruit	10	6	15	50
Puruí	*Boroja sorbilis*	Rubiaceae	fruit	16	10	3	10
Purumã	*Pourouma guianensis*	Cecropiaceae		1	1	2	7
Quebra-pedra	*Phyllanthus corcovadensis*	Euphorbiaceae	medicinal	0	0	1	3
Quiabo	*Abelmoschus* sp.	Malvacea	vegetable	8	5	1	3
Repolho	*Brassica oleraceae* var. capitata	Apiaceae	vegetable	3	2	0	0
Sapota (Sapotí?)	(Achras sapota?)	(Sapotaceae?)		0	0	2	7
Se de sangria / bacuralzinho	?	?	medicinal	0	0	1	3
Senna	*Senna* sp.	Leguminosae: Caesalpinioideae	medicinal	6	4	2	7
Seringa	*Hevea brasiliensis*	Euphorbiaceae	latex	7	4	1	3
Seringa barriguda	*Hevea spruceana*	Euphorbiaceae	latex	1	1	0	0
Sucuúba	*Himatanthus tarapotensis, H. sucuuba*	Apocynaceae	timber	1	1	2	7
Samaúma	*Ceiba pentandra*	Bombacaceae	timber	6	4	0	0
Samaumarana	?	?		1	1	0	0
Taioba	*Xanthosoma* sp.	Aracea		1	1	0	0
Tamanqueira	*Zanthoxylum* sp.	Rutaceae	timber	1	1	0	0
Tâmara	?	(palm)		1	1	0	0

Table B-1. Continued

Local Name	Scientific Name	Family	Use	Num. varzea gardens (163)	%	Num. terra firme gardens (30)	%
Tangerina	*Citrus nobilis* var. deliciosa	Rutaceae	fruit	1	1	4	13
Tanibuca	*Terminalia tanibouca*	Combretaceae	timber	5	3	0	0
Taperebá	*Spondias mombin*	Anacardiaceae	fruit, medicinal	27	17	3	10
Taxi	*Triplares schomburgkiana, Sclerolobium goeldianum*	Polygonaceae, Leguminosae: Casalpiniacea	timber	19	12	3	10
Taxi branco	*Pterocarpus* sp.	Polygonaceae, Luguminosae: Casalpiniacea	timber	1	1	0	0
Taxi vermelho	*Triplares surinamensis*	Polygonaceae	timber	0	0	1	3
Tecura	?	?	medicinal	0	0	1	3
Tomate	*Lycopersicum esculentum*	Solanaceae	vegetable	36	22	3	10
Trevo roxo	Hyptis atrorubens	Lamiaceae	medicinal, ornamental	2	1	1	3
Tucumã	*Astrocaryum vulgare, A. tucuma, A. aculeatum*	Palmacea, Arecaceae	fruit	0	0	4	13
Turima	?	?		3	2	0	0
Ucuúba	*Virola surinamensis*	Myristicaceae	timber	5	3	0	0
Urucu	*Bixa orellana*	Bixaceae	food colorant	12	7	15	50
Urucurana	*Sloanea* sp.	Elaeocarpaceae		2	1	0	0
Urucuri	*Attalea phalerata*	Arecaceae		11	7	1	3
Vence-tudo	?	?	medicinal	1	1	2	7
Vick	*Mentha spicata*	Lamiaceae	medicinal	0	0	1	3

Sources: Araujo-Lima and Goulding 1997; Brucher 1989; Cavalcante 1974; Cid 1978; Cointe 1947; Fernandes et al. 1952; Gentry 1993; Inuma 1999; Lima 1994; Popenoe 1920; Purseglove 1968a, 1968b, 1972a, 1972b; Ribeiro 1999; Smith 1999; Smith et al. 1992, 1995; Stasi 1989.
Note: Homes without a home garden were omitted. (8 home gardens surveyed on the varzea and 4 on terra firme did not have useful species). Scientific names and families are a "best guess" as no samples were collected in the field. The objective of this research was to document the spatial distribution of agrobiodiversity in the middle Solimões region rather than to identify and name each plant.
This list includes all plants found in várzea and terra firme home gardens considered useful by residents except ornamentals.

LIST OF REFERENCES

Acuña, C. (1891). Nuevo Descubrimento del Gran Rio de las Amazonas en El Año 1639. García, Madrid.

Adams, M. W., A. H. Ellingboe, and E. C. Rossman (1971). "Biological Uniformity and Disease Epidemics." BioScience 21(21): 1067-1070.

Albernaz, A. L. K. M., and Ayres, J. M. (1999). Selective Logging along the Middle Solimoes River. Várzea: diversity, development, and conservation of Amazonia's white water floodplains. C. Padoch, J. M. Ayres, M. Pinedo-Vasquez, and A. Henderson editors. New York, The New York Botanical Garden Press. 13: 135-152.

