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AS THE FOREST FALLS:
THE CHANGING USE, ECOLOGY AND VALUE OF NON-TIMBER FOREST RESOURCES FOR CABOCLO COMMUNITIES IN EASTERN AMAZONIA

A thesis submitted for the degree of
Doctor of Philosophy
in Ecology

by
Patricia Shanley

The Durrell Institute of Conservation and Ecology
The University of Kent, Canterbury, Great Britain

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by
Patricia Shanley

I have never planted a field here; I am guarding this tract.

There are piquiá in the forest,

I am saving them for my children and grandchildren.

Sr. Braz, Capimense Elder

ABSTRACT

The rapid transformation of the Brazilian Amazon through expanded logging, ranching and fire has left in its wake an impoverished resource base for large numbers of forest-dependent peoples. How current changes in land use may affect the density and distribution of widely used fruit, medicinal, fiber and game species is not known. Also unknown is how the use, management and value of forest products may change in response to the changing structure and composition of forests.

Although economic studies have demonstrated that the value of non-timber forest products can exceed that of timber, many Amazonian smallholders live in areas of low-density economic species, with long distances to market, and in regions undergoing logging, ranching and fire. The lack of locally relevant data and the rapid expansion of the timber industry in Amazonia has meant that many Amazonian communities sell trees for scant sums, without fully understanding the relative value of those forests' timber and nontimber resources.

In this dissertation the use, ecology and value of non-timber forest resources in a rapidly changing frontier area along the Capim River region in eastern Amazonia are examined. The six-year ecological study focused on three fruiting species, which had received scant prior study: *Caryocar villosum* (Aubl.) Pers., *Endopleura uchi* Cuatrec. and *Platonia insignis* Mart. Findings indicate that they exist in low densities, have complicated phenological cycles, undergo extreme variations in annual yield, and are widely consumed by humans and wildlife. At present, these fruiting species, as well as twelve of the most highly valued medicinal oil and game attracting species, are consumed by the timber industry, thus posing detrimental consequences to the health and nutrition of *caboclo* communities in the study region.

Results also demonstrate that in selectively logged forests, the subsistence value of non-timber forest resources can be substantial; that the most valuable non-timber forest products, fruit and game, are not destined for regional, national or international sale; that even in high biodiversity, low density *terra firme* forests, the net present value of NTFPs can exceed that of timber; and that, in spite of this comparatively higher value, non-timber species of substantial worth are currently being extracted for their timber. Findings underscore that there is a critical limit to the volume of timber that can be extracted from forests, after which present and future harvests of non-timber resources plummet. Results also suggest that women's participation in land-use decisions positively effects forest management.

Taken together, these findings question the common assumption that sale of non-timber forest products is possible and/or desirable for all rural communities. Instead, results highlight the need for increased forest extension to assist communities to weigh the costs and benefits of logging; to negotiate for just benefits; and to promote forest management that includes NTFPs for subsistence use and occasional sales. Findings also suggest that, for the benefit of domestic economies, policy makers need to address the interface of non-timber forest resources and timber extraction.

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Generous support to undertake the long-term field and development work on which this dissertation was based was secured from The Merck Foundation, The Biodiversity Support Program of the World Wildlife Fund, USAID/GCC - Global Climate Change Program, The Education Foundation of America, The Earth Love Fund, The Yew Tree Gallery, The Rainforest Alliance Catalyst Grants Program, PROWID, The International Center for Research on Women (ICRW), The International Union for the Conservation of Nature, Netherlands and The Rufford Foundation.

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Economic analysis of timber vs. non-timber forest benefits in Chapter Seven was carried out in collaboration with economist Sven Wunder of IPEA in Rio de Janeiro. The work of Tony Cunningham regarding the ecology of medicinal plants provided an inspirational example. I sincerely thank Ian Swingland, Nigel Leader-Williams, Chris Uhl, Douglas Daly, James Grogan, Margaret Cymerys, Paulo Moutinho and Hugh Raffles for taking time to carefully read and comment upon various chapters. An enormous debt of gratitude goes to Professor Sir Ghillean Prance, Sarah Laird and Christopher Barr, who persevered in wading through and commenting on each of the chapters.

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Timber sales leave us without fruit, game, vines and medicinal plants.
We have no wood even to make shingles.
Every timber deal has left us poorer.

Antoninho, Capim River region

CHAPTER ONE
VALUING NON-TIMBER FOREST RESOURCES: PROTECTING BIODIVERSITY FOR LOCAL USE

INTRODUCTION

Spanning 3.7 million square kilometers (Pires 1972, Daly and Prance 1989), the Brazilian Amazon contains over 30% of the world's remaining tropical forest (Schwartzman and Kingston 1997, Mittermeier 1988). Among the most diverse ecosystems on earth, Amazonian rain forests are thought to support roughly 50% of all species on the planet (Wilson 1988). However, over the last three decades, Brazil's ever-expanding logging industry, ranching, and fire have destroyed intact forests, transforming them to explored primary forest and scattered patches of secondary growth (Cochrane et al. 1999, Martini et al. 1994, Uhl et al. 1993, Veríssimo et al. 1992, Nepstad et al. 1991, Uhl et al. 1988).

Transformation of the Amazon's forest has both global and very local consequences. On the global level, the large-scale loss of forest cover in Amazonia is believed to have major implications for long-term trends toward global warming. The rapid loss of native flora and fauna may cause irreversible and as yet, largely unknown, breakdowns in ecosystem functioning. Decline in biological diversity may also signal the irretrievable loss of medicinal plants with potential pharmaceutical value. Notably, while such global consequences are granted profuse attention, local consequences of biodiversity loss to Amazonians living within tropical forests are given bare notice.

At the local level, the rapid transformation of the region's landscape has left in its wake an impoverished resource base for large numbers of Brazil's forest-dependent peoples. In this new landscape, many of the forest plants and animals which they utilized at home and others that they bring to market are declining in number. How current changes in land use may affect the density and distribution of widely used economic species is not known. Also unknown is how the management and utilization practices by forest-based communities may change in response to the changing structure and composition of forests.

In the tropical Americas and elsewhere, non-timber forest products (NTFPs) have long been ignored or undervalued by government policy makers, private sector businesses, and scientific researchers, many of whom have directed the bulk of their attention toward wood-based forest products (Falconer 1990). As a result, the economic significance of NTFPs is poorly documented and relatively little information exists concerning the ecology, use and management of even the most widely utilized non-timber forest species (Peters 1996). Since the mid-1980s, however, strategies to slow deforestation and to restore degraded areas (Uhl et al. 1997) have endorsed the expanded management and/or marketing of non-timber forest products. The basic rationale for the focus on NTFPs is that most forests have a multitude of resources - including fruits, vines, resins, barks, roots, nuts, and game - the existence of which depends upon intact forest ecosystems. As far as economic value can be assigned to these products, an argument can be made that the relative value of keeping trees standing is greater than the profits to be gained by harvesting their timber.

Over the last decade, a considerable body of literature has emerged documenting the use of a range of non-timber forest resources. Quantitative ethnobotanical inventories (Phillips and Gentry 1993, Milliken et al. 1992, Pinedo-Vasquez et al.1990, Prance et al. 1987) and research into the population ecology of various economic species (Peters 1990, Peters and Hammond 1990, Phillips 1990) have begun to provide critical information needed to assess forest composition and the feasibility of product extraction. Economic studies have elucidated the potential monetary benefits of NTFP extraction (Wollenberg and Ingles 1998, Clay and Clement 1993, Balick and Mendelsohn 1992, Plotkin and Famolare 1992, Peters et. al. 1989), demonstrating that in some contexts, income revenues from NTFPs can well exceed those of timber.

However promising financial projections may seem, the conclusions generated from many economic studies have been of little direct use to the vast majority of Amazonian communities that are under daily pressure to sell their forests to logging, ranching, or mining interests. Not only are scientific results rarely "given-back" to the communities where they were collected, but, being a relatively new body of research, the studies also suffer from some fundamental ecological and economic biases (Arnold and Ruiz Peréz 1996, Falconer 1996, Browder 1992, Pendleton 1992). Two common ecological biases are the following: one, NTFP studies demonstrating substantial economic returns in Amazonia have been conducted in forests with relatively high densities of economic species (i.e. oligarchic forests, *várzea*, extractive reserves) (Peters et al.1989, Mori 1992, Anderson and Ioris 1992). In many parts of the

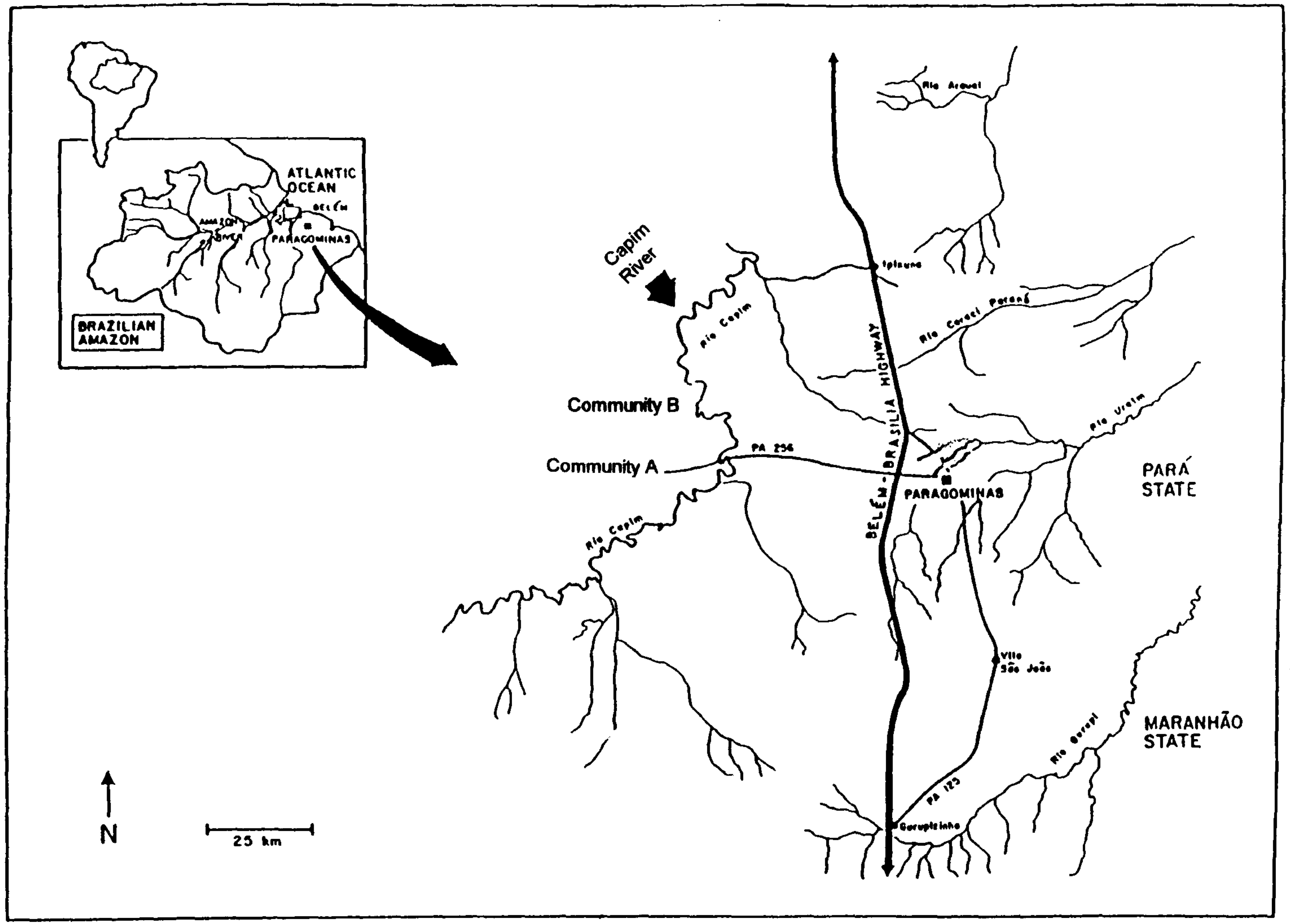
Amazon, however, forest-dependent communities inhabit ecosystems that have exceedingly high levels of floristic diversity and low densities of any one species (Phillips 1993, Browder 1992, Pendelton 1992). Secondly, many NTFP studies are based on production or utilization data that has been collected over a fairly limited time frame. Due to the lengthy, uneven phenological cycles of tropical trees, however, some species show extreme variations in yield from one season to the next, generating substantial differences in economic value when assessed over time.

In addition to ecological biases, many NTFP studies are subject to three common economic biases. First, they often highlight a few nationally or internationally traded commodities rather than the multitude of lesser-known, locally valued forest resources such as tree resins, forest fruits, larvae or game (Godoy 1992, Padoch 1988). Secondly, examples of successful NTFP extraction are often set in communities with close proximity to markets. By contrast, less attention has been given to the subsistence value of non-timber forest resources for Amazonian peoples, particularly those who have little or no access to markets (Padoch 1987). Finally, many frequently cited studies report on the "potential" economic value of NTFPs (Padoch and Pinedo-Vasquez 1996, Balick and Mendelsohn 1992, Peters et al. 1989) and while these studies have been extremely useful in illustrating the promise of non-timber forest resources, the results can overshadow the substantial reasons why many forest communities market few if any NTFPs.

The lack of locally relevant data and the rapidly changing value of timber resources in Amazonia, has meant that many Amazonian communities are making fundamental decisions about whether their forests will stand or fall without fully understanding the relative value of those forests' timber and non-timber resources. The research under which this dissertation is based was initiated in January 1992 in response to a request for assistance from the Rural Workers of Paragominas, representing smallholder communities along the Capim River in the state of Pará, eastern Brazil (Fig. 1.1).

Pará belongs to the "belt of deforestation" that has penetrated the southern Amazon states of Brazil. In the 1970s, it was the first state to experience massive deforestation, following strong fiscal subsidies for cattle ranching and the construction of the Belém-Brasília highway (BR-010). The fringes around the constructed roads were colonized relatively early, while the Capim River, a tributary to the Amazon, running inland parallel to the BR-010, is a new frontier area. Residents of communities along the Capim River have been under considerable pressure to sell their logging rights and/or land to logging companies and ranchers since the 1980s.

Figure 1.1. Map of the study region



Origin of the current research

Currently, the Capimenses face not only external pressures from loggers, ranchers and miners but also internal pressures of increasing human population growth, impoverished soils and declining populations of game and fish. In the early-1990s, a few hundred Capimenses families who had lived for several generations along a 15 km stretch of the river became concerned about the loss of locally valued species. Residents of these communities complained of a decline in useful plants and animals; longer travel times to obtain resources; and increased difficulty in collection. Many attributed these changes to the loss of forest cover brought about by the timber and ranching industries.

In an effort to stem the loss of game and locally valued tree species, Capimenses began searching for means other than the sale of trees to gain cash. At the outset of this study in 1992, few forest products other than timber were marketed from villages in the study region. Cash was derived from agricultural commodities, which principally included *farinha* (a cassava-based flour), banana, corn, rice and squash. Although agricultural extension offered by the Rural Workers' Union of Paragominas in the late 1980s and 1990s helped villagers to increase agricultural yields, such assistance did not address the communities' underlying problems stemming from timber extraction and forest degradation.

In the wake of rapid impoverishment of their resource base, the Capimenses and representatives of the Rural Workers' of Paragominas began to question the costs and benefits of logging and to consider whether there might be forest management alternatives to logging in which forest products other than timber could be marketed. Lacking sufficient technical knowledge of forestry, they began searching for collaborators. In 1991 William da Assis, the Union's extensionist, contacted the author who, at the time, was examining the role of economic species in the conservation and restoration of forests and degraded areas with The Woods Hole Research Center.

Field visits to the Capim communities and conversations with the Rural Worker's Union made it clear that the effort to seek sustainable forest management alternatives would require a team approach combining both local expertise and formally trained scientists. Therefore, over the next year, a research team was formed composed of Capimenses, a field trained Brazilian forester, Leda Luz, a wildlife biologist, Margaret Cymerys, and research assistant Jurnadir Galvão.

Cymerys' wildlife expertise and Luz's prior experience working with forest-based communities was fundamental in the research design, data collection and analysis described in Chapter Six. Luz also collected data for the Belém market study described in Chapter Four, while Galvão was instrumental in helping organize and collect data for the fruit production study (Chapter Five). The long-term experience of Museu Goeldi's botanist Nelson A. Rosa was critical during field work and follow-up plant identification for the one-hectare ethnobotanical inventory described in Chapter Three. Economic analysis in Chapter Seven was conducted in collaboration with economist Sven Wunder of IPAE, Rio de Janiero. The entire research team collaborated in sharing research results with communities.

During the first meeting with the community, the straightforward questions they posed included the following: "Are there other [i.e., non-timber] forest resources we might sell in lieu of timber?" and "Are the resources we lose from logging more valuable to us than the cash we get from selling our trees?"

Unbeknownst to the Capimenses, the questions they raised regarding the potential marketability of non-timber forest products were concurrently being posed by the international conservation community. Internationally, the NTFP conservation/development strategy was gaining wide acceptance. Might it work locally in the Capim?

OBJECTIVES

This research project sought to examine how the use and management of non-timber forest resources might contribute to conservation and development efforts within a selectively logged, *terra firme* forest in a frontier region of eastern Amazonia. The research was designed to document the present contribution of non-timber forest resources to *caboclo* livelihoods; to assess the comparative value of timber and non-timber forest resources; and to determine whether key non-timber forest resources from selectively logged *terra firme* forests could be sustainably managed and profitably marketed.

A central objective of the study was to provide information for local people in ways that they cold use. This was due to the fact that rapid forest transformation was contributing to detrimental, potentially life-threatening changes for forest-based communities. This objective influenced choice of research and analytic techniques.

This dissertation addresses five principal questions. First, within *terra firme* forests, how significant is the subsistence value of non-timber forest resources? Which species are most highly valued and where do they occur? Second, what effect does the escalating extraction of timber species have on the abundance and accessibility of non-timber forest resources? Third, how does the subsistence value of forests compare with the value of trees as sold for timber? Fourth, do the ecological characteristics of *terra firme* forests (i.e. low density of economic species, inconsistent fruit production and consumption of fruit by animals) limit the viability of marketing fruit? Fifth, can forest extension efforts utilizing ecological and economic research data effectively assist such communities in the conservation and management of locally valuable forest resources?

To answer these questions, the research was undertaken with the following objectives:

1) To describe the composition of forests in the Capim river basin and to identify the species of commercial and subsistence value to the region's *caboclo* communities;
2) To characterize the density, distribution and size-specific fruit production of *Caryocar villosum* (Aubl.) Pers., *Endopleura uchi* (Huber) Cuatrec. and *Platonia insignis* Mart. during a five-year period;
3) To assess the subsistence value of NTFPs to one community by recording the total volume of fruit, fiber and game harvested over the course of one year, and to compare this volume with the level of consumption after three selective logging events six years later;
4) To calculate the net present value of non-timber forest resources utilized by one household in one hectare over the course of six years and to compare this with the value of the hectare if sold for its timber; and
5) To convey the ecological and economic data generated to *caboclo* communities, while documenting any changes in forest management.

The research was conducted over a six-year period in two communities along the Capim River and markets in Paragominas and Belém. The upriver community (community A) is situated 4–5 km inland from the Capim River and over 110 km from Paragominas. A small part of a larger community, the village consists of only a dozen families scattered throughout the forest, many living beside a stream flowing into the Capim. The 1-ha ethnobotanical inventory (Chapter Three) and the economic valuation in Chapter Seven were conducted in this village. Strong support and assistance from the family living near the hectare plot made the study possible.

The second study community (community B) is located 15 km downriver from community A and consists of three adjacent villages, totaling approximately 4000 hectares where over fifty households reside. In this larger community many homes sit directly alongside the bank of the Capim, while others are situated inland, scattered throughout the forest and close to swidden fields. Data for the ecological study described in Chapter Five and the study of fruit, fiber and game consumption by 30 families (Chapter Six) were collected in this community.

Data collection involved a variety of methods including ethnobotanical inventories, market and household surveys, mapping of economic species, fruit production studies, daily diaries of forest product consumption, participant observation, and semi-structured interviews. Results of the research are presented in the following eight chapters, each chapter focusing on a different aspect of the ecology, use and value of non-timber forest resources.

SUMMARY OF CHAPTERS

First, to understand the historical and cultural context of the study, Chapter Two describes the Amazon basin, its inhabitants and their early trade in timber and non-timber forest products.

Next, to answer the primary question posed by the Capim communities, (can we profitably sell NTFPs in lieu of timber?) it would appear that a rapid ethnobotanical inventory and market study could suffice. These alone, however, would not provide adequate information concerning the long-term economic or ecological consequences of the sale of NTFPs. To answer the question with a view to long-term sustainability, it would be necessary to collect detailed ethnobotanical, economic and anthropological information.

At the project's beginning, no floristic inventory had been conducted in the Capim region, no ecological data existed on locally valued non-timber forest products, and no documentation was available on the utilization patterns of NTFPs by Capimenses.

Therefore, as a first step in the research, it was essential to document the floristic composition of the region and to identify species with high use-values. Chapter Three describes the methods and the results of an ethnobotanical inventory of one-hectare of *terra firme* forest. It provides a description of forest use within a rapidly changing environment. The inventory was undertaken with the objective of selecting promising non-timber forest species and exploring their potential for marketing and community development.

Chapter Four moves from the forests of the Capim region, a couple hundred kilometers downriver (north) to the principal port city of eastern Amazonia, Belém. Here, promising forest resources identified in the Capim forests were surveyed in the marketplace to learn about their prices, volumes and sources. Due to their relative abundance and market potential, fruit and medicinal species were the primary focus of this survey, while fiber and game products received less attention.

Once promising species were identified, it was necessary to know how much of the resource was available in the forest. Determination of sustainability for long-term harvest and sale required basic ecological information. In what densities and distributions do promising species occur? How much fruit do they produce? What is their size-class distribution? Among the species of greatest value to the Capimenses, little ecological information of this nature was available. Chapter Five answers these questions. In-depth descriptions are given of the methods and the results of studies measuring density, size-class and size-specific fruit production of *Caryocar villosum*, *Endopleura uchi* and *Platonia insignis*. Due to the extreme irregularity of annual fruit production, production studies were carried out over five fruiting seasons (five years).

After having generated initial market and ecological data on the species of interest, it was then theoretically possible to conclude the research by recommending sale of species occurring abundantly in Capim forests that were also in high demand in local markets. However, prior to making such a recommendation, another critical piece of information was missing — indeed, one that is too infrequently pursued. How are NTFPs used locally? What types and what volumes of products are used by Capimenses? What role do non-timber forest resources have in household nutrition and economics? As logging, ranching, and fire degrade forests throughout the region, do sufficient resources exist for community consumption?

Although overshadowed by the attention that is currently being given to the commoditization of NTFPs, subsistence use of non-timber forest products is essential to the daily livelihoods of the majority of the world's rural population. Compared to products with an international market, locally consumed and traded goods represent a very different and often unknown suite of species. For example, while international attention highlights the use of medicinal plants to heal diseases of the developed world, the non-timber forest products most valued by many rural inhabitants of the Capim region are game animals such as paca, armadillo and large rodents.

Few economic analyses, however, adequately assess the value of subsistence products; and even fewer address the combined economic value of floral and faunal resources (Godoy and Lubowsky 1992, Melnyk 1995). Despite the inherent difficulties in measuring the economic value of these resources when they are consumed rather than sold, an attempt was made to quantify the financial value of subsistence use of non-timber forest resources within one of the study communities. To this end, the types and volumes of non-timber forest resources used by thirty households over a period of one year were measured. The contribution of NTFPs to annual household income was estimated by determining the average annual market value of NTFPs consumed, and comparing this to average annual agricultural income. To understand the impact of logging on the abundance and use of NTFPs, six years later, after three additional timber sales and accidental fire, interviews were conducted with members of the original households. Data were collected on the type and volume of game, fruit and fiber consumed in 1998-1999 and compared to the volumes of these resources as consumed in 1993-1994. Detailed methods and results of this study are presented in Chapter Six.

One flaw with many NTFP utilization studies, is that they are conducted in the "present tense" — that is, they measure the production and use of non-timber forest products at one point in time (de Beer and McDermott 1989). Tropical forest ecosystems, however, often show extreme variations in fruit production from one day, month, or year to the next. This, in turn, can have a very direct effect on the volume of forest products that a household or community consumes at any given time. For example, in 1993, one piquiá (*Caryocar villosum*) tree produced close to one thousand fruits; in 1994 the same tree produced no fruit. The family living beside that tree enjoyed eating hundreds of piquiá in 1993 and none in 1994 Furthermore, because piquiá flowers are a potent game attractor, fifteen kilograms of game were captured beneath the tree in 1993, which contributed quite significantly both to the economic value of the tree and the nutritional well-being of the family.

Clearly, data describing NTFP consumption and economic value are a function of the fruiting and flowering phenology of a species response during a particular time period. Due to time and cost constraints, however, few studies of NTFP use and value have been designed to gather longitudinal data. In this study, one family's use of fruit, fiber, game and medicinal plants collected from one-hectare was measured over a six-year period. The results of this longitudinal study, which are discussed in Chapter Seven, afford a close look at the inconsistencies of fruit production and the resulting effects on household consumption. In addition, they make it possible to compare the net present value of NTFPs used on one hectare for six years versus the potential financial value accruing from the same hectare in the event it were logged.

Had they simply been reported in the chapters outlined above, the results of this study would have been of little use to the communities that had posed the initial questions driving the research. To ensure that the research project itself was not an "extractive" activity, and to concretely address the forest management dilemma facing the Capim communities, a multi-faceted strategy was developed to "give-back" the results to the people of the region in which the data had been collected.

First, the results of the study were "translated" into posters, maps and charts and shared with residents of the *caboclo* villages in which the team had worked. In the Capim, a living library was created in the area of the forest inventory and "forest value" theater and workshops were held to present relevant findings. To share the results with rural communities in a wide geographic area outside of the Capim, an illustrated booklet on medicinal plants and another on the ecology, use and management of native fruit trees were produced and disseminated. Chapter Eight describes the educational and extension programs that have grown out of the research project, focusing on how results have been disseminated and "translated" for rural *caboclo* communities and urban residents, alike.

Chapter Nine summarizes the same results for a different audience, the international scientific community. The dissertation concludes with a list of findings and recommendations for natural and social scientists, conservationists, policy makers, and educators.

Like this they exterminated in Pará one of the most beautiful, brave, and valiant tribes of Brasil. ....yet on this river today there still exists a relic of this tribe in the nation of the Tembés.

Barbosa Rodrigues 1875

CHAPTER TWO
A PHYSICAL, CULTURAL AND HISTORICAL OVERVIEW OF THE CAPIM RIVER BASIN

PHYSICAL DESCRIPTION

The geological history and hydrology giving rise to the Amazon region contributed to the evolution of great floristic and vegetational diversity. Although the region often appears to be physiognomically uniform, considerable environmental and phytogeographic variations exist (Pires and Prance 1985). For practical purposes, two principal vegetation types are recognized: *terra firme* (upland dry forest) and *várzea* (inundated forest). In addition to these primary distinctions in vegetation, however, many different types exist which differ in biomass, structure and composition; (i.e. liana forest, dry forest, open forest, and savanna) (Pires and Prance 1985).

The easternmost state of the Brazilian Amazon, Pará, covers 1.25 million square kilometers and is largely (82%) forested (Veríssimo et al. 1997). Annual rainfall ranges from 1,500 mm in the south of the state to 4,000 mm along the estuary of the Amazon with less frequent rain occurring from June to November. Most of the region consists of slightly undulating hills ranging from 100 to 300 meters in elevation, although *várzea* flood plains occur along the Amazon river and its tributaries. These flood plains, which cover approximately 6% of the state's land area, are characterized by fertile, well-drained soils.

As in much of Amazonia, the majority of Pará's landscape is composed of upland, *terra firme* forest. In this environment, great age, leaching, erosion, high temperatures and precipitation contribute to the impoverishment of soils. The deeply weathered clay soils in eastern Amazonia developed on a Pleistocene terrace cut into the Belterra clay and Tertiary Barreiras formations (Clapperton 1993, Sombroek 1966). These soils are predominantly (75%) oxisols and ultisols characterized by high acidity and low chemical fertility. They are of limited agricultural utility as they are deficient in key nutrients (phosphorus, nitrogen, potassium, calcium, magnesium and many micro nutrients) have low exchange capacity; and are subject to high levels of rainfall that promotes leaching. The vast majority of nutrients necessary for plant growth are stored not in the soil, but in the biomass itself.

Although the state of Pará is still largely forested, it is estimated that approximately 12% of the state's land area had been deforested by 1990 (IBGE 1993). Accelerated rates of deforestation in Pará have been caused by recent waves of cattle ranching (Hecht 1985), logging (Stone 1997, Veríssimo et al. 1992, Uhl et al. 1991) and associated fire (Cochrane et al. 1999, Nepstad et al. 1999, Uhl and Kauffman 1990). In the 1960s and 1970s, new roads penetrated interior forests opening the way for ranchers to clear the large expanses of land necessary to capture subsidized loans and credits. Cattle ranching became the leading land use of Brazilian Amazonia, occupying 85% of cleared land (Hecht and Cockburn 1990). Environmentally unsuited for Amazonia and lacking ongoing subsidies, ranching revenues plummeted in the 1980s, shifting the economic hopes once placed on beef to timber (Uhl et al. 1991). This, in turn, resulted in the exponential growth of the region's timber industry. Between 1970 and 1982, the number of sawmills operating in the Brazilian Amazon shot up from 300 to 1,639 (Rankin 1985).

Due to the availability of transportation, energy and communications systems, eastern Amazonia became the principal hardwood-processing center in Brazil (Veríssimo et al. 1992). At present, approximately 90% of the timber extracted in Pará is used within Brazil (FAO 1994), and domestic demand for wood has risen 10-fold in the last 50 years (Veríssimo et al. 1997). It is likely, however, that the country's timber exports will soon increase, as international demand for wood products is forecasted to rise sharply over the coming decades, particularly as Asian timber stocks decline (Barbier et al. 1992, Skole and Tucker 1993). With this growth in timber exports, Brazil's forestry sector is likely to have an enormous impact on the future development of the Amazon (Stone 1997).

CULTURAL DESCRIPTION AND HISTORY OF THE RESEARCH SITE

The Capim River is a tributary of the Amazon flowing roughly 600 miles northward from its southern headwaters in the state of Pará to the city of Belém. Until 1874, the Capim River basin remained largely unexplored and undocumented by colonial historians. At that time, naturalist João Barbosa Rodrigues was commissioned by the Imperial General of Pará to ascend the river and to document its geography, history and ethnography. Although Alfred Wallace had navigated parts of the river 50 years before, Barbosa Rodrigues disappointedly reported that Wallace's descriptions focused largely on lepidopteras (Barbosa Rodrigues 1875).

Barbosa Rodrigues described the Capim river basin as having been one of the Amazon tributaries to which Indian tribes fled after having been attacked and captured to be used as slave labor by the Portuguese (Barbosa Rodrigues 1875). Attempting to escape hostile settlers, indentured servitude and decimating disease, Indians migrated to interior forests from the late 17th through the 19th Centuries.[1] Although Barbosa Rodrigues encountered Tembé along the Capim, he related that the majority of Indian tribes had already been forced out by the time he visited the area.[2] Barbosa Rodrigues was especially struck at one elevated site along the river which had formerly been cultivated, where he found ceramic fragments and stone axes of a form he had never before encountered. Describing the annihilation of the tribe that had created these tools, the Tupinambas, Barbosa Rodrigues wrote, "Like this they exterminated in Pará one of the most beautiful, brave, and valiant tribes of Brasil. Yet on this river today there still exists a relic (of this tribe) in the nation of the Tembés" (Barbosa Rodrigues 1875).

Although the Tembés resisted acculturation during the 18th and 19th centuries, they too fled from the Capim river basin. The Capim region became gradually settled by former Afro-Brazilian slaves and detribalized Amerindians seeking new territory for the exploitation of wood, game and fish. Emerging from the detribalization of Amerindians and the subsequent syncretization of African, Portuguese, and Indian peoples, the term *caboclo* has become used to describe the disenfranchised populations of mixed descent inhabiting the flood plains and *terra firme* regions of the Brazilian Amazon (Parker 1989).[3]

During the period of Portuguese settlement and expansion, the land was owned exclusively by colonels of the state and the Catholic church. Through a system of debt servitude, government and church officials required local peoples to provide them with tribute in the form of timber, fish, game and agricultural produce. When religious and then state control eventually waned along the Capim, *regatões* (river

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[1] Transformation of Amerindians began taking place during the early settlement period (1600 - 1655), when indigenous groups were used as labor. It continued through the years of Jesuit dominance in Amazonia (1655-1755), when Amerindians were converted from subsistence to commodity producers, and under the rule of the Directorate (1755-1799), which developed a set of regulations to convert Amerindians and to make them full members of Portuguese society (Parker 1989).

[2] Rodrigues' account also indicated the presence of the Ka'apor living in the Capim River basin (Balée 1994).

[3] After losing to the state, the peasant leader of the Cabanagem revolt (1835), Eduardo Angelim, is reputed to have journeyed to the upper reaches of the Capim River to seek refuge while under protection of Indians (Hurley 1936, Raiol 1970 cited in Balée 1994).

boat traders that trade market goods for forest and agricultural products in a characteristically exploitative fashion) assumed power over the local population, increasing the extraction of timber. By the mid-20th Century, population pressure and the level of exploitation increased to such an extent that scarcity of fish, game and timber forced families to migrate upriver toward intact forest. It was at this time, prior to the founding of Paragominas, that *caboclos* first arrived along the Capim river and settled in what is now the outskirts of the city (Figueiredo et al. 1994).

During the period 1950-1970, families continued moving upriver in search of game and abundant timber, principally freijo (*Cordia goeldiana* Hub.) and cedro (*Cedrela odorata* L.). Because *regatões* still represented the sole link to urban centers, agriculturists remained dependent on them. In the late 1950s only a few families lived in the Capim river communities under study (Figueiredo et al. 1994). By 1967 there were 11 communities of agriculturalists along the margin of the Capim river in the proximity of Paragominas (Figueiredo et al. 1994). During the six-month rainy season they worked upriver extracting timber; and during the dry season they returned downriver to work in agricultural plots with their families.

During the 1960s and 1970s, a greater number of independently owned trading boats began plying the river seeking a wider range of timber. The increased exploitation of a variety of species offered locals a chance to extract logs from an area for a longer period of time, thereby enabling them to stay fixed in one locale with their families. Once settled, the population in the principal Capim communities grew steadily. By 1977, 37 families and 66 families lived in the two main study communities (Figueiredo et al. 1994).

In addition to carrying goods to barter with *caboclos* for timber and game, trading boats occasionally brought priests. In the early 1970s, the Catholic Church became active in the communities, initiating religious education, training village leaders and catalyzing the religious founding of various communities (Figueiredo et al. 1994).[4]

During this period, smallholder communities along the Capim began to stabilize and to establish informal ownership of land. At the same time, however, national government policies designed to promote occupation of the Amazon began a process leading to the political, social and ecological transformation of the region

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[4] In the Capim communities today, the presence of the Church remains: participation in Sunday masses is strong; priests make biennial visits to communities to perform christenings and marriages; and an agricultural cooperative in Paragominas has been partially financed by the church.

(Hecht 1985, Bunker 1985). In response to heavy government subsidies, ranchers arrived in the region in the 1960s and 1970s expropriating and deforesting thousands of hectares of land, some of which was already occupied by *caboclo* families. Although families united to defend their land, only 2 of the 11 communities along the river in the vicinity of Paragominas survived (Figueiredo et al. 1994).

RECENT DEVELOPMENTS IN THE CAPIM REGION

During the 1980s and 1990s, deforestation escalated markedly in many parts of Pará, including the Capim river basin. Through this period, ranchers and logging companies aggressively moved into the state in response to declining timber stocks in the distant south of Brazil and new government policies promoting occupation of Amazonia (Uhl et al. 1991). As cattle pastures and logging centers sprang up along newly built roads, crude, quickly constructed towns appeared upon what was once blanket frontier. In Paragominas, the closest city to the Capim communities, 107 sawmills had opened by the early-1990s, while just 30 years earlier there had been none (Veríssimo et al. 1992).

In the first decades of logging, these sawmills consumed only a handful of the region's top-selling timber species. As stocks of the most procured species declined in the mills' immediate vicinity, however, timber companies expanded their range of operation and began to seek out high-value species at ever-increasing distances from sawmills. (Veríssimo et al. 1992). The expansion of logging into forests throughout Pará brought about direct contact between two formerly distinct worlds, the timber industry and *caboclo* communities (Figs. 2.1 and 2.2).

As trade in timber increased, Capim communities strengthened their ties to Paragominas and requested governmental and non-governmental assistance in basic infrastructure, health care and transportation. The decade of the 1980s witnessed the creation of rural schools; more frequent transportation to the city (as a result of municipal assistance and the non-governmental donation of a boat); the construction of community-owned *cantinas* (stores), (which eliminated local dependence on river traders); and the initiation of agroforestry projects and nurseries.

In spite of advantageous socioeconomic growth for Capim communities during the 1980s and 1990s, ranching and logging became the overwhelmingly predominant forces in the municipality of Paragominas. In 1994, these two industries occupied more than 96% of the municipality's 14,338 sq km (Figueiredo 1994). According to Figueiredo (1994), smallholder agriculturalists in the municipality at that time were restricted to 16 locales situated along the Capim River or the margin of the Belém-

Figure 2.1 Logs extracted from Capim forests, 1998

Figure 2.2 A barge transporting timber from the study region along the Capim River

Brasilia highway, and each community was surrounded by loggers and/or ranchers. In addition, one of Brazil's largest mining companies, the *Vale do Rio Doce* arrived in the Capim region during the 1990s. After years of extensive testing along the river, they opened a mine less than 50 km upriver from the study communities and began extracting deposits of kaolin (a fine clay used in the manufacture of paper).

Moreover, in the late 1990s, the region began to suffer from the spread of chronic fires. The large amounts of slash and damaged trees left in the wake of logging offered plentiful fuel. In September and December of 1997 fire raged through 3000-ha of selectively logged forest in one study community over a period of weeks. Each of the fires followed closely on the heels of loggers who had recently removed trees of a wide range of species of medium and even small diameter trees. Frequent episodes of increasingly intensive timber extraction, in conjunction with fire, rapidly transformed a formerly intact, mature forest, into a degraded one.

My grandmother used this bark; we do not use it anymore.

F. S. Carvalho Brito, curandeiro's son

CHAPTER THREE
ERODING KNOWLEDGE: AN ETHNOBOTANICAL INVENTORY OF ONE-HECTARE OF *TERRA FIRME* FOREST

INTRODUCTION

During the 1950s and 1960s, the Capim River region was the site of a lively trade in non-timber forest products. Through a system of debt peonage, upriver communities regularly sold or bartered with downriver traders a variety of NTFPs, including game, latex from maçaranduba (*Manilkara* spp.), pelts, and fish. Over time however, changing economic conditions, the availability of substitute products, and increasing demand for timber brought about a decline in the sale of non-timber forest products along the Capim. When logging companies entered the region in the 1980s, *caboclo* communities were engaged in free trade along the river, held informal land tenure, and functioned in a largely subsistence economy augmented by the sale or trade of *farinha*, bananas, corn and rice.

The arrival of logging companies into the Capim created unprecedented income opportunities, and despite the meager prices that were paid for timber, many *caboclo* households and villages quickly sold their trees for cash. As stocks of valuable timber declined, however, Capim residents observed a corresponding decline in the prevalence of game, fruit, and vines. Some attributed these changes to logging and began to question whether the sale of timber adequately compensated for the loss of so many other forest products, many of which had played a critical role in their households' and communities' subsistence. Some also began to question whether there might be non-timber goods from their forests that they could sell in lieu of timber. As a first step toward addressing these questions, an ethnobotanical inventory of one hectare of mature *terra firme* forest was conducted.

Because no previous forest inventories had been carried out in the region, the inventory was undertaken with three specific objectives: 1) to gain a preliminary overview of area species composition; 2) to identify locally and regionally valued non-timber forest products; and 3) to establish a permanent plot in which to monitor species use and value for the purposes of forest extension (i.e. to create a living library).

Intended to be used as a conservation and development tool, the inventory utilized methodological tools developed by Prance et al. (1987), Pinedo-Vasquez et al. (1990) and Peters et al. (1989). The point-based inventory system developed by Prance et al. (1987) served as a means to quantify the relative use-value of species; the community reserve context of the Pinedo-Vasquez et al. (1990) inventory offered an example of utilizing floristic data for the explicit goals of community development; and the Peters et al. (1989) study set the groundwork to conduct a follow-up study incorporating economic valuation of the hectare's non-timber forest products.

After a depiction of the study site and the methodology used, this chapter begins with a brief description of the species composition of the study hectare. This is followed by the quantitative and qualitative results of the ethnobotanical inventory, including a ranking of each species use-value and comparative values as described in other South American ethnobotanical inventories (Milliken 1992, Balée 1986, Prance et al. 1987, Pinedo-Vasquez et al. 1990). While the community utilizes many species, in this study the discussion principally focuses upon non-timber products that are of substantial subsistence or commercial value. Local perceptions of the relative advantages and disadvantages of logging are then examined, as well as the effects of timber extraction on forest composition and utilization. This section is included because many of the forests surrounding the study hectare were being selectively logged at the time of the inventory, and descriptions of useful species invariably reflected the dynamic nature of the region. The chapter closes with a discussion of changes in plant use, offering examples of species whose use exists in memory only and others whose uses are expanding due to commercialization of timber.

Research site and methods

The study area is located along the Capim River, municipality of Paragominas, in the eastern Amazonian state of Para. Annual rainfall averages 1750 cm with a pronounced dry season between May and December. Temperature fluctuates between 25-28 degrees centigrade. Bearing sharp turns and bends, the river flows in a northerly direction emptying into the Amazon, more than two hundred kilometers from the study site.

A forest inventory was conducted in a 200 m x 50 m plot of *terra firme,* evergreen rainforest (canopy height 25–40 m), located approximately 3.5 km distance inland from the west bank of the Capim River. Although the study hectare and forest immediately surrounding it were intact at the time of the research, selective logging had already taken place in the five communities closest to the research site.

The site was chosen after four months of visiting forested land in three communities along the Capim River. During these visits, farmers identified fiber, fruit and medicinal species of particular value, offering an overview of economic species, forest composition, and changes in forest composition due to logging. Due to the specific objectives of the inventory, the study plot was not chosen randomly but selected based on information gathered during these visits and through use of the following criteria:

1) existence of intact, mature forest;
2) forest composition representative of surrounding forests;
3) presence of species with non-timber value;
4) low probability of logging in the near future;
5) owner willingness to participate in a long-term study.

To facilitate plant collection, identification and mapping, the study area was divided into 40 sub-plots, each of which measured 10 meters by 25 meters. Within the plots, all trees and vines with a diameter at breast height over 10 cm were permanently tagged, measured (diameter and height) and identified with the assistance of botanist Nelson A. Rosa.[1]

Plots were laid out and tagged in the spring of 1992. To quantify the usefulness of the principal species and plant families in the plot, ethnobotanical data were collected concerning the utility of all trees and lianas greater than 10 cm diameter. To offer a comparable data set, this study employed a system of ranking plant use that had been used by several prior ethnobotanical studies carried out in various parts of South America (Prance et al. 1987, Boom 1989, 1990; Pinedo-Vasquez et al. 1990).

Drawing on the methodology used by these studies, the relative utility of each species to the local population is ranked by assigning a value of 1.0 for every "major" use of a tree species, and 0.5 for every "minor" use. Information from native informants and observation is used to place species in the following use categories: edible, construction, technology, remedy, commerce and other. The use value of a species is determined by summing the values corresponding to its major and/or minor use(s).

Data on the use of trees and lianas were collected intermittently between 1992 and 1996 during informal discussions and interviews with over 80 Capimenses. Informants included men, women and children between the ages of ten and seventy

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[1] Voucher specimens are housed in the herbarium of the *Museu Emílio Paraense Goeldi*, Belém.

years (Alexiades 1996, Martin 1995). Data collection took place in the one-hectare forest plot as the inventory was conducted; afterwards in individual and group interviews using pressed plant specimens; and over the course of the following four years while living and working in three Capim communities.

Methodological considerations

Ethnobotanical studies by Balée (1986, 1987) which included fuel wood and game attractants as use categories have described use percentages as high as 100% and 87%, respectively. While revealing the spectacular knowledge and use of trees by the Ka'apor and Tembé such results do not reveal which were the most sought-after species or the species of greatest importance to daily life. By defining use more narrowly, Prance et al. (1987) quantitatively identify tree species with greatest utility to each of the groups. One way they accomplish this is by omitting fuel and game attractants from use categories since many species of trees fall into one or both of these categories.

In the present study, animal food (trees bearing fruits, seeds or flowers which are consumed by animals) is included as a use category. Interviews with *caboclos* from the Capim region revealed that particular tree species are highly valued for their ability to attract game. Indeed, many of those interviewed indicated that game were one of the most highly valued non-timber forest products. In accordance with the point system developed by Prance et al. (1987) one point is given when a tree is widely utilized as an animal food and a half point is assigned when a plant is utilized only intermittently.[2] In this way, it is possible to distinguish which plants are most and least valuable as animal food. For example, many trees may have small fruit eaten by songbirds which children seek out with slingshots, but fewer trees hold such promise for hunters that they will build *esperas* (hunting stands) by them to wait for prey at night.

In addition, because wood is the most commonly marketed forest resource by Capimenses, timber is included as a marketable commodity under the commerce use-category (Pinedo-Vasquez et al. 1990).

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[2] After this study was conducted, Oliver Phillips modified the quantification of use-value and developed more in-depth statistical analysis to refine use valuation (Phillips and Gentry 1993).

RESULTS AND DISCUSSION

Floristic composition of study hectare

Within the study plot, 153 species were recorded, 144 identified to species, and an additional nine identified to genera (see Table 3.1 at the end of this chapter). Species occurring within the study hectare are distributed within 44 families. Other studies reporting on the number of families occurring in one-hectare plots (lacking soil limitations and including trees with a minimum diameter of 10 cm) also cite representatives from between 40 and 50 families (Mori et al. 1989). Depending largely on the biophysical conditions of the site, tree species diversity in the neotropics is highly variable, trees greater than 10 cm DBH on 1-ha plots in Amazonia yielding from 87 (Pires 1957) to 300 (Gentry 1986) different species (Mori et al. 1989). It is expected that factors such as: soil conditions (specifically limiting factors such as soil moisture and organic content); topographic relief; successional stage; and rainfall, promote and/or inhibit species diversity (Mori et al. 1989).

Concurring with the study by Prance et al. (1987), results indicate that certain plant families of the *terra firme* forest are especially useful and should be considered a priority for conservation. The highest use-values accrued for several families represented by only one or a few species, but whose properties of multiple-use and excellent fruit value (Caryocaraceae, Humiraceae, and Guttiferae) and or medicinal value (Myristicaceae, Caesalpiniaceae, Moraceae) are widely appreciated. Additional families that rank relatively high in terms of familial use-values include Lecythidaceae, Chrysobalanaceae, Lauraceae, Anonaceae, Burseraceae, Celastraceae, Apocynaceae, Caesalpiniaceae and Vochysiaceae (Table 3.2).

The species identified in this survey represent only a small proportion of plant resources occurring in the Capim region. The species area curve (Fig. 3.1) demonstrates that had it been possible to survey more than one hectare of forest, the species total would have been higher. While allowing comparability with previous studies, the limited area (1 hectare) and minimum plant diameter (10 cm) restrict the study, excluding the vast diversity represented by plants such as herbs, shrubs and epiphytes (Salmões 1999, Martin 1995, Milliken 1992, Salick 1992).

Food

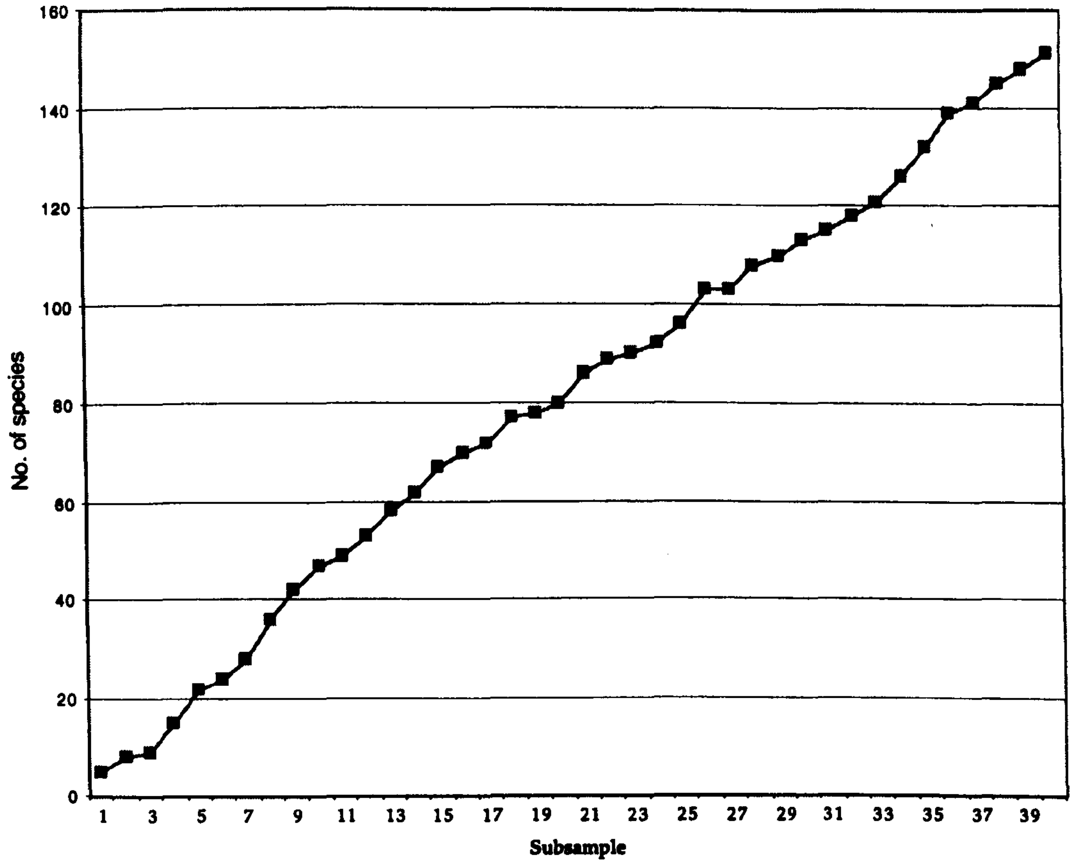
Of the 153 species in the plot, 22 (14.4%) are major or minor food plants. The most important of these include: *Caryocar villosum, Endopleura uchi, Platonia insignis, Hymenaea parvifolia* and *Lechthis pisonis* (Table 3.2). According to use values, these species (along with *Copaifera* spp.) ranked significantly higher than other species in the plot. This finding is less than the percentage use values for food (21.8% - 40.4%) reported by four South American indigenous communities (Prance et al. 1987). The Ka'apor, the group geographically closest to the Capim, reportedly use for food 34.3% of the 99 species collected in a 1-ha plot. If, following Phillips and Gentry (1993), animal food trees of major significance are included in the food category, the number of species useful as a food source rises to 44 species (28.8%).