Alcorn, J. B. (1984). "Development Policy, Forests, and Peasant Farms: Reflections on Huastec-managed Forests' Contributions to Commercial Production and Resource Conservation." Economic Botany 38(4): 389-406.

Alcorn, J. B. (1990). Indigenous Agroforestry Strategies Meeting Farmers' Needs. Alternatives to Deforestation: Steps Toward Sustainable Use of the Amazon Rain Forest. A. B. Anderson editor. New York, Colombia University Press: 141-151.

Altieri, M. A. (1989). "Rethinking Crop Genetic Resource Conservation: A View From the South." Conservation Biology 3(1): 77-79.

Altieri, M. A. (1995). Agroecology: The Science of Sustainable Agriculture. Boulder, Westview Press.

Altieri, M. A., M. K. Anderson, and L. C. Merrick (1987). "Peasant Agriculture and the Conservation of Crop and Wild Plant Resources." Conservation Biology 1(1): 49-58.

Altieri, M. A., and L. C. Merrick (1987). "In Situ Conservation of Crop Genetic Resources through Maintenance of Traditional Farming Systems." Economic Botany 4(1): 86-96.

Anderson, A. B., P. Magee, A. Gely, and M. A. G. Jardim (1995). "Forest Management Patterns in the Floodplain of the Amazon Estuary." Conservation Biology 9(1): 47-61.

Anderson, A. B., and D. A. Posey (1989). Management of a Tropical Scrub Savanna by the Gorotire Kayapó of Brasil. Resource Management in Amazonia: Indigenous and Folk Strategies. D. A. Posey and W. Baleé editors. New York, The New York Botanical Garden. 7: 159-173.

Araujo-Lima, C. and M. Goulding (1997). So Fruitful a Fish: Ecology, Conservation, and Aquaculture of the Amazon's Tambaqui. New York, Columbia University Press

Ayres, J. M. (1995). As Matas de Várzea do Mamirauá, Sociedade Civil Mamirauá.

Baleé, W. (1989). The Culture of Amazonian Forests. Resource Management in Amazonia: Indigenous and Folk Strategies. D. A. Posey and W. Baleé editors. New York, The New York Botanical Garden. 7.

Baleé, W. (1994). Footprints of the Forest: Ka'apor Ethnobotony - the Historical Ecology of Plant Utilization by an Amazonian People. New York, Columbia University Press.

Beckerman, S. (1987). Swidden in Amazonia and the Amazon Rim. Comparative Farming Systems. S. Brush editor. Guilford, CT, Guilford Press.

Behrens, C. A., M. G. Baksh, and M. Mothes (1994). "A Regional Analysis of Bari Land Use Intensification and Its Impact on Landscape Heterogeneity." Human Ecology 22(3): 279-316.

Bergman, R. W. (1980). Amazon Economics: The Simplicity of Shipibo Indian Wealth, Department of Geography, Syracuse University.

Boserup, E. (1965). The Conditions of Agricultural Growth; the economics of agrarian change under population pressure. London, G. Allen & Unwin.

Brookfield, H. (2001). Exploring Agrodiversity. New York, Columbia University Press.

Brucher, H. (1989). Useful Plants of Neotropical Origin. Berlin, Springer-Verlag.

Brush, S. B. (1989). "Rethinking Crop Genetic Resource Conservation." Conservation Biology 3(1): 19-29.

Carneiro, R. L. (1956). Slash-and-burn Agriculture: A Closer Look at its Implications for Settlement Patterns. Men and Cultures. A. F. C. Wallace editor. Philadelphia, University of Pennsylvania Press.

Carneiro, R. L. (1968). Slash-and-burn Cultivation among the Kuikuro and its implications for cultural development in the Amazon Basin. Man in Adaptation: The Cultural Present. Y. A. Cohen editor. Chicago, Aldine Publishing Company: 131-145.

Carneiro, R. L. (1970). "A Theory of the Origin of the State." Science 169: 733-738.

Carneiro, R. L. (1983). The Cultivation of Manioc Among the Kuikuru of the Upper Xingu. Adaptive Responses of Native Amazonians. R. B. Hames and W. T. Vickers editors. New York, Academic Press.

Carvajal, de (1934). The Discovery of the Amazon. New York, American Geographical Society.

Cavalcante, P. B. (1974). Frutas Comestíveis da Amazonia II. Belem, Museu Goeldi.

Chang, J. (1977). "Tropical Agriculture: Crop Diversity and Crop Yields." Economic Geography 53(3): 241-254.

Chibnik, M. (1994). Risky Rivers: The Economics and Politics of Floodplain Farming in Amazonia. Tucson, University of Arizona Press.

Cid, P. (1978). Plantas Medicinais e Ervas Feiticeiras da Amazonia. Sao Paulo, Atlantis.

Clark, J. G. D., Ed. (1952). Prehistoric Europe: The Economic Basis. London, Methuen & Co. Ltd.

Clawson, D. L. (1985). "Harvest Security and Intraspecific Diversity in Traditional Tropical Agriculture." Economic Botany 39(1): 56-67.

Colfer, C. J. P. (1997). Beyond Slash and Burn: Building On Indigenous Management of Borneo's Tropical Rain Forests. New York, The New York Botanical Garden.

Conklin, H. C. (1954). "An Ethnoecological Approach to Shifting Cultivation." Transactions of the New York Academy of Sciences, Series II 17(2): 133-142.

Conklin, H. C. (1961). "The Study of Shifting Cultivation." Current Anthropology 2(1): 27-61.

Coomes, O. T., and G. J. Burt (1997). "Indigenous Market Oriented Agroforestry: Dissecting Local Diversity in Western Amazonia." Agroforestry Systems 37: 27-44.

Dagon, R. R. (1967). Current Agricultural Practices Among the Waiwai. Montreal, Department of Geography, McGill University.

Damania, A. B. (1994). "In Situ Conservation of Biodiversity of Wild Progenitors of Cereal Crops in the Near East." Biodiversity Letters 2: 56-60.

Denevan, W. M. (1970). "Aboriginal Drained-Field Cultivation in the Americas." Science 169: 647-654.

Denevan, W. M. (1971). "Campa Subsistence in the Gran Pajonal, Eastern Peru." The Geographical Review 61(4): 496-518.

Denevan, W. M., Ed. (1976a). The Native Population of the Americas in 1492. Madison, University of Wisconsin Press.

Denevan, W. M. (1976b). The Aboriginal Population of Amazonia. The Native Population of the Americsa in 1492. W. M. Denevan editor. Madison, University of Wisconsin Press.

Denevan, W. M. (1980). Swiddens and Cattle Versus Forest: The Imminent Demise of the Amazon Rain Forest Reexamined. Where Have All the Flowers Gone? Deforestation in the Third World. Williamsburg, Department of Anthropology, College of William and Mary.

Denevan, W. M. (1984). Ecological Heterogeneity and Horizontal Zonation of Agriculture in the Amazon Floodplain. Frontier Expansion in Amazonia. M. Schmink and C. H. Woods editors. Gainesville, University of Florida Press: 311-336.

Denevan, W. M. (1992). "The Pristine Myth: The Landscape of the Americas in 1492." Annals of the Association of American Geographers 82(3): 369-385.

Denevan, W. M. (1996). "A Bluff Model of Riverine Settlement in Prehistoric Amazonia." Annals of the Association of American Geographers 86(4): 654-681.

Denevan, W. M., and C. Padoch, Ed. (1987). Swidden-Fallow Agroforestry in the Peruvian Amazon. Advances in Economic Botany. New York, The New York Botanical Garden.

Eden, M. J., and A. Andrade (1987). "Ecological aspects of swidden cultivation among the Andoke and Witoto Indians of the Columbian Amazon." Human Ecology 23(3): 335-356.

Ericson, C. (2000). “An Artificial Landscape-scale Fishery in the Bolivian Amazon.” Nature:408: 190-193.

Ericson, C. (2001). “Pre-Columbian Roads of the Amazon.” Expedition 43(2): 21-30.

Food and Agriculture Organization (1994). Land degradation in south Asia: Its severity, causes and effects upon the people. Food and Agriculture Organization of the United Nations. Rome.

Fearnside, P. M. (1987). "Rethinking Continuous Cultivation in Amazonia." BioScience 37(3): 209-214.

Fearnside, P. M. (1988). "Jári at Age 19: Lessons for Brazil's Silvicultural Plans at Carajas." Interciencia 13(1): 12-24.

Fearnside, P. M. (1990). Predominant Land Uses in Brazilian Amazonia. Alternatives to Deforestation: Steps toward the Sustainable Use of the Amazon Rain Forest. New York, Columbia University Press

Fearnside, P. M. (1995). "A Conservation Gap Analysis of Brazil's Amazonian Vegetation." Conservation Biology 9(5): 1134-1147.

Fearnside, P. M., and J. M. Rankin (1985). "Jári Revisited: Changes and the Outlook for Sustainability in Amazonia's Largest Silvicultural Estate." Interciencia 10(3): 121-128.

Fernandes, F., C. P. Luft, F. M. Guimaraes (1952). Dicionario Brasileiro Globo. Sao Paulo, Globo.