Table 3.2 Fifteen of the most useful tree species (> 10 cm) to *caboclos* of the Capim River, Brazil in a 1-ha forest plot (200 x 50)

Family	Species	Common Name	Use
Caryocaraceae	*Caryocar villosum*	Piquiá	A, B, E, G
Guttiferae	*Platonia insignis*	Bacuri	A, B, d, E, g
Humiraceae	*Endopleura uchi*	Uxi	A, b, d, E, G
Caesalpiniaceae	*Copaifera* aff. *reticulata*	Copaíba	b, D, E, G
Lecythidaceae	*Lecythis pisonis*	Sapucaia	a, b, d, E, G
Caesalpiniaceae	*Hymenaea parvifolia*	Jutaí	a, d, E, G
Moraceae	*Brosimum acutifolium*	Mururé	b, D, f, G
Sapotaceae	*Manilkara huberi*	Maçaranduba	a, B, d, e, g
Lecythidaceae	*Couratari guianensis*	Tauari	c, E, f, G
Sapotaceae	*Manilkara amazonica*	Maparajuba	a, B, e, g
Lecythidaceae	*Eschweilera coriaceae*	Maturi	b, c, d, e, g
Sapotaceae	*Manilkara paraensis*	Maçaranduba	a, B, e, g
Myristicaceae	*Virola michelii*	Ucuuba	b, D, E
Papilionaceae	*Dipteryx odorata*	Cumaru	b, D, E
Lecythidaceae	*Eschweilera grandiflora*	Mata Mata ci	B, d, e, G
Chrysobalanaceae	*Licania heteromorpha*	Caraipé	B, c, e, g

Note: A or a = food; B or b = construction; C or c = technology; D or d = remedy; E or e = commerce, F or f = "other" use; G or g = animal food. Uppercase indicates major use value; lower case indicates minor use value.

Figure 3.1 Species area curve for a 1-ha plot of mature, *terra firme* forest in the Capim River Basin, 1992



Some fruits such as *C. villosum* (piquiá) and *P. insignis* (bacuri) are so highly valued that during their harvest season village members go on expeditions to gather them. To diminish the weight of the fruit, collectors sometimes remove the sizable rind (approx. 60% of fresh weight) thereby transporting only flesh and seed. One woman recalled extracting oil from piquiá fruits and using it throughout the year as cooking oil. In years during which a sizeable crop of piquiá was produced, she lessened her expenditures by not purchasing oil for the entire year. The oil of piquiá is also employed in soap making.

The oily, grainy texture of the pulp of the egg-shaped fruit of *Endopleura uchi* (uxi) is also highly esteemed. The greenish-yellow pulp is consumed fresh from the tree or mixed with water to make juice. To collect whole fruit, individuals pass by uxi trees frequently, as they are a favorite food of a diverse array of animals, including squirrels, paca, and armadillo. Uxi often falls from the tree while green and unripe. In the past to enhance the ripening of fruit, villagers dug ditches, lined them with leaves, buried dozens of uxi in the ground, and covered them with leaves and dirt. In a couple of days the cache of uxi was unearthed, ripe for eating.

One woman in her late 50s recalled a process to extract uxi's substantial oil. She extracted it by heating the skin and pulp in water and siphoning off the rising fatty acids. Chemically and physically uxi oil is very similar to olive oil, being used to fry fish and other foods.

Local lore maintains that one must not look up to the crown of an uxi tree, for if one sees a fruit, it is believed one will die within the following year. Even villagers who ignore this admonition, however, are likely to be safe. The tree's full, lofty crown of leaves, which can grow up to 30 meters high, makes it difficult to catch sight of the relatively small (5-7 cm) green fruit.

Another favorite fruit of the Capimenses, *Platonia insignis* (bacuri), contains white pulp encircling 1-4 large seeds protected by a thick layer of green rind. Its sweet pulp is consumed fresh and is used in the making of juice and pudding-like desserts called *doces*. The fruit, which is locally called bacuri, varies quite substantially in size, shape and quality, preferred fruits are sweet, bearing substantial soft flesh. The variation between fruits is so pronounced that Capimenses sometimes name particular trees after the shape of its fruit. For example, villagers gave the name *"peito de moca"* (breast of a young girl) to one tree's fruit of which they were particularly fond. Although standing at the far reaches of the community, the sweet flavor of this tree's fruit was so highly valued that Capim residents walked distances of up to four kilometers to collect it. To arrive prior to other collectors, some village children begin hiking toward the bacuri trees in the darkness of pre-dawn.The three fruits described above, along with *Lecythis pisonis*, are occasionally attacked and eaten by animals prior to falling from the tree. While fruit production of C. *villosum*, E. *uchi*, and P. *insignis* are sufficient to meet demand by villagers, residents complain that monkeys regularly crack open the hard shell of *Lecythis pisonis*, eating its nuts before they fall from the tree. Although villagers recall their parents or grandparents eating nuts of *L. pisonis*, few Capim residents in the study area collect and consume the nuts today.

Byrsonima spp. (muruci) produces another locally consumed fruit. Small and bright yellow, its fleshy, cheese-like pulp is eaten raw and pressed into juice. The fruit is generally gathered after falling from the tree, and is found in profusion during a good production year. Although an uncommon harvesting technique in the community, one young man cut down a prime muruci tree near the village to gather its fruit. For his actions, verbal rebuke ensued by residents of his village, but he suffered no further consequences. Though greatly enjoyed, the tree is not plentiful within Capim forests.

Construction materials

Species useful in major and minor ways for construction account for 53 (34.6%) of the species in the plot. This percentage is higher than that reported by indigenous groups which range from 4%-21% as reported by Prance et al. (1987), while corresponding closely to the 31% reported by Pinedo-Vasquez et al. (1990) in their study of riberenõs in Peru. The value for construction may be comparatively high in that it includes not only locally utilized species, but also the growing number of species extracted by the timber industry. Whether working for loggers or selling timber from their properties, *caboclos* learn of the commercial value of certain species for construction. Such trees become vastly more "useful" to smallholders, who needing cash, begin to see the value of their forests through the eyes of loggers. As species increase in commercial value, new mental maps of forest value are forged.

Because of the frequently wet conditions and high rainfall, the Capim communities utilize the strongest and most resistant woods as house posts. Due in part to the abundance of silica found in the rays of its wood (Prance 1972), *Licania* spp. is important for its durable, rot resistant properties, which repel termites and a variety of other insects. *Minquarita guianensis*, which is also termite-resistant, is similarly regarded as material for house posts by Capimenses as well as by the Waimiri Atroari (Milliken et al. 1992) and the Tembé (Balée 1994, Prance et al. 1987). *Xylopia* spp. are also used as posts.

Insect-resistant and durable, *Carapa guianensis* is used for roofing material as shingles. *Manilkara* spp., are also appreciated for their strength, durability and ability to split easily. For these reasons, *Manilkara* spp. and *Lecythis pisonis* are used for roofing shingles and fence posts. One Capim resident fashioned "nails" from *Manilkara* spp., explaining that wooden nails have a number of advantages over metal nails; they are more easily acquired and do not rust.

As support for the roof, *Protium spp., Ocotea* spp. and *Cedrela* spp. are employed as rafters. Locally called angelim, *Pithecellobium* spp. is occasionally used for walls along with C. *guianensis* and the popular *Ocotea* spp. In the Capim, some homes have dirt floors, eliminating the need for additional wood.

Ten to 20 years ago, houses in the Capim were principally constructed of palm thatching or mud. The Capim inventory plot is distinct from others in South America (Boom 1986, Balée 1986, 1987, Pinedo-Vasquez et al. 1990, Milliken et al. 1992) in that no palms occurred in it. In the Capim forests, palms are most often found in disturbed areas, close to the river. Within these areas, palm leaves are collected from *Maximiliana maripa* (inajá) and *Oenocarpus bacaba* (bacaba), which are employed in the making of houses and *casas da farinha* (open structures where cassava is processed into flour). Some villagers indicate that it is best to extract palm leaves during the new moon. Palm thatch collected under these conditions is considered to be less susceptible to insects, and to deteriorate more slowly.

Today, most homes near the river are constructed of wood. The construction of wooden homes in the Capim region began over a decade ago, coinciding with accelerated activity of the timber industry. Since many communities lack chain saws, it is not uncommon for residents to trade trees from their land for sawn timber, instead of cutting trees with an axe or a machete to obtain boards.

Living along the river, Capimenses mainly travel by canoe. Their canoes are often constructed of *Ocotea caudata* (louro) which grows relatively quickly and which produces a medium-density wood that generally lasts for 2-3 years. Heavy, more durable canoes are constructed from *Caryocar villosum* (piquiá). Prized even by industrial boat builders and the naval industry, *C. villosum's* dense cross-grained wood makes it unsurpassed in durability and water-resistance. While canoes of a lighter wood may last only a few years, owners boast that a canoe of piquiá can last well over a decade.

Animal food

Of the species encountered in the study plot, 71.2% were identified as animal food, and 14.4% considered to be of major importance to hunters. This number corresponds with that of the Waimiri Atroari, who recognized 66% of the tree and liana species in a one-hectare plot as food sources for game (Milliken et al. 1992). Recognizing trees as game attractants requires knowledge of both animal diet and tree phenology. In the case of trees with exceptional ability to "attract" game, small above ground platforms may be built near the fruiting or flowering tree. These hunting stands, or *esperas*, are composed of saplings and attached to nearby trees with vines. Hunters hang their hammocks from the stands, or perch in the nighttime, awaiting prey to arrive and feed at the base of the tree.

Trees present in the hectare, which attract game and near which hunters build *esperas* include: *Brosimum acutifolium*, *Inga* spp., *Couratari guianensis* and *Coepia robusta*. Trees which provide animal food but near which hunters do not necessarily make *esperas* include: *Hymenaea parifolia*, *Eschweilera* spp., *Licania heteromorpha*, *Brysonima amazonica* and *Endopleura uchi*. The latter provides food for a diverse array of wildlife including deer, armadillo, squirrel, paca, and anta (Fig. 3.2).

Figure 3.2 Success in the hunt, capture of cutia, a small rodent

Figure 3.3 Setting a *baladore* (hunting trap)

It is recognized that some species have both fruit and flowers, which attract game. The flowers of *Caryocar villosum* are especially prized for their ability to "call" game, being the favorite tree of hunters by which to build *esperas*. While game animals are attracted to its fruit and flowers, the flowers attract a greater variety and volume of wildlife than the fruit. *Lecythis pisonis* was cited as another tree whose fruit and flower are both known to attract game.

Some hunters place traps (*baladores*) beneath especially good animal attracting trees such as *E. uchi*. The trap is placed in brush beneath the tree with a taut string leading from the trigger of a miniature, makeshift shotgun to a nearby sapling (Fig. 3.3). If an animal walks in the vicinity of the trap and its leg inadvertently pulls the string, it is shot. One Capimense family ate armadillo daily for weeks, making it appear as if they had a meat market next door. Within one and one half kilometers from his home, the head of the household revealed a series of traps placed at approximately twenty-meter intervals beneath a grove of fruiting *E. uchi* trees.[3]

Remedies

Twenty-two of the 153 species occurring in the plot (or 14.4 %) are used for medicinal purposes. The most significant of these include: *Copaifera reticulata, Brosmium acutifolium, Dipteryx odorata, Eschweilera coriaceae,* and *Virola michelli.*

Copaíba oil is one of the most popularly utilized Amazonian medicinals. A cicatriazant, it also serves as a natural antibiotic for deep wounds, a common ailment among people who use knives, axes and machetes on a daily basis (Balée 1994). In small doses (a few drops), copaíba oil is also taken internally to alleviate sore throats. One woman who had only five children, reported that she had prevented pregnancy during her childbearing years by ingesting 1-2 drops of copaíba oil daily. A few Capimenses interviewed in this study remembered extracting copaíba oil in the 1960s. One woman, who regularly gathered the oil in her youth, recalled rules of extraction, indicating that pregnant women must never extract oil and that extractors may not look up at the crown of the tree or the oil will disappear into the branches. However, neither she nor anyone else among the 50 plus persons interviewed currently extracts oil for family use. Nonetheless, informants did commonly request to borrow copaíba oil from the research team. Of all the persons interviewed, only one recalled the

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[3] To alert passerbys of danger, it is customary to place small wooden crosses on entry trails indicating the presence of traps nearby. In spite of this precaution, the legs of both adults and children walking through forests have been damaged by gunshot wounds caused by *baladores*.

technique sufficiently to instruct his fellow villagers. Upon discovering the high price of oil (in 1997 selling for $20 - $30 a liter), one community member became so anxious to sell some he attempted to extract oil with a machete; in doing so he damaged the few remaining copaíba trees.

Another highly esteemed medicinal oil used historically in the Capim region and popular throughout eastern Amazonia is *Carapa guianensis* (andiroba). Applied topically, *C. guianensis* is used for rheumatism, for bruises and in the veterinary treatment of animals. While not occurring in the study plot *C. guianensis* is found in both inundated and *terra firme* forests of the Capim region. Called "bastard mahagony" in Central America due to its dark wood, its numbers in the Brazilian Amazon are declining due to logging.

The resin of *Virola* spp. is used to treat a common ailment locally called *boqueira* (sores at the corner of the mouth), a use also documented among the Ka'apor (Balée 1994). In addition, the resin is applied to aching teeth to alleviate pain. The use of Myristicaceae bark resin for tooth pain has similarly been reported among the Paumarí (Prance et al. 1977) and Waimiri Atroari Indians in Brazil (Milliken et al. 1992), in Columbia (Schultes and Holmstedt 1971), and French Guiana (Plotkin et al. 1991).

To combat stomachaches and diarrhea, Capimenses use the ground bark of *Eschweilera spp.*, a preparation documented by Balée as utilized by the Ka'apor (1994). Capimenses relate that the medicinal powers of *Eschweilera* spp. are known not only to human residents of the Capim: monkeys also chew on the bark in times of gastrointestinal distress. Another remedy used to combat gas is to massage the ailing stomach using warm uxi oil. Warm uxi oil is also applied topically on childrens' noses as a remedy against sinitus.

Residents use the thick, white exudate of *Manilkara* spp. as a topical application in the case of sprained muscles and broken bones. Itching of both humans and dogs is alleviated by use of the young leaves of *Lecythis pisonis* in a bath.

Rheumatism, a common affliction among adults, is alleviated through the use of *Brosmimum acutifolium*. Bark is cut into small pieces, placed in alcohol for two days, after which the liquid is applied topically. Its bark is also used to make tea, but caution must be exercised as *Brosimum* spp. can be extremely toxic is high doses. Ingested, the exudate is used as a remedy to break fever; however, this is not advised for pregnant women, as too much is reported to induce abortion.

Bark from *Hymenaea* spp. is used to combat cough and flu and as an overall tonic to strengthen the body. Although not occurring within the study hectare, *Tabebuia impetiginosa* (pau d'arco, ipê roxo) is common in the Capim forests and is highly valued for its medicinal properties. *Tabebuia* spp. are used in the treatment of internal inflammations, tumors, gastric ulcers and as a general body strengthening tonic.

Women's ailments, including inflammation of the uterus, anemia and vaginal discharge are treated with *Dalbergia subcymosa* (verônica), a vine that occurs in the study hectare (but which does not appear in the inventory listing due to the small diameter of the vine). The inner-bark is used as a bath, or after soaking the bark in lukewarm water for one day, taken internally. While all women know of the use of *Dalbergia* spp. and appreciate its effect, many of the village women can no longer positively identify the vine.

Technology

Thirty-one of the 153 species found in the study plot (or 20.3%) had a major or minor use in various forms of technology. This figure is comparable to a range of 4%-27% found among four Indian tribes studied by Prance et al. (1987). Among the Waimiri Atroari in Brazil, Milliken et al. (1992) record 31% of species in a 1-ha plot as used for technology. A plethora of tools, house wares, lashing materials and hunting apparatus are fashioned from plant parts. While many of these were considered to be highly significant a generation ago, the adoption of substitute products has relegated the majority of plant-based technologies to a position of relatively minor usefulness today. The most important technological application of plant materials is the use of fiber for lashing and resins for sealants.

To seal fissures and crevices in canoes, the resin exuded from the bark of *Protium* spp. (breu) is employed as a sealant. Highly flammable, the quantity and quality of resin vary considerably from species to species (Balée and Daly 1990). Used also in illumination, a *"laterna da mata"* (flashlight of the forest) is fashioned by inserting a piece of hardened resin in the middle of a stick cut in half at its tip. The resin is lit at one end and the stick carried by the other end to light one's way through the forest.

Hunting traps (*baladors*) are fashioned from a variety of woods. *Caryocar villosum* (piquiá) is regarded as the best wood for this purpose, as it is the most durable, lasting for 3-4 years. *Copaifera* spp. are reported as lasting for 3 years, and *Pithecellobium* spp. for 2 years. *Carapa guianensis* is also used to make traps but tends to split easily. Wood with interlaced fibers is noted as the longest lasting. Tool handles may be made of *Dugetia lepidota* (envira), *Caryocar villosum*, or *Pouteria* spp.

Shotguns are the most common tool for hunters and, for the most part, have taken the place of hunting bows. Bows are still useful, however, especially to villagers who wish to hunt without dependence on lead and gunpowder, which are costly and scarce. Bows were carved from *Tabebuia impetiginosa* (pau d'arco), a practice also observed among the Ka'apor (Balée 1994).

To carry game home from the hunt, Capimenses use *Lecythis idatimon* as lashing material. Like the Ka'apor (Balée 1994) they also use it for the shoulder straps of rucksacks. The lashing material is extracted by cutting into a tree's bark with a machete and stripping the bark (stratified phloem) from the tree.

Pintadinho preto (black paint), is a common name referring to the former use of *Licania octandra* as a dye. Placed in a small container, dye is extracted by pounding the bark. Ashes of the bark of *Hiretlla excelsa* were employed in the production of ceramics. Both *L. octandra* and *H. excelsa* are examples of plants whose use as a dye a generation ago was extensive, whereas today residents regard them to be of little direct usefulness.

Another declining use is that of the inner-bark of *Couratari guianensis* as a paper substitute. Documented to be used for the same purpose in other regions of Amazonia (Mori et al. 1990) the inner-bark is peeled from the tree to roll cigarettes.

Commerce

Thirty-seven of the species occurring in the inventory hectare (or 24.2%) were cited as having a use in commerce, most of these marketed as timber. In fact, from a commercial standpoint, timber has eclipsed all other forest products in the region. This figure is comparable to that in a hectare of Peruvian forest where 24.4% of species possessed timber value (Pinedo-Vasquez et al. 1990). Because the sale of wood for industrial uses has rapidly grown in importance, responses of some Capim residents reflect non-local, urban utilization patterns. For instance, numerous Capimenses remarked on the commercial value of particular tree species as employed for home paneling and industrial boat making although they themselves live in mud, wooden or palm huts and travel by canoe. Species frequently noted by residents as having commercial value include: *Tabebuia serratifolia* (pau d'arco), *Cedrela odorata* (cedro), *Hymenaea courbaril* (jatobá), *Copaifera* spp., and *Hymenolobium* spp. (angelim).

At the outset of the study, the majority of Capimenses marketed no NTFPs. Markets in Belém and Paragominas do exist for some of the non-timber products occurring within the hectare such as: the resin from *Protium* spp. (breu); the fruits of *Platonia insignis, Caryocar villosum; Endopleura uchi* and *Brysonima amazonica;* the seeds of *Dipteryx oderata* (tonka bean); the medicinal oil of *Copaifera* spp. and a variety of medicinal barks. While approximately 15% of the species documented in the Capim inventory have a market for their non-timber products within Pará, at the time the inventory was conducted, these NTFPs were rarely, if ever, commercialized from Capim communities.

In an inventory of Peruvian forest, Pinedo-Vasquez et al. (1990) found that 22.1% of the useful NTFP species have markets in Iquitos. Their study makes a distinction, however, between species that have markets, and those that are actually marketed. Theoretical postulations as to potential markets disregard locally important reasons why communities choose not to bring certain products to market (Padoch and Pinedo-Vasquez 1996). These may include inconsistent production, low density of product, lack of transportation, inadequate monetary compensation and lack of market expertise. For these reasons and others, which will be explored in the next two chapters, Capimenses tend to market agricultural products and timber, not non-timber forest resources.

Other uses

Plants inventoried within the hectare which have a spiritual/magical association and or application make up 1.3% of the species identified. This figure is within the range Prance et al. (1987) found among Indian groups (0 - 8.5%). Two of the most widespread and active spiritual/magical beliefs surrounding forest use in the Capim communities concern the non-timber forest product most highly valued by Capimenses: game. Described below, one belief protects game, while the other aids hunters in pursuing game.

The most widely recognized spirit of the forest among the Capimenses is the *curupira*, a woodland being associated with *Couratari guianensis* (tauari). It is believed that the *curupira* rests within the huge buttresses of the grand tauari tree. The *curupira* is described as being small and black, with feet turned backward and curly hair. When a person has disrespected the forest, the *curupira* plays a trick by disorienting that person, making him or her lost by walking in circles. Residents state that the only way to leave the forest without harm is to take a vine and make a very tight knot with it (hiding its two ends) then to toss it over your shoulder to the forest floor. The *curupira* will find it and while attempting to untie the tangled knot, offers the lost person a chance to break away from his spell and run from the woods.

Belief in the *curupira* is widespread and exists among old, young, urban, rural, and professional Amazonians alike. The myth of the curupira can function as a conservation device, achieving what institutionally imposed regulations are often unable to do: that is, influencing hunters to hunt only when necessary, thereby protecting forests from harm and over harvest.

If a hunter is respectful of the forest but wishes to have more luck and success in the hunt, he may apply the exudate of *Brosimum acutifolium* to his back, sometimes by cutting the bark with a machete and then rubbing his back against the tree. As part of this ritual, *pimenta* (hot pepper) is also applied to the hunter's back. The treatment is believed to clean one's vision for the hunt.

Although not included in this inventory, various herbs and understory vegetation have religious and spiritual associations. Common names given to plants such as *cama de Jesus Cristo* (bed of Jesus Christ), and *cipo pajé* (vine of the curandiero) indicate the coexistence of Christian and traditional beliefs.

Local perceptions of logging

The relationships that exist between Capimenses and loggers are, by nature, highly ambiguous. Indeed, community member's opinions about the sale of timber often vacillated from day to day, and from one person to another. On the one hand, the benefits of logging were generally emphasized by village leaders who are apt to benefit monetarily; persons in need of cash or labor; men employed by loggers and their wives; families with sick children in need of medicine; soccer players glad to have a new field cut by the logger's machinery, and youth happy to hitch rides atop logging trucks. Although not one person interviewed during a six-year period claimed to have received a fair exchange for their trees, the sale of timber offered the only material hope during times of severe stress, poor agricultural production, illness or accidents.

On the other hand, residents of the Capim communities cited a number of negative consequences that logging had brought about, including greater distances to resources that had once been close-at-hand and the loss of game, fiber and fruit. In particular, men and women of the older generation, who recalled the forest in its time of plenty, sometimes looked unfavorably on timber extraction. For instance, women who extracted oil from the seeds of *Carapa guianensis* (andiroba) and used it in the treatment of bruises, sprains and rheumatism sadly remarked on its disappearance from the region. The highly valued medicinal oil tree, *Copaifera* spp. was also said to be scarce. Older residents were particularly dismayed at the lack of game for food, as they had consumed it daily in their youth and found its substitute, fish, to be a far inferior food.

Hunters noted the decreasing density of game, while basket makers and persons constructing homes complained of the declining number of vines and wood suitable for roof shingles near the community. Women remarked that until recently, men collected fruit for their families during hunting treks. Due to fewer game-attracting fruit trees in close proximity to the Capim communities, hunting activities are farther away. Women complain that men no longer gather fruit and that the fruit trees are no longer accessible to them. Some resources are now so scant and distant that at the start of the fruiting season one Capimense who had lived in the community his entire life inquired of me, "Where are the fruit trees?"

CONCLUSION: CHANGING STREAM OF KNOWLEDGE

The percentage-use values described above reflect that the Capimenses, even within a rapidly changing environment, know and use many species. The Capimenses utilization of 60% of inventoried species,[4] is well within the range demonstrated by Indian tribes within South America: Venezuelan Panare (48.6%); Bolivia's Chácobo (78.7%); Brazil's Ka'apor (76.8%), Tembé (61.3%) (Prance et al. 1987) and Waimiri Atroari (79%) (Milliken et al. 1992), and riberenõs in Peru, (60.1%) (Pinedo-Vasquez et al. 1990). Notable differences on the part of the Capim communities include the higher degree of trade in timber species; the lack of trade in non-timber forest products; the decreasing use of plants for technological purposes; and the extent to which the use of many species is described in the past tense (i.e. "my grandmother used this tree's bark..."). Many of the uses described exist principally in individual's memories, and it is questionable if species identification, harvest techniques, and utilization regimes can survive more than a few generations without actual practice.

Among the Capimenses interviewed, fruit producing and game attracting trees - that is species with direct food value - are most highly valued. Nevertheless, some forest foods, which were once commonly consumed by the majority of households, are now being opportunistically harvested.

In contrast to the international acclaim they receive, medicinals occupy a secondary place to species possessing nutritional value. However, as reported for other groups (Alexiades 1999, Kainer and Duryea 1992, Wilbert 1996, Amorozo and Gély 1988, Messer 1978), the retention of particular medicinal plant knowledge is

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[4] For purposes of comparison, this figure (60%) does not include species used as game attractants. If the 9 species with a major use-value as animal food are included, the percentage of useful species rises to 65%.

strong among some individuals and regularly called upon in the case of illness. This may be due to the high cost and limited availability of pharmaceuticals, preference for traditional methods, and the fact that phytotherapies may be effective without deleterious side effects (Elisabetsky and Wannamacher 1993, Balick et al. 1996).

Although cultivated herbs and exotic, non-woody plants are popularly used as remedies, many of the most highly-valued medicinals (i.e. *Tabebuia impetiginosa* (pau d'arco), *Copaífera* spp., *Brosmium acutifolium* (mururé), *Hymenaea courbaril* (jatobá) are derived from trees occurring in mature forest, many of which are now extracted by the timber industry (Martini et al. 1994). While these species also occur in mature secondary forest, residents explain that after repeated episodes of cutting or burning, a forest loses some of its components, and "*nunca volta a mesmo coisa*" (never returns to the same thing). These observations concur with those of Vieira et al. (1996) which describe the inability of vulnerable species to regenerate after repeated fire or cutting; with those of Saldarriaga (1987) who demonstrated that fewer species characterize secondary forests after shifting cultivation in Venezuelan Amazonia; and with those of Prance et al. (1987) which establish the ethnobotanical value of dense *terra firme* forests.

Although noted as being far more important only a generation ago, the technological uses of plant species have dwindled. In many cases this has been due to the availability of cheap substitute products and increased market contact. For example, grandparents of informants had used the bark of *Licania octandra* as dye and the ashes of *Hirtella excelsa* in the production of ceramics; however, not one of the informants currently use the trees for this purpose. Use of natural fibers in the making of hammocks has discontinued and processing of plant resources has declined. Capimenses no longer extract the medicinal oils *Copaifera* spp. and *Carapa guianensis* or make "milk" from the nuts of *Lecythis pisonis*.

By the same token, opportunities to learn new uses of plants arise for *caboclos* when they sell or extract timber for logging companies. From these experiences, Capimenses become exposed to new streams of knowledge and products, which reflect modern plant preferences of urban consumers. For example, although *caboclos* in the Capim region rarely have tables or chairs in their homes, many described a major use of *Pithcellobium racemosum* (angelim rojada) as wood for making beautiful furniture. In contrast to their formerly first-hand, intimate knowledge of plant use, however, new information is second-hand, and closely associated with the timber industry.

Regarding methodologies, information on current plant use was best collected during fishing, hunting and gathering activities, rather than during the ethnobotanical inventory itself. Indeed, much of the most interesting information regarding plant use was inadvertently gained while living and working in the Capim communities during a longer-term study of the ecology of fruiting species. For example, during the course of five years, little-used techniques to extract the oil of uxi and piquiá were mentioned in passing by only one woman during the final year of research. Information on medicinals was also best gleaned during illnesses, while parents collected, prepared and applied remedies to their children.

Due to embarrassment that they were still using plants as opposed to "clean, packaged medicines from the pharmacy," some women were initially reticent to share information on plant-based medicinals. Over time, recognition of the team's respect for plant-based remedies and understanding that the information would be used to strengthen local health care, created a climate in which plant knowledge was valued and proudly shared. This underscores the need for methods other than questionnaires or short-term inventories that may miss seasonal or annual cycles of plant use (Alexiades 1996, Martin 1995). Findings also highlight the critical need to value traditional knowledge through practical actions that assist communities.

The results of this inventory reinforce findings from other ethnobotanical studies that indigenous knowledge is dynamic (Alexiades 1999, Raffles 1998, Schrekenberg 1996, Alcorn 1989, Posey 1983, Ford 1978) and that botanical knowledge is diminishing (Kothari 1993, Milliken et al. 1992, Prance 1991, Schultes and Raffauf 1990, Boom 1987, Cavalcante and Frikel 1973). As communities change, knowledge about plants once considered essential may become anachronistic. Balée (1994) notes that especially in non-literate societies, which transmit knowledge orally, there is a limit to the capacity for human memory to store relevant facts, and that a kind of "mental economy" is needed to select and store information. With relatively few Capimenses being literate, all of their ethnoecological knowledge is committed to memory. When new information is incorporated to deal with markets, logging, ranching and fire, less time and know-how is devoted to trees. As trees vanish from the Capimenses landscape, botanical knowledge fades from their minds.

Table 3.1: Useful species (> 10 cm dbh) to *caboclos* of the Capim River, Brazil in a 1-ha forest plot (200 x 50 m)

A or a = food; B or b = construction; C or c = technology; D or d = remedy; E or e = commerce; F or f = commerce, E or e = "other" use; G or g = animal food. Uppercase indicates major use value; lowercase indicates minor use value.

Family	*Species*		*Voucher*	*Use*	*Value*
Annonaceae					
	Duguetia calycina	Benoist	53	b, d, g	1.5
	Duguetia lepidota	Pulle	52	B, c, g	2.0
	Guatteria poeppigiana	Mart.	50	B, c, g	2.0
	Xylopia polyantha	R.E.Fries	54	B, c	1.5
			Use value subtotal		7.0
			No. species on plot		4.0
			Familial use value		1.8
Apocynaceae					
	Aspidosperma eteanum	Markgraf	56	b, c, e, g	1.5
			Use value subtotal		1.5
			No. species on plot		1.0
			Familial use value		1.5
Bombaceae					
	Bombax longipedicellatum	Ducke	58	b, e	1.0
			Use value subtotal		1.0
			No. species on plot		1.0
			Familial use value		1.0
Boraginaceae					
	Cordia silvestris	Fresen.	57	g	0.5
			Use value subtotal		0.5
			No. species on plot		1.0
			Familial use value		0.5
Burseraceae					
	Protium decandrum	(Aublet) Marchand	65	C	1.0
	Protium paniculatum	Engl.	66	C, g	1.5
	Protium polybotryum	(Turcz.) Engl.	64	c, g	1.0
	Protium tenuifolium	(Engl.) Engl.	61	b, c, e, g	2.0
	Protium trifolioatum	Engl.	62	b, c, g	1.5

Family	Species		Voucher	Use	Value
	Trattinickia burserifolia	Mart.	59	c, g	1.0
			Use value subtotal		8.0
			No. species on plot		6.0
			Familial use value		1.3
Caesalpiniaceae					
	Bauhinia kunthiana	Vogel	74	d	0.5
	Bauhinia rutilans	Spruce, ex Benth.	73	d	0.5
	Cassia xinguensis	Ducke	67	B	1.0
	Copaifera aff. reticulata	Ducke	71	b, D, E, G	3.5
	Dialium guianense	(Aubl.) Sandw. A.C. Sm.	72	g	0.5
	Hymenaea parvifolia	Huber	69	a, d, E, G	3.0
	Macrolobium brevense	Ducke	75	G	1.0
	Macrolobium microcalyx	Ducke	76	G	1.0
	Peltogyne aff. lecointei	Ducke	70	b, d, E	2.0
	Sclerolobium paraenses	Huber	68	e	0.5
	Swartzia aborescens	Pittier	229	G	0.5
			Use value subtotal		14.0
			No. species on plot		11.0
			Familial use value		1.3
Caryocaraceae					
	Caryocar villosum	(Aubl.) Pers.		A, B, E, G	4.0
			Use value subtotal		4.0
			No. species on plot		1.0
			Familial use value		4.0
Cecropiaceae					
	Cecropia distachya	Huber	161	c, d, g	1.5
	Pourouma velutina	Mart. ex Miq.	163	g	0.5
			Use value subtotal		2.0
			No. species on plot		2.0
			Familial use value		1.0
Celastraceae					
	Goupia glabra	Aubl.	77	B, E, g	2.5

Family	Species		Voucher	Use	Value
			Use value subtotal		2.5
			No. species on plot		1.0
			Familial use value		2.5
Chrysobalanaceae					
	Couepia guianensis		80	B, c, g	2.0
	subsp divaricata	(Huber) Prance			
	Couepia robusta	Huber	81	G	1.0
	Hirtella eriandra	Benth	92	g	0.5
	Hirtella excelsa	Standley ex Prance	91	g	0.5
	Hirtella racemosa	Lamark	93	g	0.5
	Licania aff. egleri	Prance	96	g	0.5
	Licania apetala	(E.Mey.) Fritsch	88	B, c, g	2.0
	Licania canescens	R. Ben.	84	B, d, g	2.0
	Licania heteromorpha	Benth.	94	B, c, e, g	2.5
	Licania kunthiana	Hook. F.	89	b, c	1.0
	Licania micrantha	Miq.	87	b, c, g	1.5
	Licania sp. 1		82	g	0.5
	Licania sp. 2		86	c, g	1.0
	Parinari aff. excelsa	Sabine	83	c, g	1.0
			Use value subtotal		15.0
			No. species on plot		12.0
			Familial use value		1.3
Combretaceae					
	Terminalia amazonica	(J. Gmel.) Exell.	79	E	1.0
			Use value subtotal		1.0
			No. species on plot		1.0
			Familial use value		1.0
Elaeocarpaceae					
	Sloanea aff. latifolia	Schum.	98	c, g	1.0
	Sloanea grandis	Ducke	99	c, g	1.0
			Use value subtotal		2.0
			No. species on plot		2.0
			Familial use value		1.0

Family	Species		Voucher	Use	Value
Erythroxylaceae					
	Erythroxylum citrifolium	A. St. H.L.	102	g	0.5
			Use value subtotal		0.5
			No. species on plot		1.0
			Familial use value		0.5
Euphorbiaceae					
	Dodecastigma integrifolium	Lanj.	101	g	0.5
	Mabea aff. maynensis	Spruce	100	g	0.5
	Maprounea guianensis	Aubl.	230		
			Use value subtotal		1.0
			No. species on plot		3.0
			Familial use value		0.3
Flaucourtiaceae					
	Laetia procera	(Poepp. ex Endl.) Eichl.	108	g	0.5
			Use value subtotal		0.5
			No. species on plot		1.0
			Familial use value		0.5
Guttiferae					
	Caraipa densifolia	Mart.	111	b, d	1.0
	Platonia insignis	Mart.	110	A, B, d, E, g	4.0
	Vismia cayennensis	(Jacq.) Pers.	109	d, g	1.0
			Use value subtotal		6.0
			No. species on plot		3.0
			Familial use value		2.0
Humiriaceae					
	Endopleura uchi	(Huber) Cuatrec.	228	A, b, d, E, G	4.0
	Saccoglottis guianensis	Benth.	112	G	1.0
			Use value subtotal		5.0
			No. species on plot		2.0
			Familial use value		2.5
Lauraceae					
	Aniba williamsii	Brooks	113	G	0.5
	Nectandra pichurim	Mez.	114	b, e	1.0

Family	Species		Voucher	Use	Value
	Ocotea aff. rubrinervis	Mez.	115	B, e	1.5
	Ocotea caudata	Mez.	116	B, e, g	2.0
			Use value subtotal		5.0
			No. species on plot		4.0
			Familial use value		1.3
Lecythidaceae					
	Couratari guianensis	Aublet	129	c, E, f, G	3.0
	Eschweilera aff. collina	Eyma	232	c, g	1.0
	Eschweilera amazonica	R. Knuth	125	b, d, e, G	2.5
	Eschweilera apiculata	(Miers) A.C. Sm.	127	e, g	1.0
	Eschweilera coriaceae	(A.P. Cand.) Mart. ex. Berg	233	b, c, d, e, g	2.5
	Eschweilera grandiflora	(Aubl.) Sandw.	122	b, d, e, G	2.5
	Lecythis idatimon	Aublet	119	b, C, e, g	2.5
	Lecythis pisonis	(Miers) Prance	123	a, b, d, E, G	3.5
			Use value subtotal		18.5
			No. species on plot		8.0
			Familial use value		2.3
Loganiaceae					
	Strychnos aff. mutscherlichii	Rich. Schawb.	117	D	1.0
			Use value subtotal		1.0
			No. species on plot		1.0
			Familial use value		1.0
Malpighiaceae					
	Byrsonima aerugo	Sagot.	151	a, g	1.0
	Byrsonima amazonica	Griseb.	152	A, G	2.0
	Dicella aff. conwayi	Rusyy	153	g	0.5
			Use value subtotal		3.5
			No. species on plot		3.0
			Familial use value		1.2
Marantaceae					
	Calathea aff. ovata	(Nees et Mart.) Lindl.	164		
			Use value subtotal		0.0
			No. species on plot		1.0
			Familial use value		0.0

Family	Species		Voucher	Use	Value
Marcgraviaceae					
	Norantea guianensis	(Aubl.) Triana	165		0.0
			Use value subtotal		0.0
			No. species on plot		1.0
			Familial use value		0.0
Meliaceae					
	Trichilia cipo	C. DC.	156		0.0
	Trichilia lecointei	Ducke	157		0.0
	Trichilia micrantha	Benth.	158		0.0
	Trichilia schomburgkii	C. DC.	159		0.0
			Use value subtotal		0.0
			No. species on plot		4.0
			Familial use value		0.0
Mimosaceae					
	Abarema spp.		131	a, g	1.0
	Dinizia excelsa	Ducke	132	E	1.0
	Enterolobium maximum	Ducke	133	g	0.5
	Enterolobium schomburgkii	Benth.	134	e, g	1.0
	Inga aff. pezizifera	Benth.	144	G	1.0
	Inga aff. bourgeni	DC.	135	g	0.5
	Inga aff. crassiflora	Ducke	137	g	0.5
	Inga capitata	Desv.	136	g	0.5
	Inga falcistipula	Ducke	138	g	0.5
	Inga gracilifolia	Ducke	140	g	0.5
	Inga paraensis	Ducke	141	G	1.0
	Inga rubiginosa	(Rich.) DC.	145	G	1.0
	Inga thibaudiana	DC.	146	a, d, G	2.0
	Newtonia psilostachya	(DC.) Brenan	147	c, E	1.5
	Pithecellobium pedicellare	(DC.) Benth.	148	g	1.0
	Pithecellobium racemosum	Ducke	149	b, E, G	2.5
	Stryphnodendron aff. paniculatum	Poepp. & Endl.	150	B, g	1.5
			Use value subtotal		17.5
			No. species on plot		17.0
			Familial use value		1.0

Family	Species		Voucher	Use	Value
Monimiaceae					
	Siparuna crassiflora	Perkins	166		0.0
			Use value subtotal		0.0
			No. species on plot		1.0
			Familial use value		0.0
Moraceae					
	Brosimum acutifolium subsp. acutifolium	(Huber) C. C. Berg	160	b, D, f, G	3.0
	Coussapoa latifolia	Aubl.	162		0.0
			Use value subtotal		3.0
			No. species on plot		2.0
			Familial use value		1.5
Myristicaceae					
	Virola michelii	Heckel	154	b, D, e	2.0
			Use value subtotal		2.0
			No. species on plot		1.0
			Familial use value		2.0
Myrtaceae					
	Campomanesia aff. aromatica	Griseb.	167	a, g	1.0
	Myrcia sp.		170	g	0.5
	Marlierea umbraticola	Berg	168	g	0.5
	Myrciaria tenella	(DC.) Berg	171	c	0.5
			Use value subtotal		2.5
			No. species on plot		3.0
			Familial use value		0.8
Nyctaginaceae					
	Neea sp.		172		0.0
			Use value subtotal		0.0
			No. species on plot		1.0
			Familial use value		0.0
Ochnaceae					
	Ouratea polygyna	Engl.	174		0.0
			Use value subtotal		0.0

Family	Species		Voucher	Use	Value
			No. species on plot		1.0
			Familial use value		0.0
Olacaceae					
	Minquartia guianensis	Aubl.	175	B, e	1.5
			Use value subtotal		1.5
			No. species on plot		1.0
			Familial use value		1.5
Papilionaceae					
	Dipteryx odorata	(Aublet) Willd.	103	b, D, E	2.5
	Hymenolobium flavum	Kleinh.	107	b	0.5
	Machaerium aff. ferox	(Mart. ex Benth.) Ducke	105		0.0
	Machaerium madeirense	Pittier	106		0.0
	Poecilanthe effusa	(Hub.) Ducke	104		0.0
			Use value subtotal		3.0
			No. species on plot		5.0
			Familial use value		0.6
Proteaceae					
	Roupala montana	Aubl.	173	b, e	1.0
			Use value subtotal		1.0
			No. species on plot		1.0
			Familial use value		1.0
Rhabdodendraceae					
	Rhabdodendron amazonicum	(Spruce ex Benth.) Huber	176		0.0
			Use value subtotal		0.0
			No. species on plot		1.0
			Familial use value		0.0
Rubiaceae					
	Chimarrhis turbinata	DC.	177	c, g	1.0
			Use value subtotal		1.0
			No. species on plot		1.0
			Familial use value		1.0

Family	Species		Voucher	Use	Value
Rutaceae					
	Spiranthera guianensis	Sandwith	178	g	0.5
	Zanthoxylum sp.		180		
			Use value subtotal		0.5
			No. species on plot		2.0
			Familial use value		0.3
Sapindaceae					
	Cupania scrobiculata	L.C. Rich.	182	g	0.5
	Talisia aff. intermedia	Radlk.	181	g	0.5
			Use value subtotal		1.0
			No. species on plot		2.0
			Familial use value		0.5
Sapotaceae					
	Chloroluma imperialis	Huber	187	g	0.5
	Chrysophyllum anomalum	Pires	186	g	0.5
	Diploon venezuelana	Aubr.	184	g	0.5
	Ecclinusa guianensis	Eyma	185	g	0.5
	Franchetella cladantha	(Sandw.) Aubr.	188	g	0.5
	Franchetella aff. niloi	Pires	192	b, g	1.0
	Franchetella anibifolia	(A.C. Sm.) Aubrev.	189	g	0.5
	Franchetella gongrijpii	(Eyma) Aubrev.	190	a, b, g	1.5
	Manilkara amazonica	(Huber) Standley	193	a, B, e, g	2.5
	Manilkara huberi	(Ducke) Chev.	194	a, B, d, e, g	3.0
	Manilkara paraensis	(Huber) Standley	196	a, B, e, g	2.5
	Micropholis aff. egensis	Pierre	208	g	0.5
	Micropholis guyanensis	(A. DC.) Pierre	207	g	0.5
	Micropholis venulosa	(Mart. ex Eich.) Pierre	197	a, d, g	1.5
	Pouteria sp.		202	g	0.5
	Pouteria decorticans	Pennington	198	a, g	1.0
	Pouteria guianensis	Aublet	200	b, g	1.0
	Pouteria heterosepala	Pires	199	a, b, g	1.5
	Pouteria jariensis	Pires; Pennington	201	g	0.5
	Pouteria lasiocarpa	Radlk.	205	b	0.5
	Pouteria singularis	Pennington	210	a, c, g	1.5
	Pouteria trichopoda	Baehni	212	a, g	1.0
	Radlkoferella macrocarpa	(Huber) Aubrev.	214	a, b, g	1.5
	Ragala sp.		209	a, g	1.0

Family	Species		Voucher	Use	Value
	Richardella aff. krukovii	(A.C. Smith) Baehni	203	g	0.5
	Syzygiopsis oppositifolia	Ducke	216	a, G	1.5
			Use value subtotal		28.0
			No. species on plot		26.0
			Familial use value		1.1
Simarubaceae					
	Simaruba amara	Aubl.	183	b, e	1.0
			Use value subtotal		1.0
			No. species on plot		1.0
			Familial use value		1.0
Sterculiaceae					
	Sterculia pruriens	(Aubl.) K. Schum.	218	c, g	1.0
			Use value subtotal		1.0
			No. species on plot		1.0
			Familial use value		1.0
Tilliaceae					
	Apeiba burchellii	Sprague	219	c, g	1.0
	Apeiba echinata	Gaertn.	220	c	0.5
	Lueheopsis ducheana	Burrett	221	g	0.5
			Use value subtotal		2.0
			No. species on plot		3.0
			Familial use value		0.7
Violaceae					
	Rinorea guianensis	Aubl.	222	b, g	1.0
	Rinorea racemosa	(Mart.) Kuntz	223	b, g	1.0
	Rinorea riana	(DC.) Kuntz	224	g	0.5
			Use value subtotal		2.5
			No. species on plot		3.0
			Familial use value		0.8
Vochysiaceae					
	Qualea albiflora	Warm	226	b, e	1.0
	Vochysia surinamenais	Stafleu	227	b, e, g	1.5
			Use value subtotal		2.5
			No. species on plot		2.0
			Familial use value		1.3

I have heard of the "green wave", but it has not yet reached me.

Vendor of forest products, Belém

CHAPTER FOUR
THE FAINT PROMISE OF A DISTANT MARKET: A SURVEY OF BELÉM'S TRADE IN NON-TIMBER FOREST PRODUCTS

INTRODUCTION

For decades, inhabitants of the Capim river basin tapped copaíba (*Copaifera* spp.) trees to gather oil, felled thousands of maçaranduba (*Manilkara* spp.) trees to collect latex and intensively hunted forest areas for food and pelts. Although some traditional harvesting practices were unsustainable, the region's low human population density and the migration upriver by Capimenses to exploit large tracts of intact forests permitted trade in these products to thrive beginning from the last half of the 19th century until 25 years ago. During the 1970s and 1980s, the expansion of the region's timber trade, increasing sale of agricultural produce and growing use of substitute products locally and internationally, brought about a collapse in the region's national and export trade of non-timber forest products. By the time the present study was initiated in 1992, game, pelts, oils and latex were no longer bartered along the Capim; logs had become the principal market commodity extracted from the region's forests.

Paradoxically, as trade in non-timber forest resources declined in the Capim, policy analysts, scientists and environmental activists began to embrace research results suggesting that the potential economic gains from non-timber forest products could help slow tropical deforestation (Plotkin and Famolare 1992, Clay and Clement 1993). In contrast to prevalent Amazonian land-uses such as cattle ranching and logging, which contribute to biotic impoverishment and the drastic reduction of economic species, the harvest of NTFPs was portrayed as a relatively benign, sustainable form of land-use. Although NTFP-based conservation strategies have been challenged on ecological, economic and social grounds (Arnold and Ruiz-Pérez 1998, Padoch and Pinedo-Vasquez 1996, Browder 1993, Phillips 1993, Pinedo-Vasquez et al. 1992, Pendleton 1992) conservationists and researchers continue to look to non-timber forest products as an alternative and sustainable land-use strategy (Wollenberg and Ingles 1998, Ruiz-Pérez and Arnold 1996, Prance 1997) as well as a source of raw material for biodiversity prospecting (ten Kate and Laird 1999, Reid et al. 1993). At the outset of the present study, the renewed marketing of non-timber forest products in the Capim river basin appeared as if it might be a promising conservation and development tool. In part, this was due to the extremely meager returns offered by timber sales and the increasingly detrimental consequences of logging for daily livelihoods. However, before recommending a non-timber forest product management strategy to communities in the study area, it was important to assess the abundance, use and markets of economic species in the region. In eastern Amazonia, many questions about the trade of non-timber forest products remained unanswered. Which non-timber forest products were in greatest demand? Did they occur in forest or fallow? Could the sale of NTFPs adequately compensate collectors for the foregone earnings from timber? Did logging activities threaten sources of non-timber forest products?

To begin answering these questions, and in order to examine the potential for Capim communities to market non-timber products in addition to timber, an NTFP marketing study was conducted in Belém,[1] the region's commercial center. This survey had three primary aims: 1) to identify the non-timber forest resources (particularly those occurring in the Capim) for which relatively high levels of demand exist in regional markets; 2) to determine the primary sources, prices and volumes traded of these key products; and 3) to examine forces which may impact the future availability of these products for regional traders.

This chapter will present and analyze the findings of this market survey. The first four sections of the chapter describe respectively the types, volumes, prices and management of select fruit, medicinal plants, fiber and game sold in the Belém marketplace, and assess the viability of marketing these products for Capim communities. Fruits and medicinals are the most widely marketed and so receive greater emphasis. The next section examines key structural factors shaping the region's NTFP trade, such as transportation, social infrastructure and market demand. In closing, the effects of land-use change on present and future sources of non-timber forest products are briefly discussed.

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[1] A second, less extensive market survey was conducted in Paragominas, the closest city to the Capim communities and the center of the region's logging industry. Paragominas has a lively farmer's market where Capimenses regularly sell farinha and other agricultural products. Small volumes of NTFPs are also traded in the city's open-air market. Due to the small size of the market, however, the range and volume of NTFPs sold is narrow and could be easily saturated with additional volumes of extractive products. Although Paragominas may offer the most accessible sales outlet for NTFPs by Capimenses, this study focused on Belém in order to obtain a broader view of the region's NTFP trade.

RESEARCH SITE AND METHODS

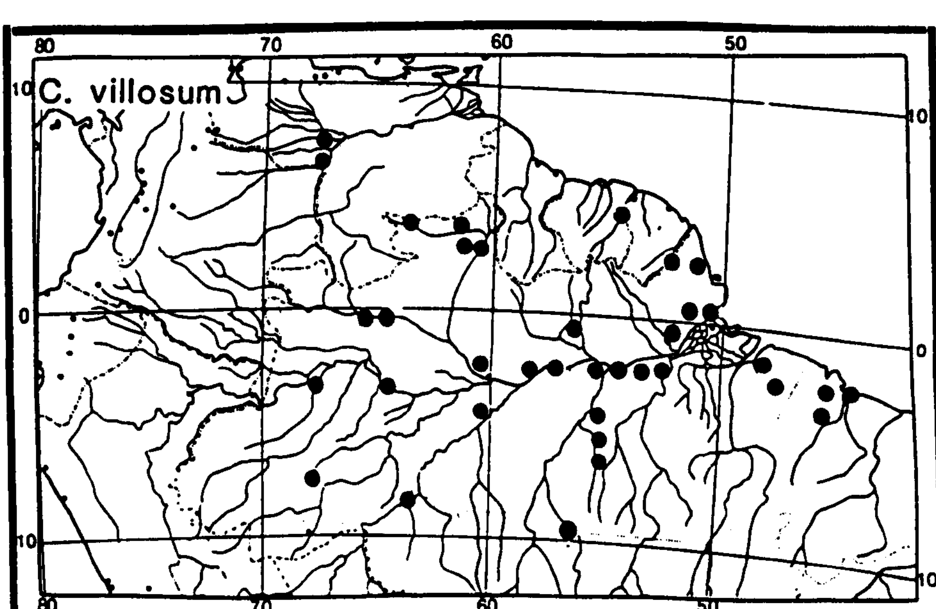
The capital of Pará and the principal port city of eastern Amazonia, Belém is located 137 miles upriver from the mouth of the Amazon River. With a population of 1.5 million, Belém lies close to two hundred km north by water, downriver from the study communities. The region's primary commercial center, Belém is home to hundreds of outdoor markets and shops selling agricultural commodities, fish, and a wide range of Amazonian flora and fauna.