Finley, J. P. and W. Churchill (1913). The Subanu: Studies of a Sub-Visayan Mountain Folk of Mindanao. Washington D. C., Carnegie Institution.

Frechione, J., D. A. Posey and L. F. da Silva (1989). The Perception of Ecological Zones and Natural Resources in the Brazilian Amazon: An Ethnoecology of Lake Coari. Resource Management in Amazonia: Indigenous and Folk Strategies. D. A. Posey and W. Balee, editors. New York, New York Botanical Gardens. 7: 260-282.

Gajaseni, J. and N. Gajaseni (1999). "Ecological rationalities of the traditional homegarden system in the Chao Phraya Basin, Thailand." Agroforestry Systems 46: 3-23.

Galvão, E. (1952). The Religion of an Amazon Community: a study in culture change, Columbia University.

Gascon, C. and T. E. Lovejoy (1998). "Ecological impacts of forest fragmentation in central Amazonia." Zoology 101: 273-280.

Gentry, A. H. (1993). A Field Guide to the Woody Plants of Northwest South America (Colombia, Ecuador, Peru). Chicago, The University of Chicago Press.

Gliessman, S. R., R. Garcia E., and M. Amador A. (1981). "The Ecological Basis for the Application of Traditional Agricultural Technology in the Management of Tropical Agro-Ecosystems." Agro-Ecosystems 7: 173-185.

Goulding, M. (1999). Introduction to the Section 1: Fish and Fisheries. Várzea: diversity, development, and conservation of Amazonia's whitewater floodplains. J. M. Ayres, C. Padoch, M. Pinedo-Vasquez, and A. Henderson editors. New York, The New York Botanical Garden Press: 3-6.

Goulding, M., N. J. H. Smith and D. J. Mahar (1996). Floods of Fortune: Ecology and Economy Along the Amazon. New York, Columbia University Press.

Gregor, T. (1977). Mehinaku: The Drama of Daily Life in a Brazilian Indian Village. Chicago, University of Chicago Press.

Hammond, D. S., P.M. Dolman, and A.R. Watkinson (1995). "Modern Ticuna Swidden-Fallow Management in the Colombian Amazon: Ecologically Integrating Market Strategies and Subsistance-Driven Economies?" Human Ecology 23(3): 335-356.

Harlan, J. R. (1975a). "Our Vanishing Genetic Resources." Science 188: 618-621.

Harlan, J. R. (1975b). Crops and Man. Madison, American Society of Agronomy and Crop Science Society of America.

Harlan, J. R. (1976). "Genetic Resources in Wild Relatives of Crops." Science 16: 329-333.

Heckenberger, M. J. (1996). War and Peace in the Shadow of Empire: Sociopolitical Change in the Upper Xingu of Southeastern Amazonia, A.D. 1400-2000. Doctoral dissertation. Department of Anthropology. University of Pittsburgh.

Heckenberger, M. J. (1998). "Manioc Agriculture and Sedentism in Amazonia: the Upper Xingu Example." Antiquity 72: 633-48.

Heckenberger, M. J., A. Kuikuro, U. T. Kuikuro, J. C. Russell, M. Schmidt, C. Fausto, and B. Franchetto (2003). "Amazonia 1492: Pristine Forest or Cultural Parkland?" Science 301: 1710-1714.

Heckenberger, M. J., J. B. Petersen, and E. G. Neves (1999). "Village Size and Permanence in Amazonia: Two Archaeological Examples From Brazil." Latin American Antiquity 10(4): 353-376.

Henrich, J. (1997). "Market Incorporation, Agricultural Change, and Sustainability Among the Machiguenga Indians of the Peruvian Amazon." Human Ecology 25(2): 319-351.

Hiraoka, M. (1985a). "Floodplain Farming in the Peruvian Amazon." Geographical Review of Japan 58 (Ser. B)(1): 1-23.

Hiraoka, M. (1985b). "Mestizo Subsistence in Riparian Amazonia." National Geographic Research Spring: 236-246.

Hiraoka, M. (1986). "Zonation of Mestizo Riverine Farming Systems in Northeast Peru." National Geographic Research 2(3): 354-371.

Hiraoka, M. (1992). Caboclo and Ribereno Resource Management in Amazonia: A Review. Conservation of Neotropical Rainforests: Working from Traditional Resource Use. K. H. Redford and C. Padoch editors. New York, Columbia University Press.

Howard, W. J., J. M. Ayres, D. Lima-Ayres, and G. Armstrong (1995). "Mamiraua: a case study of biodiversity conservation involving local people." Commonwealth Forestry Review 74(1): 76-79.

IBGE (1998). Base de Informações Municipais, Instituto Brasileiro de Geographica e Statística, São Paulo.