The largest open-air market in Belém is Ver-o-Peso, where fruit, fish, meat, medicinals, herbs and crafts are sold. Products reach the market by boat and by truck. Additional riverside ports host wholesale fruit and vegetable markets while scores of smaller, open-air retail markets are dispersed throughout the city. Forest and farm products are also sold in supermarkets, shops and pharmacies while roving vendors hawk medicinals, fruits and vegetables along sidewalks and city streets.

Fruit

In the Belém marketplace, scores of native Amazonian fruit are offered for sale (Cavalcante 1991). While some products (Brazil nut, cocoa, guarana, cashew) are traded worldwide, the majority of fruits sold are virtually unknown outside of Amazonia. This market study focused on three native fruit trees, *Caryocar villosum* (piquiá), *Platonia insignis* (bacuri), and *Endopleura uchi* (uxi). These species were selected due to: their presence and cultural importance in the Capim; significant commercial demand in the region; fairly ample distribution in Amazonia (Fig. 4.1); and lack of prior study (Prance 1990, Cavalcante 1990, Cavalcante 1990, Lane 1957).

Figure 4.1 The distribution of *C. villosum* (Prance 1990)



These criteria favored species that had been largely overlooked by previous market studies, most likely because of low species densities,[2] and lack of widespread domestication or inclusion into agroforestry schemes.

In Belém, we initially identified twenty-seven large and medium sized outdoor markets selling forest fruits. Based on rapid inventories of the 27 markets, three were selected as the focus of this study. These three are ports of entry of fruit to the city of Belém (land and water), trade in high volumes of native fruit, and serve as the principal retail and wholesale markets.

The majority of the native fruits are funneled through a small group of local (male) wholesalers who, if access can be gained, are a good source of information regarding sourcing, volumes, and prices. During the five-month fruiting season (January-May 1994), the three principal markets were visited three times weekly and wholesalers were interviewed to gather data on the volumes and prices of native fruit sold. Periodic price checks of fruit continued during the annual fruiting season from 1994 through 1998. All of the market data were collected with the assistance of local residents who had strong familiarity with both the products and vendors.

To gain an understanding of the origins of fruit arriving in Belém, several forest-based communities surrounding the city were visited which harvested and supplied large volumes of native fruit to the marketplace. Visits to these communities were made to document management techniques, harvest regimes and the volumes of fruit collected and sold by individual producers.

Medicinals

In Belém, medicinal plants are traded at open-air markets, shops, laboratories and along sidewalks. A preliminary inventory of medicinal plants for sale in the commercial center of Belém indicated that over 150 species were traded, approximately half of which are native to Amazonia. To select a subset of medicinal plants for the market study, the common names of plants occurring with the greatest frequency in twenty-three downtown establishments were tabulated. This list was crosschecked with the list of top-selling plants as indicated by store managers. The twelve most frequently traded medicinals as featured on store managers' lists and occurring in greatest frequency in the marketplace were selected to be the focus of this study. To determine the genus and species of select medicinal plants offered for

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2 With the exception of *Platonia insignis* that occurs in high densities in disturbed areas and poor soils.

sale and the habitats in which they were collected, a team of commercial collectors was followed into forests and fallows, and voucher specimens obtained.

Of the 23 medicinal plant outlets operating in the commercial center of Belém, seven were identified as "leading" establishments (1 market, 2 laboratories, 4 shops) in that they sold substantially higher volumes and a wider diversity of plants than their smaller competitors. We surveyed these outlets twice weekly for the following 9 months. During the course of two subsequent years, outlets were surveyed 4 times a year. Informal interviews of vendors were guided by questionnaires covering information on sources, volumes, pricing, numbers of customers, and impact of land-use change on sales.

To gain an idea of the size of the non-market use of medicinals within Belém, we conducted a stratified random sample of 200 urban households. Interviews were conducted in neighborhoods representing three different socioeconomic classes (lower, middle, upper). Questions focused upon the use and sourcing of medicinals.

Fiber and game

Fiber and game were assumed to have few commercial prospects due to their declining abundance in the Capim that has rendered them insufficient to meet local needs. When encountered in the marketplace, however, prices of crude fiber and game were collected. Due to its illegality, trade in game is conducted secretively. Local research assistants, persons familiar to the vendors, feigned interest in buying game, thus acquiring prices.

RESULTS AND DISCUSSION

Fruit

Descriptions of products sold

An enormous variety of tropical and temperate fruit is available for sale in the Belém marketplace. Apples, pears, peaches, grapes and other agricultural produce from southern Brazil is sold throughout the year. Most fruits native to Amazonia, however, have a seasonal fruiting period. The three most important fruits documented in the Capim ethnobotanical inventory — piquiá (*Caryocar villosum*), bacuri (*Platonia insignis*) and uxi (*Endopleura uchi*) — produce fruit during a restricted 4-5 month period. These fruits are extremely popular among Paraenses who anxiously await their arrival in the market, and who must pay steep prices to obtain fruit (often 2-10 times that of the mid-season price) at the beginning and end of the fruiting season.

Fruit from each of these species is collected after falling from the tree. Due to the thick rinds protecting the pulp of piquiá and bacuri, fruit remains marketable for approximately five days. Because uxi often falls from the tree while unripe, it can also be marketed for four to five days.

Bacuri is the first of the three fruit species to arrive in the market in December. Fortunately for consumers, the harvest season of the fruit is lengthened due to regional phenological variations. The initiation of the harvest season begins on islands in the Amazon estuary in December, moving inland towards regions in the interior of Para and Maranhão until late April. Bacuri's sweet, white pulp is eaten fresh and is used in the ice cream, jam, yogurt, and juice industries (Fig. 4.2). Piquiá is available in the market between January and April and is appreciated by native Paraenses who boil and eat the oily, nutritious yellow flesh with *farinha* (Fig. 4.3). In eastern Amazonia, production of uxi begins in late-January and continues until May. Gritty, oily, egg shaped and distinctively flavored, uxi is considered less than appealing to many non-Amazonians. However, in the city of Belem, the fruit is made into both juice and ice cream being eminently noted by popsicle vendors as one of the favorite flavors of Paraenses. During the past decade the number of juice stands, ice cream parlors and roving popsicle vendors has grown considerably in Belém. This has resulted in increased year-round market demand for native fruits. To meet the growing demand, scores of women at the Ver-o-Peso market daily process fresh fruit into pulp. To entice passers bys, vendors prominently suspend clear plastic bags filled with pink, orange, yellow, red and white fruit pulp from the ceilings of their wooden stalls. Shops and markets offer new brands and flavors of yogurt, jams, jellies and puddings based on these fruits.

The surging growth of new fruit products, coupled with the restricted fruiting season, has created a growing market for frozen fruit pulp. A rarity as recently as fifteen years ago, frozen fruit pulps are now an everyday item in supermarkets. Pulps of cupuaçu and acerola are in particularly heavy demand. Hundreds of juice bars, ice cream parlors and luncheonettes purchase, process and freeze their entire year's supply of fruit during the four-month season.

Prices and volumes of fruit sold

From the site of harvest, the market chain involves producers, or more frequently intermediaries, who transport fruit by truck, bus or boat to Belém, arriving between 3:00 and 6:00 in the morning. Many sell their fruit to wholesalers or retailers with whom they have long-standing relationships. Others sell to whomever offers the

Figure 4.2 Women extracting the pulp of *Platonia insignis* (bacuri)

Figure 4.3 *Caryocar villosum* (piquiá) fruit cut open to reveal its fleshy mesocarp and thick rind

best price. Collectors, as a general rule, receive half or less of retail prices, with wholesalers and middlemen setting the transaction price.

The harvest, transport and wholesale of much of the extractive fruit trade in Belém is dominated by men, but urban women figure prominently in the processing of fruit and the expanding retail trade in fruit products. This is true in both rural and urban environments, where women increasingly fill new market niches created by rising trade in fruit products.

Greater demand for native fruit in Belém's markets has contributed to rising prices. During the last five years, prices paid for piquiá, bacuri and uxi have increased substantially (3-6 fold). In some cases this retail price increase has been passed on to harvesters. This is illustrated by the case of uxi. Previously known as *"fruta do pobre"* (poor man's fruit) owing to its low price and accessibility to the poor, the market price of uxi has steadily increased from the equivalent of US $0.02-0.04 per fruit in 1994 to US $0.10-0.15 per fruit in 1998. Uxi currently offers a profitable return for many harvesters.

In 1996, at the beginning of the fruiting season, bacuri fruit was selling for the equivalent of approximately US $1.00 each; during midseason the price held strong at roughly US $0.25-0.30 per fruit. Processing of pulp raises the prices significantly; in 1997, one kilogram of pure pulp from bacuri, the most expensive of the three fruits, peaked at the equivalent of approximately US $14.00.

Despite lower per unit prices, increased volumes mean that profits for local merchants rise prolifically during the peak season of native fruit. The markets and street corners of the downtown swell with vendors selling bags of fruit to passing vehicles at stoplights, and temporary fruit stalls are crammed onto sidewalks along major avenues. Vendors remark that the sharp increase in the amount of money changing hands during the season of native fruit is plainly evidenced by the corresponding rise in the number of prostitutes within the market.

Although given little to no attention by economists, the three native fruit species surveyed in our study generated over US $4 million in Belém's three principal markets during the 1994 production season (four months). This figure encompasses only a portion of the total sales revenues generated by native fruits in Belém. It indicates, however, that sales of these regionally popular fruits provide work and substantial income to large numbers of rural harvesters, intermediaries, transporters, urban wholesalers, processors and retailers. The estimated volumes and approximate economic value of bacuri, piquiá and uxi sold in the city's three major markets during the fruiting season of 1994 are listed in Table 4.1.

Table 4.1 Volumes and prices of three native fruits sold in three principal markets of Belém, January-April 1994

Fruit	Volume by Unit (no. of fruit)	*Price per Unit 1994 US $	Total Value in 1994 US $
Bacuri	7,000,000	.23	1,610,000.
Piquiá	12,800,000	.10	1,280,000.
Uxi	30,100,000	.04	1,205,200.
Total fruit			4,095,200.

*Rate of currency exchange taken during the midpoint of the fruit season.

Management of fruit trees

Experienced fruit vendors recall that in the past much of the fruit sold in Belém came from forests surrounding the city. Even several decades ago, high volumes of uxi, piquiá and bacuri arrived by the boatload from these forests. Within the last few decades, many of these forests have been cleared. Today, it appears that non-domesticated fruit once sourced primarily from mature forests is being supplanted by semi-domesticated fruit harvested from intensively managed home groves.

Fruit from piquiá, bacuri and uxi are currently sourced, in part, from managed *terra firme* forests located on islands throughout the Amazon estuary as well as from communities within Zona Bragantina. Visits to these communities revealed that smallholders are effectively managing bacuri and uxi in home groves, the latter formerly described as an economically unviable species non-conducive to domestication or management in agroforestry systems (Cavalcante 1991).

However, on islands less than one-hour's boat ride from Belém, producers select seed of uxi, selectively eradicate non-economic species, use fire to control ant populations, weed, trim, and clean areas of litter during the harvest season in order to gather fruit more effectively. Unlike the scattered, low density populations (0.4 - 1.3 per ha) occurring in forests of the Capim, farmers living close to large and lucrative city markets have created densities as high as 35 trees of *E. uchi* per hectare. Producers claim that managed trees produce fruit prior to the 15 years cited in the literature (Cavalcante 1991). Individual trees can become so productive (and lucrative) that some farmers eradicate other valuable fruiting species (such as cupuaçu) to favor *E. uchi*.

Smallholders also increase the density of piquiá. Due to its ability to regenerate readily in sunny areas, piquiá sprouts are often found in disturbed, open areas along paths and within fallows where farmers guard them until maturity (Fig. 4.4). Instead of less than one tree per hectare, it is not uncommon in managed areas to encounter densities of 5-8 trees per hectare. Clumped distribution of piquiá in a number of regions of Amazonia indicate anthropogenic disturbance and suggest that piquiá has been a preferred fruit of Amazonians for centuries (Prance 1990, Clay and Clement 1993).

Bacuri is less commonly planted than managed in high-density stands, which often occur naturally in degraded areas and poor, sandy soils. Bacuri regenerates readily from both seed and sprout (Fig. 4.5). Although occurring in low densities in most *terra firme* forest, concentrations of bacuri are found in the estuary of the Amazon, on the island of Marajó, and in communities within Zona Bragantina that border waterways. In these regions, farmers selectively thin and prune natural stands of bacuri creating productive groves reaching over one hundred bacuri trees per hectare. During the fruiting season, trails are cleared throughout the groves, and the fruit is harvested once or twice daily.

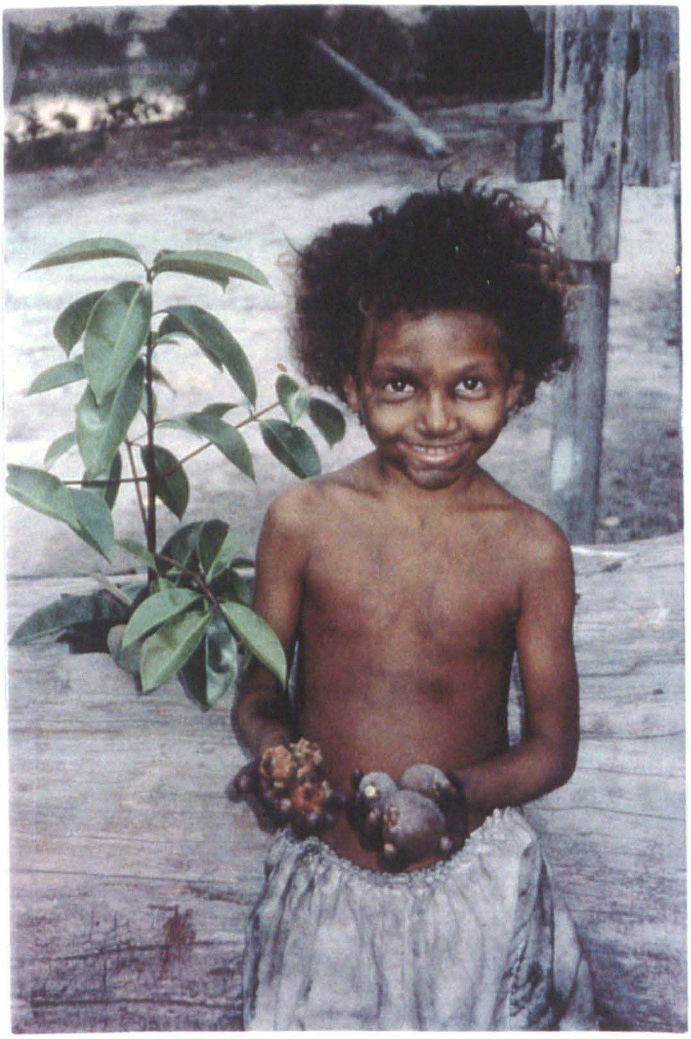
The viability of marketing fruit for distant communities

Even for communities located a substantial distance from the Belém market, and in areas where intensive management is not practiced, production of fruit from unmanaged forest populations often exceeds local demand. Therefore, in forest communities such as the Capim, for which distance to market and transportation difficulties are chronic obstacles, the rising price of fruit signifies a new income-generating opportunity. The relatively high prices paid for forest fruits may become sufficient to compensate for the costs of labor and transport.

Nevertheless, many obstacles exist. Most notably, many forest fruits are highly perishable products that spoil easily in transit and require appropriate packaging, handling, and storage. The collection of fruits that are widely dispersed through the forest may also require prohibitive amounts of search, travel and carry time (Salafsky et al. 1993). Moreover, the temporal availability of the product, dictated by species phenology, may coincide with a period when labor is needed for agricultural work. And within the Capim region, the season of fruit production and rain occur simultaneously, making roads treacherous and creating longer travel times as travelers are forced to use river transport.

Figure 4.4 Young piquiá tree conserved in open area

Figure 4.5 Child holding immature bacuri fruit next to a bacuri seedling



MEDICINALS

Profile of products and consumers

The hub of outdoor medicinal plant commerce is set within Belém's long-established river market, Ver-o-Peso, where over 80 tightly-crammed booths display fresh plant material, tonics, roots, oils, tree barks, and animal parts (van den Berg 1984). Medicinal plants from a wide geographic area are also marketed within shops, from curbsides, in supermarket carts, in laboratories and alongside pharmaceuticals in drug stores. Offering a vast array of plant-based medicines, these outlets provide a significant portion of the region's population — particularly the urban and rural poor — with treatments for virtually every imaginable ailment.

An inventory of medicinal plants in 23 establishments in downtown Belém revealed 211 different common names of medicinal herbs, shrubs, and trees. This number confirms van den Berg's (1984) finding of a steady decline in the number of medicinal plant species offered for sale. The specific parts of plants being sold included leaves, fruits, flowers, seeds, inner and outer barks, roots, and exudates. Of the 211 medicinal plants sold, we found that approximately half (55%) were not native to the Amazon. Despite the difficulties associated with identification of unlabeled medicinal plant material as sold in shops, 11 of the 12 top-selling plants collected by one pair of commercial collectors were verified by taxonomists.

Of the 12 leading medicinal plants sold in Belém's markets, nine are native to Amazonia. Eight of these occur in primary forests (Table 4.2). Two are non-substitutable medicinal oils: *Copaifera* spp. (copaíba), used for its antibacterial action in wounds, and *Carapa guianensis* (andiroba) for sprains and rheumatism, and as an insect repellent. Five of the top-selling medicinals are barks from native tree species, four of which are currently extracted for timber. Depending on species, barks are utilized for a range of illnesses such as ulcers, internal inflammations, worms, cholesterol, diabetes, cancer and diseases of the nervous system.

Interviews and observations of both buyers and sellers confirmed that all strata of Brazilian society — including rural immigrants, poor city residents and wealthy urban merchants — commonly use medicinal plants. However, distinct differences exist among these groups, especially with regard to where they purchase their plant products: poor people frequent open markets; middle-class customers buy from markets and laboratories; and upper-class consumers patronize laboratories and homeopathic shops. With such a broad cross-section of Belém's population using non-pharmaceutical remedies, demand for medicinal plants is strong. In fact, the city's

Table 4.2 Twelve leading medicinal plants traded in Belém, Brazil

Scientific Name Family	Common name	Collection number*	Plant part used, plant habit	Principal uses
Carapa guianensis Aublet Meliaceae	andiroba	435	seed oil, native tree	sprains, bruises, insect repellent, rheumatism
Chenopodium ambrosioides L. Chenopodiaceae	mastruz	471	leaf/seed, non-native herb	worms, bronchitis
Copaifera reticulata Ducke Caesalpiniaceae	copaíba	452	oleoresin, native tree	wounds, sore throat
Croton cajucara Benth. Euphorbiaceae	sacaca	440	bark/leaf, native tree	diabetes, cholesterol
Dalbergia subcymosa Ducke Fabaceae	verônica	442	inner bark, native vine	vaginal infections, uterine inflammation
Himatanthus sucuuba (Spruce) Woods Apocynaceae	sucuúba	454	bark/exudate, native tree	worms, herpes, uterine inflammation
Paullinia cupana Kunth. Sapindaceae	guaraná	473	seed, native shrub	stimulant, diuretic, weakness
Phyllanthus niruri L. Euphorbiaceae	quebra-pedra	472	root, non-native herb	urinary infections, kidney stones
Portulaca pilosa L. Portulacaceae	amor-crescida	470	leaf, non-native herb	burns, wounds, diuretic
Ptychopetalum olacoides Benth. Olacaceae	marapuama	474	root, native shrub	nerve diseases, impotence
Stryphnodendren barbatiman Mart. Mimosaceae	barbatimão	437 450	bark, native tree	hemorrhage, uterine & vaginal infections
Tabebuia impetiginosa Standley Bignoniaceae	pau d'arco ipê roxo	475	bark, native tree	inflammations, ulcers, skin ailments

*Plant specimens were collected by P. Shanley and N. A. Rosa and identified by N. A. Rosa and José Maria de Albuquerque. Voucher specimens are housed in the herbarium of the Museu Paraense Emílio Goeldi, Belem.

principal medicinal plant stores and laboratories frequently conduct over 50 transactions per hour.

Store records, interviews and direct observation undertaken as part of this study suggest that in 1994, five medicinal plant outlets in Belém's downtown area conducted more than one million sales. At the time the research began in 1994, the total population of Belém was estimated at 1.3 million (IBGE 1993). The figure of one million annual sales, however, does not include the vast, non-market consumption of medicinal plants. In a stratified random sample of 200 urban households, 45% of the families surveyed obtained medicinal plants not through purchase, but by direct collection, cultivation, or swapping with friends or neighbors.

Prices and volumes of medicinals

In Belém markets, the price of medicinal plants varies widely, depending upon the vendor, the species, availability, and demand. As a general rule, collectors receive no more than half of what unprocessed medicinals are eventually sold for, with wholesalers and middlemen largely dictating the transaction price. In Belém, a liter of andiroba oil in 1995 sold for the equivalent of US $4.00-$8.00, depending on the vendor. At the same time, processors of andiroba oil near Caméta (a five-hour boat ride from Belém), received the equivalent of US $2.00 per liter, or one-half to one-fourth the final retail price. However, due in part to rising demand, the price of andiroba has climbed in recent years, in the Ver-o-Peso market reaching the equivalent of US $15 per liter in 1998.[3]

Prices and rates of price fluctuations will also vary considerably among species, as some species are far more valuable as medicinals than others. In 1995 a commonly sold volume of herbs or bark, weighing about 200 and 700 grams respectively, cost the consumer between US $0.75-$1.00. In 1998, the price of the same quantity of these medicinals sold for the equivalent of roughly US $1.00. However, for species that have become difficult to find due to pressures from other forms of land use, such as logging, or from over-harvesting, prices have risen. For example, over the last four years, the price of copaíba oil has doubled from US $10.00-$15.00 to US $20.00-30.00 per liter, the rising price reflecting its increasing scarcity.

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[3] Interest in andiroba oil has recently grown due to its use in the manufacture of candles. Candles made of andiroba produce mosquito-repelling smoke, which is thought to assist in preventing the spread of dengue fever.

Prices also change as species come in and out of fashion. For example, although costlier than other plants due to its scarcity, the root of *Ptychopetalum olacoides* (marapuama) is tremendously popular locally, as it is used to fight diseases of the nervous system and impotence (Elisabetsky 1987, Elisabetsky et al. 1986). *Tabebuia* spp. (pau d'arco) that has been used by Amazonians for many years, has recently gained an international following for the treatment of gastric ulcers and for arresting the growth of tumors. The sales of *Croton cajucara* (sacaca) have also climbed during the last few years. Use as a treatment for diabetes, and more recently as a means to lower cholesterol and encourage weight loss, has stimulated growing demand. In 1997, a vendor in Belém offered one kilogram of C. *cajucara* bark for the equivalent of US $15.00 as opposed to other medicinal barks being sold for half that amount. Although each of these plants is costlier than other medicinals, customers insist, and their spending patterns indicate, that other less-costly plants may not serve as substitutes.

To meet the needs of the very poor, barks can be purchased in small quantities, and oils and honey sold by the spoonful. Aside from large volume wholesale transactions to shops and markets, the bulk of sales are transacted in small quantities. Although small volumes might seem trivial, a great number of sales occur on a daily basis. According to store records and interviews in seven leading medicinal plant establishments in Belém (1 wholesaler, 2 laboratories, 3 stores and the Ver-o-Peso market) their collective annual sales of barks called pau d'arco exceeded 9 metric tons (MT), while combined sales of five medicinal barks totaled approximately 30 MT (Table 4.3). In 1995, in the same seven outlets, combined annual sales of the regionally popular, andiroba and copaíba oils reached 100,000 liters.

Table 4.3 Annual volumes of five medicinal plants sold by seven major outlets in Belém, 1994

Common name	Possible species	Est. annual volume sold (kg)
pau d'arco	*Tabebuia impetiginosa* or *T. serratifolia*	9,355
sacaca	*Croton cajucara*	6,270
barbatimão	*Stryphnodendron barbatiman*	6,130
marapuama	*Ptychopetalum olacoides*	4,215
sucuúba	*Himanantus sucuuba*	3,920

On average, research conducted as part of this survey revealed that plants with pharmacologically-proven effectiveness — such as *Chenopodium ambrosiodes* (a vermifuge) (Bliss 1925), *Phyllanthus niruiri* (for urinary tract infections) (Melo et al. 1988), and *Bryophyllum callycinum* (for burns) (Nassis et al. 1991) — cost four times less per unit than their allopathic counterparts.

Collection and management of medicinals

Medicinals are sourced from primary and secondary forest, field and fallow. Cultivated herbaceous plants (often non-native such as *Chenopodium ambrosiodes* and *Bryophyllum calycinum*) are intensively managed by small holders in island and *terra firme* communities on the outskirts of Belém. Farmers interested in the use or sale of well-known medicinals such as andiroba or jatoba, may guard stands of the trees, plant them in their home gardens, and tend them when they sprout spontaneously. While some smallholders guard, plant and manage medicinal tree species such as *Carapa guianensis* and *Tabebuia* spp., the majority of native barks, roots and resins are collected from unmanaged forests, including both secondary forests surrounding Belém and distant mature forests.

Barks from valuable medicinal trees (*Tabebuia* spp. or *Hymenaea courbaril*) that are felled by loggers or for the creation of agricultural fields are sometimes rescued for sale or home use. In areas within 50 km of Belém, seasoned collectors have created bicycle and walking trails through secondary forests, taking as much as half a day to locate individual plants of the top-selling species. Bark of timber species no longer found standing within a 200 km radius of Belém are often "harvested" as by-products from the region's many sawmills. These medicinal barks include those of *Hymenaea courbaril*, *Tabebuia impetiginosa*, *Carapa guianensis* and *Copaifera* spp.

Collectors of medicinal plants bring their product to the city by way of trucks, boats, buses and bicycles. They then sell their plants to wholesalers or retailers. In some cases medicinal vendors from the city make specific requests to rural harvesters, who may collect bark in nearby forests or from recently felled trees in agricultural fields. Larger-volume enterprises maintain contact with established sources throughout the country and send carriers to gather plant material directly from harvesters.

The viability of marketing medicinals for distant communities

For communities located at considerable distances from Belém and other markets, nonperishable forest products, including, barks, roots, and exudates are conducive to marketing because they can survive rough handling, transport and long-term storage. Although possessing these and other advantages — including generally stable prices and strong demand — prices paid to collectors in eastern Amazonia for medicinals are relatively low. The potential sale of medicinal barks, roots, and resins by forest-based communities is also hampered by the diminishing abundance of many species due to logging. The medicinal trees that remain after logging are frequently used by local families who depend upon plant resources for basic health care. Moreover, destructive harvesting practices make commercial collection of many wild harvested bark and root medicinals that occur in low densities, ecologically non-sustainable.

Exceptions exist, however. If harvested sustainably, copaíba and andiroba oils can yield a fair economic return. In some cases, management of preferred species can increase their abundance. Secondary forest species with strong sales and rising prices such as *Croton cajucara* are occasionally managed for harvest and sale. In addition, the cultivation of herbaceous medicinals by many families in the suburbs of city markets offer significant monthly income.

FIBERS

Products, prices and trade

A multitude of fiber products such as baskets, brooms, home utensils and manioc sieves are offered for sale in Belém. Three of the most popular fibers used for basketry are *Heteropsis jenmanii* (titica), *Thoracocarpus bissecta* (timboaçu) and *Ischnosiphon arouma* (guaruma). Titica and timboaçu are native epiphytes, occurring in mature, *terra firme* forest. In recent decades, due to deforestation surrounding Belém, these fibers now come from increasingly distant forests. However, guaruma is an herbaceous plant that grows in inundated, edge and degraded areas and regenerates rapidly after extraction. Guaruma is used in the construction of the majority of baskets used for the transport of Amazonian products to the city of Belém. Titica and timboaçu are used in the construction of heavier baskets and as fasteners (in lieu of nails) in the construction of homes and fences. In April, 1997 the price offered to collectors for crude titica fiber in the Paragominas region was roughly the equivalent of US $2.00 per kilogram.

In contrast to the large volumes of crude fiber traded in Belém up until a decade ago, vendors report that relatively low volumes of titica and timboaçu are currently found in the city's markets. This may be due to a number of factors including: low prices for collectors, over-harvesting, decreased densities nearby, and the availability of substitute products such as plastics. In addition, consumers of high volumes of fiber, such as furniture manufacturers, send their buyers to purchase truckloads of titica directly from collectors. Thus, large volumes of fiber move directly from harvesters to industrial buyers, bypassing city markets.

Collectors throughout the region who harvest large volumes of fiber and sell them to Brazilian furniture manufacturers often gather their products in forests adjacent to major roadways, illegally harvesting on land to which they do not have title. In Pará, for example, settler communities extract titica from the Tembé Indian Reserve. Lack of land rights leads to predatory harvesting practices, precluding long-term management of the resource. Large-scale harvesting and sale of titica and timboaçu continue, however, because collection is economically advantageous to select settler communities and fills a growing demand from southern Brazilian furniture manufacturers. Additionally, fibers (being non-perishable) bear the distinct advantage of surviving rough handling and storage.

For Capim *caboclo* communities with limited forest, however, results suggest that the collection and sale of fiber over a long period of time is economically unviable and ecologically unsustainable. Prices paid to collectors for crude fibers are low and selective logging, fire, and collection for home use all contribute to a diminishing abundance of fiber. Currently, even communities that do not market fibers encounter ever-increasing scarcity and greater distances to harvest.

GAME

Products, prices and trade

For many *caboclos*, game is the most prized non-timber forest product. Subsistence use of game provides important cultural (Ellen 1993), socioeconomic, and nutritional benefits (Redford 1992, 1996).

In Brazil, commercial sale of wild game is unlawful. Nonetheless, informally designated areas exist in Belém for the illegal traffic of game. Types of game sold include armadillo, paca, peccary, tortoise and deer. While non-hunting consumers purchase game in the marketplace, restaurants that serve game frequently buy directly from hunters or middlemen. Game sold in Belém comes principally from secondary forests in island communities and suburbs surrounding the city; occasionally hunters bring game from more distant mature forests.

In urban areas, prices vary considerably from one species to another. Paca, for instance, fetches four to five times the price per kg as armadillo or small rodents. On the dock in Belém in 1995, one kg of paca was offered for sale for the equivalent of approximately US $7.00. Between 1995 and 1997, within rural communities in the Capim region, the price of locally captured and sold game, such as rodents, armadillo, and deer, remained relatively stable, roughly US $2.00 per kg.

Traditionally, belief systems in some communities protected and enhanced wildlife populations by curbing hunters from excessive game capture, encouraging the management of fallow and forest to favor game, and the creation of forest reserves. Today, however, as forest cover declines due to increased logging, ranching and fire, and as traditional sanctions to protect game erode, game populations have dwindled and hunting success has diminished (Redford 1992, Redford 1996). Consequently game capture in many rural communities with limited forest area is often insufficient to meet local needs; sale of game under these circumstances is not only illegal, but is not viable economically or ecologically.

FURTHER CONSIDERATIONS IN THE MARKETING OF NTFPS

Transport of goods

Terra firme rainforests cover over half of Amazonia (Daly and Prance 1989) and are characterized by high biodiversity levels and low species density. The practical consequences of biodiversity for collectors of NTFPs means walking long distances to encounter conspecific trees. When gathering fruit for sale, a collector may walk up to three km to find productive trees, after which he must carry the fruit (which often weights 60 kg or more) back on foot to the river bank for transport to market. There, the fruit must be packed in hand-made baskets, wooden crates or plastic sacks.

Without saws, nails and hammers, crates are not easily built in the Capim communities and baskets require collecting trips to gather fiber and time for their construction. Therefore, some inexperienced collectors and those lacking alternatives resort to using recycled, plastic *farinha* sacks as a readily accessible means of transporting fruit and other products. However, uxi, piquiá and bacuri, which can normally last up to five days after falling from the tree, spoil more quickly within plastic sacks.

Transportation to and from the Capim communities is infrequent, unpredictable, and highly problematic. Depending on the weather and available options Capimenses may hitch a ride on a logging truck, flag down a passing boat, or wait for a municipal truck which is sent to transport agricultural produce to the city twice each month. The quickest route to Paragominas from the Capim communities is 120 km of dirt logging roads and poorly maintained paved roads. However, during the rainy season (the season of forest fruits), logging roads often become impassable and wooden bridges collapse under the weight of logging trucks. During this season, river transport must be used, requiring six to eight hours by boat and two hours by road.

Normally, products from the Capim are sold in Paragominas. But if Capimenses wish to reach the Belém market, they must travel an additional six hours from Paragominas by bus at a cost equivalent to roughly US $12.00. With this option being so costly, the few Capimenses seeking to reach Belém generally do so by boat, making the three-day journey from their community at an approximate cost of US $8.00.

Social infrastructure

Informed planning and organization are critical components of the social infrastructure necessary for successful marketing (Salafsky et al. 1993, Jessup and Peluso 1986), yet these are often lacking in remote forest communities such as the Capim. Indeed, once they reach the market, Capimenses generally find themselves to be at a gross disadvantage. First, they must compete for commercial space with market-savvy urban dwellers. More often than not, villagers are left on the fringes of the sales area, where few customers pass their way. Those prospective buyers that do pass by often take advantage of their inexperience, taste testing fruit, with no intention of buying. To compensate for the considerable time and labor needed to get their fruit to market, Capimenses must also set competitive prices. However, semi-literate, lacking knowledge of numbers and current prices, they often take whatever cash is offered.

The minimum time spent away from agricultural work to sell their products is two days; more commonly trips to market take three or four days. Away from home, hard-earned profits quickly evaporate, not infrequently spent on alcohol.

As Capimenses experiment, however, signs of a strengthening social infrastructure are evident. This is particularly the case among village women, who on two occasions during the study period, successfully navigated their way to the Paragominas market to sell forest fruit. Each time they returned with goods purchased for the entire community from their profits: used clothing for their families; lye for soap making; and a young pig that they fattened and later sold. Such incremental increases in local and regional trade of forest products offers a feasible path toward community development. For many rural poor who possess meager education, have scant market expertise, and cannot afford to bear additional risk, however, sales of forest products to distant markets as opposed to local and regional sales, is a remote and ill-advised prospect.

In contrast to the Capim communities, villages close to large city markets often have well-developed physical and social infrastructure, which can make the marketing of extractive products considerably less difficult. In areas surrounding cities, however, forest clearing has eroded the natural occurrence of many of the fruits and medicinals popular in the marketplace. This obstacle is being overcome in ingenious ways by smallholders who are managing native fruit species and by collectors who search secondary forests and sawmills for medicinal plant products. Where transportation to market is assured, groves of fruiting species tend to be managed in high densities, thereby slashing search and carry time and offering more profit for less labor.

Market demand — local and international

In Belém, extractive products such as fruits and medicinals have strong and growing markets. Robust local and regional sales of Amazonian extractive products have also been well described by Padoch (Padoch and de Jong 1987, Padoch 1988) and Anderson (Anderson and Jardim 1989, Anderson and Ioris 1992), who document NTFPs as providing significant employment and income to rural and urban families. In hypothesizing about prospective gains from increased product extraction for local and regional markets, however, it is important to exercise caution. Indeed, due to their shallow nature, local and regional markets cannot absorb the volume of products that could result from highly intensified extraction (Padoch and Pinedo-Vasquez 1996, Padoch 1988). In addition, destructive harvesting techniques can rapidly deplete wild populations (Peters 1996, Redford 1996, Cunningham 1993, Vasquez and Gentry 1989).

It is difficult to estimate trends in national and international sales of NTFPs because there is no systematic accounting of the bulk of non-timber forest products that leave the Amazon region, and because NTFPs often bypass formal channels of commerce. Historically, international demand for extractive products from Brazil has demonstrated wide fluctuations and has been subject to boom-bust market cycles (Homma 1983, 1993). Between 1974-1986, 11 of the 15 major extractive products from the Brazilian Amazon showed a decrease in production (Anderson and Ioris 1992). This trend towards a decline in the relative significance of NTFPs is also documented in Peru, where swidden agriculture has exceeded extraction of forest products in economic importance since the 1950s (San Román 1975; cited in Pinedo-Vasquez et al. 1992). Internationally, however, green and niche markets for a limited number of NTFPs are growing as specialty food, personal care and herbal medicine companies seek out novel ingredients and products (ten Kate and Laird 1999).

In spite of the increased use of some forest-based products, the volume of most Amazonian NTFPs in trade has declined due to resource degradation, the emergence of substitute products and competitive displacement of the production and marketing systems. For example, several wholesalers in Belém with decades of experience trading lesser-known forest products have experienced a marked decline in demand for NTFPs. Three to five decades ago, these wholesalers claimed, their families had access to thriving international markets, exporting tree latex, oils and seeds (e.g. *Dipteryx odorata, Manilkara* spp.) to Europe and the United States. One wholesaler traveled a number of times to Newark, New Jersey to collect payment for the lucrative sale of *Manilkara* spp. latex, at that time used in the production of golf balls.[4] Today, however, for these particular wholesalers, sales have collapsed. When asked about rekindled industry utilization of tropical forest products, one elderly gentleman commented from his dark, empty warehouse, "*Sim, eu ouvi falar desse 'onda verde', mas ele não tem chegada aqui ainda.*"— "Yes, I have heard of the 'green wave', but it has not reached me yet."

Marketing prospects for Capimenses

In summary, the market survey highlighted how the long distance to market, lack of transportation and lack of market expertise are significant obstacles for Capimenses to market most non-timber forest products in Belém. Prices paid for both fiber and medicinal barks are low and would poorly compensate for collection and transport time. By contrast, the popular medicinal oils copaíba and andiroba command stable prices that rise significantly pre and post harvest season. However, because both species exist in naturally low densities in the Capim basin and have been extracted by the timber industry, they occur only rarely and are difficult to find

[4] By traveling to New Jersey to collect payment in US dollars, he explained, he was able to protect his business against an unfavorable exchange rate and sharply rising inflation in Brazil.

even for home use. Game populations in the Capim are also currently inadequate to meet local needs; moreover, the sale of game is illegal.

Of the NTFPs surveyed, fruits represented the most promising resource, in that sufficient quantities are available and prices for both raw fruit and a multitude of processed products are steadily climbing. While lack of transportation excludes the possibility of marketing in Belém, incipient fruit sales by Capimenses in Paragominas indicate promise for the future. Demand for ice cream, yogurt, jams and juice in native fruit flavors is on the rise in cities and towns throughout Amazonia.

Land-use change — ecological considerations

As high forests within reach of Belém are cleared, collectors increasingly turn to secondary forests and managed forest groves to supply medicinal plants and fruits to market. Although secondary forests contain a wealth of economic species, some popular species do not regenerate naturally in secondary forest conditions. The occurrence and densities of economic species in secondary forests vary and depend on factors such as their sprouting response following cutting or burning; their ability to invade disturbed areas; and their presence or absence in soil seed banks.

While many studies have recorded relatively high use values for secondary forest species, (Arnold and Ruiz Pérez 1998, Schreckenberg 1996, Voeks 1992, Kainer and Duryea 1992, Pinedo-Vasquez et al. 1990, Denevan et al. 1987, Amorozo and Gély 1988, Branch and Silva 1983, Posey 1982, Alcorn 1981, 1989) the native fruit, fiber and medicinal species found in the Capim which are marketed in Belém, occur principally in mature forests. Some of these, such as key fruit species (piquiá, bacuri, uxi) are being successfully managed in forest groves near Belém. However, germplasm existing in forest-based populations which may be useful to breed increased yields, longer harvest seasons, and improved fruit may soon be lost to increasing deforestation (Clement 1989). In addition, non-substitutable medicinal species, such as *Copaifera* spp. and *Himatanthus sucuuba*, which are rarely managed in home gardens, are being extracted for timber.

A substantial number of the eastern Amazonian NTFPs in high commercial demand occur in mature forests and these forests are undergoing rapid change. It is important to assess whether the harvest and sale of certain non-timber forest products is sustainable and how logging, ranching and fire may threaten vulnerable species. Slow-growing mature forest species that occur in low densities, those whose roots are harvested, or whose bark or oil is extracted unsustainably are particularly vulnerable (Cunningham 1993).

For the future, the successful harvest and sale of fruits and medicinals will require determination of sustainable harvesting strategies. These must be based on ecological information such as: density, distribution, production, regeneration (Peters 1996, Cunningham 1993) and species response to fire, logging and harvesting practices (Laird 1996). Unfortunately, basic ecological information is lacking on the majority of non-timber forest products currently used and marketed in eastern Amazonia, including several of the most widely used medicinal species such as *Ptychopetalum alacoides*, *Tabebuia* spp., *Copaifera* spp. and three promising fruit species: *Caryocar villosum* (piquiá), *Platonia insignis* (bacuri) and *Endopleura uchi* (uxi). In the next chapter, the population ecology of these understudied fruit species will be explored.

The Indians wander 3 or 4 miles back from the bluff hunting or looking for piquiá fruits... Forest monarchs these are: the branches, contrary to the rules of forest trees are spreading and rough, like an oak but vastly larger than any oak I ever saw...

Smith, 1879

CHAPTER FIVE
ASPECTS OF THE USE AND POPULATION ECOLOGY OF *CARYOCAR VILLOSUM, ENDOPLEURA UCHI* AND *PLATONIA INSIGNIS*

INTRODUCTION

Information concerning the population ecology of economic species is fundamental to determine the sustainable extraction of non-timber forest products. This is also, however, the information most often lacking (Peters and Hammond 1990, Phillips 1992). Few demographic studies have been conducted on tropical species and even fewer take into consideration the practical objectives of sustainable extraction at the local level. Moreover, species whose size class distribution and growth form are conducive to demographic study (perennials, palms) have been preferred candidates for research (Hartshorn 1980, Peters 1990, Sarukhan 1980). This tendency has favored species occurring in high-density ecosystems such as *várzea*, as opposed to *terra firme* forests (Phillips 1993). Finally, although fundamental to an understanding of the ecology or economics of tropical forests, fruit production rates have rarely been quantified for upper canopy tropical tree species or tropical edible species (Peters 1989).

Knowledge concerning the population dynamics of an economic species — information on growth, density, distribution, regeneration — are essential to understand the reproductive cycle of trees. Remarkably, in spite of their ecological, economic and cultural importance, there remains much to be learned about fruit production, regeneration, and management practices regarding even internationally traded commodities, such as palm heart, brazil nut and chiclé. Species with regional and or national importance, receive even less study. As Peters (1987) states, the relative difficulty of quantifying different aspects of the population ecology for large, long-lived woody plants is reflected by the restricted number of studies which have focused on the population dynamics of forest trees.

The communities' idea to gain income through increased use and marketing of non-timber forest products (NTFPs) carried with it implicit ecological questions.

Specifically, how abundant are economic species? What is their annual yield? While easily posed, these questions are less easily answered. Accurate assessments of the densities, distributions and production/yield of many economic species are difficult to determine without direct measurement. Although there is some information in the existing literature on average yields of *Platonia insignis* (bacuri), and *Caryocar villosum* (piquiá), there is no description of how these figures were obtained. Extreme discrepancies regarding yield, 200 to 6000 piquiá fruit per tree annually, (Le Cointe 1947, Loureiro et al. 1979) and density differentials of .1 to 4 individuals per hectare (Lane 1957, Higuchi et al. 1985) may reflect natural variation but also indicate the need for additional field data. At the initiation of the study, however, no data with documented methods existed to describe the average or potential harvests of *C. villosum*, *P. insignis* or *E. uchi*.

The density and fruit production of *Caryocar villosum* (Aubl.) Pers., *Endopleura uchi* Cuatrec. and *Platonia insignis* Mart. were examined in a series of observational field studies. The studies were designed to assess the density of the species in natural forest and to document the phenology and magnitude of fruiting. Of special importance was the collection of data on size-specific fruit production which could be used for community purposes to compare the value of fruit production as opposed to the value of timber at the individual and population level.

In this chapter, a descriptive overview of methods is given followed by a description of the three fruits and their local uses. Next, findings concerning the phenology, density, size-class distribution, fruit production, and mortality of the three species are shown and discussed.

Study site

The selection of an appropriate study area for the autoecological investigations of *C. villosum*, *P. insignis* and *E. uchi* was based on several criteria. First, a forest was sought affording adequate size and occurrence of the species under study, and low likelihood of logging in the near future. Secondly, to ensure long-term cooperation, forest ownership needed to be clear. Preferably, the forest would be owned by an interested community (as opposed to individually owned lots of forest), which would invite and take part in the study. Third, successful implementation of the project would require accessibility to the site and the necessary infrastructural/political support.

On this basis of these criteria, three communities were chosen, each located contiguously on the western bank of the Capim River, 20 km downriver from the one-hectare inventory plot described in Chapter Two. These communities were among the few Capim communities in the region that had not divided their land into individual lots.

Through an informal but regionally recognized land titling system, the communities occupy 4000 hectares of land with approximately half composed of partially logged *terra firme* forest and the remaining half consisting of agricultural fields, fallows, restinga and settlement. Families practice swidden agriculture, each annually cutting and burning approximately 2-3 hectares of secondary or mature forest. Families are free to cut and burn any portion of the forest they choose, no formal consultative process takes place within the communities as a whole.

The communities recalled approximately four selective logging events as occurring prior to the study. Until the onset of the 1990s, species removed from the forest were relatively few, including: *Cedrela odorata* (cedro), *Cordia goeldiana* (freijo), *Euxylophora paraensis* (pau amarelo), and *Tabebuia serratifolia* (pau d'arco, ipé).

Species selection

Taking into account the results of ethnobotanical inventories, market surveys and interviews with over 60 farmers, the following five criteria were used to select species to study:

1. Exist in significant densities within regional forests;
2. Occur in a relatively broad distribution throughout Amazonia;
3. Are widely utilized by the community for subsistence purposes;
4. Demonstrate strong market value; and
5. Are considered as meriting study by local farmers and botanical authorities.

Two classes of nontimber forest products met the majority of the above criteria, medicinal oil trees and edible fruit producing trees. The occurrence of the medicinal oil trees (*Carapa guianensis* and *Copaifera* spp), however, was insufficient owing to naturally low densities compounded by diminished abundance due to extraction by the timber industry. Three mature forest fruiting species meeting all of the above criteria and which were cited by community members as the most important to study were: *Caryocar villosum*, *Endopleura uchi*, and *Platonia insignis*. The fruits produced by these trees are popular for home consumption and have a strong regional market. They occur widely throughout forests of the region and are prized both for the fruit they provide to families and for the game they attract by their fruits and flowers. Moreover, one of Amazonia's premier botanists, Paulo Cavalcante, highlights uxi and piquiá as two prime examples of noncultivated, forest species under increasing threat due to deforestation (1991).

Descriptions of species and their uses

Piquiá — Caryocar villosum *(Aubl.) Pers.*

Piquiá is a majestic forest tree extending skyward up to 40-50 meters in height with average diameter of one meter, sometimes reaching close to ten meters in circumference. Even in highly diverse tropical forest, the enormous trunk, and freely spreading thick branches rapidly distinguish piquiá from its neighbors. During the rainy season, the branches yield tan, softball sized, fleshy fruits containing a bright yellow oily mesocarp that is widely consumed after being boiled. Occurring in *terra firme* forests of the Brazilian Amazon and the Guianas, it fruits have been appreciated by indigenous populations for centuries; many journeying long distances to sample its rich fruit.

The pulp of *Caryocar* mesocarp is very nutritious, rich in calories, riboflavin, niacin, iron, phosphorous, carotene and Vitamin A (often lacking in Amazonian diets) (Carvalho and Burger 1960, Prance 1990). The quality of fruits vary, those bearing bitter flesh need to be boiled in several changes of salty water to enhance edibility. The yellow mesocarp surrounds a thick, spiny endocarp that contains the seed kernel. Although difficult to obtain, the small kernel was a prized food by Amerindians; yielding 45% oil, high in palmitic and unsaturated oleic fatty acids (Eckey 1954, Lane 1957). On a dry weight basis, piquiá is recorded as yielding between 61% (Eckey 1954) and 76% oil (LeCointe 1927). The high oil yield of the fresh mesocarp, 47%, led Henry Wickham to take not only rubber seeds from Amazonia, but piquiá seeds as well. His firm belief in the potential of piquiá as an oil crop to lessen potential world oil shortages, brought him to Malaya where he spent many years trying to promote the development of piquiá in plantations. More recently, confirming Wickham's claim, piquiá has been listed by the U.S. National Academy of Sciences as an under exploited tropical plant with promising economic value (NAS 1975). However, since this time little research has been conducted to explore this potential (Prance 1990).

Although its international use has been little explored, in rural areas the oil is extracted from fruit and employed in cooking and soap making. Moreover, the large rind of piquiá, comprising 65% fresh weight, is rich in tannin, sometimes substituted for ink, and employed as dye to color thread, and cord used in hammock-making.

C. villosum is of extreme importance as a game attracting species, the majority of farmers cited it as their favorite tree to hunt beneath. While game are attracted to its fruit and flowers, the flowers "call" a greater variety and higher volume of wildlife than the fruit.

The wood of piquiá is also highly prized. Both local communities and the timber industry hold piquiá in high esteem; its dense, interlaced fibers and high specific gravity (0.80-0.91), make it exceptionally durable for civil and naval construction as well as for railroad ties and posts (Prance 1990). Piquiá is employed in the interior framework of almost all boats in the eastern Amazon.

Uxi — Endopleura uchi *Cuatrec.*

Occurring throughout the Amazon basin from the western Amazon in Peru to the central and eastern states of Pará and Amazonas in Brazil, *Endopleura uchi* has received scant study. A species of the *terra firme* forest, the straight, gray-barked trees attain 25-30 meters in height, with diameters reaching until one meter. Well adapted to acidic soils, uxi grows best in well-drained areas.

The infloresence is a racime, composed of small whitish flowers. Uxi produces a green, egg-shaped fruit, which is widely appreciated by both human and animal populations throughout Amazonia. Almost all forest mammals feast on its fruit, making uxi a favored tree for hunters to place traps. Uxi is also used for its oil, seed, and wood.

Fruits have a large endocarp, containing 1-5 small (2-3 cm length) seeds, surrounded by a thin layer of oily, orange/yellow mesocarp. People generally eat the fruit in its fresh form, chewing the thin layer of gritty flesh off of the raw fruit. At times they scrape the flesh off with an implement, and stir it into water to make juice. The pulp of uxi is high in calories, calcium and phosphorous, containing: 1.2% protein, 30.6% carbohydrates, 20% lipids and 10% fiber (Villachia 1996). Chemically and physically its oil is very similar to olive oil.

In the past, the endocarp of uxi was cut in half to collect a small amount of powder inside, which was employed as a makeup to cover marks on the skin and also to lessen itching. By cutting the endocarp of uxi in half, stars are formed; some Amazonians fashion thin, circular slices of the endocarp into necklaces, belts and earrings. In some regions, the endocarp of uxi is also employed as an insect repellent and amulet; for these purposes it is simply broken into pieces and burned inside of a can, purportedly chasing away both mosquitoes and bad spirits.

At the initiation of this study, uxi was not a wood included in the suite of species favored by the timber industry. By 1998, E. uchi began to be extracted by loggers in the Capim region.

Bacuri — Platonia insignis *Mart.*

In *terra firme* forests, bacuri reaches 25-30 meters of height and one and a half meters in diameter. Bacuri is distinguished by a straight trunk with linear branches that are oriented in positions between 50 and 60 degrees, forming grand crowns composed of opposite, deep green leathery leaves. During the months of June-August, the characteristic crown becomes adorned with large, showy, rose-colored flowers. Abrasions to its rough, thick-barked trunk yield a bright yellow, sticky latex.

Occurring in low densities in *terra firme* forests, bacuri grows well from seed or root sprouts in degraded sites, seemingly indifferent to impoverished soils whether they be of sand or clay. Jacques Huber of Para commented, "the bacuri is a hardy tree with us and does not require careful cultivation. Cut it down, it springs up easily from suckers that arise from the roots. In Marajo it is considered a weed, difficult to exterminate, especially in pastures near houses" (Popenoe 1920).

The enormous popularity of bacuri's distinct fruit has triggered sharply escalating prices and new markets. Such commercial promise has led to experiments in EMBRAPA, Belém to enhance bacuri's sprouting ability (Villachia 1996) to develop new products using its pulp (12% fresh weight) as well as attempting to extract its flavor from the sizeable rind (60% fresh weight) (Nazare and Melo 1981). In some regions the seeds (18% fresh weight) are employed as animal feed. (Villachia 1996). In addition to its fruit, the yellow exudate of bacuri is used medicinally in the treatment of eczemas, herpes and other skin problems (Braga 1976).

The wood of bacuri is prized by both the timber industry and *caboclo* communities. Due to its durability and resistance to insects, bacuri is used by rural communities in the fabrication of roof shingles and in the construction of canoes. Bacuri is also employed in civil and naval construction and in the manufacture of furniture.

METHODS

Density

To determine the volume of forest fruit available to the community for use and potential sale, it was first necessary to determine how many trees occur per unit area. Because of extensive selective logging throughout the forest in the decade prior to the study, plots with minimal disturbance were sought to measure densities. One area was selected four kilometers from the river where logging had not occurred in the recent past, and another area one kilometer from the river. During the decade prior to the commencement of the study, in the plot closest to the river, large specimens of three species of trees, *Tabebuia serratifolia* (ipe), *Cedrela odorata* (cedro), and *Cordia goeldiana* (freijo) had been extracted by one logger using oxen.

Density was determined through inventories of two plots (700 x 400m) of *terra firme* forest. Within these 28 ha plots, *C. villosum* and *E. uchi* trees > 1.0 and > 0.5 cm DBH (diameter at breast height), respectively, were labeled, measured and mapped.

Selecting trees to measure fruit production

Studies of tropical fruit production make use of various sample sizes. Schrekenberg samples a minimum of five individual per species as recommended by (Frankie et al. in Schrekenberg 1997); Peters and Hammond (1990) sample between 15-25 trees in monodominant stands in the Peruvian Amazon. In this study, the number of trees sampled for each species was determined on the basis their particular fruiting phenology and the number of conspecific trees available in the forest. In the case of *E. uchi,* which was relatively plentiful in area forests, (as it was not extracted from the region prior to 1998), twenty-four trees were sampled.

Due to extraction for timber and naturally lower density, fewer adult individuals of *P. insignis* occurred in the community forest, therefore, only 16 mature individuals were marked for study. In the case of *C. villosum*, twenty trees were originally marked in 1993, however, after one fruiting season it became clear that individual trees do not produce fruit each year. In fact, only a small percentage of *C. villosum* produce fruit during any particular year. Thus, throughout the course of the next year, community members assisted the research team to identify and tag an additional 89 *C. villosum* trees for a total sample size of 109 trees.[1]

Selected trees occurred widely scattered throughout a 4000-hectare area of community forest, thus minimizing bias due to soil or topographic conditions. On occasion, conspecific adults occurred in distributions of two or more individuals per hectare. In selecting trees, care was taken to ensure that crowns of individual trees did not overlap with conspecific adults. Although a range of diameters was sought, due to the age and size structure of the forest, most diameters are relatively large, reflecting the mature nature of the forest.

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[1] Hunters were especially helpful in locating conspecific trees, especially of *C. villosum*, which is highly regarded as a game attracting species.

Measuring fruit production

Trees were numbered and labeled with aluminum tags and, for easier viewing by the community, also marked with larger (15 x 15 cm) painted wooden plaques color-coded by species indicating each tree's number. To facilitate the counting of fruit during the harvest season, a thin trail network of twenty kilometers traversing the 4000 ha forest area was annually cut linking all of the marked trees. Initial preparation of the trail system required three and a half months. Subsequent maintenance of the trails and the individual trees for the fruiting season required the full time labor of 3-4 persons annually during a minimum thirty day period.

In order to predict which and how many of the 109 marked *C. villosum* trees would produce fruit, in August and September, six months prior to the fruiting season, marked individuals of *C. villosum* were censused to determine individuals producing flower. Piquiá produces large, showy hermaphrodite flowers with numerous large stamens exceeding the five pale yellow petals (Prance 1990). While all trees that produce flowers do not produce fruit, trees that do not flower can be disregarded as nonproductive for the season. This annual census offered a rough estimate of how many trees, and therefore how much labor, would be required by the *C. villosum* production study each particular year.

In December, approximately one month prior to fruit production, when it was clear which trees would bear fruit (by the sight of juvenile fruit on the branches), the vertical projection of the crown of each tree was determined by measuring out from the trunk to the outermost branches along four radii. In order to facilitate the finding and counting of fruit, vegetation and debris were cleared from beneath the crown extending to one meter beyond it. Clearing was accomplished with a machete, taking 2-3 persons from one half to one full day per tree.

Production/yield was measured by periodically (2-3 times per week) visiting individual trees and counting all fruit fall during the four to five month (January - May) fruiting season. Litter traps covering only a percent of the area beneath the crown were not used, as due to the relatively low numbers of fruit produced in a two or three day interval, it was possible to collect and count all fruit, rather than to extrapolate using traps. If possible, fruit was counted in the crown of the tree, however, due to large crown size and thick leaf cover, this was possible for only a few trees each season. The fruit production of all marked individuals of *C. villosum, E. uchi*, and *P. insignis* was censused and recorded during a five-year period, 1994-1998.

During visits, fruit production was collected in bags, removed to a distance of 15-20 meters from the parent tree, separated into different classes (depending on species these included: whole, early aborted fruit, immature fruit, no. of seeds present per fruit, fruit eaten by one animal, fruit eaten by > one animal), counted and recorded. In the case of *E. uchi*, deep, vertical furrows in the endocarp indicated when seeds as well as fruit had been consumed.

Due to its highly unpredictable fruiting, a sub-sample of six *C. villosum* trees was chosen to measure fecundity. During one season, flower drop of these six trees was censused on a daily basis for the purposes of comparing flower and fruit production. Regression analysis was employed to determine if a significant relationship existed between fruit production and DBH, or flower production, and whether these might be used as a predictor of fruit production.

Community participation

The first three years of the study, three research assistants and I took principal responsibility for trail preparation and data gathering. During this time we trained eight community members (two formerly non-literate) in the collection and recording of data. During subsequent years, community members took on increasing responsibility for trail preparation and data collection, gradually assuming critical roles in communicating results of the ecological study to the wider community. Frequent visits by the research team during the harvest season, counting of fruit and seeds in piles near marked trees and rotation of team members within the community provided checks on the accuracy of recorded information.

Because of the long distance to reach the majority of sample trees from the main village, relatively few fruit from marked trees were collected and consumed by the community. However, to account for any fruit that may have been collected by community members, villagers were trained to count and record the number of fruit they had consumed from sample trees.[2] Large painted plaques alerted residents as to the tree numbers; additionally, community research assistants regularly conversed with their neighbors for the purpose of checking and recording the number of fruit collected from marked trees.

Methodological considerations

Due to its extensive nature, both geographically and temporally, the study met with numerous difficulties; the principal ones are listed below.

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[2] Intensive training regarding the documentation of fruit consumption was part of a concurrent study (Chapter Five).

1) Initial ten-fold overestimation by community members of the number of fruit trees occurring within their community forest.
2) The low density of species necessitated larger forest areas than anticipated and the creation of lengthy trails to attain a reasonable sample size of trees.
3) Ongoing logging operations planned by the community prior to the study (and not revealed to the research team) destroyed parts of fruit tree trails during successive years and threatened marked trees.
4) The significant time frame (at minimum three years) and labor needed to gain an understanding of fruit production.
5) The warm phase of the southern oscillation cycle (El Niño) occurred in both 1997 and 1998, effecting precipitation and possibly fruit production.
6) Potential disruption of hunting activities due to clearance of brush beneath the prized game attracting species *C. villosum*.
7) Significant lag time until production data acquired meaning for community members and could be useful in conservation or development activities.
8) Potential under estimation of fruit production due to dispersal and predation.

RESULTS AND DISCUSSION

Phenology: seasonal patterns of flowering, fruiting and leaf production

Results of the phenological study reveal that flower and fruit production of *C. villosum, E. uchi* and *P. insignis* is markedly seasonal, flowers being produced during the dry season and mature fruit falling during the rainy season. Within the six-month rainy season characteristic of the region, fruit production is staggered for the three species. In the Capim basin, *P. insignis* fruits first, beginning in December and ending in March; *C. villosum* fruits in January, ending in April and *E. uchi* begins fruit production in February, finishing at the close of the rainy season in May. During the five-year study period, changes in phenological patterns occurred; in 1997 and 1998 fruit production of all three species began 4-6 weeks later than usual.

Uxi produces numerous tiny white blossoms during the dry season. Unlike piquiá and bacuri, the majority of uxi trees produce both flowers and fruit every year. Uxi flowers during the last months in the dry season, from September through November. Fruit production begins in February, ending in May. Uxi does not display pronounced leaf drop; uxi loses and regenerates its leaves gradually throughout the year.

Peak flowering of *C. villosum* occurs in August-September during the dry season, producing fruit six months later during the rainy season, January - April.

During a period of approximately one month, trees may produce only a handful, or, at their peak, up to over 12,000 flowers per day. At peak flowering a hint of wind can cause several hundred flowers to drop from a tree's canopy in a few minutes, leaving a thick carpet of pale yellow petals on the forest floor. The fresh weight of one thousand flowers is approximately one kg. During a month, a single tree can produce well over 100 kg of flowers. This high production of protein-rich flowers offers an excellent resource for animals, and indicates its value for attracting game.

Each year of the study, a few of the 108 marked piquiá trees displayed flowering out of synch with other trees, sometimes flowering during the fruiting season, 6-8 months later than the rest of the population. In some cases only one branch of a tree produced flowers. Bat pollinated, not all trees that produce flower produce fruit. While over one third of the marked trees may produce flowers in a given year, on average only 22% of the sample population produced fruit. In 1999, 22 of 45 *C. villosum* trees produced flower. This relatively high degree of flower production, and the fact that many piquiá trees throughout the region "rested" in 1997 and 1998, lead smallholders in both the Capim River basin and the Amazon estuary near Belém, to predict a good crop of piquiá in the year 2000.

During or after fruit production, prior to flowering, many piquiá trees exhibit pronounced leaf drop, leaving the enormous crowns completely bare. While not all trees simultaneously lose their leaf canopy each year, some individual trees display leaf drop during both the flowering and fruiting seasons (June-August, February-March). Bacuri also exhibits pronounced leaf drop, in some cases also leaving its canopy entirely bare. Leaf drop generally occurs at the close of the rainy season, close to or coincident with, the time of fruit production, or as residents state, "in preparation for flowering". Like piquiá, the large, showy flowers of bacuri are produced during the dry season.

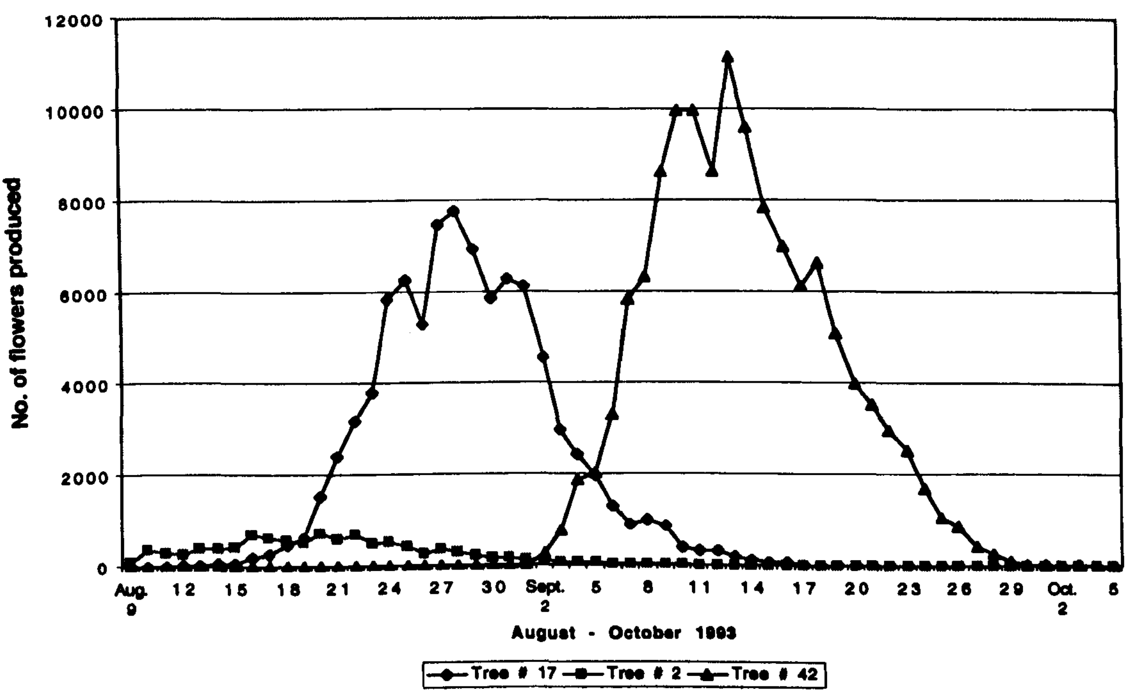
Results of a one-year census of the flower and fruit production of six *C. villosum* trees are shown in Table 5.1. Findings indicate the wide variability in flowering between trees. Regression analysis of the fruit and flower production indicates that number of flowers produced by a tree is not a reliable predictor of volume of fruits produced; at least in this small sample, no correlation existed between flower and fruit production. Observations of additional closed forest, gap and secondary forest trees indicate that habitat is also not a useful predictor of flower production.

In Figure 5.1, flower production of tree no. 42 occurring in a field, is compared with the flower production of two forest trees, numbers 2 and 17. The graph demonstrates the large variability in flower production, the months during which trees flower, and temporal differences in flowering between trees.

Table 5.1 Flower and fruit production of six *C. villosum* trees of varying diameters at breast height (DBH), in forest, gap, field and secondary forest habitat, 1993-1994

Tree no.	1	2	3	4tf	17	42
Habitat	forest	forest	gap	2nd forest	forest	field
DBH (cm)	82	111	107	27	107	114
No. flowers	2604	10261	17	1717	88155	129064
No. fruit	45	302	0	40	249	421

Figure 5.1 Comparative flower production of three *Caryocar villosum* individuals, 1993.



Game attracting flowers

C. villosum flowers play a critical role as an important game attracting tree. Although a variety of animals eat the fruit of piquiá, the protein-rich flowers, as opposed to the fruit, are the preferred food of animals. The majority of hunters in the three study communities consider piquiá the "champion" game attracting tree, many constructing *esperas* (hunting stands) under the boughs of the flowering piquiá on which they poise to await the arrival of game at night. In a study of 30 families over the course of one year 3.7 times the amount of game, as measured by weight, were captured beneath *C. villosum* than beneath the next most important game attracting species. Chemical analysis reveals that its flowers contain 7% protein. The enormous popularity of piquiá as a game attracting tree may be, in part, due to phenology. Piquiá flowers appear during the dry season (July-September), when the majority of native Amazonian fruit produced during the rainy season (January-April), are unavailable.

Density

Density of *C. villosum* and *E. uchi* as inventoried in two 28 hectare plots of *terra firme*, mature forest are recorded in Table 5.2. There was little difference in density of *C. villosum* between the two plots; overall density of *C. villosum* trees above 10 cm DBH in 56 hectares is .36 trees per/ha. This density of *Caryocar villosum* is similar to those recorded by Rodrigues (1963) and FAO (1986). Density of *E. uchi* trees over 10 cm DBH within plot A is over 3 times that of plot B; density of *E. uchi* in the 56 hectares is .75 trees/ha.

Table 5.2 Recorded densities of *C. villosum* and *E. uchi* in eastern and central Amazonia

Species	Density Plot A	Density Plot B	Recorded Densities	Reference
Caryocar villosum	.39	.32		
			0.4	Rodrigues 1963
			0.1	Higuchi et al.1985
			0.4-0.6	FAO 1986
Platonia insignis	0	0		
			0.5-1.5 (forest)	FAO 1986
			50-100	FAO 1986
Endopleura uchi	1.2	.36		Shanley et al. 1998

Although densities are generally low, clumped distributions and up to 7 *C. villosum* and 15 *E. uchi* per ha in the community forest may suggest historic anthropogenic disturbance. Relatively high concentrations of piquiá have been recorded in other regions and have been hypothesized to be due to Amerindian or *caboclo* management (FAO 1986). Existence of anthropogenic forests is further supported by the occurrence of charcoal and potshards in certain areas of the community forest and greater concentrations of palms, and fruit trees near archaeological sites.

Notably, although large mature individuals of *P. insignis* occurred within 500 meters of the study plots, seedlings and mature adults were absent from the 28-ha study plots. Lack of bacuri trees within the plot is likely to be due to naturally low densities in *terra firme* forest and also possible extraction of the prized wood by local villagers and/or the timber industry.

The size-class distribution of *C. villosum* and *E. uchi* in two 28-ha plots are recorded in Figures 5.2 and 5.3, respectively. *C. villosum* displays low recruitment in closed forest, over half of the individual trees in each of the 28-hectare inventories are over 10 cm diameter at breast height (DBH), the majority of these, mature individuals over 70 cm diameter. In a closed forest, a typical size-class structure of *C. villosum* has few seedlings or juveniles, consisting only or principally of adults. The large size which piquiá trees attain is evidenced by the fact that one third of all trees within the marked plots exceed one meter in DBH.

In closed forest, recruitment of juveniles appears to be low. Exceptions to the low recruitment are noted in tree fall gaps and in open areas that permit sunlight. Within the community forest, trail sides, logging platforms and open areas near houses are areas in which piquiá juveniles establish well. This is likely due to the suitability of the regeneration niche and to the fact that villagers often discard seeds of piquiá surrounding their homes and alongside paths.

Figure 5.2 Size-class distribution of *Caryocar villosum* in two 28-ha plots of *terra firme* forest, 1995

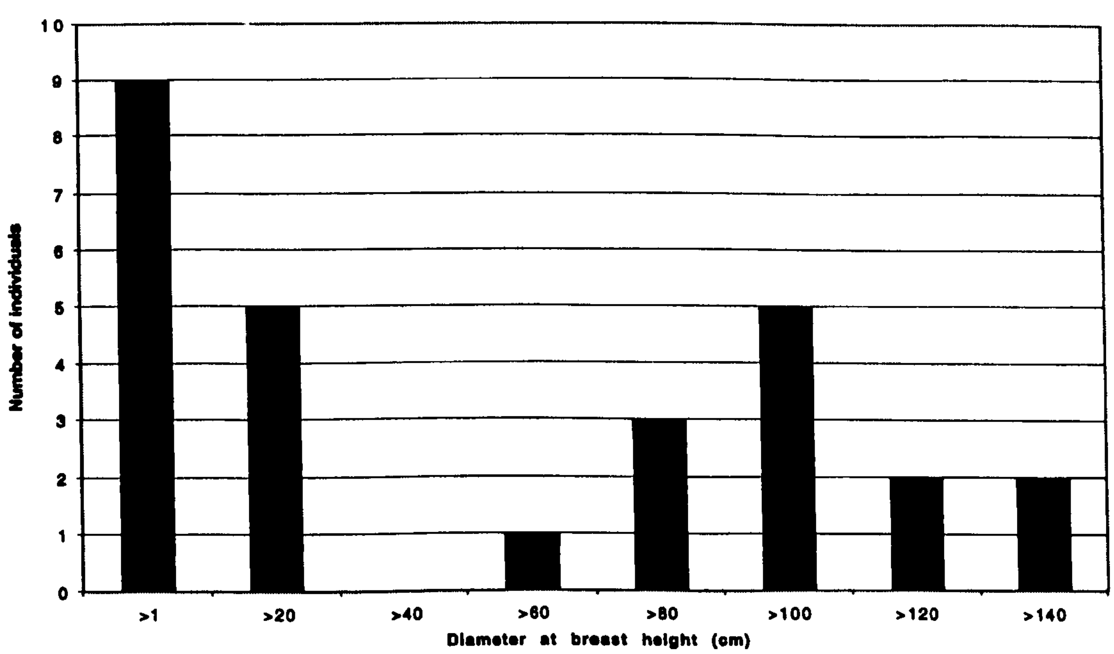
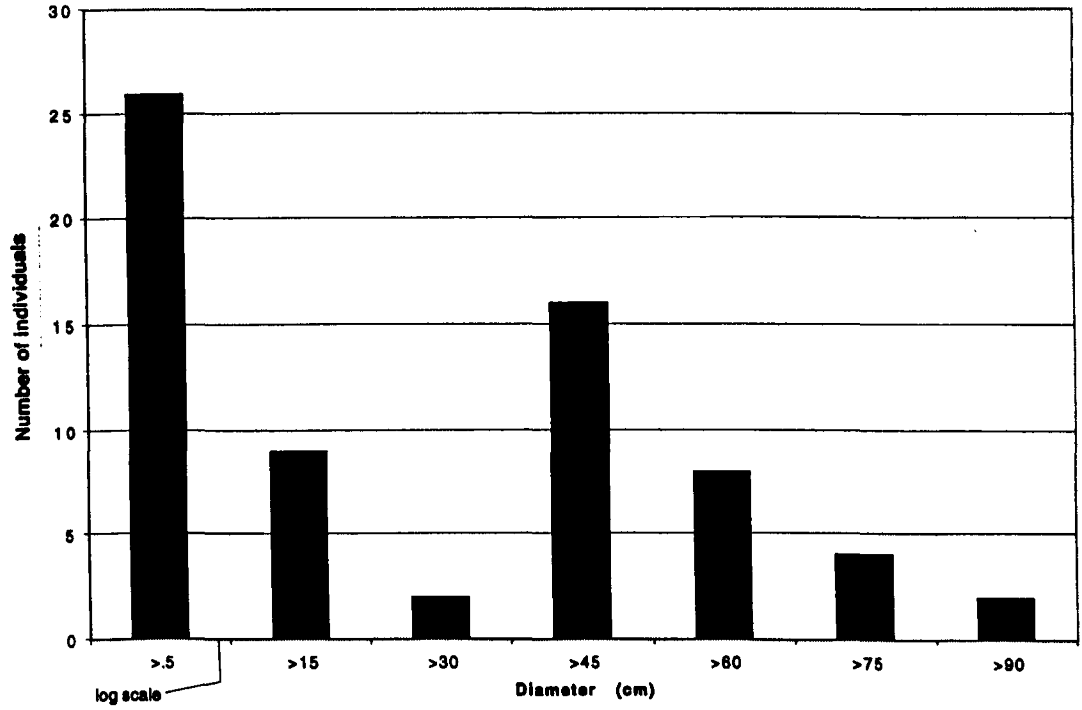


Figure 5.3 Size-class distribution of *Endopleura uchi* in two 28-ha plots of *terra firme* forest, 1995



By contrast, *E. uchi* is shade tolerant, regenerating well in the primary forest. The population structure of *E. uchi* is more evenly spread throughout size-classes. In both 28 hectare plots, uxi demonstrates an ample number of seedlings, recruitment is more favorable in plot A, nearest to the river, where from 1-7 trees are found in almost each of the larger size-classes. Uxi trees do not reach the size of piquiá trees, few attain diameters of one meter, mature trees more commonly occur at diameters of 60 cm.

The size-class distributions for C. *villosum* and *E. uchi* are not uncommon for tropical trees. In tropical environments, high rates of mortality during early seedling growth and establishment are characteristic, in part, due to the lengthy and severe dry season. Survivorship is often recorded as low, generally far less than 50% of seedlings survive and in some studies mortality reaches as high as 75-95% (Sarukhan 1980, Peters 1989, Prance and Elias 1977).

Size-class distributions and the ample number of mature, nonproductive trees indicate that the population of C. *villosum* is in senescence. Openings in the forest canopy due to logging may encourage recruitment, but increased incidence of fire and swidden agriculture may combine to inhibit future populations of *P. insignis* and C. *villosum* from establishing. Logging of all three species will further diminish seed availability, leading to decreasing potential for regeneration. Without management, populations are likely to continue to decline in the region.

The common practice of guarding seedlings of shade intolerant bacuri and piquiá in old fields can allow them temporary reproductive success in terms of broadening the population structure to include young individuals. However, seedlings often have little time to establish due to the shortened fallows and increasing cultivation. In such an environment, the decreasing reproductive success of young trees becomes insufficient to maintain former stand diversity. As cultivation of fields becomes more extensive, forest density decreases, allowing vulnerable species no chance to establish.

In the recent past, management of these forest species was largely unnecessary due to expansive, undisturbed forest and sufficient fruit volume to meet subsistence needs. Currently, as tree density and fruit availability decrease, some residents have begun to guard seedlings and juveniles of piquiá and bacuri near their homes, in areas that will not be perturbed by logging or agriculture.

Fruit production

Mean fruit production for *P. insignis C. villosum* and *E. uchi* are shown in Figures 5.4, 5.5 and 5.6, the results being based on 68, 24 and 16 individuals, respectively. Values represent the total number of mature fruits that were produced in a given fruiting season. The total number of fruit produced by each tree was calculated by summing the number of mature, intact fruit, and mature fruit predated upon found under the tree, whether on the ground or pre dispersal. Immature fruit are not included here, as one of the principal objectives of the study was to determine the total number of edible, potentially marketable fruit available to the community.

Trees producing less than ten fruits in a season are also not included in the sample; based on observations, such production is anomalous. Note that fruit removed by predators or dispersors beyond the crown of the tree could not be accounted for, therefore, final numbers are likely to be lower than full production. Due to the large number of non-fruiting individual trees, a mean is given for the entire population of trees (Table 5.3), as well as the mean of only productive individuals (Table 5.4).

The variation between trees was used to calculate standard deviation. Due to the substantial number of annually nonproductive individuals found in each of the populations and the enormous variability in volume of fruit produced by productive individuals, standard deviations are high.

Figure 5.4 Mean fruit production of *Platonia insignis*, 1994–1998 (n = 16).

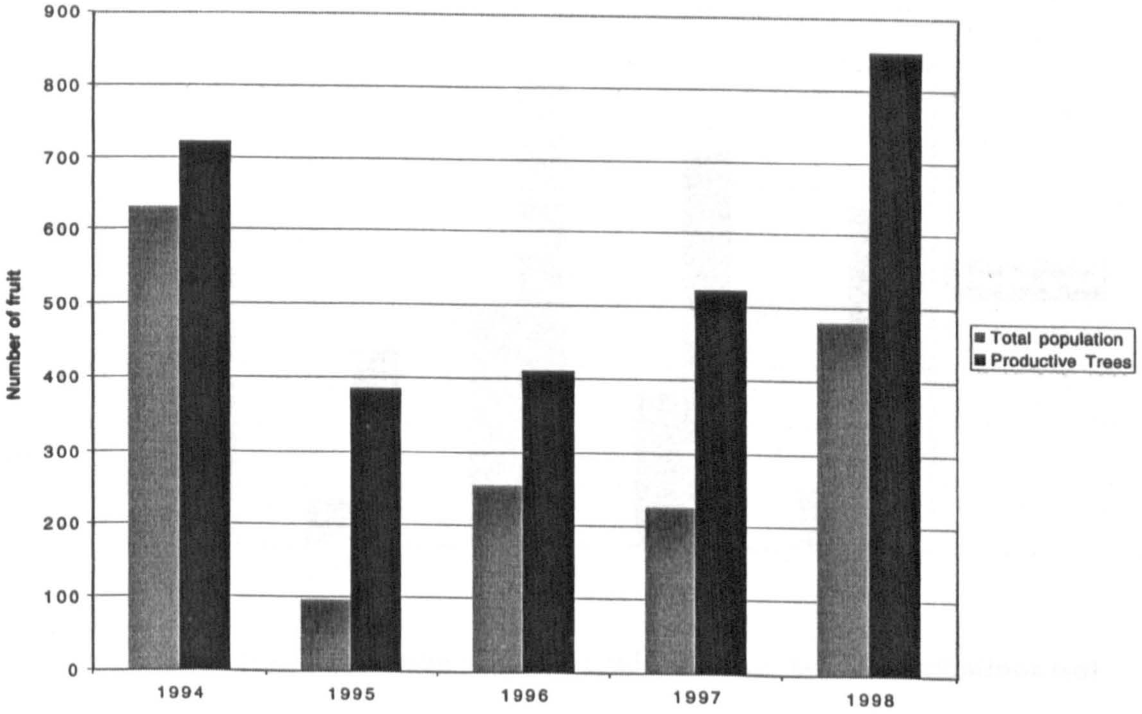


Figure 5.5 Mean fruit production of *Endopleura uchi*, 1994–1998 (n = 24).

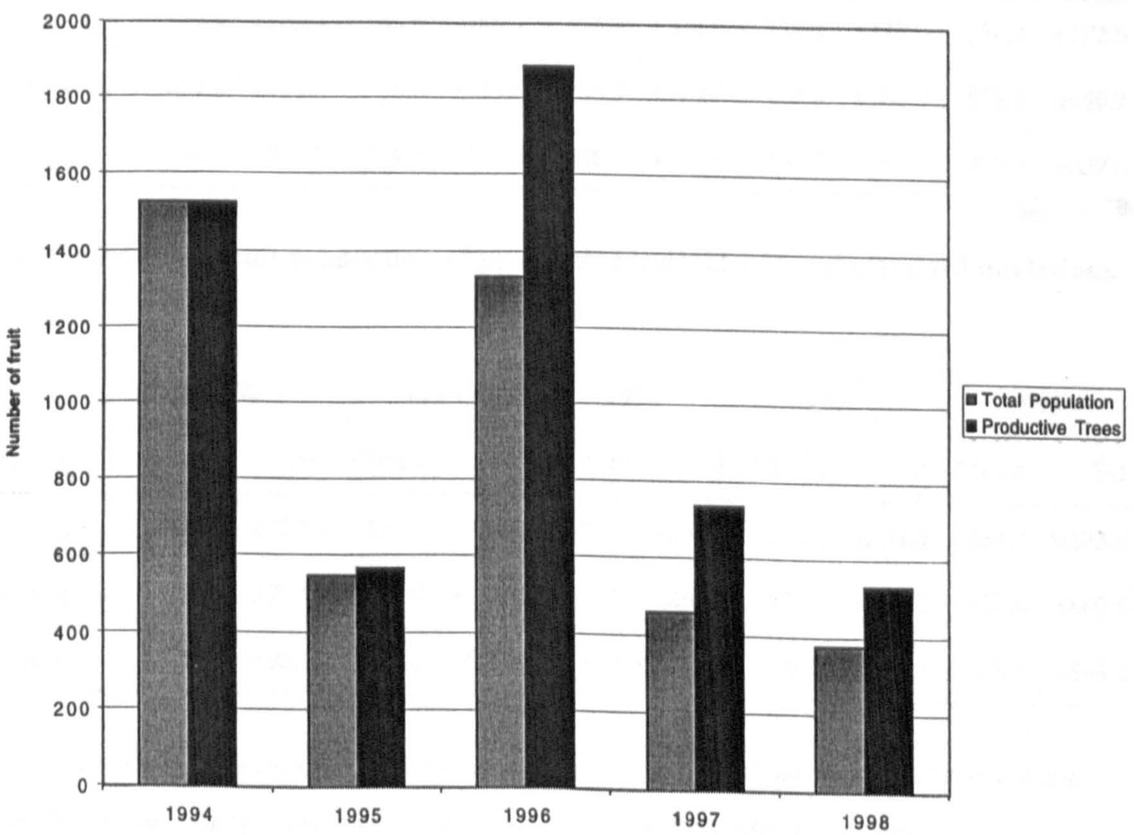


Figure 5.6 Mean fruit production of *Caryocar villosum*, 1994–1999 (n = 108).

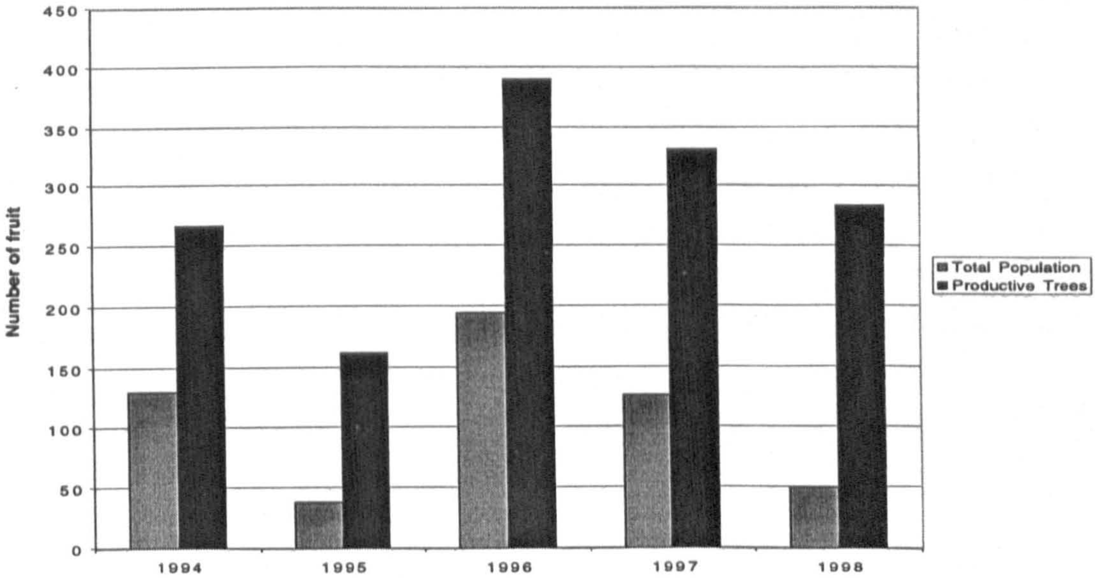


Table 5.3 Mean fruit production of total population and standard deviations (sd)

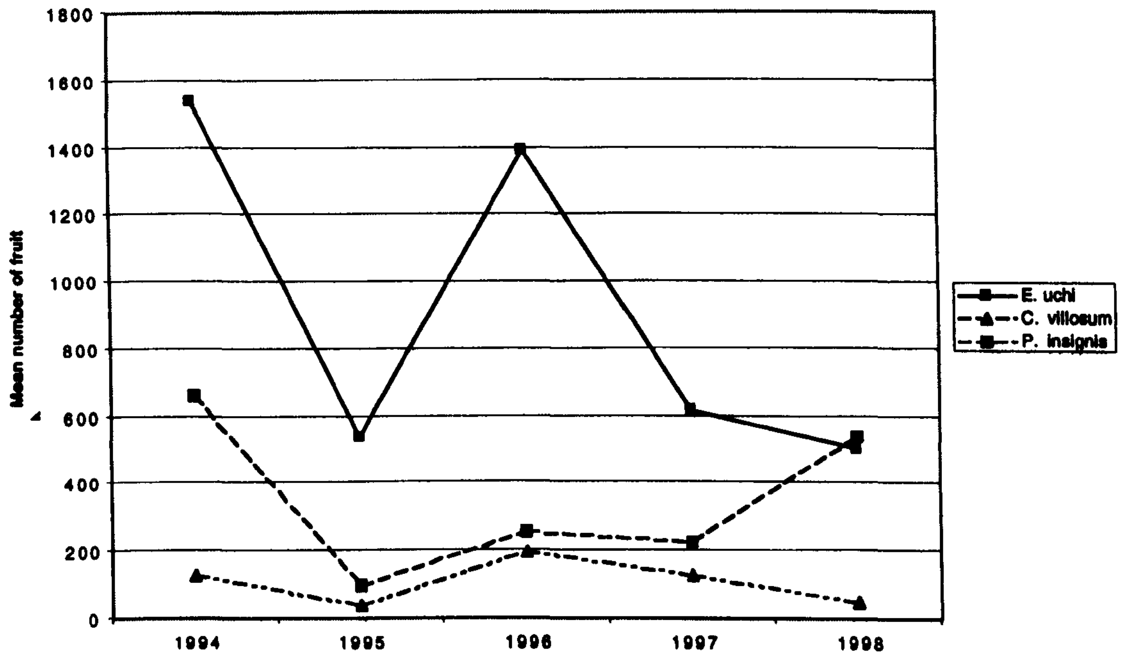
	1994		1995		1996		1997		1998	
Species	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**
C. villosum	129.4	±268.4	38.0	±119.1	194.8	±334.6	126.4	±329.5	50.2	±172.5
P. insignis	631.1	±751.5	96.3	±219.0	256.3	±279.2	228.0	±480.0	479.6	±640.7
E. uchi	1530.7	±962.1	546.6	±537.8	1336.2	±997.9	462.5	±545.6	379.4	±537.6

Table 5.4 Mean fruit production of productive individuals and standard deviations (sd)

	1994		1995		1996		1997		1998	
Species	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**
C. villosum	266.9	±270.3	161.7	±120.0	389.5	±337.0	330.5	±331.9	284.3	±173.8
P. insignis	721.3	±790.5	385.0	±328.0	410.0	±261.8	521.1	±558.1	852.6	±680.6
E. uchi	1530.7	±982.8	570.3	±549.6	1886.4	±1019.4	740.1	±557.3	535.6	±549.2

Results demonstrate a sharp annual variation in fruit production levels of the species under study. Standard deviations reinforce the wide variability, for many years, standard deviation exceeds the mean. Mean production of each of the three fruiting species is compared in Figure 5.7. Notably, although aggregate numbers differ considerably for each species, there is a general correspondence in fruit production trends during the period 1994-1998. While each of the species demonstrated widely different volumes of fruit production, each followed a similar pattern of annually alternating production. Annual fruit production of *C. villosum, E. uchi* and *P. insignis* began high in 1994 dropping and rising by more than one half in the subsequent two years. For example, from '94 to '95, the annual production of *E. uchi* fell by almost two thirds from 1531 to 547 fruit, climbing again to 1336 in 1996 and dropping again in 1997 to 463 fruit.

Figure 5.7 Comparison of the mean fruit production of *E. uchi, C. villosum,* and *P. insignis,* 1994–1998



As noted for other tropical fruiting trees such as cupuaçu (Müeller and Carvalho 1997), castahna (Müeller 1981) and manga (Valmayor 1968 in ITAL 1981), fruit production is highly erratic, varying in volume considerably each year. The size of a fruit crop depends on many factors such as age, variety, climate, density and the size of the previous year's production. Variability in production has been well described for manga by Valmayor (1968 in ITAL 1981) as *ano de safra* and *ano sem safra* (year with crop and year without crop). However, an *ano sem safra* does not signify that no fruit were produced, "young trees can produce 50-100 fruits in the years without crop and 500-2000 in the years with a crop" (ITAL 1981). Such variability in fruit production was noted in piquiá, bacuri and uxi. After witnessing fruit production over a number of years, years in which comparatively few fruit were produced appeared to be years of "rest" for that tree, and not years of true fruit production.

The number of productive trees (trees producing over 10 fruits) for each of the species over a five-year period is shown in Table 5.5. This table underscores the second most notable characteristic of the species under study; that of the three, only *E. uchi* fruits consistently each year. A great deal of variability in production exists both between and within species. Such temporal variability in fruit production within a population is not uncommon among tropical trees; some species produce fruit only once every three or four years.

Table 5.5. Number of fruit producing trees of *Caryocar villosum, Platonia insignis* and *Endopleura uchi*, 1994–1998

Species	1994	1995	1996	1997	1998	
C. villosum	33	16	34	26	12	n = 108
P. insignis	14	4	10	7	9	n = 16
E. uchi	24	23	17	15	17	n = 24

During the five-year study, of the living, total population of *E. uchi* trees, an average of 80% produce fruit each year (Fig. 5.8). A mean of 55% percent of the living *P. insignis* produced fruit (Fig. 5.9). This is in marked contrast to *C. villosum*, of which a mean of only 36% of the productive population (68 trees) and 22% of the total population (108 trees) produced fruit (Figs. 5.10 and 5.11).

Figure 5.8 Average annual percentage of fruit producing trees *Endopleura uchi* (n = 24), 1994–1998

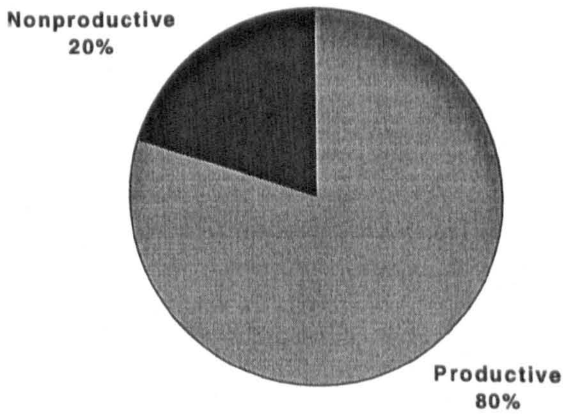


Figure 5.9 Average annual percentage of fruit producing trees *Platonia insignis* (n = 16), 1994–1998

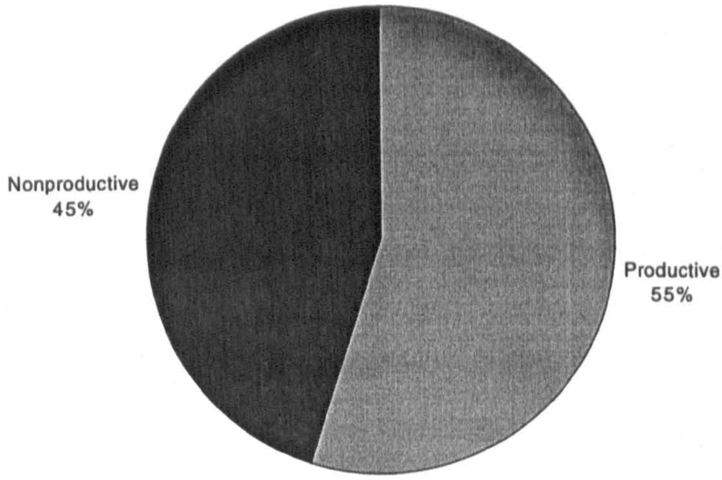


Figure 5.10 Average annual percentage of fruit producing trees of productive population of *Caryocar villosum* (n = 68), 1994–1998

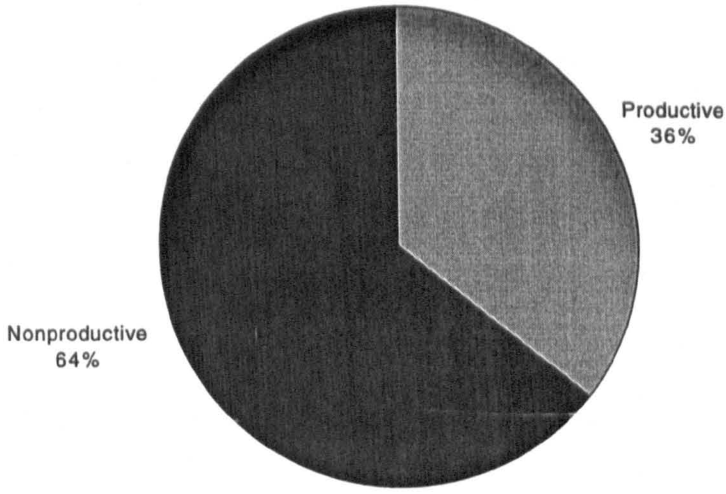
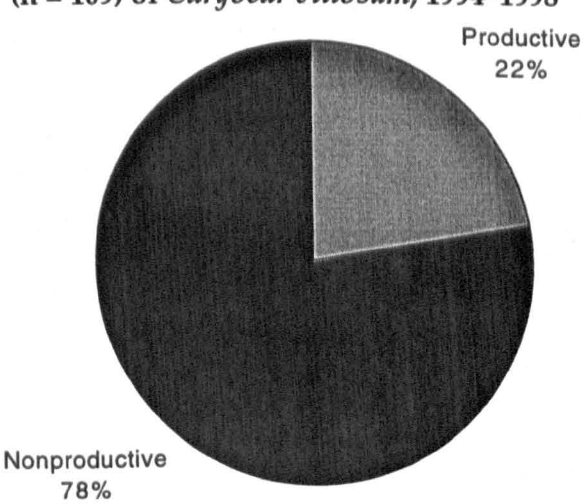


Figure 5.11 Average annual percentage of fruit producing trees in total population (n = 109) of *Caryocar villosum*, 1994–1998



Regression analyses performed using fruit production values each of the five years reveal that fruit production by *C. villosum, E. uchi* and *P. insignis* could not be estimated with reasonable accuracy based on tree diameter or crown size. Graphs showing the annual fruit production of each species as compared with diameter are shown in Figures 5.12 to 5.26. In these graphs, the annual variation of fruit production and the variation between individual trees can be observed more closely. The fruit production of *C. villosum* is the least predictable of the three species, demonstrating high standard deviation and wide variability between trees. Due to the lack of correlation between *C. villosum* fruit production and diameter, regression lines are not included in the *C. villosum* graphs.