Inuma, J. C. (1999). Caraterizacão das Praticas de Manejo dos Sistemas Agroflorestais em Quintais pelos productores na Reserva de Desenvolvimento Sustentável de Mamirauá, Tefé (AM). Unpublished thesis. Manaus, INPA/UA.

Johnson, A. (1983). Machiguenga Gardens. Adaptive Responses of Native Amazonians. R. B. H. a. W. T. Vickers. New York, Academic Press: 29-63.

Jong, W. de (1996). "Swidden-Fallow Agroforestry in Amazonia: Diversity at a Close Distance." Agroforestry Systems 34: 277-290.

Junk, W. J. (1982). "Amazonian Floodplains: Their Ecology, Present and Potential Use." Rev. Hydrobiol. Trop. 15(4): 285-301.

Junk, W. J., J. J. Ohly, M. T. F. Piedade and M. G. M. Soares, Ed. (2000). The Central Amazon Floodplain: Actual Use and Options for a Sustainable Management. Leiden, Backhuys Publishers.

Kleinman, P. J. A., D. Pimentel, R. B. Bryant (1995). "The Ecological Sustainability of Slash-and-Burn Agriculture." Agriculture, Ecosystems and Environment 52: 235-249.

Lageras, P. (1996). "Farming and Forest Dynamics in an Agriculturally Marginal Area of Southern Sweden, 5000 BC to Present: A Palynological Study of Lake Avegol in the Smaland Uplands." The Holocene 6: 301-314.

Lanley, J. P. (1982). "Tropical Forest Resources." Food and Agriculture Organization of the United Nations, Rome, Forestry Paper 30.

Lathrap, D. (1968). “Aboriginal Occupation and Changes in River Channel on the Central Ucayali, Peru.” American Antiquity 33(1):62-79.

Lathrap, D. (1970). The Upper Amazon. New York, Praeger.

Lavelle, P. (1987). "Letters." BioScience 37(9): 639.

Le Cointe, P. (1947). Amazonia Brasileira III: Arvores e Plantas Uteis. Sao Paulo, Companhia Editora Nacional.

Lehtonen, H. and P. Huttunen (1997). "History of Forest Fires in Eastern Finland from the Fifteenth Century AD: The Possible Effects of Slash-and-burn Cultivation." The Holocene 7: 223-228.

Lima-Ayres, D. M. (1992). The Social Category Caboclo: History, Social Organization, Identity and Outsider's Social Classification or the Rural Population of an Amazonian Region (The Middle Solimoes). Unpublished dissertation. Social Anthropology, University of Cambridge.

Lima, D. M. (1999). Equity, Sustainable Development, and Biodiversity Preservation: Some Questions about Ecological Partnerships in the Brazilian Amazon. Varzea: Diversity, Development, and Conservation of Amazonia's Whitewater Floodplains. C. Padoch, J. M. Ayres, M. Pinedo-Vasquez, A. Henderson, editors. New York, The New York Botanical Garden Press. 13: 247-263.

Lima, R. M. B. (1994). Descricão, Composicão e Manejo dos Cultivos Mixtos de Quintal na Várzea da "Costa do Calderão", Iranduba, AM. Manaus, INPA/UA.

Lopinot, N. H. and W. I. Woods (1993). Wood Overexploitation and the Collapse of Cahokia. Foraging and Farming in the Eastern Woodlands. C. M. Scarry. Gainesville, University of Florida Press: 206-231.

Matlock (1997). "Four Centuries of Forest Clearance and Regeneration in the Hinterland of a Large City." Journal of Biogeography 24: 281-295.

Meggars, B. J. (1992). Prehistoric Population Density in the Amazon Basin. Disease and Demography in the Americas. J. W. V. a. D. H. Ubelaker. Washington D. C., Smithsonian Institution Press.

Milliken, B. (1992). "Tropical deforestation, land degradation and society." Latin American Perspectives 72(19): 45-72.

Moran, E. F. (1974). The Adaptive System of the Amazonian Caboclo. Man in the Amazon. C. Wagley. Gainesville, The University Presses of Florida: 136-159.

Moran, E. F. (1984). Colonization in the Transamazon and Rondonia. Frontier Expansion in Amazonia. M. S. a. C. H. Wood. Gainesville, University of Florida Press: 285-303.

Moran, E. F. (1993). Through Amazonian Eyes: The Human Ecology of Amazonian Populations. Iowa City, University of Iowa Press.

Nabhan, G. P. (1985). "Native American Crop Diversity, Genetic Resource Conservation, and the Policy of Neglect." Agriculture and Human Values 2: 14-17.

National Academy of Sciences (1972). Genetic Vulnerability of Major Crops. Washington D. C., National Academy of Sciences.