Figure 5.12 Fruit production of *Endopleura uchi*, 1994 (n = 24)

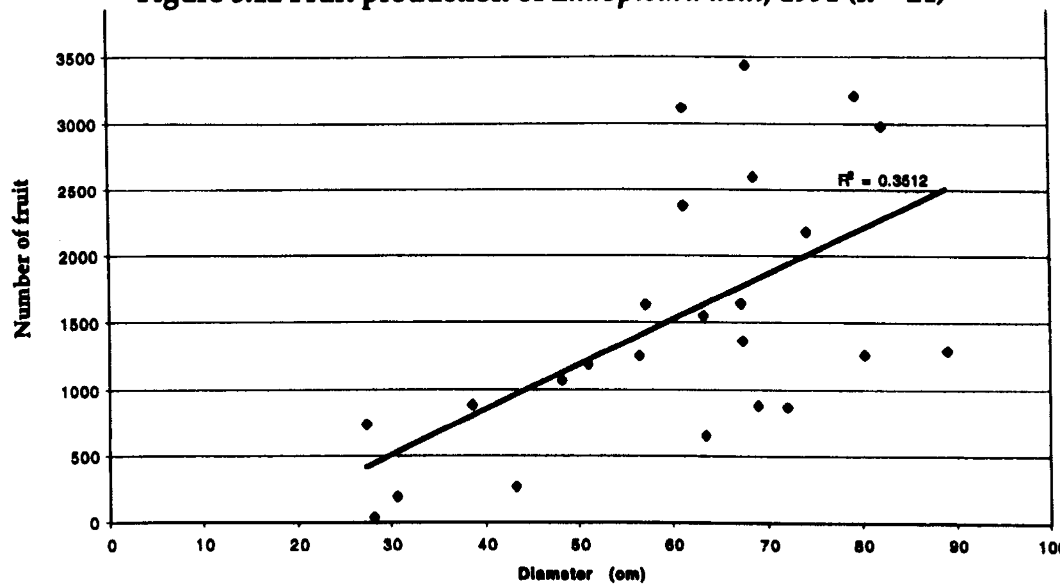


Figure 5.13 Fruit production of *Endopleura uchi*, 1995 (n = 24)

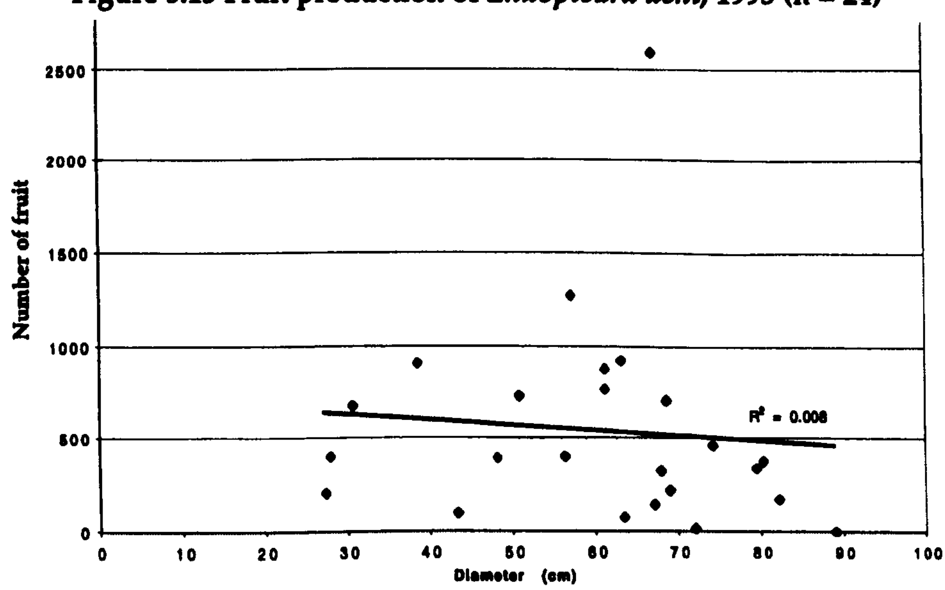


Figure 5.14 Fruit production of *Endopleura uchi*, 1996 (n = 24)

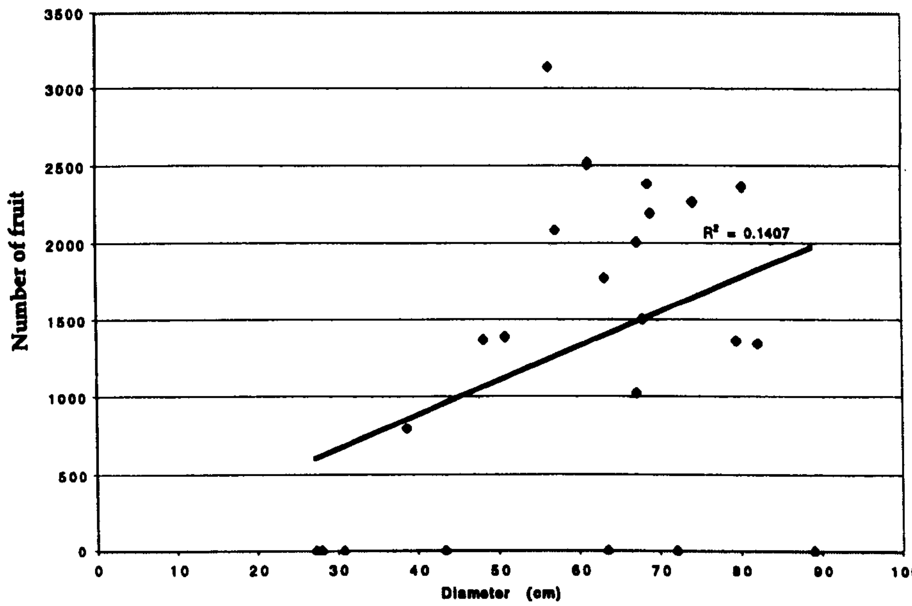


Figure 5.15 Fruit production of *Endopleura uchi*, 1997 (n = 24)

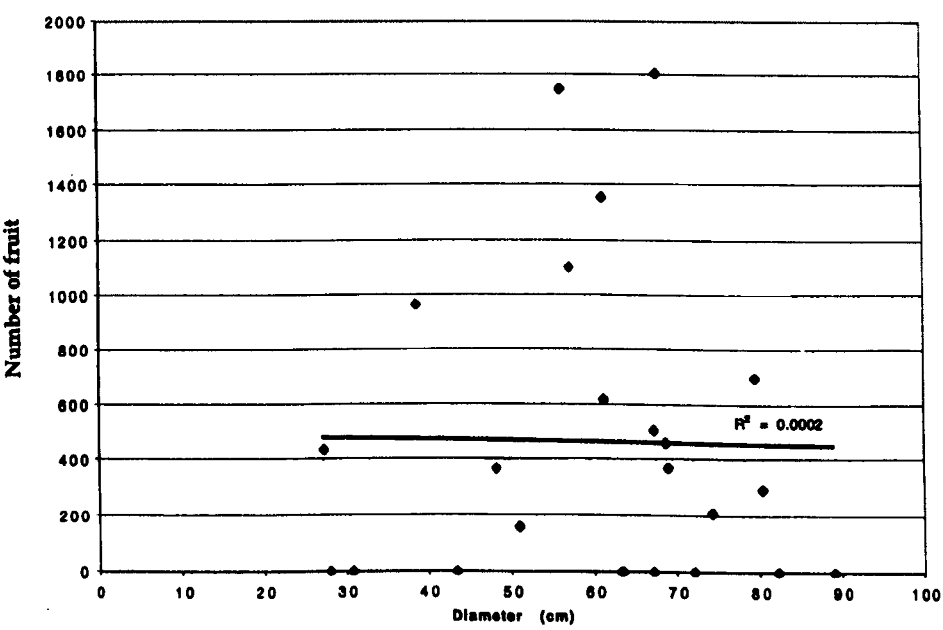


Figure 5.16 Fruit production of *Endopleura uchi*, 1998 (n = 24)

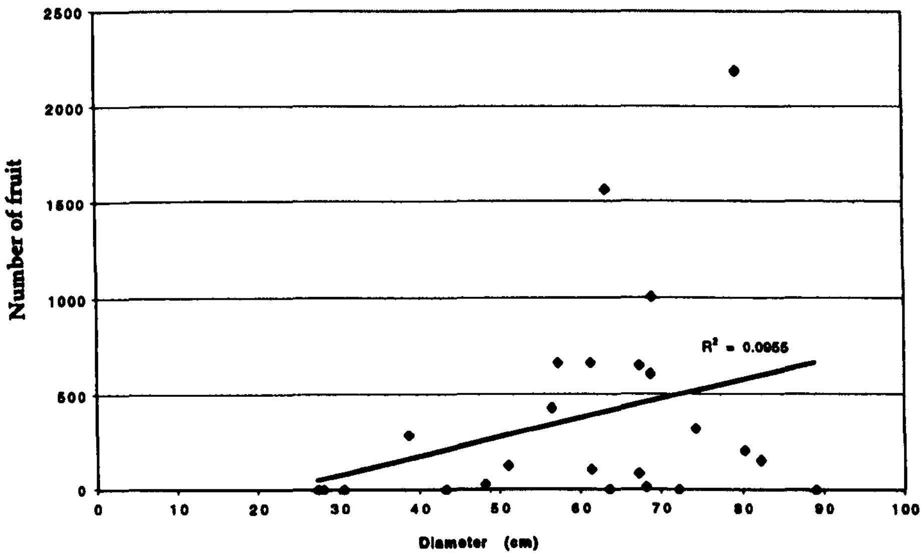


Figure 5.17 Fruit production of *Platonia insignis*, 1994 (n = 16)

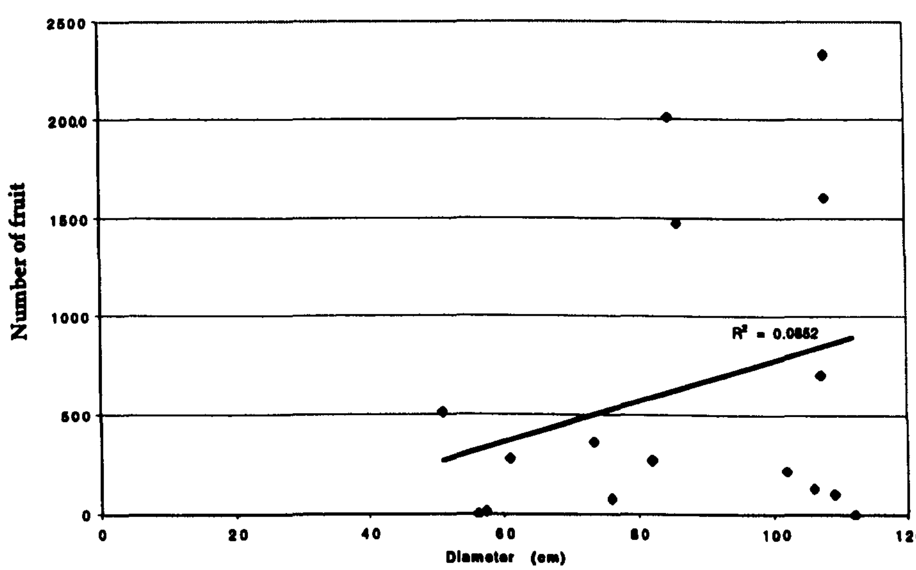


Figure 5.18 Fruit production of *Platonia insignis*, 1995 (n = 16)

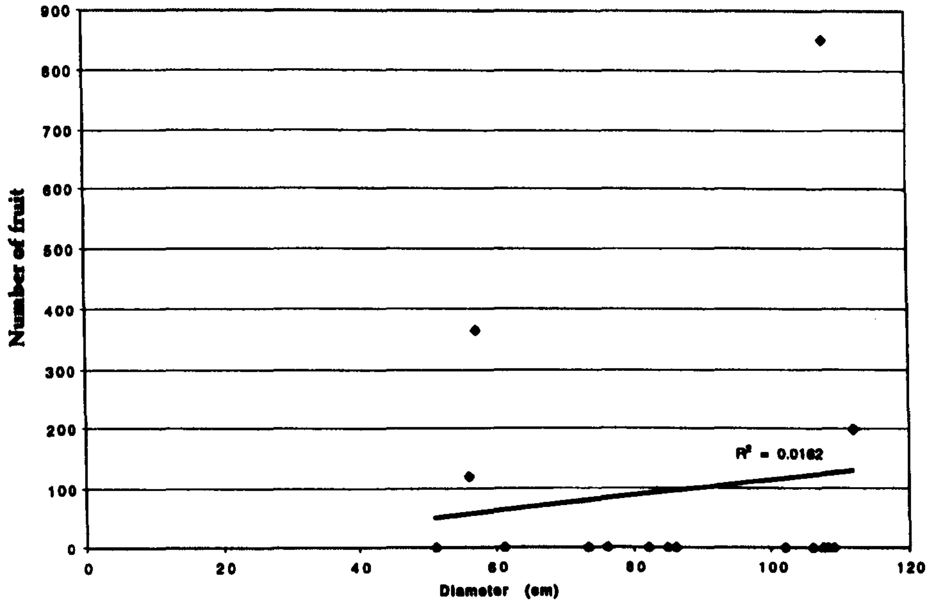


Figure 5.19 Fruit production of *Platonia insignis*, 1996 (n = 16)

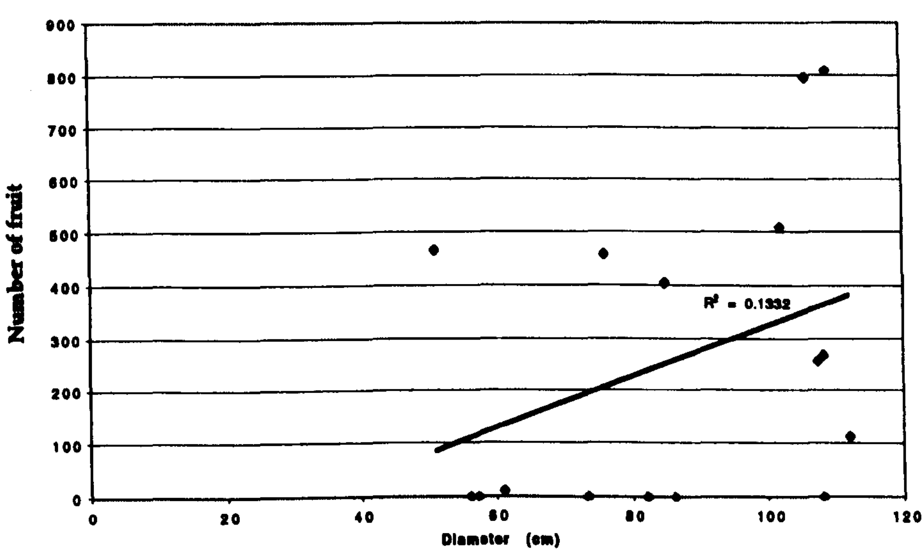


Figure 5.20 Fruit production of *Platonia insignis*, 1997 (n = 16)

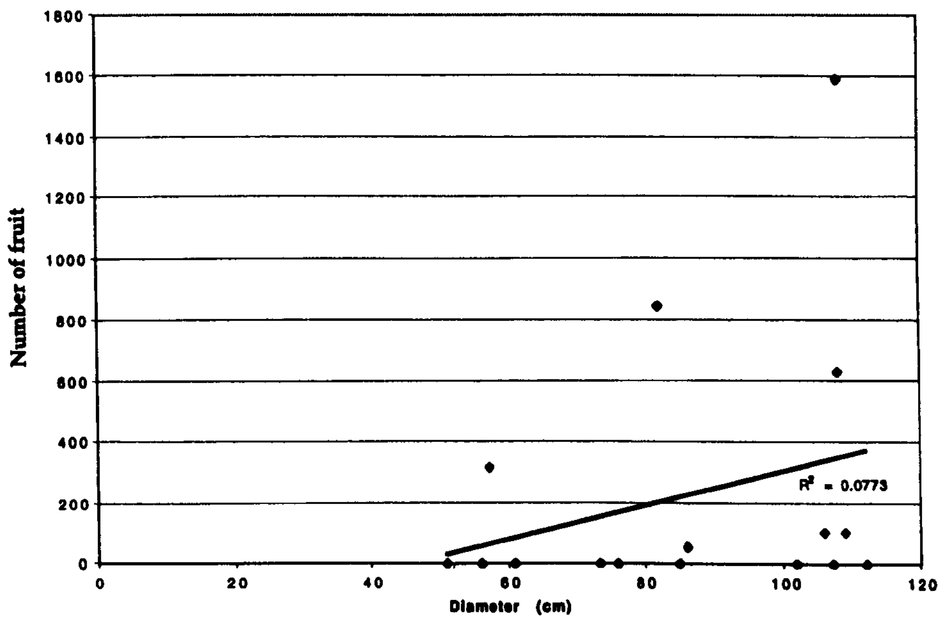


Figure 5.21 Fruit production of *Platonia insignis*, 1998 (n = 16)

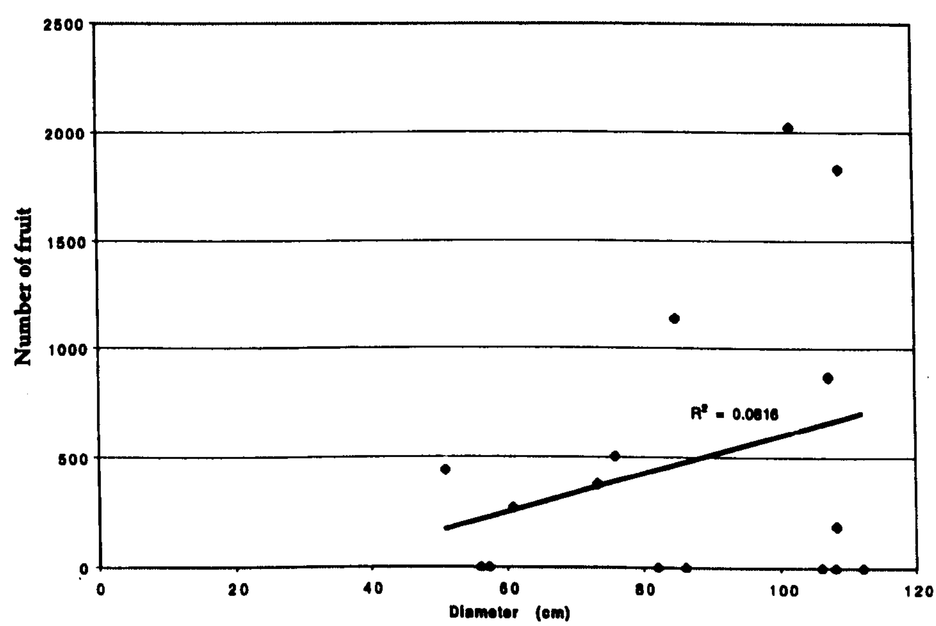


Figure 5.22 Fruit production of productive subsample of *Caryocar villosum*, 1994 (n = 68)

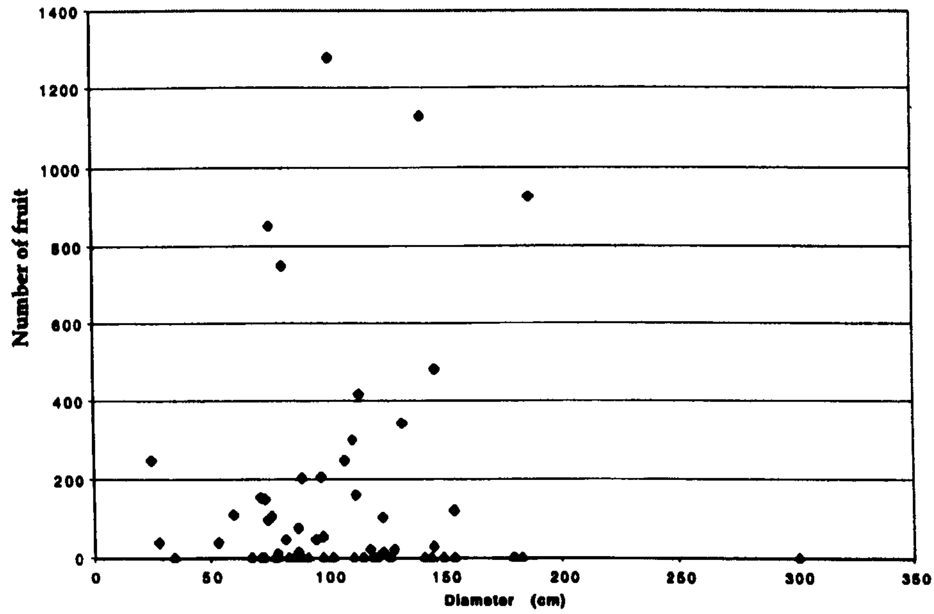


Figure 5.23 Fruit production of productive subsample of *Caryocar villosum*, 1995 (n = 68)

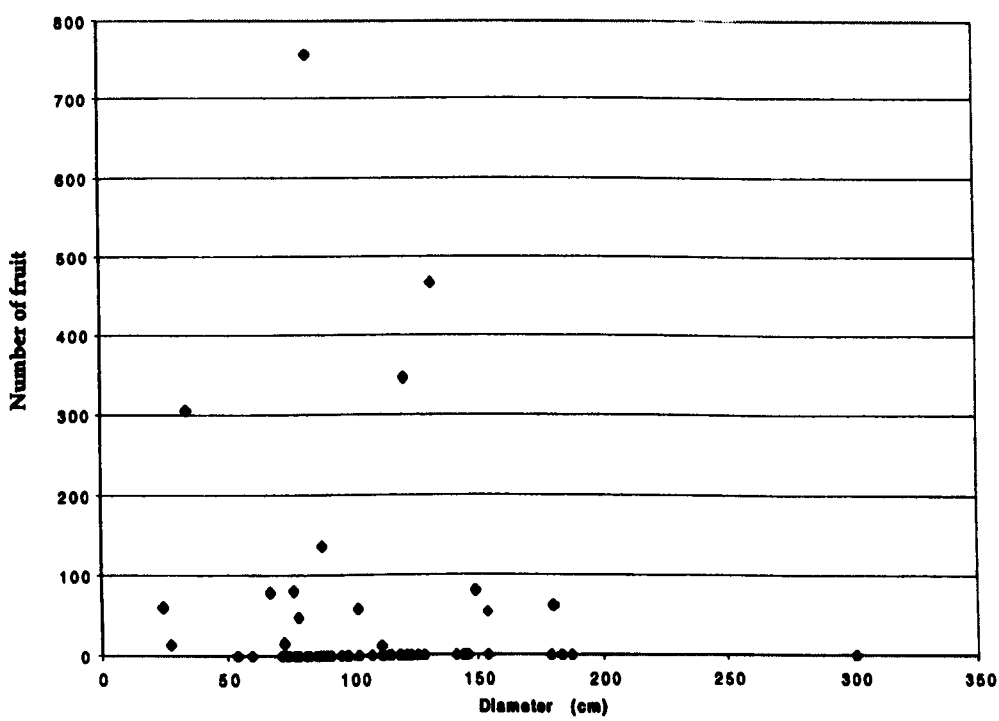


Figure 5.24 Fruit production of productive subsample of *Caryocar villosum*, 1996 (n = 68)

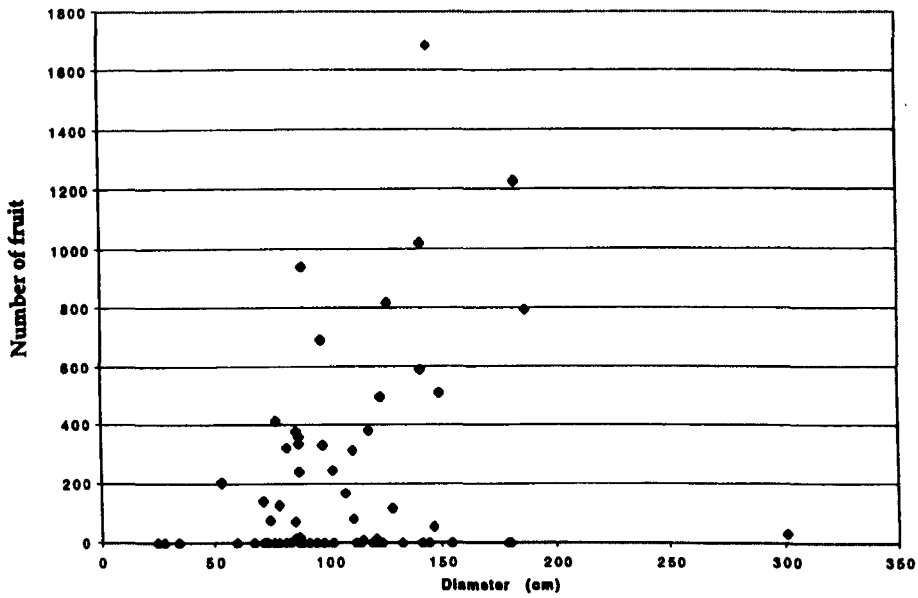


Figure 5.25 Fruit production of productive subsample of *Caryocar villosum*, 1997 (n = 68)

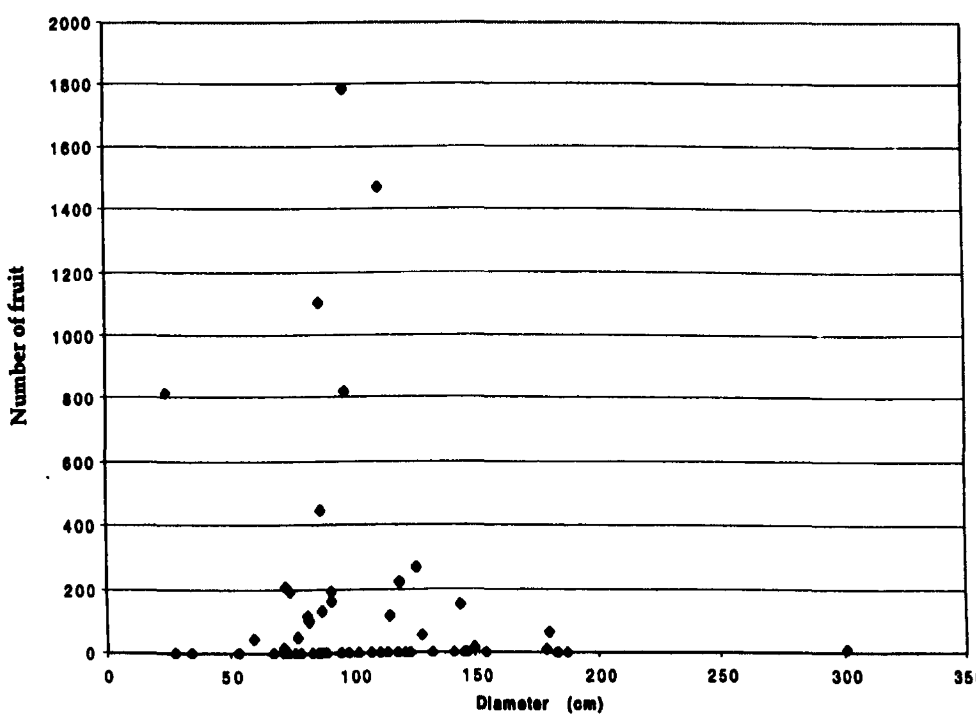
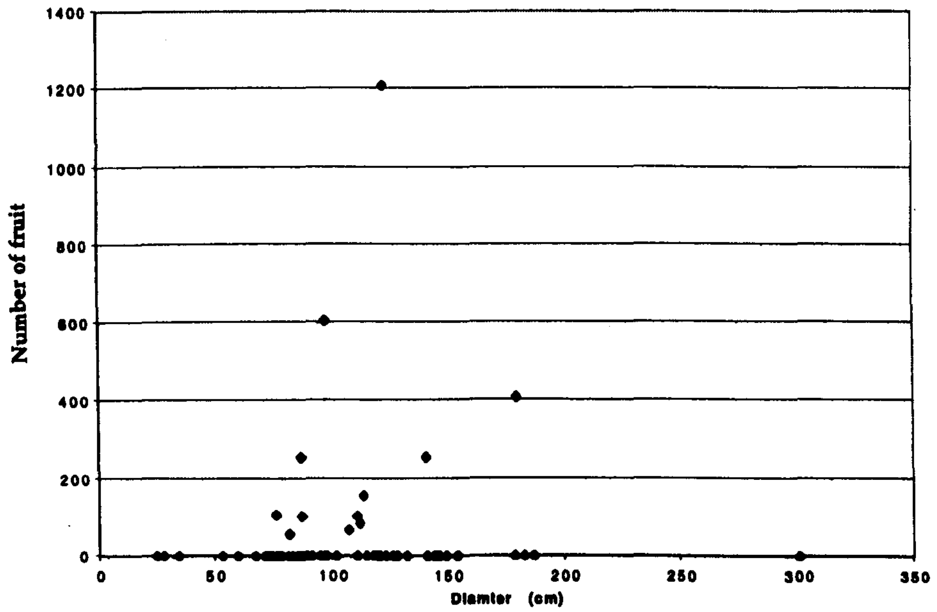


Figure 5.26 Fruit production of productive subsample of *Caryocar villosum*, 1998 (n = 68)



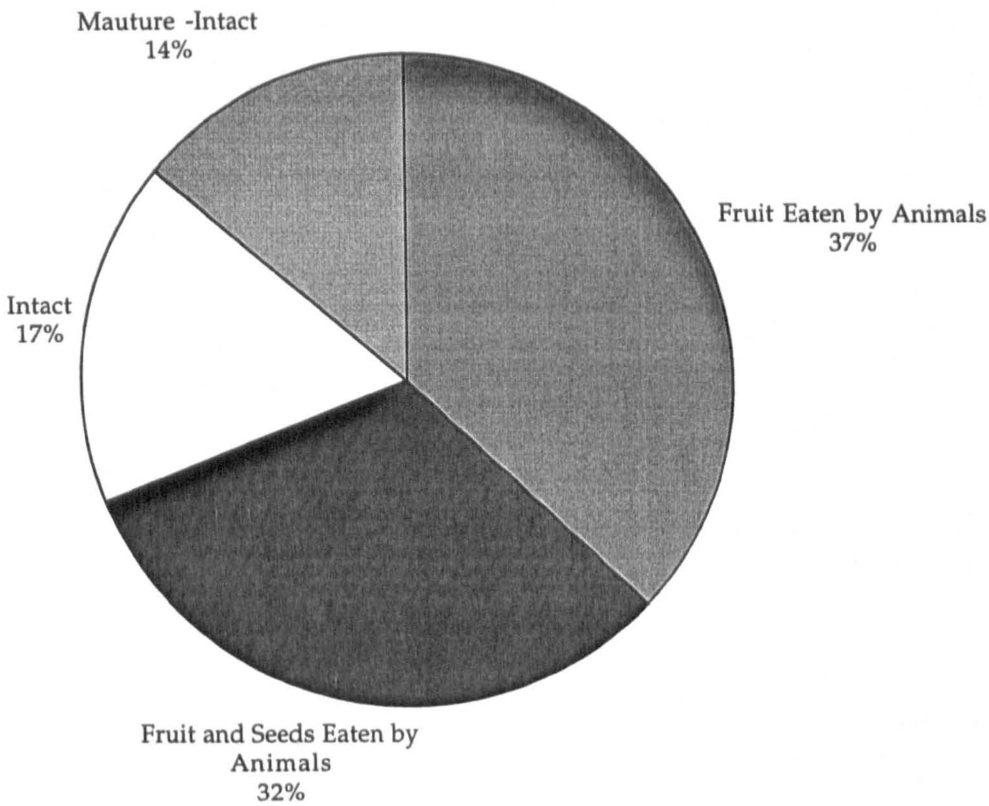
The relatively large number of immature fruits that were collected under many *E. uchi* trees, indicate that many of the flowers pollinated were aborted in some early stages of fruit formation. In spite of the fairly large abortion rate, female fruit production reaches up to a maximum of approximately 3,000 fruits per year. Early in the season, a large number of very small (2-3 cm) aborted fruit on the forest floor under a particular tree generally signal that a large volume of fruit will be produced. By contrast, bearing larger (4-6 times the size) and producing far less fruit than uxi, *C. villosum* and *P. insignis* generally abort relatively low numbers of immature fruit.

Dispersors and predation

The fruit of piquiá and bacuri are consumed by a variety of animals including squirrel, armadillo, and agouti. However, in comparison to uxi, predation of fruit is relatively low for piquiá and bacuri; this may in part be due to their thick rinds (4-5 cm), and in the case of piquiá, a spiny endocarp. Predation of fruit is much higher for *E. uchi*; the paper-thin skin is easily broken to reach the rich, oily mesocarp. Uxi is widely appreciated by wildlife, including squirrels, paca, agouti, deer, peccary, armadillo and wild pigs. Macaws also favor uxi; feeding on uxi in the canopy they are an agent of predispersal predation.

In addition to appreciating the mesocarp, sharp-toothed squirrels are able to gnaw through the hard endocarp of uxi to reach the 1-5 seeds inside. In 1993, squirrels consumed seeds of 32% of the total fruit crop, thus reducing the reproductive potential of the population by close to one-third. Figure 5.27 demonstrates the fate of the fruit crop of uxi in 1993. As the pie chart reveals, combined predation of uxi reached 69%. The figure also shows another notable finding, that in addition to the 69% of the production eaten by wildlife, 17% of the production was immature, leaving only 14% available for human consumption or sale.

Figure 5.27 Fruit crop fate of *Endopleura uchi*, January–May 1993



The majority of residents interviewed believe that predators rarely carry *C. villosum*, *E. uchi* or *P. insignis* more than 10-30 m from any tree to be eaten. Large numbers of seeds and hidden caches found directly beneath trees appear to substantiate this local knowledge. However, some percentage of fruit is likely to have been carried away from the crown of the tree by animals, and thus go unrecorded.

Mortality

In the course of the five years, trees within sample populations of each of the species suffered mortality. Of the original 109 *C. villosum* trees (Fig. 5.28), 11 died; one to wind; one to fire; six to swidden agriculture; and three to logging. The community advised loggers not to extract fruit trees, especially trees bearing plaques. However, unattended, loggers occasionally made their own decisions and extracted fruit trees, sometimes claiming that a particular tree was not fruit bearing.

Of the three species, *E. uchi* lost the highest percentage of trees, 12 of the 24 original trees died (Table 5.6). Six uxi trees were lost to wind (weakened post logging and fire), four to agricultural cultivation and two to fire (in one case accidental, in one case fire from the clearing of a swidden field) (Fig. 5.29).

Table 5.6. Total population, number of fruit producing trees, and mortality of *C. villosum, E. uchi* and *P. insignis* between 1994 and 1998.

	Total pop.	Prod. pop.	Mortality	% mortality
C. villosum	109	68	11	10%
P. insignis	16	16	2	12.5%
E. uchi	24	24	12	50%

P. insignis suffered the least mortality; of the 16 sample trees, two died. One succumbed to accidental fire. A community member living on the periphery of the forest felled the other bacuri tree. He purportedly extracted it to make a canoe, however, disgruntled neighbors who appreciated its fruit report that two years later, the bacuri tree still lies on the forest floor.

Of the total (25) deaths suffered by the three species, ten were due to agriculture, seven to wind post-logging and fire, four to fire, and four to logging. However, mortality is often the result not of a single factor but a combination of factors that cumulatively damage the tree until its eventual death. In this case, external agents caused 13 of the 25 deaths, specifically a synergy between logging and fire that weaken trees to the extent that they are vulnerable to wind. Twelve of the deaths were caused directly by community members cutting and burning agricultural fields, and in one case felling a tree to build a canoe. When questioned which of four factors (logging, fire, wind, agriculture) caused the mortality of the majority of trees, community members cited fire and industrial logging as the primary agents in fruit tree mortality.

The impact of fire

Depending on factors such as: bark thickness, age, individual history, surrounding vegetation, and species resistance, fire also impacts fruit trees. Both small and large-scale fires occurred within the community forest during the study period. On a small scale, when swidden fields are cleared by fire, fruit bearing trees

Figure 5.28 A grand *C. villosum* tree, locally called piquiá *garafa* due to its bottle-like shape

Figure 5.29 Taking the final dbh reading of a felled and burned *E. uchi* tree

within or nearby the agricultural field suffer from the flames and heat. While many villagers avoided placing agricultural fields in areas with fruit trees, some did not take this into account; nine fruit trees were lost to swidden agriculture, and two to fire used in the clearing of those fields.

On a large scale in 1997, over half of the community forest suffered from fire. Although generally accidental, post-logging fires can be anticipated as without clear safeguards the risk of fire is extremely high after timber extraction. Dry down of the substantial slash produced as a result of the logging, increases fuel loads and the probability of fire (Cochran and Schulz 1998, Uhl and Kauffman 1990). Although the community agreed not to place swidden fields in recently logged forest, one village member broke this rule. In September of 1997, fire used in the clearing of his swidden field went out of control, instead of burning his field for a day it burned throughout the community forest for several weeks. In November, another fire followed in its wake.

Due to their thick bark, piquiá and bacuri fare remarkably well post-fire. For example, one piquiá tree in the middle of a frequently used swidden field in Quiandeua bears four prominent crowns, each sprouted in response to a fire event. Based on its distinctive profile of layered crowns against the open sky, tree 42 is called *"piquiá dois copas"*. Attesting to the ability of piquiá to survive fire, of the 109-piquiá trees, only one, an old, ailing tree, within a swidden field at the edge of the community forest, succumbed to fire.

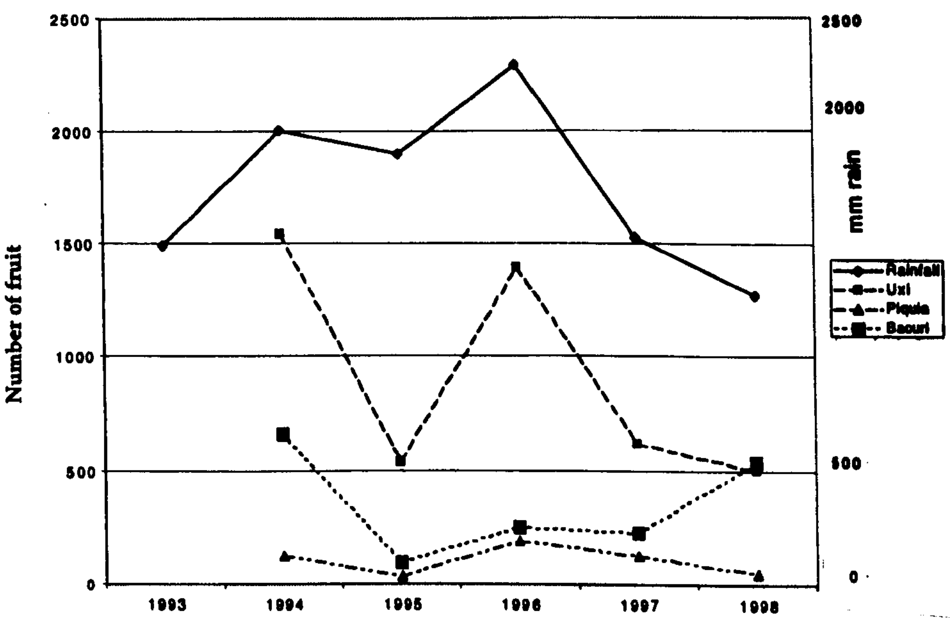
Bearing thinner bark than piquiá and bacuri, fire most heavily affected *E. uchi*. Arriving just before the fruiting season, flames scorched mature and immature fruit, causing fruit to fall prematurely and weakening trees for the following season.

Remarkably, years of clearing vegetation and fallen branches from beneath fruit trees for the purpose of counting fruit during the previous four years assisted post-fire survival of many of the marked trees. Free of slash, fire passed relatively quickly by fruit trees. Although many of these fruit trees escaped the ravages of fire and survived in a weakened condition, their isolated positions, unprotected by neighbors, made some susceptible to wind. Six months to one year after the fire, six uxi trees in the sample succumbed to strong winds and blew over.

Rainfall[3]

Given the different rainfall regimes throughout the course of the study, the graph shown in Figure 5.30 can be used to speculate on the general relationship between precipitation and fruiting although a longer data set would be necessary to determine any relationship with more certainty. Although aggregate numbers differ considerably among the three species, there is a general correspondence between each species fruit production curve and that of rainfall during the period 1994-1998.

Figure 5.30 Mean fruit production of *C. villosum, E. uchi* and *P. insignis* vs. rainfall, 1994–1998



During 1997 and 1998, the delayed onset of the rainy season coincided with a delay in the initiation of fruit production. It should be noted that the warm phase of the southern oscillation cycle (El Niño) occurred during both of these years. Generally, the year following the warm phase experiences a decrease in precipitation. Relatively low rainfall in 1997 and 1998 coincided with low fruit production for uxi and piquiá, and high rainfall in 1994 and 1996 coincided with the highest fruit producing years. As Peter's discovered in his 1989 study of *B. alicastrum*, "year to year fluctuations in rainfall, therefore, may affect both the duration and synchronicity of the reproductive phenology of the species."

According to Hans Müeller of EMBRAPA who has observed the fruiting of scores of native Amazonian species for decades in the region of Belém, the months of

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[3] Rainfall data was acquired from the Woods Hole Research Center field station, approx. 130 km from the field site.

July through November *"comanda tudo"* (command all) (pers. communication Sept. 1999). Müeller's observations indicate that these months are of principal importance to the level of fruit production. During this time period — the flowering season — annual changes cause precipitation to diminish and sunlight to increase, offering ample luminosity for flowering and sufficient rain for fruit set. During this period, too much rain, or even cloudiness, can contribute to a poor fruiting year.

Regarding the fruit production of piquiá, bacuri and uxi during the years 1993 through 1995, rainfall was relatively ample between July and November, measuring between 163 and 193 mm each season. During 1996-1998 precipitation between July and November decreased to 86, 121 and 99 mm respectively. For these few years, the level of precipitation during July through November is not a reliable indicator of the following season's fruit production.

CONCLUSION

Results of this ecological study of *C. villosum*, *P. insignis*, and *E. uchi* indicate that in mature *terra firme* forests they occur in relatively low densities (.36-1.2). In a given population, widely varying percentages of trees produce fruit in any given year (21%-100%). Cycles of production may be annual, every other year or sporadically once or twice in a five-year period. An individual tree may produce 3000 fruit one season and none the next, while its conspecific neighbor produces only a handful of fruit. Results are thus consistent with findings that demonstrate that characteristically, tropical *terra firme* forest trees display low density, inconsistent production, and complicated phenology (Phillips 1993). The high variability and enormous inter and intra-specific variation of the three tree species are compatible with findings in tropical forests elsewhere in Central and South America, Africa and Asia.

Due to their complex natural history, to understand the ecology of tropical trees it is necessary to study them closely over long periods of time. While some ecological information can be gathered through traditional knowledge, we discovered that local estimates of both density and fruit production were site and tree specific, and not reliable for extrapolation to the forest population (Shanley et al. 1997).

Although the results of the study did not offer immediate solutions to the communities' forest management dilemma, the data does clarify a number of inaccurate assumptions regarding fruit availability on the part of the villagers. The census of fruit trees, for example, corrected misconceptions regarding forest composition by demonstrating that not thousands, but only a few hundred mature trees of *C. villosum* occurred in the community forest and that, with only a few dozen productive individuals available, *P. insignis* is even less plentiful. Second, the study identified trees that produce consistently, and those that extend the harvest by producing early and late in the season. Third, data collection — the daily act of counting thousands of fruits and flowers over the course of five years — offered some community members a deeper sense of the relative value of these forest trees as used for their fruit, as opposed to their wood.

To address the community's question regarding the potential for fruit sales, results show that individual fruit production is highly variable (and in the case of uxi, heavily predated) and, therefore, bears risk for commercialization. Large distances between trees, wildly inconsistent production, low fecundity (piquiá and bacuri) and high degree of predation are substantial ecological obstacles to harvesting fruits for sale. In addition, low recruitment for piquiá and bacuri, a senescing population, potential difficulties in pollination, and high rates of mortality signify that fruit tree populations will decline markedly, eroding the population base and further limiting the availability of fruit.

The majority of fruit tree mortality (25 trees) was due to a combination of synergistic factors that cumulatively weaken trees until their death. The catalyzing activity was logging, followed by fire, agricultural activity and/or wind. Logging, fire and wind caused the death of 15 fruit trees. Felling of locally valued fruit trees by loggers occurred in spite of the fact that the community forbid extraction of mature fruit trees. Preparation of swidden fields contributed to the mortality of 10 of the 25 fruit trees. Community members sometimes place swidden fields in selectively logged areas, where trees are already vulnerable to fire and weakened by the consequences of logging.

Even with the high rate of fruit tree mortality and without achieving fruit sales, forest fruit offer a highly valued contribution to the livelihoods of community members. In addition to direct consumption of fruit, high levels of predation highlight the very significant value of forest fruit trees, particularly uxi and piquiá, to wildlife. Given that many community members value game more than any other non-timber forest product, the importance of fruiting species as game attractants cannot be underestimated. Thus, to better understand the value of forest fruits to families, information is needed not only on potential commercial benefit of fruit sales, but also on local consumption levels of both wildlife and fruit. Chapters Five and Six describe subsistence consumption of three nontimber forest products, fiber, fruit and game.

I was born into a forest of prosperity, I will die in misery.

Horacio Santos, Capimense elder

CHAPTER SIX

INVISIBLE INCOME: THE SUBSISTENCE USE OF NON-TIMBER FOREST RESOURCES IN A LOGGED AMAZONIAN FOREST[1]

INTRODUCTION

Plants and animals are widely utilized throughout the Amazon basin, yet little detailed information is available on the changing volumes and values of these resources for rural families. Largely focusing on exceptional products fitting conventional economic models, the discourse on non-timber forest products has often framed research questions narrowly, resulting in distorted conclusions. For example, due to a concentration on internationally traded resources, such as rubber and Brazil nut, non-timber forest products have been labeled "boom-bust" commodities (Homma 1983, Homma 1993, Sizer 1992). Locally consumed and traded forest goods, however, seldom demonstrate such extremes (Laird 1995). The general failure to recognize this is due, in part, to the fact that data on locally consumed forest products such as fruits, fibers and game are hard to come by.

Rural livelihoods include activities such as trading, lending and direct consumption of forest goods such as resins, fungi and insect larvae. Lacking existing data quantifying such transactions, many analyses exclude the predominant use and value of non-timber forest products worldwide. For instance, while most Amazonian non-timber forest product research focuses on plants, in many locales, the most highly valued non-timber forest products are animals (Godoy 1992, Bodner et al. 1994).

In addition to the lack of attention to subsistence utilization, remarkably little notice has been given to the changing abundance of non-timber forest products as Amazonian landscapes are transformed. As logging, fire and ranching have escalated in Amazonia, the volume and composition of forest products has been radically altered causing unknown consequences for rural communities. In this changing landscape, it is critical to understand the sources of widely used NTFPs. Are they collected from mature forests or fallows? Are they vulnerable to logging or fire?

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[1] NTFP utilization data in this chapter was collected and analyzed in collaboration with M. Cymerys and L. Luz.

During the last three decades in eastern Amazonia, for example, the number of species extracted by loggers has escalated from only a select few to over three hundred, causing increasing overlap between timber and non-timber species (Martini and Uhl 1994). Fruit and medicinal oil species — once primarily exploited for their medicines and fruits — are currently felled for their timber. Another methodological difficulty is that case studies of NTFP utilization have often been conducted in the "present tense" (De Beer and McDermott 1989). The compact time frame of many studies contrasts markedly with the lengthy phenological cycles of tropical fruiting species. A tree may produce thousands of fruit one month and none the next with obvious consequences for faunal populations, game capture, and fruit and game consumption by forest dwellers. Clearly, data acquired during short-term time frames can grossly misrepresent the potential or actual value of NTFPs. To more accurately describe the value of non-timber forest products, long-term studies are needed. In addition, due to the difficulty and considerable inconvenience of measuring NTFP extraction by forest villagers, small sample sizes are commonly used. However, wide variation exists between and within households with regards to NTFP consumption indicating that larger sample sizes are needed (Wallenberg and Nawir 1998).

In this chapter quantitative data is provided on the use of plant and animal forest resources by thirty households, residing in an area of *terra firme* forest undergoing selective logging. From 1993 to 1994, the volumes of fruit, fiber and game utilized by each household were counted and weighed daily and the economic value to the average household calculated. In 1999, after three additional logging episodes, interviews with half of the original households were conducted to estimate current levels of consumption of fruit, fiber and game.

First, quantitative results of 1993-1994 research study are presented followed by results of the follow-up 1999 study. Next, a discussion focuses on the direct and indirect effects of logging on the abundance and utilization of NTFPs, the critical nature of NTFPs for subsistence livelihoods, and the threats to non-timber forest products due to the increasing overlap of timber and non-timber forest species.

STUDY SITE

Field research was conducted in a small *caboclo* community, located on the western bank of the Capim River in the municipality of Ipixuna, in the Brazilian Amazonian state of Pará. During 1994, the community consisted of approximately 37 *caboclo* households; an average household was composed of 7.2 persons (Mattos et al. 1993). Through an informal but locally recognized land titling system, the community occupies 3000 hectares of land consisting of selectively logged forest, agricultural fields, secondary forest, *restinga* and settlement.[2] Families practice swidden agriculture with their principal market commodity being *farinha*, a coarse, flour-like product made from cassava. Households also market bananas, rice, corn and squash. Because wage labor and other income opportunities are scarce, the majority of households' cash income is derived solely from sale of agricultural produce. Residents also extract game, fruits, fibers and medicinals from area forests for subsistence use. Extraction of forest products (game, fruit and fiber) in the village is principally an occupation of men and children. In the Capim communities, women are responsible for most agricultural, household and child care duties, leaving little time or opportunity to gather forest products. For their personal consumption, children collect many edible insects, fish, fruits and birds from nearby their homesteads, some venturing 2-4 km away to gather bacuri fruit during its season.

Prior to the initiation of the study in 1993, the community had sold timber several times. However, the community forest was relatively intact; game animals, fruits and fibers were still accessible within two km of the village center. In the 1970s and 1980s, timber extraction throughout the region concentrated on only a select suite of up to twenty species. At this time little machinery was used, trees were cut, pulled out by oxen or men, and dragged to the river where they were floated to lumber mills located downstream. During the present decade in the Capim region, logging roads course through forests, hundreds of species of trees are extracted by trucks or bulldozers and driven by 16 wheelers or carried on large barges to nearby cities.

From 1993 to 1999, three additional timber sales occurred within the study community. In each case, a logger related the terms of the sale to the community leader; the deal was discussed among village men and readily accepted. Depending on the equipment used and the number of hectares of forest being logged, each of these logging episodes lasted between six months and two years. The 1993 logging contract entailed the extraction of 1500 trees from the community's last area of undisturbed forest. In 1995 and again in 1997, additional timber sales occurred. By 1997, instead of paying per tree, the logger offered a flat rate to extract any commercially desirable trees per alqueire (4.8 ha). This reduced value was offered given the fact that the top quality trees had previously been logged out. During this logging episode, the logger paid US$100 per alqueire (4.8 ha) and remained in the

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[2] The study community occupies the forested area described in Chapter Five.

community extracting logs for a period of fifteen months. By 1999, all of the 3000-hectare forest had been selectively logged consecutive times.[3]

METHODS

The consumption of non-timber forest products was measured using daily notation. To make it easier for non-literate individuals to participate, illustrated notebooks of household consumption were designed jointly with the community.[4] In this chapter the types and volume of fruit, fiber and game utilized by 30 families over a one-year period from September 1993 to September 1994 is compared with the estimated level of these products utilized from 1998-1999. Five introductory months (April–August 1993) were needed to familiarize households with the notebooks, to train community members in their use, and to stabilize the sample size. Although the study began with the participation of all 37 families living in the community, seven dropped out during the five initial months due to disinterest, lack of cooperation or migration outside of the community.

Households involved in the study were equipped with a scale and a monthly notebook and were trained to weigh, count and record extractive products collected by the household. Fruits were counted in units, while fibers were recorded in kilograms (Fig. 6.1). In addition to the name and weight of game: the location of the hunting event; sex of the animal; type of capture technique; and weapon employed were also noted. A village monitor visited each household weekly to assist with the recording of data. Monthly home visits provided additional support and examination of data entry. Frequent walks along the riverbank where game is cleaned and prepared served as a check to see what animals had been captured (Fig. 6.2). At the close of each month, notebooks were collected.

Because game is bought and sold within the village, subsistence values of game were calculated using prices of game meat as traded within the community. Prices of fruits and vine products were obtained from the nearest marketplace that is located in Paragominas, over 100 km from the village. In the Capim region, one resident will frequently go to market, carrying the goods of many, thus diminishing the transport

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[3] During each logging episode community leaders explicitly prohibited loggers from extracting mature piquiá, bacuri and uxi trees. Their stance was due, in part, to the concurrent ecological study of fruit trees underway, as well as to the community's predilection for forest fruits.

[4] Sample pages from the illustrated notebooks can be found in Appendix A: Sample Pages from Illustrated Notebook of Household Consumption, 1993–1994, of game (*caça*), Fibers (*cipo*), and Medicinal Plants.

Figure 6.1 Weighing *Heteropsis jenmanii titica*, a forest fiber, along the Capim River, 1994

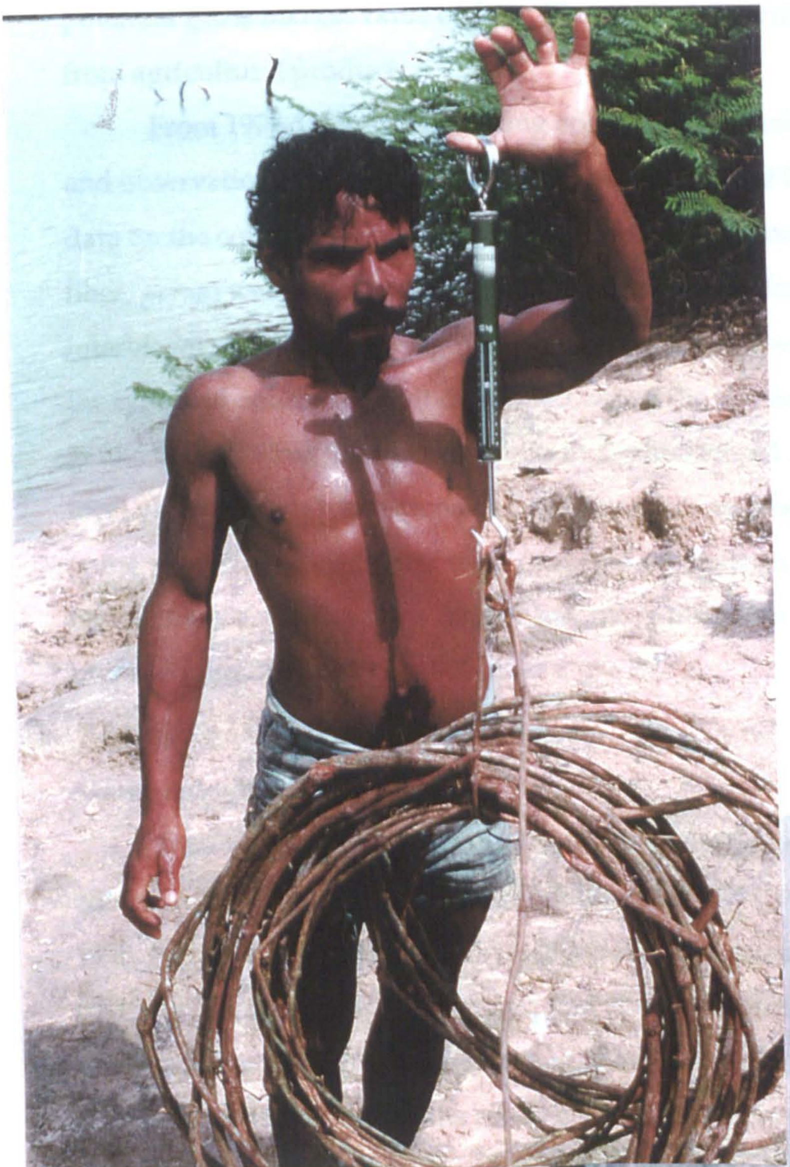

Figure 6.2 Cleaning and preparing a sloth

and time costs for all. It is not uncommon, therefore, for residents to receive full or close to full market value for the product they sell. In this study, we compare the potential gross market value of fruit, fiber and game with the gross income derived from agricultural products.

From 1993-1999 corresponding ecological research continued in the community and observations were made as to the type and level of NTFPs consumed. In 1999 data on the consumption of each of the non-timber forest product categories (fruit, fiber, game) were gathered during field observations throughout the community and interviews with 15 of the original households. Interviews included questions such as the type and volume of fruit consumed, when the last time the family had consumed game, and whether the fiber products in the household were purchased or made with local vines. Through questions and observations, aggregate volumes of fruit, fiber and game used during 1998-1999 were collected for a subset of the original sample. Based on this data, estimates were made concerning the value of fruit, fiber and game used by the community in 1998-1999.

Methodological difficulties

Inadequate quantification of the use of non-timber resources by rural communities is in part due to methodological difficulties (Wollenberg and Ingles 1998, Falconer 1996). Rigorous investigation of the subsistence use of forest products requires large amounts of time; frequent and often intrusive home visits; an interdisciplinary approach; and strong, durable relationships with rural communities. In spite of precautions, results are likely to underestimate the quantities and diversity of forest products used. This is due in part to the considerable inconvenience involved in the weighing or counting of forest products used each day over an entire year.

Additional difficulties included: widespread illiteracy, lack of recall of details (Bernard et al. 1984) frequent under recording of forest goods consumed in minute quantities (Godoy 1993) and under recording of products extracted and used by children. Moreover, although illustrated notebooks helped orient families involved in the study, it was not possible to illustrate all forest products. This bias is likely to have caused families to underreport species for which no illustration existed. On the other hand, the study itself and the daily act of recording may have served initially as a competitive incentive for some households to extract higher quantities of products than their neighbors. Furthermore, although the objective of the notebooks was explained numerous times both to the entire community and to individual families, some older individuals feared that the notebooks might be linked to a system of taxation based on the quantity of forest products consumed. These individuals initially may have under reported extracted products. Because families used the notebooks over an extended period, however, initial effects of the study were likely to diminish over time.

Also, due to methodological differences, the data gathered in 1999 is not as fine-grained as that collected in 1993-1994. However, by 1998-1999, availability of non-timber forest products had diminished so drastically that daily diaries used during this time period would most often have been empty. Even during 1994, some residents expressed reluctance at measuring declining resources and highlighting foodstuffs they did not have. Thus, in 1998, daily diaries would have been an inappropriate exercise, underscoring loss felt in a very concrete way.

A further methodological challenge in measuring subsistence utilization is that to place a monetary value on forest products utilized but not sold and infrequently or never purchased by families is extremely difficult (Wollenberg and Ingles 1998, Scoones et al. 1989). Most families would never purchase from the market the type or quantity of forest products that they utilize from the forest for free. Moreover, market prices can fluctuate considerably over time and between different geographical regions, markets, and vendors.

RESULTS

Fibers: sources and use

In 1994, the principal sources of fiber used in the community were: titica (*Heteropsis jenmanii* Oliv.), timboaçu (*Thoracocarpus bissecta* Vell.), and guaruma (*Ischnosiphon arouma* (Aubl) Koern.). Titica and timboaçu are epiphytes that occur in primary forests, guaruma is an herbaceous plant found in inundated areas. Barks from a variety of trees were also stripped from trunks and used as fibers. Of the fibers consumed, titica was by far the most widely used; per weight titica was used twice as much as timboaçu and three times more than guaruma (Table 6.1). Titica was preferred because of its accessibility, resistance and flexibility. Of the fibers utilized in the village during 1993-1994, 84% were extracted from mature forest.

Fibers were locally used to manufacture baskets, fences, sieves, brooms, fishing traps, fiber backpacks and *tipitis* - a tubular sieve used to squeeze liquid from cassava. Elevated extraction of fiber during specific months was due to their use as fasteners and nail substitutes in the construction of fences, chicken coops, and houses. In December, at the start of the rainy season, most extracted fibers were used as cords to transport logs from the forest to the river. Average monthly use of fiber by thirty households totaled approximately 50 kg or 1.7 kg per household per month.

Table 6.1 Principal fibers consumed in the study community, 1993-1994, shown as mean kilograms per household per year (kg/hh/yr), and standard deviation (sd)

Species	Common name	Plant part	Mean kg/hh/yr	Sd
Heteropsis jenmanii Oliv.	titica	root	10.0	± 16.5
Thoracocarpus bissecta Vell.	timboaçu	root	4.3	± 8.6
Ischnosiphon arouma (Aubl.) Koern.	guaruma	stem	3.3	± 7.4
Others			2.5	± 6.3

Although basic manufacture of simple home utensils such as brooms, baskets and flat sieves are known to many community members, techniques to construct *tipitis* and *caçuas* (a large, twin-sided basket that fits atop a horse) were practiced by only a few village residents. In 1994, three village residents regularly manufactured fiber products: one young woman, a teenage boy and one elderly man whose production was in decline. Specialty items were made upon request and traded within the village. In 1993, although villagers complained about increasing distance to collect fibers, none lacked basic household implements such as brooms, baskets and sieves. During the period of the study, residents marketed no fiber products outside of the village.[5] Prices for fiber goods offered at the closest town compensate poorly for labor and resource extraction time. Due to cost and time constraints, some villagers began to phase out the use of *tipitis*, preferring wood presses as substitutes.

Fruit: sources and use

During the 1994 study few village families maintained orchards or groves of planted fruit trees. A few mango (*Mangifera indica*), cashew (*Anacardium occidentale*), and cocoa (*Theobroma cacau*) trees grew along the riverbank. The principal fruits consumed by the community were three non-cultivated species occurring in mature forest— bacuri (*Platonia insignis*), uxi (*Endopleura uchi*) and piquiá (*Caryocar villosum*)

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[5] Although not commercialized in the Capim region, H. jenmanii is extracted and sold as a raw material for wicker furniture (in areas with better road access). In some parts of the states of Maranhão (Balée 1994) and Pará, *H. jenmanii* is undergoing rapid depletion due to commercialization.

— and one native palm species found in fallows, tucumã (*Astrocaryum vulgare*) (Table 6.2). Although the duration and schedule of fruit production vary between the four species within the region of study, all fruit during the rainy season, January - April. The majority (87%) of the wild fruits consumed during 1994 were collected from trees in mature forest.

Table 6.2 Principal fruit species consumed in the study community, 1993-1994, shown as mean number of fruit per household per year (mean # fruit/hh/yr), the standard deviation (sd), and the range

Species	Common name	Mean # fruit/hh/year	Sd	Range
Platonia insignis Mart.	bacuri	161.43	± 331	0-1765
Endopleura uchi Cuatrec.	uxi	150.80	± 284	0-1416
Caryocar villosum (Aubl.) Pers.	piquiá	72.53	± 75	0-333
Astrocaryum vulgare Mart.	tucumã	8.20	± 138	0-689

During the three-month fruiting season of 1994, bacuri and uxi were the most heavily consumed fruits, averaging 161 fruit per family per year or 50 fruit per family per month during the fruiting season. Averages mask considerable differences in consumption among families, with some families consuming little or no fruits and others consuming over 1000 fruits per month. As standard deviations indicate, wide variation existed between families. Two families accounted for 63% of the recorded fruit consumption in February while 12 families recorded little or no consumption. In March, fruit consumption was more evenly distributed among families. The two families showing particularly high fruit consumption (>1000 fruits/month during the harvest) lived far from the main village and close to intact forest.

According to Quiandeua residents, no forest fruits had ever been marketed from the community forest prior to 1993. As an experiment associated with the research project in 1993, community members transported a few thousand fruits of piquiá, bacuri and uxi 122 km to the nearest market (Shenley 1999). Difficulties associated with the sale included: lack of transportation, perishability of fruit, lack of market expertise and poor organization. Villagers exchanged ideas about how to improve sales and made plans to market fruits during a subsequent harvest.

Game: sources and use

In 1994, Quiandeua residents used a wide variety of fauna, hunting at least 40 species. Mammals were most commonly captured accounting for 65% of the game taken and 90% of the total mass of game consumed, while birds and reptiles accounted for 22% and 13% of the animals hunted respectively. Eleven game species taken had an average adult weight of less than 1 kg.

Relatively small species like armadillos, tortoises and median size rodents were the most commonly taken game. The top ten ranking game species included nine mammals and one tortoise (*Geochelone* spp.) (Table 6.3). Larger ungulates contributed significantly to the total weight of annual game capture. Collared peccary (*Tayassu tajacu*) made up 18% of the total weight and red brocket deer (*Mazama americana*) 10%, but the nine-banded long-nosed armadillo weighing an average of 4.5 kg contributed 20% of the total weight of animal capture. From 1993-1994, all 30 of the participating families acquired wildlife but the extent of their hunting efforts varied greatly. Thirteen families captured less than ten animals during the year. The family with the highest capture rate consumed a total of 427 kg from 76 animals, averaging 36 kg per

Table 6.3 The top 10 ranking game species taken by the study community during 1993-1994, listed as mean consumption per household per year (kg/hh/yr), standard deviation (sd), and total weight of captures (kg)

Species	Common name	Kg/hh/yr	Sd	Total weight (kg)
Dasypus novemcinctus	armadillo	19	±20.7	572.7
Tayassu tajacu	collard peccary	17	±28.7	518.0
Mazama americana	brocket deer	9.2	±17.1	278.0
Agouti paca	paca	8	±12.6	230.0
Alouatta belzebul	howler monkey	6	±13.5	185.5
Geochelone denticulate	tortoise	5	±11.5	152.2
Mazama gouazoubira	brocket deer	5	±12.0	152.0
Dasyprocta prynaolopha	agouti	5	±8.8	150.5
Bradypus variegatus	3-toed sloth	4	±6.6	124.1
Choloepus didactylus	2-toed sloth	4	±8.4	108.5

month. In 1994, large catches were often shared or traded within the community. Average game take for the community was 2.6 individuals/person/yr and 8 kg/household/mo. Hunting activity and capture rate fluctuates with low game consumption during the late dry season, the period of agricultural field preparation. Large numbers of game were taken early in the rainy season and during the period of "*espera*" when hunters wait for their prey by fruiting or flowering trees.

Game was captured primarily in forest habitat with 79% of the game taken in primary or logged forest. To meet their needs hunters also relied on forests outside the community's territory, including ranchers' forests (14% of game taken) and neighboring communities' forests (12% of game taken). For some hunters, cattle ranchers' forests had become the closest remaining hunting area, while others travel up to 15 km to hunt, sometimes for days at a time in the forests of more distant ranchers. Some residents chose to hunt in forests of neighboring communities that experience less hunting. Secondary forests provided only 13% of the game taken; and a small number of animals (8%) were caught in agricultural fields, rivers, *restingas* and other habitats.

Subsistence value of fiber, fruit and game

Capimenses earn the majority of their cash income through sale of agricultural products (*farinha*, bananas, corn, rice and squash) the mean of which approximates $1200 per household per year. [6] To place an economic value on extractive products consumed but not sold, the mean economic value of fruit, fiber and game consumed by households was compared with mean annual income. Results demonstrate that during 1993-1994, on average, households consumed the equivalent of 25% of their annual income from extractive products (Table 6.4). Because use of non-timber forest resources varies so widely between households, however, the percentage of NTFP value for individual households also varied considerably. For example, households which hunted and gathered fruits extensively earned the equivalent of greater than 50% of their annual agricultural income from game, while households that concentrated their energies on swidden agriculture, may have earned as little 10% or less of their income from extraction.

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[6] Mean income is derived from an unpublished study by M. Mattos et al. 1994.

Table 6.4 Mean subsistence value of non-timber forest products consumed in the study community, 1993-94

Resource	kg/hh/yr	$ value/hh/yr	% annual income
Fiber	20.1	$30.15	2.51 %
Fruit	89.1	$74.71	6.25%
Game	96.0	$192.00	16.00%
Total		$296.86	24.76 %

Six years later, in 1999, after three additional selective logging episodes and fire, the estimated value of freely extracted fruit, fiber and game utilized by households comprised approximately 5% of the family income – a 20% decline since 1993-94 (Table 6.5). Game consumption dropped by 83.4%; fruit consumption by 68.5%; and fiber use by 80.6%. Field observations demonstrated significant changes in livelihoods that this decreased use-level of non-timber forest products catalyzed. For example, in the Capim region, a broom is an indispensable household implement. Floors are rigorously swept numerous times each day and serve as sitting, eating and sleeping places. Cultural practices dictate that the ground surrounding each home is cleared of vegetation and swept free of dust. In 1993, every household owned a hand fashioned titica broom; in 1999, many households lacked such a basic household implement.

Table 6.5 Estimate of mean subsistence value of non-timber forest products consumed by the study community, 1998-1999[7]

Resource	kg/hh/yr	$ value/hh/yr	% annual income
Fiber	3.9 kg	$7.80	.65 %
Fruit	28.1 kg	$19.64	1.64 %
Game	15.9 kg	$ 31.80	2.67 %
Total		$ 57.44	4.96 %

Due to lack of vines, families had begun to borrow the few remaining brooms and *caçuas* (large baskets used to carry manioc atop a horse) left in the community. Since carrying harvest home from the fields and sweeping house are frequent

[7] Based on field observations and interviews with a subset of the original households.

activities conducted by all village households, lack of forest fibers to construct backpacks and brooms caused considerable daily inconvenience. Humiliated at borrowing a neighbor's broom each day, one Capim woman broke down and purchased one from a passing river vendor stating, "It costs money, its far inferior to titica, and it lasts only a couple of weeks."

Consumption of fruit also declined. During the harvest season of 1994, fruit was accessible to all household members. In 1999, community members consuming fruit tended to be men and children, traveling distances of three to six km from the village to collect it. Women complained that men no longer carried fruit home from the hunt; in fact, due to lack of game they stated that the men hunted far less. Numerous women related that they had not eaten a piquiá, bacuri or uxi fruit during the entire harvest season of 1999.

Post logging and fire, game consumption also declined. Whereas many families had consumed game three to four times a month in 1993, in 1999 the same families consumed game only three to four times a year. In 1999, the village matriarch related that in the past whenever one hunter was successful, meat was evenly divided among village members. Recently she stated, "Now only if my own son brings home game do I eat it. If a neighboring relative captures game, I must buy it."

Changes in resource use and abundance

In the Capim region, each family annually clears and burns approximately 1-2 hectares of primary or secondary forest for agriculture. Because it is less labor intensive to prepare fields in previously logged forests, families sometimes choose these sites for their swidden fields. However, in some cases, fire used in the clearing of the land enters neighboring forest, where it burns out of control. Selectively logged forests burn easily as logging creates conditions that favor fire by opening the canopy and leaving slash as fuel on the forest floor (Cochrane et al. 1999, Uhl and Kauffman 1990). Following closely on the heels of a logging event in 1997, accidental fires during September and again in November raged for weeks; burning an estimated one third of the community forest.

Although fires have significantly damaged the community forest, the practice that sets the stage for this and other types of forest impoverishment is logging. During the early 1970s in eastern Pará, the logging industry was highly selective, extracting only a few tree species of hundreds available (Veríssimo et al. 1992). As stocks of the most valuable timber declined in the vicinity of the sawmills, loggers gradually began to extract an ever-growing number of species.

Three decades later, over 300 species of trees are extracted by loggers in eastern Pará. In addition to their timber value, one-third of these species are also valued for food, medicines, and/or gums and resins (Martini et al. 1994). In the Capim region, these include species valued for their fruit (piquiá, bacuri and uxi) medicinal oils (copaíba, *Copaifera* spp.) and others that attract game (andiroba, *Carapa guianensis*). Because game is the most highly prized non-timber forest product for many villagers, game attracting trees hold exceptional value for hunters. Piquiá and jatobá (*Hymenaea courbaril*) are excellent game attractants, bear widely consumed, marketable fruit and are currently highly valuable timber trees. During the past decade, within 3-4 km of the village, the majority of mature C. *villosum*, E. *uchi*, and P. *insignis* trees have been either damaged by logging or burned.

Changes in vegetation composition and structure resulting from agriculture and logging appear most pronounced near river edges. Swatches of secondary forests and fallows currently extend up to three km from riverbanks where most villages are located, thereby increasing the distance to primary forests where fruits and vines are collected. Some species such as tucumã, respond favorably to disturbance, expanding their distribution into fallows and areas of secondary growth while species occurring in mature forest decline.

As mature forest becomes progressively degraded, the distance to extractive products sourced principally in primary forests increases. For example, as recently as twelve years ago, community members recall collecting titica and timboaçu close to their homes; in 1996 they traveled 2 to 3 km to secure these fibers; in 1999 they are difficult to find within 4 to 5 km of their homes. Although the community deliberately spared mature forest fruit trees from logging, collateral damage and fire weakened trees so that many blew over during strong winds.

Game is also severely depleted due to forest loss, and changes in forest structure and composition. In other regions, logging operations have directly and indirectly contributed to the depletion of local stocks of wildlife (Wilkie et al. 1992, John 1992, John 1988, Caldecott 1988). In lieu of being a commonplace event in the community forest itself, hunters began to form traveling hunting parties to visit the distant forests of neighboring ranches. Whereas the consumption of game was once an everyday event, when a large animal is captured today word spreads rapidly throughout the village. Hunters maintain that as recently as 15 years ago, they neither journeyed long distances nor strategized to capture game. As one community member recalled, "Dinner walked past my front door, and I shot it."

After selective logging events, forest fruits, fibers and game may become not only less abundant and more distant, but also less convenient to extract. After a timber sale, crowns and trunks of felled trees obstruct passage through the forest, networks of logging roads become overgrown by thick secondary growth and kilometers of tractor tracks fill with winter rains. Due to difficult mobility, hunters avoid recently logged forests. Detours must be created to avoid flooded timber roads, and residents, who travel barefoot, maintain that snakes are more common in open, inundated areas. Lying beneath weighty branches and litter of felled trees, fruits, seeds and perishable non-timber forest products become difficult or impossible to harvest.

The impacts of forest loss, decreased habitat, and increased exploitation of declining resources are not abstract to the Capim communities. They have directly contributed to food shortages and hunger in the Capim region. Today as compared to ten years ago, it is not unusual for individuals to go 2 to 3 days eating only *chimbo* (*farinha* and water) mixed with a few meager slivers of fish. Diets presently lack sufficient protein and calories that, a decade ago, were amply supplied by forest foods.

DISCUSSION

The research results demonstrate that in the Capim, where fallows are minimally managed, local communities are heavily dependent upon mature forest as a source of non-timber forest products. While secondary forests and fallows have been shown to offer substantial medicines, fruits and fibers in other regions (Voeks 1996, Schreckenberg 1996, Kainer and Duryea 1992, Grenand 1992, Davies and Richards 1991, Falconer 1990, Denevan et al. 1987, Alcorn 1984, Posey 1982), in this study most non-timber forest resources: 87% of fruits; 85% of fibers; and 79% of game, were extracted from mature forests. In 1994, on average, Capim households earned the equivalent of 25% of their annual income from extractive products. Among *ribrenõs* in Peru, Padoch (1987) reports that even among villages dependent upon staple crops and fishing for the majority of their income, households could earn as much as 39% of their income from forest products. In Africa, Kant and Metah (1993) assigned a monetary value to non-timber forests bought and sold accounted for two thirds of village income. In both these examples and others (Denevan 1987, Davies 1991), economic benefits accrue largely from fallow. In part, lack of intensive forest management in the Capim may be due to the fact that only in the last decade has logging significantly reduced the density of locally valued NTFPs. Until relatively recently management was not needed; the supply of forest products met demand.

Notably, in 1994, even after three selective logging events, the data show substantial inputs of fruit, fiber and game for community residents. However, three additional episodes of heavy, "selective" timber extraction, coupled with consequent fire, significantly degraded the forest resource base. Over a period of six years, successive logging events and consequent fires rapidly transformed over 1000 hectares of selectively logged primary forest to regrowth forest. The extent of depletion depends on the scale, mode and intensity of forest disturbance. Results demonstrate that to effectively meet both timber and non-timber demands, there is a critical limit to the volume of timber that can be extracted before the composition and volume of economically valuable timber and non-timber forest resources plummet.

In addition to the immediate loss of desirable species, the manner and intensity in which logging takes place effects residual stands. In Amazonia, logging operations aiming to extract 8 trees/ha killed or damaged 26% of all pre-harvest trees $\geq$ 10 cm DBH and reduced canopy cover by close to one-half (Uhl and Vieira 1989). Collateral damages associated with tree harvesting such as seedling destruction, topsoil removal, soil erosion and soil compaction directly effect present and future harvests of both timber and non-timber forest products (Laird 1995).

CONCLUSION

Logging, ranching and associated fires currently threaten to dominate and destroy the forest resource base upon which a majority of rural Amazonian communities depend. If timber sales and associated fire continue at the present rate in the Capim communities, the most highly valued non-timber forest resources will soon be threatened with local extinction. In the study community, where *caboclos* have lived for four generations, these last few years are the first time that older residents remember hunger as an ever present reality. As wild food resources decline, forest residents must substitute native animal and plant products with market goods. However, for families whose annual incomes approximate US $1000, regular purchases of meat, fruits, fibers and pharmaceuticals are out of economic reach.

To conserve NTFPs within limited forest areas and to sustainably manage existing agricultural land, forest communities will need to intensify agriculture (Toniolo and Uhl 1995, Almeida and Uhl 1995) and to actively plan and control the placement and size of future swidden fields. Modified agricultural practices are needed in which swidden fields are placed in fallows instead of forest and in which fire barriers are routinely created to protect croplands and forest.

To manage forest resources sustainably, improved timber extraction techniques and integrated management must be practiced (Amaral et al. 1998, Veríssimo et al. 1998, Uhl et al. 1997, Laird 1995). Communities will need access to reliable information that allows them to negotiate for a just share of economic benefits deriving from logging, including the commercial and subsistence value of both their timber and non-timber forest products (Shanley et al. 1998). Well-managed timber extraction involving significant community input could allow commercial exploitation of desirable timber species in conjunction with the management of valuable non-timber resources (Laird 1995).

While logging and swidden agriculture will continue to play an important role in rural communities, the results of this study demonstrate that the continued existence of mature forest is also critical to support subsistence livelihoods. As such, policies are needed which actively promote sustainable logging practices, intensified agriculture, fire control, and the creation of forest reserves. For future generations to benefit from the myriad of goods that forests offer, local and global assessments of forest worth must incorporate the subsistence value, as well as the market benefits, of non-timber forest products.

I have nothing but the shirt on my back and a machete, but I am planting fruit trees, and I have forest with piquiá, bacuri and uxi.

J. F. Brito, Capimense

CHAPTER SEVEN

PLACING A VALUE ON SUBSISTENCE: A COMPARATIVE ECONOMIC ANALYSIS OF NON-TIMBER FOREST PRODUCT USE IN EASTERN AMAZONIA'S LOGGING FRONTIER[1]

INTRODUCTION

Non-timber forest products (NTFPs) are intrinsic to the daily livelihoods of rural dwellers in many developing countries, yet they continue to be undervalued in global, national and household accounting systems. The economic invisibility of non-timber forest products skews economic comparisons of land use, often in favor of forest conversion options (Hecht et al. 1988, de Beer and McDermott 1989). Indeed, the routine omission of subsistence uses is often used to question the validity of economic valuation studies.

To adequately determine the comparative benefits of extractive resources to household economies, it is useful to evaluate regions that represent not atypical, but commonplace scenarios and to look at subsistence in lieu of merely market benefits (Padoch 1987). To date, the bulk of the non-timber forest product literature on the economic value of Amazon rainforests has focused not on subsistence use but on the commercial extraction of NTFPs, frequently in exceptional settings (Anderson and Ioris 1992, Anderson and Jardim 1989, Peters et al. 1989). Cases studies are often located in the vicinity of urban markets and in seasonally inundated forests with high density of economic species (*várzea*) which tend to favor high values of NTFP extraction. However, *várzea* forests make up only 7% of Amazonia, compared to *terra firme* (upland dry) forests, which comprise over 50% (Daly and Prance 1989). Contrary to the typical *várzea* scenario, *terra firme* forests exhibit high diversity, low species densities, scattered distribution, low productivity and inconsistent yields over time (Phillips 1993).

Furthermore, for remote forest communities, lack of transportation, perishable products, insufficient knowledge about market prices and unpredictable demand

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[1] The economic analysis in this chapter was carried out in collaboration with Dr. Sven Wunder of IPEA, Rio de Janeiro, Brazil.

fluctuations combine to place them at a gross disadvantage in the marketplace. Thus, in many isolated rural communities in the Eastern Amazon, the majority of non-timber resources are used directly, shared, borrowed or swapped, but rarely sold.

By contrast, wood is easily and conveniently sold. For a majority of poor forest residents in the Eastern Amazon, sale of timber exploitation rights to logging companies offers a singular, low-risk means to acquire a lump sum of cash. The timber and cattle industries have aggressively penetrated formerly inaccessible areas of the Eastern Amazon since the 1980s. Although offering but a fraction of what the processed wood is eventually sold for, this sum represents a tempting offer in a traditionally cash-poor economy where forests have formerly been abundant. Loggers appear at doorsteps with cash in hand, thereby eliminating travel to distant and unpredictable markets. Moreover, any one timber sale may not appear to significantly damage a farmer's forest. In the eastern Amazon, selective logging of high-value species dominated until the late 1980s. Many locally-valued fruit, medicinal and game attracting tree species were not included in the suite of preferred species until recent changes in market and production favored exploitation of a significantly broader range of species (Stone 1991, Martini et al. 1994, Veríssimo et al. 1992). In spite of rising exploitation of ever increasing numbers of species, the potential monetary promise from timber sales continues to sway many smallholders to market not NTFPs but trees.

Nonetheless, some forest communities and individual farmers choose to guard forests, protecting them from advancing loggers and ranchers. To understand the motivation for the decision to conserve, sell or to convert forested lands, it is necessary to take a closer look at local values, utilization patterns and the monetary and non-monetary benefits of standing forests versus forest conversion over time. The following study will use both per-hectare valuation and comparative labor remuneration to determine the significance of non-market benefits accruing to one family on one hectare over the course of several years.

Per hectare economic valuations have been criticized for shortcomings in terms of spatial, temporal and economic biases (Chomitz and Kumari 1998, Schrekenberg 1997, Scoones at al. 1992). The following study will, in part, make use of the per hectare valuation method in order to offer a comparable data set, while also departing from it in order to stretch the analysis in new directions. First, instead of quantifying the "potential" economic value of the hectare, as predominates in the literature, we offer the value of actual, subsistence use of the study hectare. Second, while some attention has been paid to seasonal fluctuations in NTFP extraction (Phillips 1993, Vasquez and Gentry 1989), we are not aware of any study of hectare valuation that has assessed utilization over a long-term time frame while also quantifying the benefit of both floral and faunal resources (Godoy et al. 1993). Based on the diversity of uses and observed fluctuations over time, we measure both the plant and animal resources harvested, and do this not "simply in the present tense" (de Beer and McDermott 1989) but over a period of six years.

Results of the six-year study demonstrate that the subsistence value of NTFPs is substantial; that the most valuable non-timber forest products, fruit and game, are not destined for regional, national or international sale; that even in high biodiversity, low density *terra firme* forests, the net present value of NTFPs can exceed that of timber; and that, in spite of this comparatively higher value, non-timber species of substantial value are currently being extracted for their timber. Taken together, these findings question the rural development assumption that sale of non-timber forest products is possible and/or desirable for all rural communities, instead indicating the need for increased forest extension: to assist communities to weigh the costs and benefits of logging; to negotiate for just benefits; and to promote management of NTFPs for subsistence use and occasional sales. Findings also suggest that, for the benefit of domestic economies, policy makers need to address the interface of NTFPs and timber extraction.

The chapter begins by describing the study site, household and measurement methods; and then proceeds to the presentation of quantitative data on the household's utilization of plant and animal resources in one forest hectare over a six-year study period. This is followed by an economic valuation of these subsistence uses, discussing the relevance of different methods for the particular case. Next the basic features of agricultural profitability are described, and the net present value of logging-cum-agriculture compared with that of NTFP uses in the standing forest. The implication of the comparative one-hectare exercise for the household's farming system is then considered, including variations in labor remuneration across different land uses. Finally, results are summarized and their relevance in broader scenarios of land-use change in the Amazon discussed.

STUDY SITE AND METHODS

The study was conducted in a rural Amazonian river community, in the municipality of Paragominas, located in Pará. The study site is located approximately 250 kilometers upstream from the port of Belém, state capital and the largest city in Pará. Annual rainfall in this region averages 1750 mm, while temperatures generally range between 24-28 C. Local vegetation is dominated by *terra firme* forest. Soils are predominantly yellow latisols. Various aged fallows and heavily explored forests extend 1-5 km from the river's edge (Mendonza and Brown 1992). Conversion has accelerated during the last decade, due to the insatiable demand for logs by the approximately 250 sawmills in the town of Paragominas. The construction of access-providing logging roads, the sale of forested lands from local dwellers to loggers and ranchers, the degradation of primary forests and the escalating incidence of uncontrolled fires consuming degraded forests are the main land-use changes that characterize the region in the neighborhood of the study site.

One family, consisting of a father, Senhor M., his wife and their five children live within one kilometer of the hectare under study. Their home is an open structure, consisting of nine beams and a roof. Possessions include a few agricultural implements, a *machete*, rifle, canoe, pots and hammocks for sleeping. A recently built logging road passes about two kilometers from the family's farm, but there is only sporadic river, truck or bus transport available from the tiny port at 5 kilometers distance. All goods are transported to and from the farm in person. The family's farm production is focused on subsistence uses, rather than marketed products. This is due to both the remote farm location and to an explicit preference on behalf of the family for a diversified, self-sufficient and forest-based production. Similar to the majority of households in the region, their main source of monetary income is the sale of *farinha*, a cassava product, supplemented by the sale of corn, rice and beans.

Like most households in the Capim, the family has no official land title, neither to forested nor to agricultural land. Land is claimed through a locally recognized system of individual family rights and occupation. Boundaries defined through this system are generally well respected by neighboring *caboclos*, ranchers, loggers, and local government organizations. The property consists of approximately 40 hectares (ha) of primary forest, 7 ha of secondary forest/ fallow and 3.3 ha of agricultural fields. Sr. M. and his wife were born in the river basin, have lived on this piece of land for ten years and, like many of their neighbors, plan to stay on the property for life.

One hectare of mature *terra firme* forest within the family's property was inventoried in April 1992.[2] With participation of the forest owner, boundaries of the 200m x 50m forest hectare were marked using painted wooden stakes. To record forest products extracted from the plot, the family was equipped with a scale and an

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[2] Results of the ethnobotanical inventory of this forest hectare are described in Chapter Three.

illustrated notebook of forest products that included: medicinal plants, fruits, fibers, and game. Quantities of forest products consumed were counted and measured (fruits, medicinal plants) or weighed (fiber, game) and daily recorded in monthly notebooks. Over a six-year period, regular home visits and checks were made on the accuracy of recorded information.

RESULTS

Patterns of NTFP use: fruit, game, fiber and medicinal plants

Since the early 1900s, when caboclos first entered the Capim region, forest fruits and game have served as the primary source of nutrition and medicinal plants as the sole source of health care. Today, households continue to use both plant and animal resources but forest transformation has significantly reduced the availability of and access to these resources. Households like Sr. M's., which retain intact forest nearby their homes, generally utilize higher volumes of forest resources than families that have no remaining forest cover close by. The fruits, game, fibers and medicinal plants extracted by Sr. M's. family commonly occur in area forests and are used by the majority of families throughout the region. Non-timber forest products harvested from the hectare are listed in Table 7.1 and described below.

Table 7.1 Non-timber forest products collected from the study hectare 1993-1998

Scientific Name	Common name	Type of NTFP
Caryocar villosum	piquiá	fruit
Endopleura uchi	uchi	fruit
Platonia insignis	bacuri	fruit
Dasypus spp.	armadillo	game
Alouatta belzebul	howler monkey	game
Heteropsis jenamanii	titica	epiphyte, fiber
Manilkara spp.	maçaranduba	latex, medicinal
Dalbergia subcymosa	verônica	bark, medicinal

Seasonally, fruits constitute a highly important category. The bright yellow pulp of piquiá is consumed after being boiled; the gritty, oily, egg-shaped uchi is eaten raw or in juices; and the sweet, white pulp of bacuri is eaten straight from the tree. Both piquiá and uxi have high caloric value and possess significant quantities of vitamin A, frequently lacking in Amazonian diets (Figs. 7.1 and 7.2).

Figure 7.1 Carrying home *Platonia insignis* (bacuri) in a handmade basket

Figure 7.2 *Endopleura uchi* showing immature, intact, and predated fruit

Table 7.2 Quantity of three forest fruits collected and consumed by the household from the study hectare during the four-month fruiting season 1993-1998 (in no. of fruit)

	1993	1994	1995	1996	1997	1998
C. villosum	937	0	0	430	0	0
P. insignis	298	417	0	618	0	439
E. uchi	2544	3654	0	1321	0	0

The consumed amount of these three most prominent fruits are shown in Table 7.2. Results demonstrate the extreme variability of fruit consumption during different years, reflecting the complex and unpredictable phenology of tropical fruiting species; not all trees fruit every year. For example, while over 3500 fruits of uxi were consumed by the family during the four-month fruiting season in 1994, none was consumed from the hectare in 1995. During 1995 and again in 1997 not one of these three species within the hectare produced fruit. Trees demonstrate such inconsistencies both in frequency of production and in volume of fruit produced (Shanley et al. 1998, Phillips 1993). Consumption is thus contingent upon the unpredictable vagaries of fruit production.

During the approximately four months when these fruits can be harvested, they come to make up about half of the household's diet. This level of consumption is high but not unmatched by other households in the Capim who also retain forest near their homes. Prior to recently improved agricultural production, the season of forest fruits represented one of the few periods of the year that food was assured for the household. Because during the remaining eight months of the year readily available foodstuffs are often scarce; it is not uncommon to find only manioc flour in the home.

To evaluate the representativeness of the results, it is necessary to compare the density of fruit trees within the study plot with other recorded densities. Within the study hectare occur one tree each of *C. villosum* and *P. insignis* and 2 trees of *E. uchi*. These fall within the high range of densities of these species as reported in other regions of Amazonia, and are comparable with neighboring forests.[3] (Shanley et al.

[3] Piquiá generally occurs in densities of up to one per hectare (0.4-1.0) (Rodrigues 1963, FAO 1986), bacuri 0.5-1.5 trees/ha (FAO, 1986, Shanley 1998) and uchi 0.3-3.0 trees/ha (Shanley et al. 1998). Densities of up to 5 trees/ha of piquiá and uxi occur in neighboring forests.

1998, FAO 1986, Rodrigues 1963). From the harvester's perspective, the hectare bears an advantage of the fruit trees being clustered; not uncommon throughout the Capim, this is a possible indication of historic anthropogenic disturbance. Due to the proximity of the fruit trees to the house, the majority of wild fruit, roughly 75%, is gathered from within the hectare. In years during which trees within the hectare do not produce, fruit is gathered from trees in surrounding forest.

In addition to consuming substantial quantities of fruit, the family extracts wildlife, fiber and medicinals from nearby forest. Results show that, in contrast to fruit, relatively small volumes of game, medicinal plants and fiber were extracted from the hectare during the six-year period. The volumes extracted of these NTFPs appear in Table 7.3 and are discussed below.

Table 7.3. Quantities of game, medicinal plants and fiber extracted from the study plot, 1993-1998

	1993	1994	1995	1996	1997	1998
Game	0	0	0	15kg	45 kg	0
Med. Plants	0	0	0	2 liters latex .5 kg vine	0	0
Fiber	0	0	0	0	40 kg titica	0

As for many forest-dwelling people, hunting is a prime source of protein in the household's diet. Game capture is, in part, a function of the phenology of fruiting species that attract game during productive years. However, in spite of no fruit production of *C. villosum*, *E. uchi* and *P. insignis* within the hectare in 1997, Sr. M. captured 45 kg of game within the hectare. Game capture within the hectare represents approximately 10% of the total game consumed by the family during the study. In surrounding forest the household captured approximately 560 kg; on average the household consumed 10 kg of game per month. According to Sr. M., game stocks have significantly declined over the ten years the family has resided there, indicating both habitat loss and over-hunting.[4] Game available for hunting on the one-hectare plot is intrinsically related to the rapidly changing habitat and stocks

[4] There is no exclusion in the access to the family's forest for hunting, but large walking distances make it unattractive for others to make use of this access right in practice.

in surrounding forests.[5] It may be reasonable to expect a further reduction of hunting yields for the following years, even if no forest is cut down.

In addition to game and fruit, two medicinal plants were recorded as collected in the hectare; the latex of maçaranduba (*Manilkara* spp.) and verônica (Dalbergia subcymosa), a medicinal vine. The maçaranduba latex was used as a cast on Sr. M's. shoulder to set a serious sprain. Verônica was steeped to make a bath commonly used for "women's ailments". In terms of number of use-applications, medicinal plants within the hectare represent only a minor part (3%) of medicinal plant use during the six-year study. This reflects the fact that medicinals barks, roots and leaves are sourced not only from forest, but also from fallow and cultivated gardens surrounding the house. Although the household has occasional access to pharmaceuticals, it continues to rely on medicinal plants for both minor and serious ailments due to their efficacious nature and affordability.

The household's use of fiber flucuates depending upon need, being extensively used for carrying containers, as fasteners and in construction. During the six-year study period, fibers were only removed from the study hectare in 1997 when the household collected and sold 20 kg of titica (*Heteropsis jenamanii*), a resilient and commonly used epiphyte. This 20 kg of titica represents 14.2% of the total fibers utilized by the family during the six-year study. In surrounding forest, the household collected 120 kg of fiber during the study period; the majority of this (76.7%) was sold, leaving 28 kg for household use.

Although prices paid for fibers are relatively low, households like Sr. M's., which retain intact forest nearby, are able to market fiber for the purpose of raising small sums of needed cash. However, titica is highly vulnerable to logging and fire and during the last decade, its abundance in the region has been greatly reduced. Due to declining availability of natural fibers, wood, nails, textiles and plastics are some of the emerging alternatives.

Notably, the majority of the non-timber forest products consumed from the hectare were used for subsistence purposes and not sold. The family's pattern of use closely resembles that of neighbors who occasionally swap or trade forest resources at the village level but who rarely sell to external markets. During 1997, of close to 100 Capim households, only 4% sold non-timber forest products in the nearest town of Paragominas.

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[5] External habitat reduction will reduce the availability in the long run, but in the short run deforestation in the neighboring plots may also increase the availability of certain species that migrate to take refuge in the remaining forest.

The economic value of NTFP subsistence uses

To achieve the central objective of economic valuation — an economic comparison of the welfare implications of different land-use options — it is necessary to put a monetary value on those products and services that do not enter the marketplace. Various methods exist to accomplish this. First, though not traded by the household, subsistence goods may be traded in nearby markets so that these prices may be adapted to assess the value of the household's consumption. Second, the price of close substitutes may be applied, with the assumption that these would probably be used in the absence of the corresponding subsistence good, (e.g. in the case that forest is converted and access to certain NTFPs disappears or diminishes). Third, the previous approach may be combined with an estimate of saved costs, (e.g. transport costs and labor time that would be necessary to obtain a substitute in an urban market). Fourth, determining the barter value of a good may make it possible to calculate its indirect value compared to a key traded commodity, (e.g. an essential staple crop). Fifth, labor and other costs invested by the household in the production or collection of a subsistence good, provides a lower boundary to the full value that this good has to the household.[6]

To a varying degree, each of these methods will be used in the following analysis. It should be kept in mind, however, that in addition to the maximization of current benefits, objectives like risk minimization, food security and nutritional balance play an important role in a micro subsistence economy, so that one monetary unit of value can not always be plainly replaced by another. Following, each of the relevant NTFP categories will be evaluated using the most appropriate options.

Fruits

As explained in the last section, fruits are available only seasonally, but during productive years are relatively abundant and are regularly harvested by the family from the forest floor. Can such a fluctuating commodity actually fetch a positive resource rent? One affirmative *a priori* indication is that outsiders' access to collection is not unregulated: while neighbors do not actually pay for collection, they are required explicitly to ask for permission to harvest fruits from another family's land. Such requests subsequently enter into the informal exchange system of mutual favors and services between households.

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[6] Total costs invested equal the subsistence value when the good is infinitely abundant so that no resource rent for its collection materializes.

A second hint is that the household's diet changes dramatically during harvesting months, when fruit consumption enables a 50% reduction in the use of other foodstuff, thus economizing on other (tradable) items. In qualitative terms, the fruits are highly appreciated for their nutritional value; in this and neighboring villages, the incidence of diseases is observed to decline during the fruit season. A final clue is that all three species actually command good prices in the distant market of Belém (at 1994 unit prices between US$ 0.10 and US$ 1.00[7] - Shanley et al. 1998), in the municipal capital of Paragominas[8] and even in the close village of Nazaré.

Urban market prices are not directly applicable to the subsistence scenario, but one could argue that village prices give an accurate reflection of farm values: in early 1998, *E. uchi* was traded in Nazaré at 0.11 US$/piece and *P. insignis* at 0.18 US$/piece. In fact, Sr. M. in 1998 singularly sold 200 pieces of *P. insignis* in the village at 0.18 US$/piece. If these two prices, together with the observed minimum Paragominas price for *C. villos*um (0.14 US$/piece), are multiplied by the average quantity production of the two fruits during 1993-97, this adds up to the considerable total of US$ 224.11, the value in the nearest available market place.

However, village fruit sales seem to be extremely limited, destined only for occasional leisure. This means that the observed price is likely to collapse to zero if, hypothetically, Sr. M. were to sell all his fruit production in the village. The use of village prices may thus lead to an over-estimation of subsistence values. Furthermore, the family's use of the fruit is not intermittent, but rather needs to be seen as a seasonal staple foodstuff. Therefore, it may appear more reasonable to calculate the value saved in terms of the reduced expenses for other consumption goods (substitute value).

The family's consumption basket contains regular monthly purchases (average: US$ 125.73), of which about half is foodstuff (US$ 62.87). Their agricultural production for auto-consumption (at a yearly US$ 377; US$ 31.44 per month) has to be added to this amount to obtain the total monthly value of the family's food consumption basket (US$ 94.31). Calculating the alleged 50% reduction in staple food

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[7] Unless otherwise indicated, the November 1998 commercial exchange rate of 1 US$ = 1.19 R$ is used in the following.

[8] For instance, E. uchi was sold at rather stable prices (in US$/unit, at the corresponding commercial exchange rates; 1996: 0,12, 1997: 0.13, 1998: 0.10), the same is true for C. villosum (1996: 0.27, 1997: 0.30); P. Insignis fluctuated slightly more (1996: 0.39, 1997: 0.39, 1998: 0.18).

consumption over the four months of fruit harvest yields: 94.31 x 4 x 50% =US$ 188.63.

The substitute valuation (US$ 188.63) thus provides a useful consistency check, as it reduces fruit values by only about 15%, compared to the local market value (US$ 224.11). Yet the subsistence value does not take into account that fruit is actually preferred to the common diet in nutritional terms, which would justify a premium on the calculated value. As a pragmatic approach, a simple average of the two methods (US$ 206.36) is used in the following.

In terms of labor time, the collection of fruit requires a little less than one hour to walk from the house to the fruit trees, collect the daily harvest, and walk back. On average fruit is collected approximately once every three days during the four months of harvest, yielding:

10 days x 4 x 1 hour = 40 hours

120 hours/ [8 hours/day] = 5 working days

5 working days x 5 R$/day = 25 R$ (US$ 21.01 at 1.19 Nov. 98 exchange rate)

Yearly net fruit income per hectare: US$ 206.36 - US$ 21.01 = **US$ 185.35.**

Game

Consumption originating from the study hectare was 15 kg in 1996, 45 kg in 1997, and zero kg in 1998.[9] This corresponds to a yearly average yield of 20 kg, which will be used in the following analysis.[10] On average, game hunted in the surrounding forest amounted to roughly five times that figure, i.e. 100 kg. To a small extent, game is traded locally among village households, which makes it preferable to employ the market evaluation method to value game, in spite of the fact that the family neither buys nor sells game. Game was for many years sold in the village at a fixed priced of 2 R$/kg for "cleaned" meat, but in 1998 this price rose to 3 R$/kg, mainly due to the increasing local scarcity of game. In value terms, diminished extraction was thus partially counteracted by increasing prices over time, especially as long as substitutes are poorly developed.[11]

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[9] This refers to "cleaned" meat, deducting the weight of skin, bones, head, etc.

[10] The reason for excluding 1993-95 from the calculated average is that, according to Sr. M. the inventory work done by researchers on the study hectare during these years disturbed wildlife too much to allow for successful hunting.

[11] In a neighboring village, increasing scarcity was not accompanied by higher prices (they remained at 2 R$/kg of "clean" meat) partially because the raising of pigs experienced an upswing, producing a substitute product that is sold at the same price as hunted game.

At the price of 2 R$/kg, the yearly extraction of 20 kg of game thus represents a gross value of 40 R$; at the current price of 3 R$/kg, it would hypothetically be 60 R$.[12] Average labor efforts depend on the hunted species: about two hours for monkeys and four hours for armadillos, including the walk back and forth; in addition, we include a 30% miss rate for hunting trips where no game at all is caught. According to the two species' weight in total hunting yields, labor inputs can be calculated together with other costs. Subtracting these from the gross income allows us to obtain the net gains from hunting on the study hectare over the three years:

5 units of D. novemcintus x 2 hours =	10 hours
5 units of A. belzebul x 4 hours =	20 hours
Total time for 10 animals:	30 hours
Miss rate 30% x 30 hours	9 hours
Total hunting time 1996/97/98:	39 hours
Yearly time: 39 hours/3 years	13 hours
13 hours/8 hours = 1.625 working days;	
1.625 working days x 5 R$/day =	8.13 R$
Other inputs (bullets etc.) and depreciation (rifle)	9.00 R$
Total yearly costs	17.13 R$
Gross average hunting benefits	40.00 R$
Total yearly costs	17.13 R$
Yearly net game income per hectare	22.87 R$
22.87 R$/1.19 (Nov.98 comm. exchange rate) =	**US$ 19.22**

Medicinal plants

Economic valuation of medicinal plants is difficult for a number of reasons; in Capim communities, medicinals are swapped or offered as gifts but they are not sold in the village. Prices in town, although relatively low, reflect commercial margins that make them inaccessible to most caboclos. Alternatively, the substitute value of forest medicine can be determined by the costs avoided for purchasing a corresponding commercial medicine. However, the two types of medicines may not always be perfect substitutes. Some commercial medicine may not have a corresponding natural

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[12] Then higher price has implications for expected future incomes, but for calculating the average yield, *de facto* yearly prices and quantities should be applied (no game was caught in 1998).

counterpart, or the latter may be excessively time-consuming to collect and produce, compared to the low price of a common synthetic substitute.

On the other hand, many forest barks, roots, and resins that are used as powerful ingredients in remedies to combat serious illnesses, have neither plant-based substitutes nor allopathic counterparts. Moreover, it is impossible to place a price on plants which for many remote communities, not infrequently act as lifesavers. Keeping a natural "pharmacy" in the backyard, offers health "security"; instead of lengthy travel to town to buy medicines, during which money, labor, time, and perhaps even the patient, is lost.[13]

Within the study hectare, Sr. M. extracted approximately 2 liters of latex of maçaranduba (*Manilkara* spp.) for use as a cast. In doing so he expended roughly one hour; during 1995, hourly labor rate was R$4.00. With the price for medicinal exudates being R$10.00 per liter, Sr. M's. harvesting of maçaranduba represents approximately R$16. in foregone expenditures. At the time of collection, the bark of verônica cost approximately R$6.00 per kg. Subtracting time expended for collection (one hour), the value equals approximately R$2.00. Summing the value of the two medicinals and converting to dollars, the net income from the study hectare in 1995 equals US$15.00. Over the six-year study period this equals US$2.52.

Interviews of households in the neighboring village of Quiandeua, where access to nearby forest areas had already been severely reduced, indicated a flexible adaptation to the declining availability of forest medicines. Households tended to follow one of two paths: they increased the budget for synthetic products (from about 8 R$ to around 10 R$ per month) and or they increased collection time by looking for more distant sources of plant extraction.[14] If the trend is extrapolated to this household, the logging and/or conversion of the study hectare would trigger one yearly extra man-day of work for collection (R$ 5), and an increase in the monthly budget for external purchases (R$ 2). The substitute/saved cost value thus totals R$ 2x12+10=34 R$ (US$ 20.17) per year. Deducting an estimated 1.5 working day necessary for current extraction (R$ 5 x 1.5= 7.50 R$; 6.30 US$) produces a net yearly benefit of US$ 20.17-6.30 = **US$ 13.87**.

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[13] On several occasions, for instance, Sr. M. has received potentially mortal snake bites which he was recovered from using only plant remedies.

[14] Potentially, domestication in home gardens is a third reaction that would be feasible for certain herbaceous plants.

Fibers

In 1997, 20 kg of titica (*Heteropsis jenmanii* Oliv.) was sold from the study hectare at a total of 22 R$ (with a 3 R$ labor cost), but this was a once-and-for-all event. In the surrounding forest, the household collected an additional 120 kg of titica, 25 kg for household use, the rest sold. Subtracting labor and transport time, and converting to dollars, the yearly value of fibers approximates $3 from the study hectare. Outside of the study hectare during the six years, value equals US $110.92, annual value, therefore, US$18.49.

COMPARATIVE PER-HECTARE VALUES OF AGRICULTURE, LOGGING AND NTFPS

Agriculture

Due to the dominant role of agriculture in the region, it is difficult to understand competing land uses without a clear perception of agricultural dynamics. Within the family's farming system, agriculture is clearly the principal activity in terms of labor use, with *farinha* (cassava flour) production occupying more than half (1.8 ha) of the total cultivated area of 3.3 ha, and producing almost two thirds of the agricultural production value. *Farinha* production is extremely labor-intensive, and constitutes the mainstay of the local economy.

Over the family's ten years of residence at the site, agricultural production value has increased gradually, due to various factors: increasing labor pool from growing children, the introduction of new profitable crops (beans), improved land productivity (incipient use of fertilizer for rice, beans and corn), improved means of village commercialization, labor-saving processing methods (cassava) and an increase in cultivated area.

Some of these innovations have been facilitated by agricultural extension work at the farm,[15] and production results will only show their full impact in the years to come. This is evidenced by current land productivity yields, which still correspond much more to traditional, extensive cropping than to the potential yields of an improved, intensified agricultural system. Gross agricultural production in 1998 totaled R$2201.75 (US$1850.42), a significant improvement compared to the values in the mid-1990s. Subsistence values in agriculture were calculated using farm-gate prices, imputed from current village market prices minus the costs of transport from the farm to the village.

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[15] We are indebted to Cassio Pereira for valuable information and checks on parameters related to on-site agricultural production.

The agricultural gains net of labor costs (calculated at a flat R$ 5.00 (US$ 4.20) per working day of 8 hours)[16] are highly variable across products: for cassava and rice, there are modest net profits, for corn there is a negative net yield (reflecting unfavorable 1998 prices), and for beans there is a substantial per-hectare profit. Weighting these figures according to the current distribution of Sr. M's. cultivated land, an average per-hectare profitability can be calculated (US$ 79.48) that is representative of the family's entire agricultural plot.

Logging and NTFPs

In the economic valuation of different land use options, it is important to have a clear perception of alternative scenarios to compare with. In assigning the different values to the NTFP uses above, the comparative counterfactual was the logging and/or slash and burn of that particular forest hectare, not the complete loss of forest-based goods and services. Thus, at this point we are looking at the marginal, not the total forest benefits and opportunity costs. Below we describe and compare the net present value of four different scenarios of land uses of the hectare: exclusive use of non-timber forest products; logging and subsequent agriculture, logging and subsequent timber extraction, and logging with the conservation of fruit trees.

Scenario 1 in Table 7.4, gives a quantitative summary of the results of the continuous and exclusive extraction of NTFPs from the study hectare. A time horizon of 15 years and a discount rate of 10% are used; the latter choice was made based on local empirical observations.[17] For fruits, the yearly net value of US$185.35 can be projected infinitely into the future, reflecting that production is sustainable over time; the same is observed for fibers and medicinal plants. In such a case of a constant and infinite flow A over time, and a temporal discount rate r, the net present value (NPV) will converge to the value A/r. We thus present both the NPV after 15 years, and for an infinite time horizon (A/r). For game, however, the situation is different, in the

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[16] This is the current local wage rate used for farm hands exchange, and even for work on larger farms (fazendas). External payments, however, also include three meals. We do not distinguish between male, female and children's wages, as there seems to be no locally established market discrimination.