National Research Council (1982). Ecological Aspects of Development in the Humid Tropics. National Research Council, Washington D. C., National Academy Press.

National Research Council (1993). Sustainable Agriculture and the Environment in the Humid Tropics. National Research Council, Washington D. C., National Academy Press.

Oliveira, L. A., F. W. Moreira, N. P. Falcao, and V. S. G. Pinto (2000). Floodplain Soils of Central Amazonia: Chemical and Physical Characteristics and Agricultural Sustainability. The Central Amazon Floodplain: Actual Use and Options for a Sustainable Management. W. J. Junk, J. J. Ohly, M. T. F. Piedade and M. G. M. Soares, editors. Leiden, Backhuys Publishers.

Olsen, K. M., and B. A. Schaal (1999). "Evidence on the Origin of Cassava: Phylogeography of *Maniot Esculenta*." Proceedings of the National Academy of Sciences 96: 5586-5591.

Orejuela, J. E. (1992). Traditional Productive Systems of the Awa (Cuaiquer) Indians of Southwestern Colombia and Neighboring Ecuador. Conservation of Neotropical Forests: Working from Traditional Resource Use. K. H. Redford and C. Padoch. New York, Columbia University Press: 58-81.

Padoch, C. and W. Jong (1992). Diversity, Variation, and Change in Ribereno Agriculture. Conservation of Neotropical Forests. K. Redford and C. Padoch, editors. New York, Columbia University Press.

Padoch, C. and W. Jong (1991). "The house gardens of Santa Rosa: diversity and variability in an Amazonian agricultural system." Economic Botany 45(2): 166-175.

Padoch, C., J. C. Inuma, and W. Jong, and J. Unruh (1985). "Amazonian Agroforestry: a market-oriented system in Peru." Agroforestry Systems 3: 47-58.

Padoch, C., M. Pinedo-Vasquez, and J. C. Inuma (1996). Atividades Produtivas e de Manejo, para a Conservacão de Recursos e Incremento da Renda Familiar, na Reserva de Mamirauá. Tefé, Instituto de Desenvolvimento Sustentável Mamirauá.

Padoch, C. and M. Pinedo-Vasquez. (1999). Farming Above the Flood in the Varzea of Amapá: Some Preliminary Results of the Projeto Várzea. Várzea: Diversity, Development, and Conservation of Amazonia's Whitewater Floodplains. J. M. Ayres, C. Padoch, M. Pinedo-Vasquez and A. Henderson, editors. New York, New York Botanical Garden Press. 13.

Parker, E. (1985). The Amazon Caboclo: An Introduction and Overview. The Amazon Caboclo: Historical and Contemporary Perspectives. N. A. V. H. Sutlive, M. D. Zamora, V. Kerns. Williamsburg VA, Dept. of Anthropology, College of William and Mary.

Parker, E. P. (1989). A Neglected Human Resource in Amazonia: The Amazon Caboclo. Resource Management in Amazonia: Indigenous and Folk Strategies. D. A. Posey and W. Balee. New York, The New York Botanical Garden. 7: 249-259.

Pimentel, D., C. Wilson, C. McCullum, R. Huang, P. Dwen, J. Flack, Q. Tran, T. Saltman, and B. Cliff (1997). "Economic and Environmental Benefits of Biodiversity." BioScience 47(11): 747-757.

Pinedo-Vasquez, M., C. Padoch, and J. C. Inuma (1996). Identifying and Understanding Agricultural, Agroforestry and Forest Management Systems and Techniques Practiced in Mamirauá. Tefé, Sociedade Civil Mamirauá.

Pinedo-Vasquez, M., C. Padoch, and J. C. Inuma (1999). Change in the Agricultural Patterns of Communities and Households of the Mamirauá Sustainable Development Reserve. Tefé, Sociedade Civil Mamirauá.

Plucknett, D. L., N. J. H. Smith, J. T. Williams, N. Murthi Anishetty (1983). "Crop Germplasm Conservation and Developing Countries." Science 220: 163-169.

Pope, K. O., M. E. D. Pohl, J. G. Jones, D. L. Lentz, C. von Nagy, F. J. Vega, I. R. Quitmyer (2001). "Origin and Environmental Setting of Ancient Agriculture in the Lowlands of Mesoamerica." Science 292: 1370-1373.

Popenoe, W. (1920). Manual of Tropical and Subtropical Fruits. New York, Macmillan.

Porro (1994). Social Organization and Political Power in the Amazon Floodplain. Amazonian Indians from Prehistory to the Present. A. Roosevelt. Tucson, University of Arizona Press: 79-94.

Posey, D. A. (1981). Indigenous ecological knowledge and development of the Amazon. The Dilemma of Amazonian Development. E. F. Moran, editor. Boulder, Westview: 225-250.

Posey, D. A. (1985). Native and indigenous guidelines for new Amazonian development strategies: Understanding biodiversity through ethnoecology. Change in the Amazon. J. Hemming editor. Manchester, Manchester University Press: 156-181.

Posey, D. A. (1993). Indigenous knowledge in the conservation and use of world forests. World Forests for the Future: Their Use and Conservation. K. R. a. G. M. Woodwell. Binghamton, Yale University Press: 156.

Pratap, A. (2000). The Hoe and the Axe: An Ethnohistory of Shifting Cultivation in Eastern India. New Delhi, Oxford University Press.

Purseglove, J. W. (1968a). Tropical Crops: Dicotyledons 1. New York, John Wiley & Sons, Inc.

Purseglove, J. W. (1968b). Tropical Crops: Dicotyledons 2. New York, John Wiley & Sons, Inc.

Purseglove, J. W. (1972a). Tropical Crops: Monocotyledons 1. New York, John Wiley & Sons, Inc.

Purseglove, J. W. (1972b). Tropical Crops: Monocotyledons 2. New York, John Wiley & Sons, Inc.

Raffles, H. (1999). Exploring the Anthropogenic Amazon: Esturine Landscape Transformations in Amapa, Brazil. Varzea: Diversity, Development, and Conservation of Amazonia's Whitewater Floodplains. Padoch, C., J. M. Ayres, M. Pinedo-Vasquez, A. Henderson editors. New York. The New York Botanical Garden Press. Pp. 355-370.

Ribeiro, J. E. L. de S., M. J. G. Hopkins, A. Vicentini, C. A. Sothers, M. A. da S. Costa, J. M. de Brito, M. A. D. de Souza, L. H. P. Martins, L. G. Lohmann, P. A. C. L. Assuncão, E. da C. Pereira, C. F. da Silva, M. R. Mesquita, L. C. Procopio (1999). Flora da Reserva Ducke: Guia de Identificacao das Plantas Vasculares de Uma Floresta de Terra-firme na Amazonia Central. Manaus, INPA-DFID.

Roosevelt, A. C. (1980). Parmana: Prehistoric Maize and Manioc Subsistence along the Amazon and Orinoco. New York, Academic Press.

Roosevelt, A. C., M. L. Costa, C. L. Machado, M. Michab, N. Mercier, H. Valladas, J. Feathers, W. Barnett, M. I. da Silveira, A. Henderson, J. Silva, B. Chernoff, D. S. Reese, J. A. Holman, N. Toth, and K. Schick (1996). "Paleoindian Cave Dwellers in the Amazon: The Peopling of the Americas." Science 272(5260): 373-384.

Roosevelt, A. C., R. A. Housley, M. Imazio da Silveira, S. Maranca, and R. Johnson (1991). "Eighth Millennium Pottery from a Prehistoric Shell Midden in the Brazilian Amazon." Science 254(1621-1624).

Ross, E. B. (1978). "The Evolution of the Amazon Peasantry." Journal of Latin American Studies 10(2): 193-218.

Sauer, C. O. (1952). Agricultural Origins and Dispersals: The Domestication of Animals and Foodstuffs. Cambridge, MIT Press.

Schmink, M., K. H. Redford, and C. Padoch (1992). Traditional Peoples and the Biosphere: Framing the Issues and Defining the Terms. Conservation of Neotropical Forests: Working form Traditional Resource Use. K. H. R. a. C. Padoch. New York, Columbia University Press: 3-13.

Sociedade Civil Mamirauá (1996). Mamirauá Management Plan. Tefé, Sociedade Civil Mamirauá.

Serrão, E. A. S. and A. K. O. Homma (1993). Brazil. Sustainable Agriculture and the Environment in the Humid Tropics. National Research Council. Washington D.C., National Academy Press: 265-351.

Shorr, N. (1999). Agricultural Intensification in a Large Tikuna Community on the Floodplain of the Upper Brazilian Amazon. Unpublished dissertation. Anthropology, Indiana University.

Smith, N. J. H. (1980). "Anthrosols and Human Carrying Capacity in Amazonia." Annals of the Association of American Geographers 70(4): 553-566.

Smith, N. J. H. (1981). "Colonization Lessons from a Tropical Forest." Science 214: 755-761.

Smith, N. J. H. (1996a). Effects of Land-Use Systems on the Use and Conservation of Biodiversity. Biodiversity and Agricultural Intensification: Partners for Development and Conservation. Washington D. C., The World Bank.

Smith, N. J. H. (1996b). "Home Gardens as a Springboard for Agroforestry Development in Amazonia." International Tree Crops Journal 9: 11-30.