[17] For a cash-poor, isolated rural region like the Capim river, one might expect a larger discount rate to be more appropriate. However, there is a little formal and informal local credit used in the area (usury rates may otherwise give such an indication); if credit is given inter-personally, no interest is charged, and repayment is highly accidental. This characterizes informal credit more as a personal favor than a true reflection of inter-temporal preferences. A 10% yearly rate was adopted by vote (sic!) in the local agricultural cooperative (Cassio Pereira, pers. comm., Belém 8 November 1998), and does thus represent our best estimate of an adequate discount rate.

sense that hunting yields are unlikely to be sustainable over time. We assume in scenario 1 (Table 7.4) a 5% yearly reduction in the value of game extraction.[18]

Table 7.4 Net present value of one-hectare study plot for alternative land-use options, 10% discount rate, in 1998 US$

	Scneario 1: NTFP Uses Exclsuively[1]				Scenario 2: Logging[2] and agriculture[3]		Scenario 3: Logging
Year	Fruits	Game	Fibers, medicinals	All NTFPs	Current agriculture	Improved agriculture	Cum NFTP[4]
0	185.26	19.22	16.80	221.28	26.26	26.26	215.12
1	168.42	16.72	15.27	200.41	72.25	93.93	171.62
2	153.11	14.53	13.88	181.52	65.69	85.39	155.95
3	139.19	12.64	12.62	164.45	59.71	77.63	141.71
4	126.54	10.99	11.47	149.00	0.00	70.57	128.78
5	115.03	9.56	10.43	135.02	0.00	64.16	117.03
6	104.57	8.31	9.48	122.36	0.00	0.00	106.35
7	95.07	7.23	8.62	110.92	0.00	0.00	96.65
8	86.43	6.28	7.84	100.55	0.00	0.00	87.84
9	78.57	5.46	7.12	91.15	0.00	43.82	79.83
10	71.43	4.75	6.48	82.66	0.00	39.84	72.55
11	64.93	4.13	5.89	74.95	27.86	36.21	65.93
12	59.03	3.59	5.35	67.97	25.32	32.92	59.92
13	53.66	3.12	4.87	61.65	23.02	29.93	54.46
14	48.78	2.72	4.42	55.92	0.00	27.21	49.50
15	44.35	2.36	4.02	50.73	0.00	0.00	44.99
NPV t = 15	1594.36	131.61	144.58	1870.55	300.12	627.87	1648.24
NPV t = ∞	1852.60	128.13	168.00	2148.73			

Notes: [1]Fruits 185.26, medicinals and fibers 16.80 (both indefinitely); game 19.22 at 5% discount yearly. [2]Logging rights sold off to loggers at 150 R$ per alqueire (1 alqueire = 4.8 ha) = 26.26 US$/ha. [3]Current agriculture: 79.48 average yearly yield; four years production, seven years fallow. Improved agriculture: 30% increased net yield (103.32); six years production, three years fallow. Logging income year 0; agricultural incomes years 1–15 except for fallow years. [4]Logging rights 26.26 US$/ha; fruits 100%, medicinals, game and fibers all 10% of scenario 1.

[18] As explained above, a physical yield reduction of, for example, 7% per year may in value terms be partially counteracted by a real rise in prices of 2% per year. This sums up to a 5% yearly value depreciation of yields.

Scenario 2 represents the sale of logging rights to a logging company (year 0), followed by conversion to agricultural use. From the 1980s until the mid 1990s, farmers generally sold wood at a set value for each tree, from between (US$1.68-US$4.20/tree). Since 1996, however, after having logged out many of the most valuable species, loggers initiated a new system by which they purchase the rights to extract any number of trees from a predetermined area for a flat rate per area. Whereas previously, when a hectare was selectively logged an average of 7 trees per hectare were extracted, the new system favors increased extraction, normally leaving the landowner without any influence on the mode and targets of logging on his forest plot. The most common price in the area by end of 1998 was US $126 per *alqueire*.[19] This amounts to an unimpressive per-hectare price of US$26.26. It should be added that loggers often default on even this reduced payment, but farmers generally perceive that there are secondary benefits (jobs, free transport, road and soccer field establishment, etc.) from the loggers' presence in the area.

An alternative scenario to agricultural conversion of the logged forest is that the forest is left to gradually regenerate timber capacity. With an approximate cutting cycle of thirty years, however, the time-discounted value of the current payment of US$ 26.26 at a 10% interest rate is a mere US$1.50 per hectare. Even if we assume rising stumpage prices due to increased wood scarcity, better transport access and more market-consciousness and bargaining power on behalf of forest owners, continuous wood extraction or timber management schemes are highly unlikely to become economically attractive in the present context.

Presently, agricultural conversion is thus the economically best use of the heavily logged-over forest for the landowner, provided that his household possesses sufficient labor resources to cultivate the plot. The agricultural assumptions in scenario 2A reflect the current average profitability of Sr. M.'s traditional slash-and-burn agriculture (with minor improvements, at the experimental stage). According to the owner, the usual cultivation cycle entails three years of production followed by seven years of fallow. The emerging secondary vegetation is again slashed and burnt in year 11; we assume optimistically that there is no decline in productivity for this and subsequent cultivation cycles. In contrast, scenario 2B provides the perspective of an improved, intensified system where production yields are 30% higher than in 2A, years of consecutive production are expanded to five, and fallow is shortened to three years.

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[19] 1 *alqueire* equals 16 *tarefas* and 4.8 hectares.

The comparative results give a surprisingly clear profitability ranking of the different land uses. At a 10% discount rate, the continuous NTFP use of the forest plot accounts for a net present per-hectare value (US$ 1870.55) that is three to six times higher than logging sales combined with traditional (US$ 300.12) and modern agriculture (US$ 627.87), respectively. Logging sale alone (US$ 26.26) provides revenues that represent 1.4% of the NTFP net present value after 15 years, and just 12% of the current undiscounted value of NTFP uses in the first year (US$ 221.37). In terms of per-hectare yields, the inferiority of timber use of the study hectare is thus evident beyond any doubt.

It is also noteworthy that the yearly flow of NTFP extraction benefits (scenario 1) is larger than both of the agriculture-cum-logging scenarios — for any of the years under analysis — no single year can be identified where the sum of conversion benefits exceeds the sum of NTFP extraction benefits. In terms of sensitivity analysis of the results, this has the convenient implication that the ranking of land-use options under the present parameters is independent of the choice of discount rate: even for an extremely capital-scarce or "myopic" household with a high preference for current versus future incomes, NTFP extraction would always be the most profitable land-use option.

Regarding the internal composition of the NTFP net present value, it is remarkable that fruits account for no less than 85% of the total (game 7%, medicinal plants and fibers 8%). This is in large part due to the presence of the cluster of fruit trees and the fact that fibers and medicinal plants occur heterogenously throughout the forest and are gathered in an extensive manner. Furthermore, although many important forest-derived medicines are collected exclusively from forests, fallows and home gardens supply many commonly used medicinals.

In comparison to fibers and medicinals, the collection of forest fruits represents larger economic value (defined as substitute or as approximate market value) to the household, due to a significant seasonal contribution to the family's food consumption basket. Although it is obvious that the household is making "multiple use" of the studied forest plot, the economic valuation makes quantitatively explicit the different priority that specialized forest uses have in the specific livelihood strategy.

Furthermore, the hypothetical scenario 3 in Table 7.4 considers a situation where the landowner decides to sell the logging rights to the studied forest hectare, but he is able to persuade the logger to spare his fruit trees. We assume that the fee paid by the logger is the same as in scenario 2 (US$26.26) and that game, fiber and medicinal plant extraction is reduced to 10% of the current value. On the other hand, the damage done to the forest by logging, and the higher exposure of fruit trees to wind etc. imply a risk that fruit production will also be reduced, so that the expected yearly fruit values after logging may be roughly 70% of what they were in the intact forest.

In assessing the distribution and comparative remuneration of the household's labor time, the source of net income is primarily agriculture (86.8%), almost 60% from cassava flour production, while the rest is generated by NTFPs (13.2%) — more than 10% alone by fruits. A distribution of labor time on commodity-producing activities shows that no less than 97.5% of labor time is spent on agriculture, leaving only 2.5% to the extraction of NTFPs. Dividing the income net of non-labor cost by the corresponding working days spent, we obtain an implicit remuneration per workday assigned to each activity. This "shadow wage" of self-employed household labor allows for a profitability comparison of labor allocated to different land-use options. Results also exhibit a very clear picture: for all three NTFP extraction activities, labor remuneration is higher than for agriculture.

The results of this tentative exploration into the quantitative trade-offs of timber vs. non-timber forest benefits show that a combined forest use is yielding a value that is clearly superior to that of both agriculture conversion scenarios, but also inferior to the one for exclusive NTFP use (scenario 1). This conclusion results from the fact that diminutive logging fees that are currently paid can barely compensate for any reduction in NTFP benefits. However, the exercise can also be used to shed light on the normative question of how large logging fees should be in order to make the application of this scenario worthwhile to the landowner. Knowledge about this site-specific threshold value may make it easier for the landowner to design a rational bargaining strategy for making informed land-use decisions.

DISCUSSION

Considering the increasing numbers of colonizing smallholders throughout the Amazon with abundant forested land at their disposal, a number of broad regional Amazonian studies stress the value not of intact forest, but the economic rationality of forest conversion at the forest frontier, achieving competitive and growing remuneration levels (Ozório de Almeida 1993, Young 1993, Andersen et al. 1996, Schneider 1996). In a context characterized by lack of land tenure, fluctuating markets, unstable prices and high inflation, commercialization of agricultural staples can be more dependable than that for extractive products; indeed in many scenarios, conversion of forest to swidden fields makes economic sense (Pinedo-Vasquez et al. 1990).

Such studies favoring an agricultural conversion contrast markedly with per-hectare valuations conducted in high value Amazonian forests which have tended to favor non-timber forestry and the retention of intact forest. Per-hectare valuations are commonly criticized for choosing particularly productive plots of forest and for overstating the economic benefits by neglecting to consider the costs of extraction, and by extrapolating to large areas of forest that will not be commercially exploitable due to distance to market (Chomitz and Kumari 1998).

In this case study, the forest hectare represents the most geographically extensive scenario in Amazonia, *terra firme* forest with high biodiversity, low density of any one species and wildly inconsistent production. However, the presence of fruit trees within the hectare considerably elevates its value. Clearly, the results change radically if instead of averaging fruit consumption over several years, we measure fruit consumption during only one year in which fruit trees are wholly unproductive; in forest plots naturally lacking in fruit trees; or in forest plots in which fruit trees have been logged out.

During the past decade, the principal fruit and medicinal oil species with non-timber value for communities; *C. villosum*, *P. insignis* and *E. uchi* have been extracted from area forests by the timber industry. Whether due to natural or anthropogenic causes, minus locally valued NTFP species, the subsistence value of forest dramatically declines. However, even without the presence of fruit species, the meager logging fees currently offered indicate that logging sale without subsequent conversion to agriculture is not a competitive option in economic terms.

A second and main critique against per-hectare valuation is that it assumes land to be a scarce production factor, where diversification of uses is crucial to maximize the rural household's welfare. This may be misleading in an agricultural frontier environment where forested land is abundant, and household labor, as well as financial capital, are likely to be the limiting production factors.[20] Though relatively little of the household's working time is spent on NTFP collection, the economic benefit from, say, collecting a basket of forest fruits is clearly superior to

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[20] This is relevant in the Parogominas case where Almeida & Uhl (1995) find that cattle ranching in Paragominas county yields yearly per-hectare profits of, at best, 55 US$. This compares to 802 US$ per hectare for perennial crops. In spite of this land-use profitability gap, ranching is still the dominating land use while perennials occupy but a tiny fraction. 43% of the deforested land is apparently abandoned.

that of the same time spent on cultivating crops in the field: NTFP extraction is a minor but highly profitable use of labor time.

From a neoclassical point of view, a pressing question arises: why does the household not allocate more labor time to NTFP extraction, in order to take advantage of the apparently higher value created by this activity? There are several answers to that question, which relate to supply and demand constraints, and the restrictions that subsistence-led NTFP extraction poses on the choices of the household. For instance, although hunting is still a profitable activity, game resources are in progressive decline, and more to be viewed as a non-renewable resource in the present context. A higher extraction of medicinal plants and fibers is not really needed for household consumption, transportation is difficult and marketing options are highly restricted.

As the most economically valuable product type, the prospects for increased fruit production deserve more elaborate comments. Fruit supplies are by nature limited seasonally and the demand is at present limited by both the amount of fruit production and by the amount the family is able to consume during the harvest season. In addition, lack of transportation represents a chronic and overriding barrier to sales. However, as incipient successful experiments have indicated, rising prices and increasing demand make commercialization of fruit in nearby towns increasingly attractive. In that case, production could be increased through management and by harvesting trees from a more remote forest location. A supplement of forest fruits by planted fruit species is another option that is already partially employed.

CONCLUSION

One hectare of *terra firme* forest, intensively used by the household for extraction of fruits, game, fibers and medicinal plants, was investigated, analyzing from different angles its economic value as intact forest as compared to logging and swidden agriculture. Because the bulk of the products from the hectare were directly used, not sold, various methods including substitute pricing, saved costs, and labor remuneration were used to place a monetary value on subsistence goods. The results obtained reconfirm those studies that find a superior per-hectare value of NTFP extraction compared to the sale of logging rights, and to the combination of logging and posterior agricultural conversion. A sizeable gap in per-hectare economic value was found in favor of the scenario of exclusive NTFP extraction on the one study hectare, making the results robust to different changes in assumptions. Notably, the ranking of land-use options proves to be independent of the choice of time discount rate.

In addition, an analysis of alternative remuneration of household labor time showed a clear superiority of NTFP extraction, compared to the assignment of time to each of the four cultivated crops. In other words, our results confirm that there is a much higher "subsidy from nature"(Anderson et al. 1991, Hecht et al. 1988) from forests than from other land uses, both if we look at alternative land uses and at alternative uses of labor time.

However, the highly optimistic results need to be scrutinized as the net present value exercise is merely illustrative. First, a forest specifically used and managed for NTFPs will more likely demonstrate superior per hectare values than for other land uses. In addition, because demand for wage labor is so scant in the study region, labor involved in fruit collection likely has a low economic value, thus lowering the estimated value calculated for fruits.

Finally many forest users in the area choose to sell timber in lieu of managing forests for non-timber forest products indicating that for many smallholders, net present value does not reflect local perspectives on forest value. Although the numeric results presented are subject to wide variation and depend on many factors, findings do highlight how much can be lost when forests become severely degraded.

Results demonstrate four additional points. First, the study makes abundantly clear that the economic value of NTFPs is dependent not only on spatial but temporal factors. Sharp annual variations in fruit production signify that while even low density NTFPs from *terra firme* forests can out compete agriculture and logging during productive years, in years such as 1995, no NTFPs were gathered from the hectare yielding an annual NTFP value of zero. Such inconsistent fruit production of *terra firme* species contrast sharply with consistently high annual yields from *várzea* species and contribute a high risk factor regarding potential commercialization (Phillips 1993).

Second, the majority of forest products gathered from the forest were directly consumed, not sold. Direct use as opposed to commercialization of non-timber products is paralleled by the majority of households in neighboring communities and is common for thousands of households in remote areas of Amazonia. Results indicate that extractive products offer vital subsistence benefits to smallholders and suggest that rural communities have reasons they are not marketing NTFPs — reasons that are not born out in purely economic or ecological appraisals (Padoch and Pinedo-Vasquez 1996). Furthermore, in spite of the robust economic value NTFPs demonstrate in this study, the widespread trend is not to sell non-timber forest products, but trees. Thus, net present value may be a poor tool to reflect the realities of local livelihoods.

Third, according to local consumption patterns, wild fruit and game are the most valuable NTFPs. The importance of subsistence game and fruit as bearing the principal economic value, contrasts with the media attention customarily afforded internationally traded commodities and tropical medicinal plants. Of the products used within the hectare, fruits have a clearly dominating role of economic value generation; none of which are marketed outside of Amazonia. Vital to rural communities, medicinal plants and game occupy an intermediate position; as forest declines, substitutes are increasingly sought. To a large extent fibers represents a forest use that tends to be gradually reduced or to disappear with higher cash incomes, this occurs in spite of the fact that the use of fibers are widespread and is mostly due to the existence of substitutes such as wood, nails and plastic.

Finally, logging operations advance rapidly in the region and a couple of points may be noticed. First, prices paid to local dwellers for logging rights are extremely low, both in regard to some of the high-value harvested species and in relation to the average value of foregone NTFP extraction benefits (reduced value of subsistence production). Second, changes in the mode and targets of timber extraction have dramatically altered the consequences of logging for small holders. In lieu of only a score of species extracted a few decades ago, current logging practices extract over 300 species, take lower diameter trees and harvest by area instead of by species. In this scenario, the non-timber forest species of greatest value are felled, transforming the former, relatively symbiotic relationship between logger and smallholder to a predatory one. Disorderly exploitation of the forest resource base holds long term, deleterious effects not only for rural smallholder households but also for domestic economies (Hecht et al. 1988). Results thus indicate the need for policies promoting improved timber extraction methods that consider wood and non-wood values (Laird 1997), forest zoning initiatives (Uhl et al. 1997), and innovative forest extension to develop alternative management strategies for smallholders (Shanley 1999).

With relatively secure land tenure, many eastern Amazonian farmers retain the right to decide the fate of their forests. Due to cash shortages, insufficient economic information, and the pressure of neighboring sales, farmers repeatedly sell timber rights for scant sums, losing the substantial economic values associated with standing forest. When faced with the option to sell logging rights, farmers who decide to retain forests demonstrate an implicit understanding of the economic value of forest to families. This indicates that concrete information documenting the economic and ecological value of forests needs to be shared not only with the scientific but with local communities, and makes an important case for strengthening local dwellers' organization and bargaining power vis-à-vis commercial logging interests.

As the head of the household a woman is linked with plants; she needs fruits, leaves and remedies and gives value to nature. Plants give rural women a type of economic independence. Although some knowledge has been lost through modern changes, the old traditions can help her grow...

Gloria Rodrigues Gaia

CHAPTER EIGHT

EXTENDING ECOLOGICAL RESEARCH TO MEET LOCAL NEEDS[1]

INTRODUCTION

The ecological research process often involves an outside team entering an area, taking measurements, posing questions, leaving and writing scientific articles. Unfortunately, the results presented in dissertations and scientific articles rarely reach the local communities in which they were generated. Indeed, if the pages of such manuscripts ever were to reach the local level, it is doubtful that they would be useful for anything other than rolling tobacco or lighting fires.

Although policy makers and scientists are important audiences for research results, forest-based communities are also a critical public to reach. First, there is a strategic reason for sharing research results with forest-based communities: local communities represent a critical set of actors in determining how forest resources are used and protected. Second, rural communities often have their own key research questions upon which their livelihoods may depend upon. Third, after taking up considerable amounts of a host community's time, eating their food and involving them in the research process — there is a moral imperative for outside researchers to give back their results in a locally-useful form.

To meet the needs of both local and international communities, an ecological research program must often accommodate two distinct research agendas. On the one hand, it needs to generate rigorous data aimed at informing the scientific community and policy makers; on the other, it needs to produce and disseminate information useful to communities directly dependent on forest resources. Juggling these two agendas may require that data is collected, analyzed and presented in different ways for different audiences.

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[1] A version of this chapter is published in: The Non-Wood Forest Products of Central Africa, edited by Terry Sunderland, 1999, FAO, Rome.

This chapter addresses this challenge by describing the education and extension spin-offs of the non-timber forest product research presented in the former chapters. After a brief outline of the research setting, a description is given of each facet of the research (ethnobotanical, ecological and economic), conventional scientific products resulting from the research, and the limitations of these products in meeting local needs. Subsequent sections describe how the research results were presented in a practical way for local communities and how they were disseminated through outreach.

BACKGROUND: NTFP RESEARCH DESIGNED TO MEET LOCAL NEEDS

While logging offers much-needed cash to swidden agriculturalists in eastern Amazonia, the local costs of timber extraction, such as lower densities of fruit and medicinal species, longer travel time to collect forest resources, and lower game populations, catalyzed some *caboclo* communities to search for forest management alternatives. During the early 1990s, in the Capim River region, community members questioned whether non-timber forest resources might offer a comparable or higher economic value than timber while simultaneously conserving forest resources. Concurrently, this question was also being posed by the international conservation community. In this case, by tackling locally relevant questions the research could also contribute to filling gaps concerning the role of NTFPs in a potential conservation/development strategy (Scoones et al. 1992, Godoy and Lubowski 1992).

In spite of the similarity of questions, many differences nonetheless existed between the scientific and local communities regarding the time frame and products. For instance, *caboclo* communities sought rapid answers that would result in cash for forest goods and an increased density of game and fruit species. Due to the inconsistent phenology of locally valuable forest products, however, a rigorous ecological and economic study of select NTFPs would require many years. Accommodating these two agendas took flexibility and patience on the part of both the research team and the community (Shanley et al. 1997).

Ethnobotanical inventory

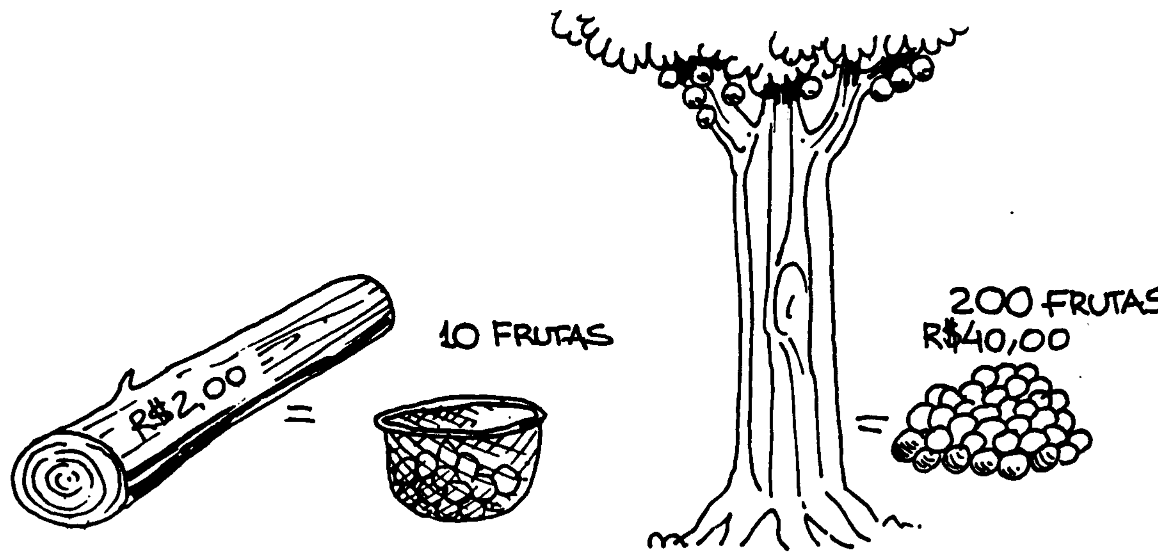
As a first step in the research process (Chapter Three), a one-hectare ethnobotanical inventory was conducted to document the floristic composition of the region and to identify species with high use-values. Traditional outcomes of ethnobotanical inventories are lists of the scientific names of plants and collections of voucher specimens that are sent to national and international herbaria. Although critically important to botanists, such products are inaccessible to semi-literate rural communities. To address this, our research team gathered extra plant specimens for the community's use in addition to those collected for herbaria. Although they will disintegrate with time, the specimens catalyzed group discussion, promoted an exchange as to plant uses, and demonstrated how scientific names clarify the identity of plants possessing various common names (Alexiades 1996, Martin 1995). To familiarize literate community members with botanical nomenclature and to remove doubt about the identity of certain species, common names as well as scientific names were placed on aluminum tree tags.

Instead of abandoning the study hectare after the inventory was concluded, the hectare continues to support ongoing research efforts aimed at documenting the longitudinal use of non-timber forest products (Chapter Seven). To this day, (seven years later), the owner of the hectare and his family weigh the game, fruit, fiber and medicinal plants which they consume from the study site. Annually, we jointly compare the subsistence value of these products with that of the value of the hectare if logged. While a graph of net present value might mean little to the family, they know that their long-term survival is linked to the fruit trees and the game their fruit attracts. This is in contrast to the sale of their trees, which offers a single, and relatively trivial, amount of money.

To ensure the usefulness of the hectare to the wider community, we designed it as a forest "reserve." To this purpose, a winding trail was constructed to guide visitors by trees of economic interest. Underneath several of the largest trees, small clearings were made to serve as resting and meeting points. As research in the Capim basin bore results, the small reserve served as a "forest value" workshop site in which villagers shared the project's results with neighboring communities. One weekend workshop drew 140 elders, mothers, children and villagers of all ages who trekked to the site by canoe and foot from as far away as 50 km. Villagers who had been involved in the research process presented ecological and economic data through stories and illustrated posters (Fig. 8.1). Upon viewing the grandeur of the piquiá (*Caryocar villosum*) and bacuri (*Platonia insignis*) trees, visitors from a heavily deforested neighboring region spontaneously hugged trees and filled their pockets with seeds.

In addition to sharing data resulting from the research, community members exchanged recipes, management techniques, non-timber forest products processing tips, and lore. Hands-on sessions with local experts included medicinal plant preparation, soap making from forest fruits, jam and basket making. Such

Figure 8.1 Poster demonstrating the comparative value of wood and fruit



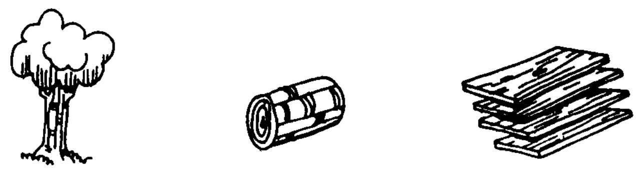
traditional ethnobotanical information had immediate utility for households, many of which no longer recalled how to extract oil from the fruit of uxi (*Endopleura uchi*), how much oil of andiroba (*Carapa guianensis*) was needed to make soap, or the proper dosage of pau d'arco bark (*Tabebuia* spp.) for internal inflammation.

Population ecology studies

To explore the marketing potential of products with the highest use-values as indicated by the ethnobotanical inventory, it was necessary to know how much of the various resources were present in the forest. Therefore, basic ecological information was gathered concerning the density, size-class distribution, and fruit production of the three most promising species (*Caryocar villosum, Platonia insignis, Endopleura uchi*). Local research assistants took part in species selection and helped to locate conspecific trees throughout a 3000-hectare area. Due to the extreme irregularity of annual fruit production, production studies were carried out over a relatively long-term time frame (five years). The work involved was often tedious and time-consuming and the routine results, histograms and regressions (Chapter Five), do nothing to fill the stomachs of hungry small holders.

To provide more rapid results to the community, preliminary data from the first and second years were presented in conjunction with market data. Research assistants who had learned how to use a compass and create transects exhibited the information on maps. Other villagers made posters displaying the mean fruit production of different species, showing how entire trees sell for values equivalent to the cost of a meager basket of ten fruits. The escalation of prices along the marketing chain became abundantly clear when villagers presented posters showing the prices of wood as sold from their own forests ($5 - $40/tree) as opposed to the prices of wood as sold in sawmills ($100–$300/m3) (Fig. 8.2).

Figure 8.2 Price of wood sold by the community vs. the price of wood sold at the sawmill in Paragominas, 1998



	árvore em pé	1 metro cúbico de tora*	1 metro cúbico serrado
madeira branca	R$ 5	R$ 10	R$ 100
maçaranduba	R$ 10	R$ 25	R$ 120
piquiá	R$ 15	R$ 45	R$ 140
ipê	R$ 40	R$ 105	R$ 300

To make data fully accessible, data give back to villagers required different analyses and presentation than for a scientific audience. For instance, a commonly used unit of measurement for ecologists and economists, yield per hectare, was of little use to *caboclos* when applied to species that exist in densities of less than one tree per hectare. Instead, illustrations depicted production per tree. Similarly, the economic value of a pile of fruit may be meaningless in monetary terms to persons with little access to cash. However, comparing prices and sacks of fruit with sacks of *farinha* (the primary agricultural commodity) was clearly understood - as was the amount of labor involved in each activity.

To determine where clumped densities of economic species occurred, the research team made poster-size maps indicating different species of fruit trees and the trails that linked these. Although mapping the forest resources was time-consuming and, in and of itself, did not offer any immediate source of cash to the community, understanding how much of the resource existed in the community's forest was a first step in estimating the economic value of their standing forest and was critical for successful negotiations with loggers. Prior to mapping the trees, residents had severely overestimated the abundance of particular fruiting species occurring on their land, inaccurately assuming that it was possible to sell timber from large swaths of land and still retain a profusion of fruit and medicinal oil trees. Mapping the economic species present on their 3000 hectares made clear that instead of the estimated thousands of particular fruiting trees, a few hundred actually existed.

Market studies and subsistence use of NTFPs

To examine the comparative economic value of non-timber forest products and timber, market surveys of locally valued fruits, medicinals, game and fibers were conducted in the closest city to the communities, Paragominas, and in the state's capital, Belém (Chapter Four). Rather than offering complicated economic analysis to villagers, we discovered that the research team's greatest contribution to the community's economic understanding was simply keeping them informed of up-to-date market prices. Time and again villagers underestimated the value of forest goods (two to ten-fold).

The community had hoped that the research would demonstrate that they could gain more from the sale of NTFPs than timber. While the combined ecological and economic results did highlight the significantly higher economic value of select forest fruits and medicinal oils as opposed to timber, this did not necessarily translate into increased income for many villagers. Logging companies arrive in distant communities; fruit vendors do not. Because loggers appear with money-in-hand, cash-poor villagers commonly accept anything they are offered from timber companies.

The tendency of many communities to market wood in lieu of non-timber forest products does not signify that NTFPs have no economic value. As discussed in Chapters Six and Seven, subsistence (direct use) of non-timber forest products contributes significantly to the well being of rural households (Arnold and Ruiz-Pérez 1998, Schrekenberg 1996, Melnyk 1996, Falconer 1990). However, both smallholders and economists rarely account for the economic value of subsistence use of non-timber forest products. One reason for this is that measurement of the "invisible" economic value of subsistence utilization of NTFPs requires tedious, invasive methodologies (i.e., daily diaries). In this instance, our research team asked 30 families from one community to weigh all fibers, fish, game and medicinal plants and to count and record all fruits they consumed each day throughout the course of an entire year. While the exercise itself may have acted as a learning tool for the families involved, the conventional products (i.e., graphs of fruit consumption and pie charts of game off-take) did nothing to solve the problem of decreasing game capture and hunger.

What did appear to be useful to the community was to portray the economic value of the direct-use (subsistence or non-market) value of NTFPs to individual households. For example, the heads of four families stood in front of the community holding posters (hidden behind their backs) with a number representing the weight of game or the fruits their families had consumed monthly and the cost of these products if purchased in the nearest market. Other community members guessed the market value of the game or fruit these families had consumed. They frequently based their estimates on the household's hunting ability, the number of children, the proximity of the home to forest or, in one case, the size of the father's stomach. Invariably, the value of NTFPs consumed from forests was hugely underestimated, awakening villagers to the very substantial "invisible income" that they daily gain from their forest (Fig. 8.3).

Figure 8.3 The subsistence value of game compared with an economically equivalent volume of farinha and its local price

Forest value workshops

Generating information and giving it back to the communities in which it was generated was only a first step. Disseminating concrete information to surrounding communities under pressure from logging and ranching posed additional challenges. In the hopes of slowing rampant deforestation throughout the region, extension teams composed of villagers and researchers traveled to neighboring communities, sharing the data described above in participatory workshops (Shanley et al. 1997).

To effectively reach different audiences and to accurately portray the value of NTFPs in various regions, it was necessary to recognize the fact that fruits and medicinal plants were not the most highly valued non-timber forest product. Instead, to a chronically hungry and sometimes protein-deficient population, game animals often took precedence as the forest product of greatest local value (Bodmer et al. 1997, Redford et al. 1992). Data demonstrating that during one year, 79% of game consumed by the community were captured in the mature forest (as opposed to secondary forests or agricultural fields) offered a strong incentive for habitat protection and the creation of community forest reserves (Cymerys et al. 1997). By ranking select fruit species according to their ability to attract game, hunters quantified the fact that the economic value of particular species is not limited to the fruit that they produce. Over time, avid hunters became workshop presenters and proponents of reserves, recognizing that without an area to reproduce, the game population would continue to steadily decline (Fig. 8.4).

To further highlight the value of standing forests and the substantial economic loss that often accompanies their sale, socioeconomic and ecological data were woven together and used in skits. *Caboclos* acted out the roles of loggers, ranchers and fruit vendors, while their fellow villagers watched with a mixture of mirth and sorrow as small-holders were sweet-talked out of their forest for a pittance. Based on real-life tales, 40-hectares of virgin forest were traded to a logger for a piece of metal; seven piquiá trees worth hundreds of dollars were traded to a logger for an injection for a sick child, and one logger removed thousands of dollars worth of trees from a villager's forest and left, without ever paying.

As our extension team traveled to different villages, we collected additional ethnobotanical, ecological and market information, songs, stories and lore on a wide range of species. We preferentially focused on locally and regionally valued forest tree and palm species, with wide distribution throughout Amazonia, and those that had received insufficient research attention. As the team's species-specific knowledge base grew, so did the relevance of our workshops throughout a greater geographic range.

A different kind of manuscript: illustrated booklets

After traveling on foot, canoe and muddy logging roads to arrive in remote villages throughout Pará, the extension team realized that the need for such information in isolated niches of Amazonia was far greater than direct outreach efforts could meet. Although the written word is not fully understood by all residents of rural communities, the question arose as to whether it would be possible to put the research results on paper in book form, in a way that would be readily comprehensible to both literate and semi-literate audiences. Such an illustrated text could reinforce outreach efforts where workshops were conducted, be used as a training tool for extensionists, and arrive in distant, scattered communities.

Figure 8.4 Hunters demonstrate the comparative economic value of fruit and wood

Figure 8.5 Rescuing medicinal bark after a timber sale in a Capim River community

To reach this objective, the ecological and market data presented in this dissertation were illustrated, and placed on paper with pictures, songs and lore. The resulting book, *Frutíferas da Mata na Vida Amazônica* (Fruit Trees of the Forest in the Lives of Amazonians) describes thirteen forest fruit and medicinal oil species that have broad distribution and economic significance throughout Amazonia (Shanley et al. 1998). Blending scientific literature, market data, forest inventory results, recipes and traditional knowledge, the book offers an example of how to return relevant data to communities to assist in improving rural livelihoods and in conserving forest resources. To help all populations comprehend the fruit and medicinal plant booklets, many botanical and popular illustrations are included on each page. A second booklet, *Receítas sem Palavras: Plantas Medicinais da Amazônia* (Recipes without Words: Medicinal Plants of Amazonia) uses illustrations to convey safe and effective medicinal plant remedies.[2]

Practical outcomes of give back

When the extension team began to give back the research data to communities through workshops and books, it was done so in the hopes that the information could, in a small way, contribute to lessening deforestation and to improving rural livelihoods. The outcome of workshops exceeded the team's expectations. The data, posters, and stories embedded in the forest value workshops and the fruit book served not only to expose unfavorable prices, but to catalyze improved strategies for negotiating logging contracts. In subsequent interactions with timber companies, villagers began negotiating to conserve fruit and medicinal oil species. They also limited the number of hectares logged, in some cases preserving areas with clumped distributions of economic species as forest and game reserves. In a number of cases, logging contracts were canceled. In some communities in which trees had already been felled, villagers rescued medicinal barks for home use (Fig. 8.5). Return visits to communities in which workshops had been conducted demonstrated that in each case favorable forest management choices had been made (Fig. 8.6).

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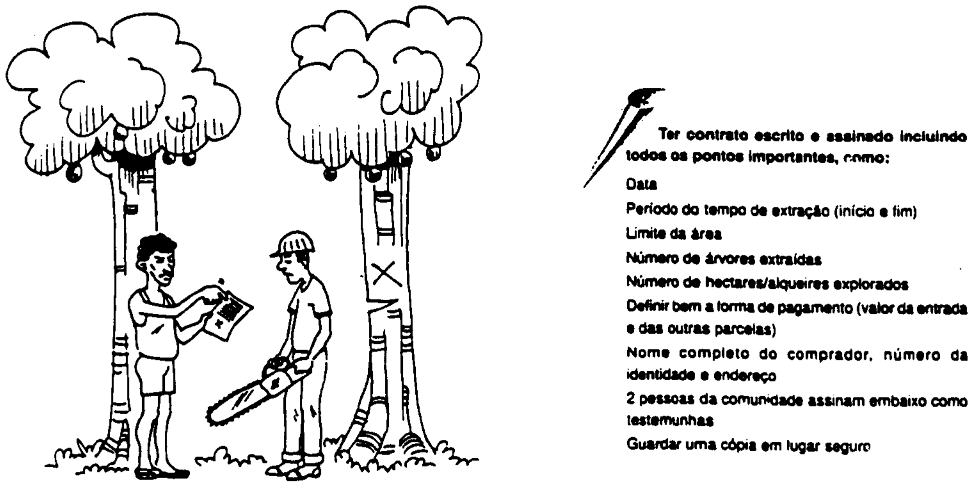
[2] Sample pages of both books are available in Appendix B: Three Sample Chapters: Piquia, Bacuri, and Uxi, of *Frutíferas da Mata na Vida Amazônica* [Fruit Trees of the Forest in the Lives of Amazonians] and Appendix C. Sample Pages of *Receitas sem Palavras: Plantas Medicinais do Amazônia* [Recipes without Words: Medicinal Plants of Amazonia].

Figure 8.6 *Caboclo* and logger review a timber contract in which fruit and medicinal oil species are conserved



Through the rescue and exchange of traditional recipes, families preserved fruit by making jams, jellies and soaps, thereby increasing the use and processing of non-timber forest products while decreasing timber sales. In a deforested area women began a campaign to plant native fruit and medicinal oil species. Women of one forested community, who customarily said little regarding the sale of timber rights, began to speak up and to attend community meetings, urging the men not to sell the logging rights cheaply and to preserve the fruit and medicinal oil trees for the future.

Newly aware of market prices for extractive products, women of various communities began experimental sales of fruit and medicinal oils and contributed a section to the fruit book entitled "lessons learned from fruit sales" which offers practical tips on packaging, transport, and marketing. The incremental income that they earned was wisely invested in goods to benefit their families and community. This was in stark contrast to the profits from timber sales which, landing in the hands of husbands, was commonly spent on bicycles, radios, and liquor (Shanley 1999).

Rural extension: underutilized potential in conservation and development

In spite of the success that can result from solid educational programs, a cautionary note is needed. Even the best extension programs cannot forestall the waves of logging and fire that are sweeping forested regions worldwide. While smallholders can make fire barriers, conserve forest fruit trees, and create reserves, fundamental changes in forest policy are needed to lessen both biotic and human impoverishment.

Moreover, as deforestation proceeds at an unprecedented pace, it is imperative that ecologists begin to recognize that scientific publications are no longer a tenable measuring stick of success for our research endeavors (Amaral and Corrêa 1997). We need to question, rather, who the primary beneficiaries of our research really are, as well as the common assumption that our research is complete once the scientific article has been sent to press. Rural extension is an underutilized, cost-effective way to ensure that hard-won field data not only lands on the desks of other scientists but is also given back to the forest-based communities who need it most.

If I had been present, the timber sale would never have occurred.

Dona Ana, Village Matriarch

CHAPTER NINE

CONCLUSION: FROM SYMBIOTIC TO PREDATORY: LOCAL CONSEQUENCES OF BIODIVERSITY LOSS THROUGH LOGGING

SUMMARY OF RESEARCH QUESTIONS AND RESULTS

Considering the importance of non-timber forest resources to subsistence livelihoods, the increased rate of logging in Amazonia, and the pronounced overlap of timber and non-timber species, it is important to evaluate the altered composition, abundance and use of NTFPs. In this changing landscape it is vital to understand which species are widely utilized for their non-timber value, which NTFP species are extracted for timber, what their comparative timber and non-timber value is, and whether they occur in mature or secondary forest.

Answers to these, and to the original questions guiding the research presented in Chapter One, are summarized below. Next, reasons are given why the substantial value of non-timber forest products, as suggested by the results, is discounted in everyday transactions in Amazonia. In conclusion, recommendations are made as to how the value of non-timber forest resources may be better integrated into decision making by communities, researchers and policy makers.

Within *terra firme* forests, how significant is the subsistence value of non-timber forest resources? Which species are most highly valued and where do they occur?

- Capimenses used 60% of inventoried species (> 10 cm DBH) in a one-hectare forest plot. Fruit producing and game attracting trees are most highly valued. Knowledge and use of species is in decline; many uses exist in memory only.
- Game and forest fruits such as *Caryocar villosum*, *Endopleura uchi* and *Platonia insignis* are of extreme importance to families, serving as a buffer against hunger and nutritional prevention against disease. Medicinal plants are widely utilized due to both their efficacy and affordability.
- Of the 12 most widely utilized medicinals in eastern Amazonia, nine are native, eight occur in mature forests and five are extracted by the timber industry. Medicinal plants are used to treat a range of illnesses such as rheumatism, herpes, cancer, and diseases of the nervous system for which effective allopathic remedies are lacking. All strata of Brazilian society use plant remedies. In the city of Belem, markets are only one source of plants, 45% of medicinals used by households are obtained from direct collection, cultivation or swapping with friends and neighbors.

- In local and regional economies of the study area, species occurring in mature forest are significantly more important than species occurring in secondary forest. In this study 87% of fruits, 85% of fibers and 79% of game utilized by Capim families during the course of one year were extracted from mature forests.

What effect does the escalating extraction of timber species have on the abundance and accessibility of non-timber forest resources?

- Selectively logged *terra firme* forests can provide substantial game, fruit and fiber for Eastern Amazonian *caboclo* communities. Even after several selective logging events, on average Capim families continued to consume the equivalent of 25% of their annual agricultural income from game, fruit and fiber. However, after three additional heavy logging episodes and fire, the value of NTFPs extracted from forests plummeted to an estimated 5%. Post-logging availability of locally valued non-timber forest resources is directly related to the scale, mode and intensity of logging events. Early logging practices, which targeted particular species, had relatively low impact on locally valued NTFPs as compared with current extraction practices in which timber rights are sold to an area of forest and the logger has the right to extract all timber of commercial value. Results demonstrate that while early logging practices offered a relatively symbiotic relationship for *caboclos*, current logging practices are increasingly predatory.

- Selective logging events have significantly reduced the abundance and utilization of non-timber forest products in the communities under study. The recent growth of eastern Amazonia's timber industry has expanded the range of species being extracted to 300 species, including important food, medicines, and/or gums and resins (Martini et al. 1994). Loggers currently extract all of the 15 most highly value fruit, medicinal oil and game attracting species in the Capim region. For the communities studied, the consequences of forest disturbance included: decreased game capture, lowered densities of fruit trees, and longer distances to harvest fibers and medicinal oil.

How does the subsistence value of non-timber forest products compare with the value of trees as sold for timber?

- During the six-year study period the net present value of the subsistence use of game and fruit utilized on one hectare of primary forest significantly exceeded the net value possible from timber sale and subsequent agricultural conversion. Labor remuneration for NTFPs also exceeded that for agriculture. However, net present value is a poor tool to reflect the realities of local livelihoods. Local smallholders continue to sell not non-timber forest products, but timber.

- The economic value of *C. villosum* and *E. uchi* is not limited to the fruits they produce. They also serve an important function as game attractants. *C. villosum* attracted 3.7 times the amount of game, as measured by weight, as the next most important game attracting tree species, thus elevating the tree's economic and subsistence value substantially.

Do the ecological characteristics of *terra firme* forests (i.e. low density of economic species, inconsistent fruit production, and consumption of fruit by animals) limit the viability of marketing non-timber forest products?

- Regionally, the three most important forest fruits to subsistence livelihoods, *Caryocar villosum*, *Endopleura uchi* and *Platonia insignis* occur in low densities

(.3-2.0/ha) and undergo wide annual fluctuations in fruit production. Mean fruit production of productive trees of *E. uchi* equals 1052.6, *P. insignis* 578.0, and *C. villo*sum 286.6. Of the three species only individuals of *E. uchi* produce fruit annually. Of the total populations, on average, 80% of *E. uchi*, 55% of *P. insignis*, and 22% of *C. villosum* produce fruit in any given year. Fruit predation of piquiá and bacuri is relatively low compared with uxi; in 1994, animals consumed 69% of the total uxi crop. During the five-year study, mortality was 10% for *C. villosum*, 12.5% for *P. insignis*, and 50% for *E. uchi*. Mortality was due to logging, preparation of swidden fields, wind and fire. If this rate of mortality continues, within only a few decades, these fruit trees could become locally extinct.

- Ecological and socioeconomic barriers to commercialization of *terra firme* non-timber forest products prohibit many *caboclos* from marketing forest fruit. Obstacles include low density of most fruit species, inconsistent yields, high predation, perishability, lack of transportation and insufficient market experience. Whereas, non-timber forest products were once widely marketed along the river basin, the region's prime forest commodity is now timber.

- Of non-timber forest products utilized, forest fruits held the greatest potential for generating profits. New forest fruit products developed in urban markets (jams, juices, yogurts, ice creams) contribute to rising demand and prices. Prices paid for fiber and medicinal plant products are meager, inhibiting their commercialization. Exceptions to this are the medicinal oils, *Carapa guianensis* and *Copaifera* spp., which command relatively high prices in the marketplace.

Can forest extension efforts utilizing ecological and economic research data effectively assist rural communities in the conservation and management of locally valuable forest resources?

- Communities with access to economic and ecological data showing the comparative market value of timber and non-timber forest resources generally demonstrated improved decision-making processes regarding the sale of timber rights. They utilized this information to guard fruit trees, negotiate better prices and to make more informed decisions about whether to sell or not to sell. Because approximately one third of the state of Pará is occupied by smallholders and Indians who retain the right to decide the fate of their forests, forest extension has strong potential to assist rural residents make better informed decisions.

- Fruit species once harvested primarily from forests for sale in city markets are now, in part, being sourced from semi-domesticated groves in managed home gardens. Management of the three fruit species increases in inverse relationship with distance to market. Techniques of sustainable management can be successfully transferred through direct farmer to farmer exchanges and cross-visits.

- In the communities studied, women's participation in land-use decisions positively impacted timber negotiations by promoting the conservation of fruit and medicinal oil species and by discouraging sales at unfavorable prices. Women generally showed greatest interest in locally innovative activities, such as fruit sales and the processing of fruits, oils and medicines.

DECISION-MAKING WITHIN *CABOCLO* HOUSEHOLDS

Why sell trees in lieu of fruit?

In spite of the ethnobotanical, ecological and economic results outlined above, *caboclo* communities in eastern Amazonia regularly sell timber rights for scant sums. In fact, as the research was being conducted and disseminated, Capim communities sold timber, and cut and burned areas of forest, which included wild fruit trees for the purpose of preparing swidden fields.

Clearly, there are many reasons why *caboclos* do not evaluate or allocate their resources as ecologists or economists would have them do. Classic economic analysis may, in many ways, be inapplicable to the smallholder scenario (Padoch and Pinedo-Vasquez 1996). To shed light on decision making within *caboclo* households and villages, it is worthwhile to briefly address the gulf between what the above research results demonstrate and what local actions declare. To do so it is useful:

1) to recall the rapidness with which change is occurring throughout the region; and
2) to consider a number of commonplace scenarios in which timber sales occurred.

Only two decades ago, living in expansive tracts of forest, forest residents in the Capim region had little need to burden themselves about game levels, access to fruit-producing trees or fibers. Within a couple of kilometers of home, their needs could be amply met. At the time no roads entered the area, only the infrequent boats of middlemen occasionally plying the river to trade coffee, sugar or gunshot for farm and forest products.

In the 1960s, less than 150 km away from the villages, construction of the Belém-Brasilia highway created an artery from which loggers and ranchers departed to penetrate formerly inaccessible forest. The exponential growth of these industries swiftly changed the face of the region. Suddenly, small producers had powerful new neighbors. But how did the logging industry so effectively penetrate forest areas that are legally in the hands of small producers? To demonstrate how and why timber is sold by village after village, three brief stories will be related.

■ *Sr. S. was in desperate need of a piece of metal, used as an outdoor stove, on which to cook his farinha. Farinha is the sole source of cash for many villagers. After years of use, Sr. S's stove had so many holes in it; it looked much like a giant sieve. Without cash earned from the sale of farinha, he had little means to sustain his elderly father, wife and grandchildren. In need of cash to buy the piece of metal, but unable to generate money without one, he made a* *deal with a logger to trade timber rights to 25 hectares of intact, primary forest for a rustic stove (worth roughly US $120).*

■ *Sr. P. of the lower Tocantins basin had an extremely sick son. He was in desperate need to bring him to a hospital for treatment. Lacking farinha or anything else to sell, Sr. P. turned to his trees. He made a deal with a logger to trade 5 C. villosum trees for cash. Sr. P. earned enough to purchase one pharmaceutical injection for his sick son. Change from the deal allowed him to buy a plate of food at the hospital roadside. At the sawmill the sawn wood of the five sizable piquiá trees was worth over US $600.*

■ *In the Capim region in 1994, one community suffered from a poor crop of manioc. Sr. V., the leader of the community and head of the church had 11 children, one on the way and a sick wife. Years before, he had sworn off further timber sales, proclaiming "vines are more and more distant to collect, and game disappearing, we cannot again sell our trees." However, one particularly bad day during the harvest of hunger, he came across a logger on a trailside. The deal they struck was everything the logger could extract from 700 hectares of community forest. Barge after barge rolled down the river.*

Profits were not scant. The community garnered R$14,800 from the sale. Each family involved in the sale received the equivalent of a few thousand dollars. Some men bought gas stoves for their wives. Others ate store bought beans and rice, and canned meat. Never having held such a sum, many quickly spent it on radios, bicycles, and alcohol. Post-logging slash from the sale piled high. Although the community had agreed not to place swidden fields within the newly logged forest, one community member did. Dry conditions permitted his fire to run free through the forest, consuming whatever the logger had left and leaving broken radio and bicycle parts scattered throughout the ashes.

Timber sales: a Faustian deal

Why do so many villagers sell timber for scant sums? First, change arrived extremely rapidly, and non-literate *caboclos* lacked any clear notion about the market value of their timber and non-timber resources. Also, in remote forest communities, prospects for money and visitors that offer it are rare. Loggers, ranchers and river vendors are some of the only persons to reach isolated areas and villagers gladly welcome them. Accustomed to accepting whatever is offered for their goods, and desperate for food and cash, small holders generally accept whatever they are presented.

After the first disadvantageous deal why do villagers continue to trade? First, other than *farinha*, wood is the only lucrative commodity which traveling vendors purchase. Second, the ecological and socioeconomic costs of timber transactions do not immediately arise; biotic impoverishment does not occur overnight.

In 1990, the forests inhabited by communities in which the research was conducted were relatively intact. Early negotiations in the 1970s and early 1980s involved extraction of only 2-10 species and the consequences for the communities were not grave. Fruit trees, game and fiber could still be collected within a reasonable distance from the riverfront. When loggers returned for a second round, prior experience gaining quick cash encouraged villagers to sell. This round 10-20 species were taken, now swept into barges or trucked to town. Like swidden rotations, visits from loggers became increasingly frequent, and timber sales more common.

In the period from 1992-1998, the intensity of logging escalated from a few dozen trees to include over three hundred species. In 1997, on the heels of one logging event, fire entered one community forest, consuming the substantial slash left on the ground. In only six years a forest with approximately 150 species over 10 cm DBH per hectare, became a degraded forest with few mature trees possessing non-timber value.

Slowing deforestation through wise management

To evaluate if and how deforestation might be slowed, it may be useful to look at households and communities in which disadvantageous timber deals were not struck, or in which negotiations with loggers or family management styles led to conservation of locally valued species.

■ *Sr. C. is an excellent hunter and son of a respected healer. His father had guarded a few hundred hectares of forest due to the presence of piquiá – declaring "I want to leave them for my children and grandchildren." Following in his father's footsteps, Sr. C. led an effort to stop loggers from entering his village's forest. He and others mapped their community, establishing a clear boundary with a neighboring village so that the logger cutting in the adjacent community would not enter. Sr. C. had a clear notion of where fruit trees occurred, which parts of his forest were best for hunting and which trees could be spared. Instead of selling the timber rights to cut any species, the community decided to sell only four species of high timber quality. By negotiating, they sold fewer trees, suffered less collateral damage, and received a higher net gain than the neighboring community.*

■ *Sr. M's. forest reserve is rich with old growth fruit, medicinal, and game attracting trees. Sr. M. places swidden fields only in secondary forest, guards whatever useful species grow there and plants perennial crops (Fig. 9.1). Throughout the year, the game, fruit and fiber resources occurring in the family's forest reserve sustains them (Fig. 9.2). In 1997,*

Figure 9.1 Jaime climbing a *Caryocar villosum* tree conserved in his families fallow

Figure 9.2 A Capim River family collecting medicinal bark in their forest reserve

neighbors surrounding Sr. M. sold timber to loggers for a few dollars a tree. Aware of the bountiful, intact forest on Sr. M.'s property, the logger 'generously' offered the family the equivalent of US $8 per tree. Recognizing the high subsistence value of his forest, Sr. M. told him to go away and to return when he could pay $800 per tree.