Smith, N. J. H. (1999). The Amazon River Forest: A Natural History of Plants, Animals, and People. New York, Oxford University Press.

Smith, N. J. H. (2002). Amazon Sweet Sea: Land, Life, and Water at the River's Mouth. Austin. University of Texas Press.

Smith, N. J. H., I. C. Falesi, P. de T. Alvim, and E. A. S. Serrão (1996). "Agroforestry trajectories among smallholders in the Brazilian Amazon: Innovation and Resiliency in Pioneer and Older Settled Areas." Ecological Economics 18: 15-27.

Smith, N. J. H., T. J. Fik, P. de T. Alvim, I. C. Falesi and E. A. S. Serrão (1995). "Agroforestry Developments and Potential in the Brazilian Amazon." Land Degradation & Rehabilitation 6: 251-263.

Smith, N. J. H., J. T. Williams, D. L. Plucknett, and J. P. Talbot (1992). Tropical Forests And Their Crops. London, Cornell University Press.

Srivastava, J. P., N. J. H. Smith and D. A. Forno (1999). Integrating Biodiversity in Agricultural Intensification: Towards Sound Practices. Washington D. C., The World Bank.

Stasi, L. C. di, E. M. G. Santos, C. M. dos Santos, C. A. Hiruma (1989). Plantas Medicinais na Amazonia. Sao Paulo, UNESP.

Steinberg, M. K. (1998). "Mopan Maya Forest Resources in Southern Belize." The Geographical Review 88(1): 131-137.

Sutlive, V. H., N. Altshuler, M. D. Zamora, and V. Kerns, Ed. (1985). The Amazon Caboclo: Historical and Contemporary Perspectives. Studies in Third World Societies. Williamsburg, Department of Anthropology, College of William and Mary.

Swales, S. (1999). Dynamics of Land Use and Agricultural Practices on the Uplands and Adjacent Flood Plain in the Lower Amazon. Doctoral dissertation. Gainesville. Department of Geography. University of Florida.

Turner, B. L., R. Q. Hanham, and A. V. Portararo (1977). "Population Pressure and Agricultural Intensity." Annals of the Association of American Geographers 67(3): 384-396.

Ugent (1986). "Archaeological Manioc (*Maniot*) from Coastal Peru." Economic Botany 40(1): 78-102.

UNESCO (1983). Swidden Cultivation in Asia. Bangkok, UNESCO.

Unruh, J. D. (1990). "Iterative Increase of Economic Tree Species in Managed Swidden-Fallows of the Amazon." Agroforestry Systems 11: 175-197.

Vasey, D. E. (1979). "Population and Agricultural Intensity in the Humid Tropics." Human Ecology 7(3): 269-283.

Vavilov, N. I. (1987). Origin and Geography of Cultivated Plants. Cambridge, Cambridge University Press.

Wagley, C. (1953). Amazon Town: A study of Man in the Tropics. Oxford, Oxford University Press.

Whitmore, T. C. (1990). An Introduction to Tropical Rainforests. Oxford, Clarendon Press.

Woods, W. I. (1987). Maize Agriculture and the Late Prehistoric: A Characterization of Settlement Location Strategies. Emergent Horticultural Economies of the Eastern Woodlands. W. F. Keegan, Center for Archaeological Investigations, Southern Illinois University. Occasional Paper No. 7: 275-293.

World Bank (1992). World Development Report: Development and the Environment. Oxford, World Bank.

Zandstra, H. G. (1993). Preserving the Options: International Research for Sustainable Agriculture. 13th Agricultural Sector Symposium, Washington D. C., The World Bank.

BIOGRAPHICAL SKETCH

Morgan Schmidt graduated from the University of North Dakota with a B.S. in geography (and a minor in space studies) in 1993. He pursued a wide range of interests as an undergraduate, including physical geography, environmental science, space science, geology, remote sensing, GIS, anthropology, and Chinese language. After graduation, he decided to postpone graduate school in order to travel. His travels eventually took him to the Brazilian Amazon where he decided to pursue a career in research and conservation.

In Manaus, Brazil, Morgan worked on several internships and taught English. The last job was at the Biological Dynamics of Forest Fragments Project jointly sponsored by the Smithsonian Institute and the National Institute for Amazon Research. He worked as part of a NASA/LBA team to set up a GIS laboratory and begin to incorporate data into a GIS from the previous 20 years of the project. He left this job to enroll in a Ph.D. program in geography at the University of Florida.

After finishing masters research, Morgan became involved in an ethno-archaeology project in the Upper Xingu of southeastern Amazonia, Mato Grosso, Brazil. His dissertation research examines the formation and distribution of anthrosols and how they can contribute to an understanding of prehistoric complex society and land use in the region.