■ *Tired of ever increasing distances to fruits and fiber, and hunting trips from which their husbands returned with nothing to show, women of one Capim village met to discuss how and why their community forest had become so impoverished. Their meeting was unprecedented, as to date, their roles included farming, washing, cooking and child care with little to no involvement in land-use decision-making. Jointly they agreed that timber sales had brought nothing but fire, increased poverty and hunger. Although much of the timber had been logged out, they decided to prohibit any further logging. Their stance changed the dialogue in the community, encouraging the majority of men to vote with them in the ban.*

RECOMMENDATIONS

Why do some families decide to keep forests, while other sell timber rights for scant sums? Below is a brief list of six elements that our research team found to be important in assisting communities to better evaluate their forest management options.

Recognizing subsistence value

Results above demonstrate that although forest resources offer substantial economic input to families this is infrequently accounted for at the household level. For some families, the value of the forest for game, fruit and fibers is implicit; for others, free commodities from the forest are little valued. Recognition of the substantial input of non-timber forest resources to a family's livelihood, however, can greatly assist communities to make more informed decisions regarding forest management. Such recognition can be encouraged through increasing access to market prices, costs of substitute goods and costs of valued added products. As the caretakers of the health and nutritional needs of the family, women suffer disproportionately from forest impoverishment; at the same time, they can offer significant input towards locally beneficial forest management.

Improving negotiations with loggers

Negotiations between loggers and small holders are largely uninformed, resulting in timber extraction methods that neglect to consider the basic nutrition and health care needs of forest-based communities. Not accustomed to bargaining, non-literate and unprepared for modern land transactions, villagers commonly accept whatever is offered, many unaware of downstream values for their trees. Many villagers are also unaware of the extremely high risk of fire associated with selectively logged forests. When made aware of timber and non-timber resource values, and of the high costs and currently low earnings available through logging, villagers tend to pause before entering into disadvantageous deals.

However, if regionally valuable NTFPs are identified and singled out for conservation would this not negatively impact overall timber production? In Amazonia, due to the extremely low densities at which many highly valued non-timber forest species occur ($\leq$ than 1 per hectare), conservation of important NTFP species need not significantly reduce timber output. Within one hectare in the Capim region, for example, 2-4 trees per hectare might be singled out as highly important game attracting, fruit or medicinal trees to actively conserve.

Marketing locally and regionally

For gatherers of non-timber forest resources who occupy marginal niches in society, the assumption that increased trade in NTFPs to global markets is likely to be favorable may be largely erroneous. Many gatherers face substantial difficulties to reach a local, much less a national or international market. In some regions, cultural and socioeconomic characteristics of subsistence livelihoods render them inherently contradictory to the formal market economy (Crook and Clapp 1998, Emery 1998, Pierce 1999). For these reasons and more, in many isolated rural communities, non-timber forest resources offer the most assured profit and least risk when used directly or traded locally, but not sold to external markets.

Processing and home use of non-timber forest products

Increased use and processing of non-timber forest resources for home use can substantially decrease expenditures, thereby indirectly adding to a family's income. To best utilize forest resources, not only valuable species but also recipes and processing techniques must be conserved. In households which guarded forests and which have oil and fruit trees nearby, soap making, oil extraction and jam making indirectly contribute to a family's "income" – doing so, as one villager stated, "by avoiding spending money we do not have."

Integrating local and scientific knowledge to generate relevant results

Traditional knowledge was fundamental to guide the ethnobotanical and ecological research on which this dissertation was based. The research process also helped to shed light on the limits of local knowledge and to identify where scientific expertise could help complement traditional knowledge. In the face of sudden change, smallholders were in need of basic ecological and market information with which to make appropriate forest management plans. Many required assistance in inventorying their forest resources, measuring fruit and/or medicinal oil production, comparing the financial value of timber and non-timber products and mapping. At the same time, the inclusion of decades-long, local understanding of fruit and medicinal species strengthened the research immeasurably, and made the results relevant to and respectful of local knowledge.

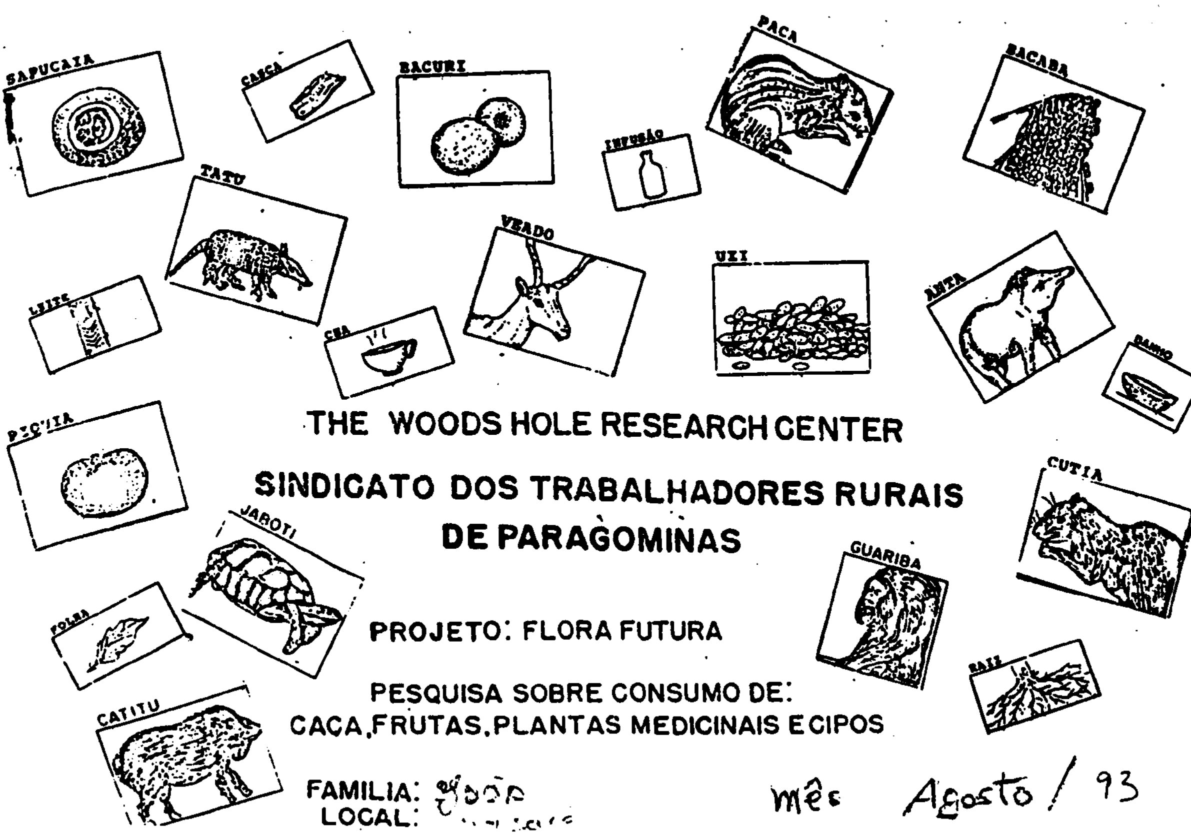
Disseminating information equitably

Predatory timber extraction is not only unsustainable from a local perspective through the loss of fruit, medicine and game, but from a state and national perspective in terms maintaining a viable timber industry for the future. To combat this destabilizing trend, forest residents and policy makers need clear, relevant information to evaluate the costs and benefits associated with intact forests. Needed is a full assessment of the relative value and contribution of the forests' timber and non-timber resources to the region's economic, nutritional and health status. It is fundamental to understand which species of fruit and medicinal plants are critical to day-to-day livelihoods and which offer more to the domestic economy standing than cut.

Although conservation and development projects throughout the world have compiled massive data sets in ecological, resource management and non-timber forest resources, few have managed to extend the results in a useful way to local communities. Scientists who collect data are not required or encouraged to give it back to the communities in which it was generated or to make it accessible in the policy realm. Communities dependent upon non-timber forest resources are frequently disadvantaged members of society such as women and the rural poor, who have scant access to information. The results of this research indicate that innovative transfer of relevant information can be an effective means for achieving meaningful conservation and development goals, and for improving equity for forest-based communities.

APPENDIX A

A. SAMPLE PAGES FROM ILLUSTRATED NOTEBOOK OF HOUSEHOLD CONSUMPTION, 1993–1994, OF GAME (*CAÇA*), FIBERS (*CIPO*), AND MEDICINAL PLANTS



FICHA DE CIPÓS

NOME: João S. Mes: Agosto '93

CIPÓS USADOS

DATA	TITICA	TIMBÓ-AÇU	JACITARA	GUARUMÃ	OBSERVAÇÃO
16					
17	0,5kg			4 duzia de guaruma	48 2 peneiras
18	fora				
19					
20					
21					
22					
23					
24		1 kg			
25					
26					
27					
28					
29					
30					

FICHA DE CAÇA

NOME: João dos Santos — Mes: Agosto '93

ANIMAIS CAPTURADOS

DATA	CAÇAS-> TATU	PACA	VEADO	JABOTI	CATITU	CUTIA	GUARIBA
16							
17							
18							
19							
20				um jaboti 9 kg (tartaruga da cabeça torta) (Paca) Igarapé [illegible]			
21							
22							
23							
24	um 3 kg Tatu						
25							
26							
27							
28						2 kg cutia	
29							
30							

NOME: Horacio e Graça — Mes: Outubro 94

PLANTAS USADAS

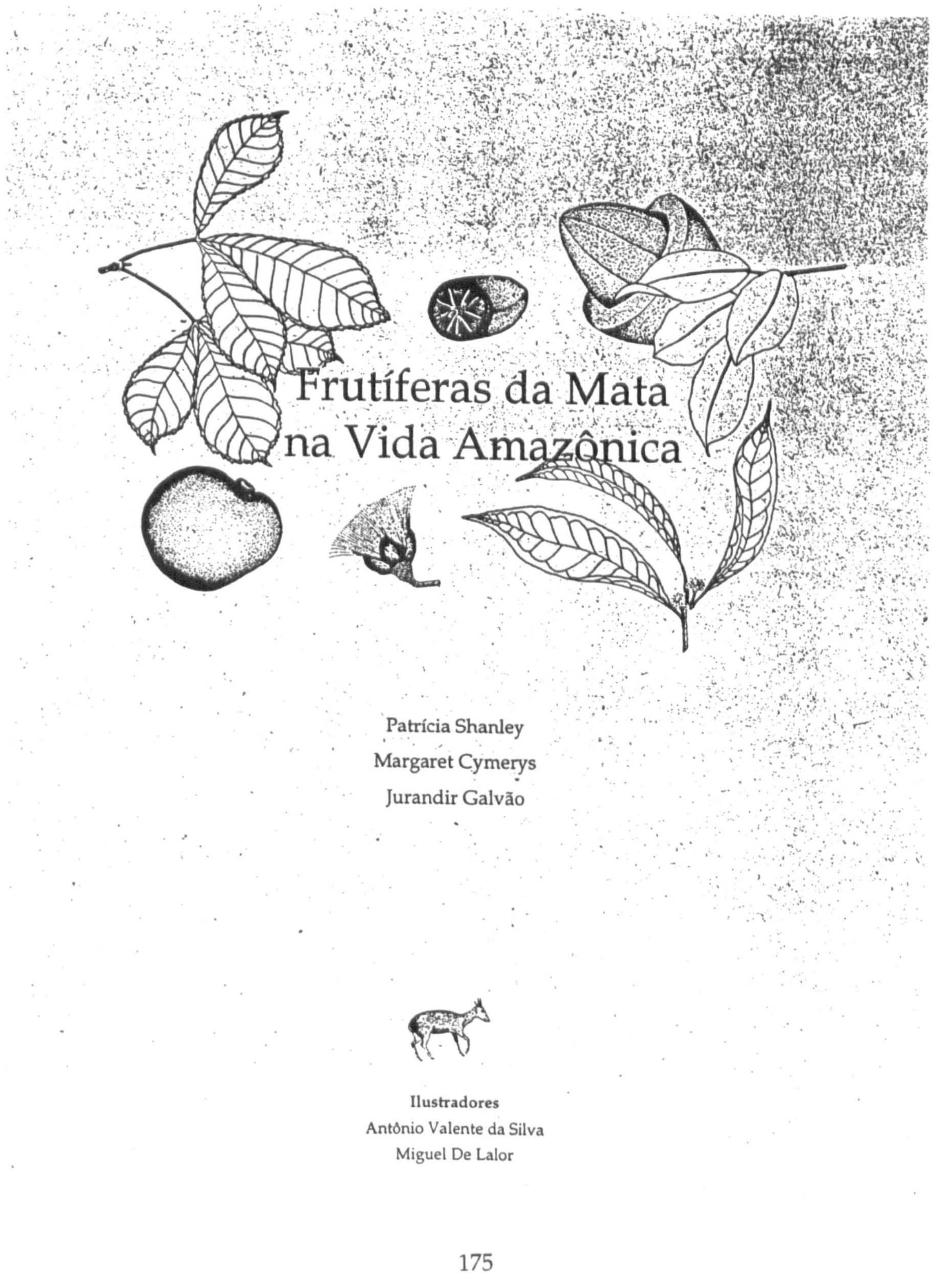
DATA	NOME DA PLANTA	LEITE	FOLHA	CASCA	RAIZ	CHÁ	INFUSÃO	BANHO	OBSERVAÇÃO
1									
2									
3									
4									
5	Ipê			ipê 2 dedos					para inflamação Poca
6									
7									
8									
9		Sucuba							
10									
11									
12	cabacinha	½ [illegible]				X			Ferver em 2 copos até 1 copo. Tomou 4x/dia. Para fígado
13	verônica — form			3x3 cm					
14									
15									

APPENDIX B

THREE SAMPLE CHAPTERS:

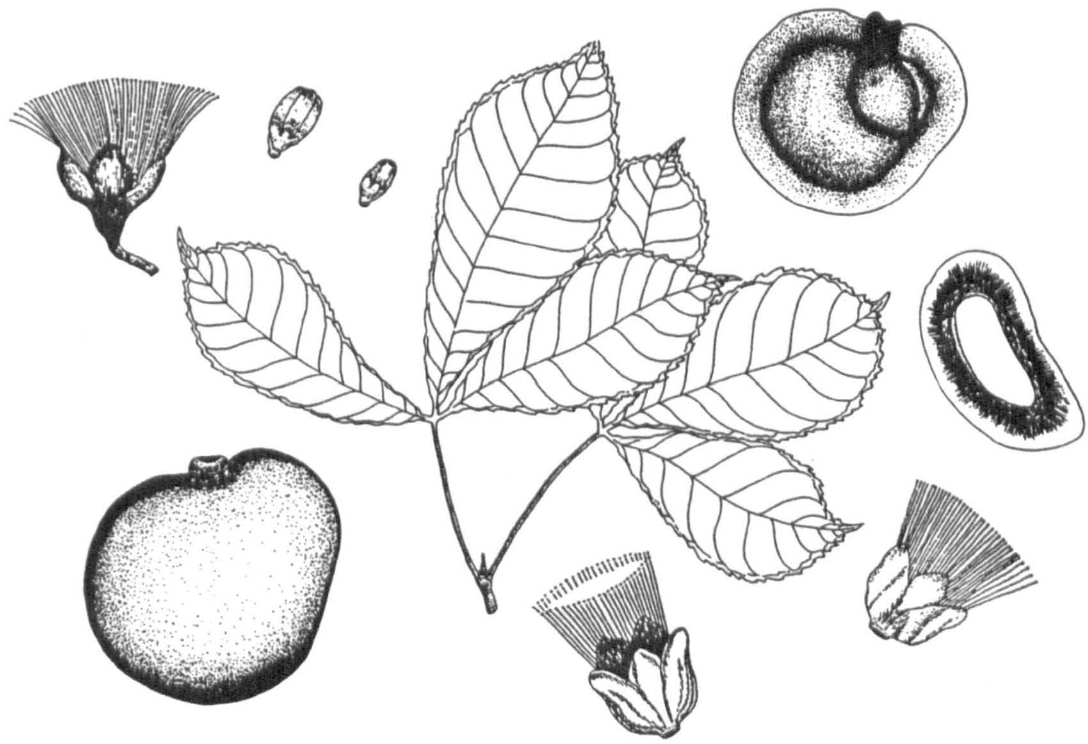
PIQUIA, BACURI, AND UXI OF *FRUTÍFERAS DA MATA NA VIDA AMAZÔNICA*

[FRUIT TREES OF THE FOREST IN THE LIVES OF AMAZONIANS]



Piquiá

Caryocar villosum (Aubl.) Pers.



Uma árvore majestosa da mata primária, atingindo grandes dimensões como 40 a 50 metros de altura, tronco até 2,5 metros de diâmetro, ou roda até mais que 5 metros, e com copa enorme, sobressaindo-se na mata. É distribuída em toda a Amazônia, com maior concentração na terra firme da região do grande estuário.[1] A fruta é bastante apreciada pelas classes populares que se deliciam com o sabor e cheiro incomuns de sua polpa, sendo comestível só depois do cozimento.[2] Sua madeira é de qualidade superior, com fibras entrelaçadas, possuindo grande resistência e, por isso, utilizada na indústria naval. As flores do piquiazeiro são muito apreciadas tanto pela caça quanto pelos caçadores. Durante a floração, os caçadores esperam pela caça embaixo das árvores, quando as bonitas flores amarelas caem no chão.

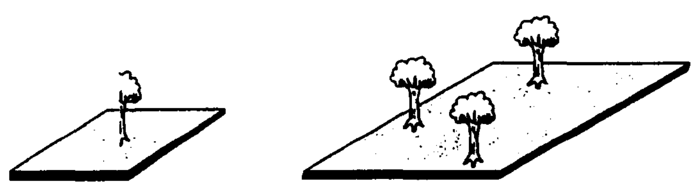
ECOLOGIA

Época de flor e fruta

J F M A M J J A S O N D

O piquiazeiro produz flores durante a estação da seca, de agosto até outubro, e frutas de fevereiro até abril. Suas folhas caem no início da floração e, às vezes, também durante a frutificação.

Densidade



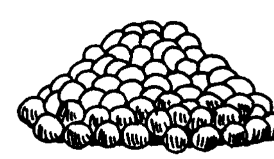
0,4 - 0,6 árvores por hectare

2 - 3 árvores por alqueire

Densidades maiores, de 2 a 7 árvores por hectare, ocorrem em algumas regiões, provavelmente por causa do manejo indígena.

Produção

De 500 a 1.000 frutas por árvore (em média 350 frutas).

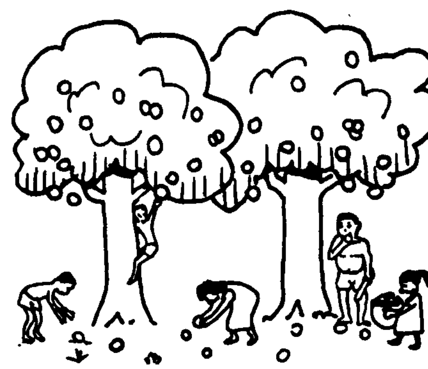


média de 350 frutas por árvore

Uma árvore de piquiá normalmente não produz frutas todos os anos. Muitas árvores "descansam" num ano e produzem no próximo. Em uma amostra de 100 árvores de piquiá, entre 20 e 33% das árvores produziam frutas a cada ano. Por exemplo, em 1994, de uma amostra de 100 árvores, só 20 deram frutas. A produção varia bastante de uma árvore para outra e de um ano para o outro. Diz-se em Boa Vista do Pará que para saber se a fruta está madura é só olhar para o topo da árvore. Se as folhas estão verdes a fruta ainda não está boa. O piquiá cai e está bom para comer somente quando as folhas estão maduras. Na região do Capim também dizem que enquanto alguns piquiazeiros jogam frutas saborosas, outros só produzem frutas amargas. Por isso, é bom conhecer o vendedor da feira para poder comprar piquiá gostoso. Quem não conhece a fruta pode ser facilmente enganado.

O piquiazeiro produz muitas flores. Durante uma safra, uma árvore no Capim jogou até 14.000 flores por dia e, na safra inteira, aproximadamente 120.000 flores. Mesmo jogando tantas flores, não significa que a árvore produzirá muitas frutas. Porém, observando quais árvores florescem, pode-se ter uma idéia melhor de quais delas frutificarão. Como Antoninho do Quiandeua diz: "Piquiá tem um segredo que ninguém vai descobrir."

Valor Econômico



A madeira da árvore de piquiá é altamente útil na indústria naval. Por isso, a abundância das árvores perto dos centros de fabricação dos barcos tem sido reduzida. Também nas comunidades rurais, essa árvore é a preferida para fazer canoas e, muitas vezes, tem sido derrubada nas áreas ao longo dos rios. O valor das frutas tem crescido nos últimos anos. Em 1998, um piquiá nas feiras de Belém custou entre R$ 0,15 e R$ 0,50. Cerca de 13 milhões de frutas foram vendidas nas principais feiras em 1994, gerando aproximadamente US$ 13 milhões.

É importante considerar a conservação das árvores perto das casas onde as frutas são fáceis de colher. Uma família no Capim guardou apenas uma árvore grande de piquiá, a cerca de1/2 km da sua casa. Todos os anos, seus filhos, Neca, Antônia, Simeão e Jaime esperam pela safra e correm para a mata para colher o piquiá. Só no mês de março, essa família comeu 868 piquiás. Na feira, essas frutas custariam entre R$ 90 a R$ 170.

Com uma tecnologia apropriada de exportação, as sementes podem ser uma excelente fonte de alimentação para as pessoas e, possivelmente, de óleo para usar na indústria cosmética.

Uso

Fruta: cozinhar com água e sal para comer a polpa.

Caça: as flores atraem muitas espécies de caça, especialmente paca, cutia, veado, quati e tatu.

Madeira: de alta qualidade, compactada, pesada, não se decompõe facilmente e fornece peças de grandes dimensões. Muito utilizada na construção civil e naval, sendo de grande importância para armação do fundo interno das embarcações. Nas áreas rurais, o piquiazeiro é a árvore preferida para fazer canoas. Essas canoas têm longa durabilidade, chegando até 10 anos. Os fazendeiros gostam da sua madeira para fazer curral e portão, porque ela não racha e agüenta a água.

Óleo: serve para cozinhar e é muito bom para fritar peixe.

Amêndoa: é comestível e deliciosa, mas cuidado com os espinhos. Os caboclos do Rio Negro não jogam nenhuma semente fora.[3] Cortam, extraem e comem todas as amêndoas.

Casca da fruta: é rica em tanino, substitui a noz de galha na preparação da tinta para escrever, para tingir rede de dormir e fio. A casca também é usada para fazer sabão.

Óleo de piquiá

Durante uma boa safra de piquiá, Senhorinha de Ananaí juntou muitas frutas e tirou tanto óleo que ela não precisou comprar nenhum litro no ano inteiro. Como ela mesma diz: "evitando a compra do óleo do mercado, a gente economiza o dinheiro que não tem". Para tirar óleo: junte as frutas e deixe amadurecer por 3 ou 4 dias. Quando todas as frutas amolecerem, cozinhe por 1 hora. Derrame numa peneira para enxugar. No próximo dia, raspe e amasse bem a polpa, levando ao fogo baixo (sem água). Em seguida, retire a massa aos poucos enquanto o óleo derrete. Três dúzias de piquiá podem dar 2 1/2 litros de óleo.

Sabão da polpa de piquiá

Ingredientes:

- 1 lata de 18 litros de piquiá descascado
- 5 litros de água
- 500 gramas de soda cáustica
- 50 gramas de breu (ou silicato)
- 1 saco de estopa ou linhagem
- 1 lata grande de manteiga ou margarina vazia
- 1 colher de pau
- caixas de madeira

Modo de fazer:

Dissolva a soda cáustica na água. Deixe o piquiá de molho na solução de soda cáustica e água por um período de 12 horas. Em seguida, retire os caroços dos piquiás com uma colher de pau. Bata os ingredientes (piquiá, água e soda cáustica) até formar uma massa. Adicione o breu pouco a pouco. Quando a massa estiver com boa consistência, despeje-a nas caixas de madeira forradas com os sacos de estopa ou linhagem até 5 cm de altura. Deixe a massa em repouso por um período de 12 horas e depois corte-a em barras. ***Lembre:*** a soda cáustica é tóxica (evite o contato direto). A lata usada não deve ser reaproveitada para outros fins.

Sabão da casca de piquiá 

Desde que 65% da fruta do piquiá é casca, por que não aproveitá-la?

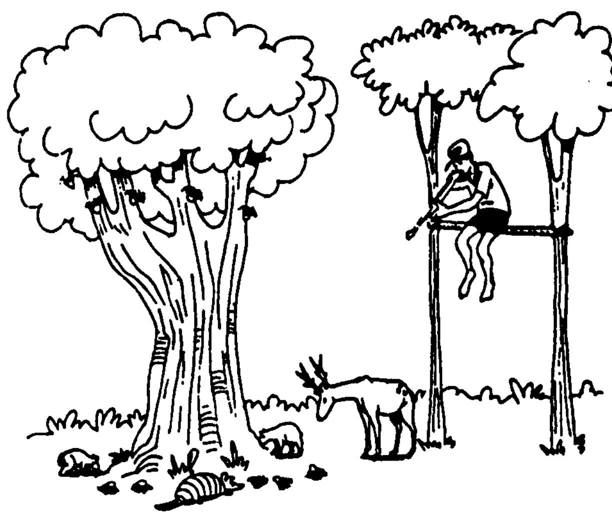
Descasque 12 piquiás graúdos. Deixe a casca de molho (não cozinhe). Machuque e coloque a massa numa latá de 2 litros de sebo derretido. Leve ao fogo baixo e mexa. Coloque 4 colheres de soda cáustica (ou 50 gramas de breu ou 4 colheres de silicato) e 5 folhas de mamão pilado bem miudinho (para fazer espuma e ajudar a limpar e clarear a roupa). Mexa até que todos os ingredientes estejam desmanchados e dissolvidos (15 minutos). Coloque na fôrma. Depois de 24 horas pode usá-lo.

Nutrição

A fruta é composta de 65% de casca, 30% de polpa e 5% de amêndoa. A polpa tem 72% de óleo, 3% de proteína, 14% de fibra e 11% de outros carboidratos. O piquiá é uma excelente fonte de calorias e energia. Os animais que comem as flores também aproveitam os nutrientes do piquiá. As flores são compostas de 71% de carboidratos, 8% de proteína e 3% de gordura.

CAÇA

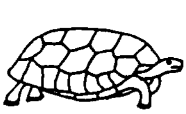
As flores do piquiá: bonitas e úteis



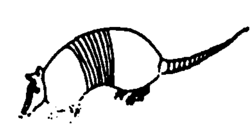
O piquiazeiro é a árvore favorita de muitos caçadores porque suas flores "chamam" a caça. Por exemplo, Raimundinho capturou 67 kg de caça embaixo das árvores de piquiá em apenas dois meses de floração. Se ele tivesse que comprar essa carne no mercado local, custaria em torno de R$ 130. Isso representa aproximadamente o mesmo valor de 13 sacos de farinha.

Durante três meses de floração do piquiá, 7 caçadores de uma comunidade do Rio Capim no Pará pegaram: 18 pacas, 4 veados, 4 tatus e 1 cutia embaixo das árvores de piquiá. Essa caça pesou um total de 232 kg. A comunidade capturou quase 4 vezes mais quilos de caça embaixo do piquiazeiro do que de qualquer outra árvore. Essa caça custaria cerca de R$ 900 no mercado de Belém, ou seja, a maior parte da renda anual de uma família do Capim (tabela na próxima página).

Caça, pessoas, frutas e suas ligações



Muitas espécies de caça são frugívoras, ou seja, alimentam-se principalmente de frutas. A dieta do veado, por exemplo, é mais de 80% frutas. Caititu, queixada, anta, paca, cutia, macacos, papagaio, araras e outros animais silvestres dependem muito das frutas. As florestas que possuem muitas frutíferas que florescem e frutificam durante várias épocas do ano são capazes de abrigar muitos animais silvestres. Pessoas que querem aumentar a caça nas suas florestas podem manejar e proteger as frutíferas que a caça gosta, aumentando assim a sua própria alimentação. A quantidade de caça está ligada com a qualidade e quantidade da floresta.

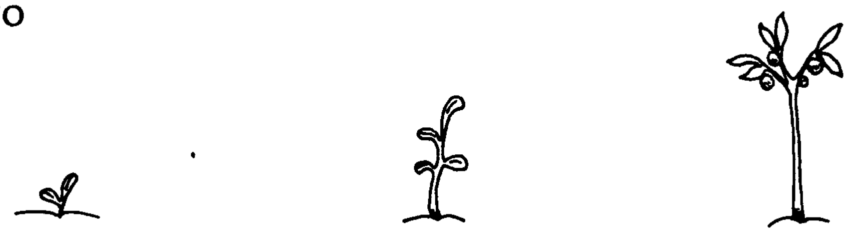


Muitas frutíferas são também as toras favoritas dos madeireiros. Então é bom pensar bem nos negócios com madeireiros e lembrar que, muitas vezes, para cada árvore que o madeireiro compra e tira, ele mata mais de 10 árvores no processo. Assim, durante a extração de madeira pode-se perder fruteiras com suas frutas que seriam vendidas ou consumidas em casa.

A quantidade de caça capturada embaixo das frutíferas, durante um ano, na comunidade de Quiandeua, Pará, mostra a importância das frutas e flores para a alimentação de animais e pessoas.

Árvore	Nº de animais	Peso total
Piquiá 	18 pacas 4 veados vermelhos 3 tatus brancos 1 tatu preto 1 cutia	232 kg
Copaiba 	1 veado vermelho 1 jabuti branco	63 kg
Uxi 	3 tatus brancos 1 paca 1 veado vermelho 1 cutia	38 kg
 Tatajuba	7 jabutis, 1 veado, 1 cotia	60 kg
Ingá 	2 pacas, 2 cutias, 1 caititu, 1 preguiça e 1 papagaio	40 kg
Maturi	5 pacas	31 kg

MANEJO



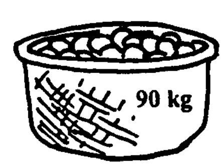
germinação	crescimento	produção
2 meses a 1 ano	inicia rápido 1 metro cada ano por 10 anos	depois 10 a 15 anos

É difícil para a árvore do piquiá nascer e crescer na mata, porque os filhos não crescem bem na sombra, e sim ao sol. No caso de usar essa árvore para o enriquecimento das florestas, são necessárias grandes clareiras ou picos para receber a maior quantidade de sol possível.

Na comunidade de Ananaí, Sr. Paulo plantou 70 pés de piquiá 8 anos atrás. Hoje, eles alcançam mais de 8 metros de altura. Daqui a alguns anos, Sr. Paulo pretende comer e vender muitos piquiás. O uso do piquiá em sistemas agroflorestais é possível por causa do seu crescimento rápido.

Para enriquecer a capoeira, pode-se plantar 50 árvores por hectare estimando uma produção de 200 frutas por árvore e 300 g por fruta, assim você terá 6 toneladas de fruta fresca por hectare ou:

- 1 tonelada de polpa
- 90 kg de sementes
- 330 kg de taninos
- 105 kg de óleo de polpa
- 30 kg de óleo de semente[4]



Para maiores informações veja os trabalhos de:

[1] G. Prance e M. F. Silva.

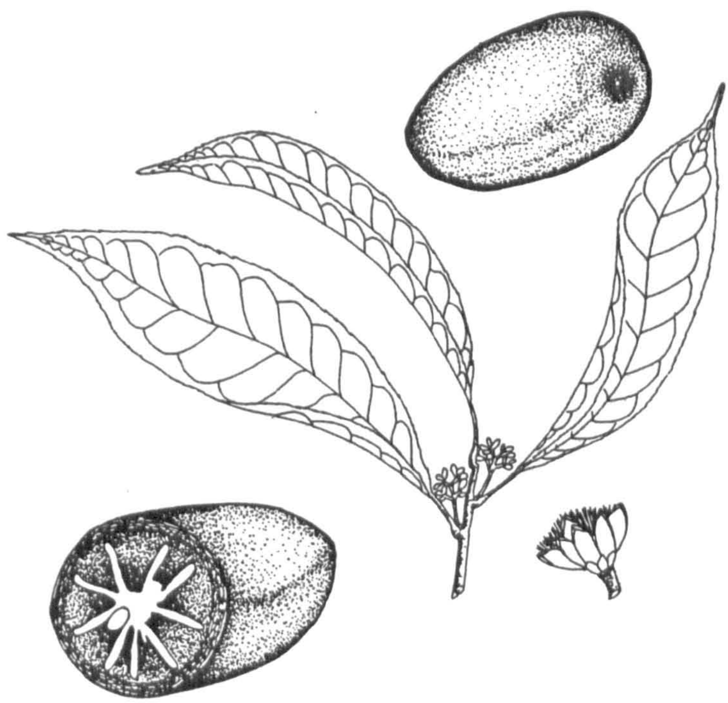
[2] P. B. Cavalcante.

[3] Segundo Nelson A. Rosa.

[4] H. Villachica.

Uxi

Endopleura uchi Cuatrec.



Uxi é uma das frutas bem populares no Pará e, até recentemente, era chamado "fruta de pobre" porque era vendido bem baratinho. Hoje em dia, o preço tem subido, e o uxi está mais valorizado. O uxizeiro é uma árvore grande com cerca de 25 a 30 metros de altura, 1 metro de diâmetro, ou até 2,5 metros de roda. O uxi é de origem do Pará e Amazonas. É uma espécie tipicamente silvestre da mata alta de terra firme, freqüente no estuário do Pará e regiões Bragantina, Guamá e Capim, na parte ocidental do Marajó e regiões dos Furos.[1]

O uxi é uma fruta muito apreciada, e atinge bons preços no mercado. Dela pode-se extrair um óleo muito semelhante, química e fisicamente, ao azeite de oliva. O uxi pode ser comido cru, no suco, sorvete ou picolé. Na cidade de Belém, o picolé de uxi é um dos sabores mais populares.

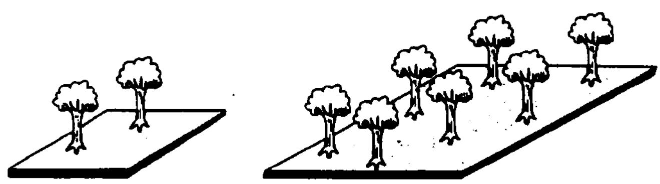
ECOLOGIA

Época de flor e fruta

J F M A M J J A S O N D

O uxizeiro floresce entre outubro e novembro. As frutas caem entre fevereiro e maio.

Densidade



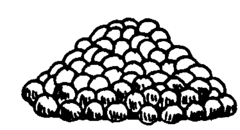
0,03 - 3 árvores por hectare

1,4 - 14 árvores por alqueire

Em alguns casos de maior densidade pode-se encontrar até 9 árvores por hectare.

Produção

De 300 a 4.000 frutas por árvore (em média 1.000 frutas).



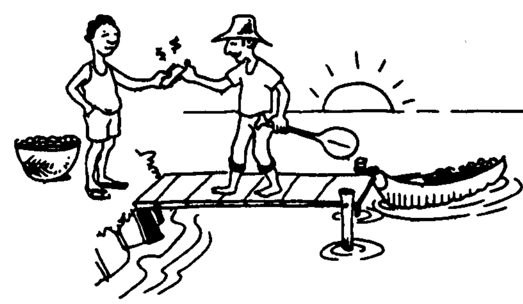
média de 1.000 frutas por árvore

Muitos uxizeiros produzem frutas todo ano, mas o número de frutas produzidas varia. Por exemplo, em 1993, a produção média de uma amostra de 24 árvores de uxi foi cerca de 1.600 frutas por árvore. Em 1994, a média de produção para as mesmas árvores caíram pela metade, 800 frutas. Em uma amostra de 22 árvores de uxi, a média de 80% das árvores produziam frutas todo ano. Se você pretende colher uxi para vender, chegue antes do tatu, paca, cutia e veado. O quatipuru come até as sementes do uxi. Cuidado também porque araras e papagaios derrubam as frutas mesmo verdes. Encontramos casos onde a caça comeu até 80% da produção das frutas.

Na região do Rio Capim tem pouca gente que olha para cima dos uxizeiros para ver quantas frutas tem. Sabe por que? As pessoas acreditam que podem morrer no mesmo ano se virem algum uxi em cima da árvore, por isso elas não olham.

VALOR ECONÔMICO

O uxi cai ainda duro da árvore e pode ficar bom para comer ou vender por até 6 dias. Cerca de 30 milhões de frutas foram vendidas nas feiras principais de Belém em 1994, gerando aproximadamente R$ 1,2 milhão. O preço do uxi tem aumentado no mercado, com o preço médio de R$ 0,10 por fruta em 1995. Em 1998, um uxi nas feiras de Belém custou entre R$ 0,10 e R$ 0,20. Existem comunidades nas ilhas perto de Belém que obtêm a maior parte da sua renda anual com a venda do uxi. Manejam, plantam, podam, limpam e protegem os uxizeiros.



Antigamente, muitos barcos chegavam na pedra (mercado do Ver-o-Peso) com milhares e milhares de uxis. Hoje, é raro encontrar barcos exclusivamente com uxi. O preço tem subido, e o uxi está sendo mais valorizado, talvez por causa do crescimento de novos mercados e produtos feitos das frutas, como as grandes redes de sorveterias que têm se multiplicado recentemente pela Amazônia.

Roupas das frutas

O clube das Mães do Joíra no Capim juntou cerca de 400 frutas (uxi, piquiá e bacuri) e levaram para a feira. Venderam quase todas as frutas e compraram roupas usadas para 10 famílias, soda cáustica para fazer sabão e um porquinho para obter mais lucro ainda. Domingo, depois da missa, passeando pela vila pôde-se ver todo mundo usando as roupas novas, que são chamadas "roupas das frutas". O porquinho está engordando, e vai ser vendido.

USO

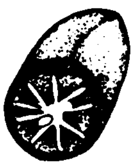
 Fruta:  picolé,  sorvete, vinho, suco e óleo.

 Madeira: recentemente extraída pela indústria madeireira, prestando-se para marcenaria.

 Caça: muita caça se alimenta de uxi.

 Óleo: de muito boa qualidade, utilizado na comida e como remédio.

 Semente: artesanato, defumação.



Maquiagem, colares e defumação

Corte o caroço de uxi e descubra dentro um pozinho que era utilizado antigamente como maquiagem para cobrir manchas e para coceiras.

Quando você corta a semente de uxi, ela forma várias estrelas. Cortando a semente em rodelas finas, pode-se fazer lindos colares, brincos ou cintos.

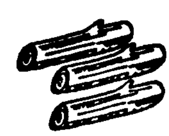
Se você quiser espantar o carapanã ou os espíritos maus, quebre as sementes de uxi, coloque dentro de uma lata e acenda. A fumaça forte espanta os insetos e os espíritos maus.

Uma família, um hectare, um ano

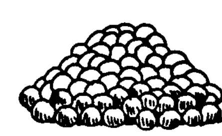
A família do Sr. Mangueira marcou um hectare de sua mata e, por 5 anos, contou e pesou todas as frutas e caças que colheu nesse lugar. Com esses dados, eles perceberam a "renda invisível" que ganharam, comparando com o que ganhariam se tivessem vendido o mesmo hectare de madeira. Um fato interessante que eles notaram foi que, a cada ano, a quantidade dos produtos florestais extraídos foi diferente. Por exemplo, em 1993, a família comeu 2.544 uxis. Em 1994, comeu 3.654 uxis e, em 1995 e 1997, nenhum uxi. Por que? Você acha que eles ficaram enjoados de uxi? Não. Isso aconteceu porque a árvore de uxi daquele hectare não produziu nenhuma fruta em 1995 e 1997.

Também em alguns anos eles capturaram uma boa quantidade de caça e em outros, não. Os resultados preliminares mostraram que essa família consumiu do hectare durante 5 anos, em média, o equivalente a aproximadamente R$ 200. Se as árvores desse hectare tivessem sido cortadas e vendidas como madeira, a família receberia R$ 20 a R$ 30, somente um décimo da renda das frutas e da caça. Além disso, as frutíferas produzirão por um longo período, oferecendo frutas por muito tempo. Conhecendo o grande valor que a mata tem, essa família decidiu fazer uma reserva, conservando os recursos para os netos e bisnetos.

Lucro de 1 hectare: madeira x frutas



R$ 20



R$ 200

Consumo das frutas pela família do Sr. Mangueira

	Número de frutas				
	1993	1994	1995	1996	1997
Piquiá	937	0	0	430	0
Bacuri	298	417	0	618	0
Uxi	2.544	3.654	0	1.321	0
Total	**3.779**	**4.071**	**0**	**2.369**	**0**

Nutrição

A polpa do uxi tem:

Proteína:	9%	Lipídios:	20%
Carboidratos:	12%	Fibra:	26%

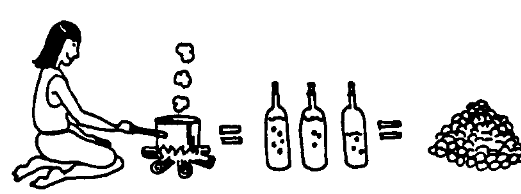
Energia: excelente fonte de calorias.

Na comunidade Nazaré do Rio Capim, Nenzinho e sua família comeram 1.123 uxis em apenas um mês. O seu vizinho, a família de João Brito, consumiu cerca de 6.000 frutas. Se eles tivessem que comprar todas essas frutas, o valor estimado estaria entre R$ 300 e R$ 700. Segundo eles, durante a safra do uxi, não pegaram gripe e nem tosse. Outras pessoas acham que engordam durante a safra. A mãe da Socorro, Neusa do Limão, diz que felizmente ganha até 2 quilos anualmente durante a safra do uxi.

Óleo de uxi por Senhorinha

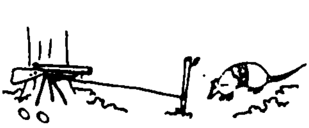
Hoje em dia apenas poucos idosos sabem tirar óleo de uxi. Senhorinha de Ananaí resgatou a receita e repassou para nós. Ela disse que o óleo de uxi é limpinho e serve tanto como óleo na comida como remédio. Senhorinha recomenda óleo de uxi no tratamento de sinusite da criança (passe óleo morno nas narinas) e para prisão de ventre em adulto (faça fricção na barriga com óleo morno).

Para tirar o óleo, deixe as frutas amadurecerem, depois lave bem. Raspe e coloque a massa e casca na vasilha com água apenas cobrindo a massa. Leve ao fogo para ferver enquanto ferve, mexa com uma colher. Quando a água seca, o óleo começa a sair. Com pouca massa, leva 1 hora para sair todo o óleo; com 500 uxis leva 2 horas fervendo. Quinhentos uxis bem carnudos podem dar 2 litros e meio de óleo. A qualidade do óleo de uxi é tão boa quanto a qualidade do óleo de oliva.



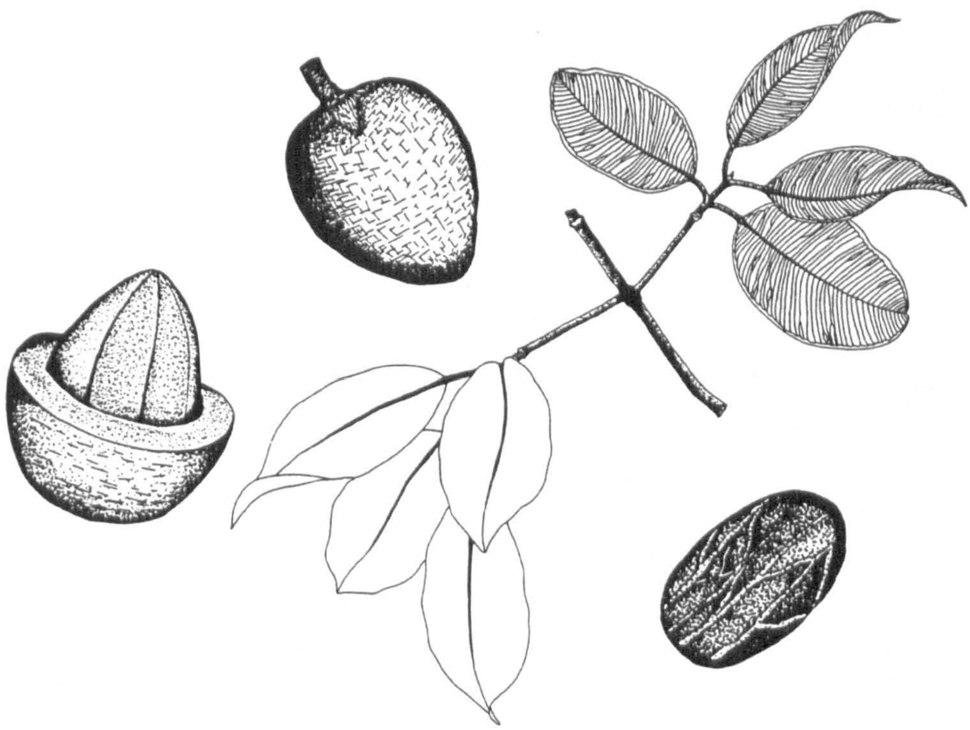
Caça

O uxi tem grande importância na alimentação dos animais silvestres. Num estudo da produção do uxi, encontramos casos onde a caça comeu até 80% da produção das árvores. Veado, anta, queixada, caititu, tatu, paca, cutia, quati, macacos, araras e outros pássaros comem essa fruta. O quatipuru rói o caroço atingindo até a semente. Às vezes, os caçadores colocam baladores perto dos uxizeiros para capturarem cutia e tatu. Um caçador de Joíra chamado Chuva tem o hábito de colocar baladores nos caminhos de caça perto dos pés de uxi durante a safra. Por algumas semanas, parece até que ele tem um açougue ao lado da sua casa porque quase todos os dias ele pega um tatu.



Bacuri

Platonia insignis Mart.



Essa árvore bonita pode alcançar de 15 a 25 metros de altura e 1,5 metro de diâmetro, ou 4 metros de roda. Tem tronco reto com galhos orientados numa posição entre 50º e 60º e látex amarelo. Possui folhas opostas, subcoriáceas e flores grandes com pétalas róseas. A área de maior concentração dos bacurizeiros é o estuário do rio Amazonas, com ocorrência mais acentuada na região do Salgado e na ilha de Marajó.[1]

Ocorre naturalmente na capoeira e em áreas degradadas e arenosas, indiferente aos tipos de solos, sejam eles pobres ou argilosos. Ocasionalmente é encontrado na floresta alta. O bacurizeiro reproduz facilmente por sementes e por brotações das raízes. A popularidade e o preço da fruta têm aumentado muito, surgindo diferentes variedades de produtos nos mercados como iogurte, geléia, doces, além da polpa.

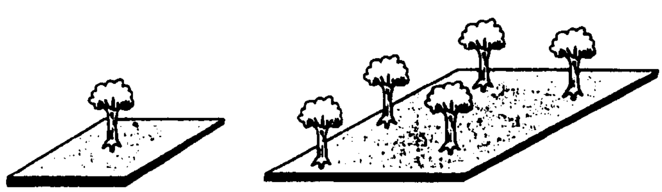
ECOLOGIA

Época de flor e fruta

J F M A M J J A S O N D

O bacuri aparece nos mercados de Belém entre dezembro e abril. Felizmente, a safra dessa fruta deliciosa varia em diferentes regiões, prolongando o seu fornecimento no mercado. No início da safra, a região das ilhas, como o Marajó, abastece Belém. Depois é a vez das regiões do interior do Pará, como a Zona Bragantina, fornecer os bacuris. Também o Estado do Maranhão está fornecendo muito bacuri para Belém. Os bacurizeiros florescem de junho a agosto.

Densidade



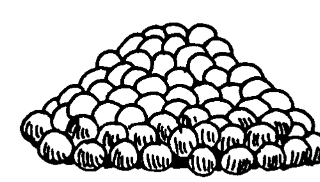
0,5 - 1,5 árvore por hectare — 2 - 7 árvores por alqueire

Varia muito em diferentes regiões e agüenta bem o fogo. Em casos especiais, pode ter 30 a 100 árvores por 1 hectare. Há quem diga que, quanto mais o bacurizeiro queima, mais ele brota.

Produção

De 100 a 800 frutas por árvore (em média 400 frutas).

Muitas árvores de bacuri não produzem frutas anualmente, pois "descansam" de um ano para outro. Com 50 árvores por hectare pode-se produzir aproximadamente:



média de 400 frutas por árvore

9,5 toneladas de frutas por hectare
= 1 toneladas de polpa por hectare
= 6 toneladas de casca
= 2,5 toneladas de sementes por hectare, que podem ser utilizadas para alimentação animal.[2]

Algumas pessoas batem na árvore com um facão, pois acreditam que assim ela jogará melhor. Mas cuidado, essa prática, às vezes, só faz com que a fruta verde caia.

VALOR ECONÔMICO

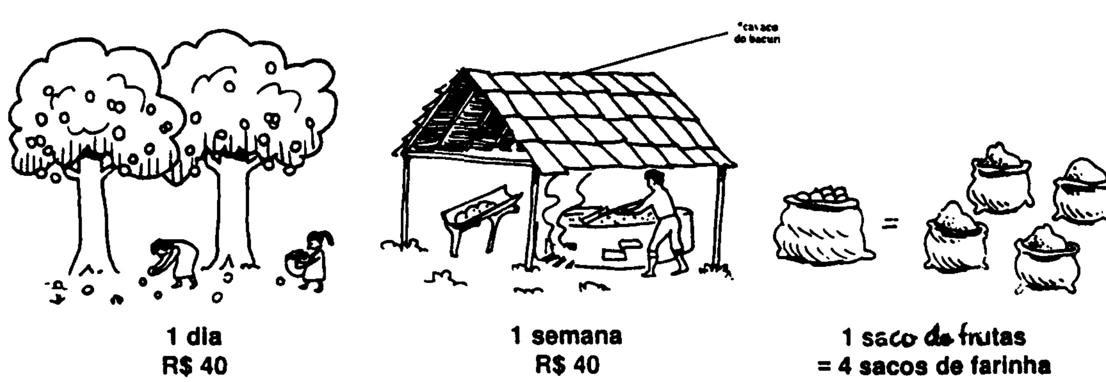
Segundo um vendedor, "bacuri está virando ouro no mercado". Sua polpa é doce e muito agradável. Ela vem sendo utilizada na fabricação de cremes, sorvetes, sucos e xaropes e torna-se, a cada dia, num dos sabores mais populares em Belém. Os preços recentes refletem essa popularidade: cerca de sete milhões de frutas foram vendidas nas feiras principais de Belém em 1994, gerando aproximadamente R$ 1,6 milhão. Em Belém, em1998, um bacuri custou entre R$ 0,25 e R$ 1. Na entressafra de 1996, o quilo da polpa de bacuri atingiu R$ 16, custando 3 vezes mais que a polpa de cupuaçu. Os preços altos ocorrem durante a entressafra, mas também mostram que o número de bacurizeiros produtivos tem diminuído, por causa da extração de madeira e também pela produção de cavaco* no interior.

USO

- Fruta: polpa, suco, creme, sorvete, geléia, doce, iogurte, picolé, chopp.
- Madeira: excelente qualidade, utilizada para móveis, construção civil e naval.
- Látex amarelo: em algumas regiões é utilizado para o tratamento de eczemas, vírus da herpes e outros problemas da pele.[3]

Fruta e farinha

Durante uma safra, quando Curumi e Antoninho venderam bacuri, o valor de 1 saco de frutas (150-200 unidades) era aproximadamente igual ao valor de 4 sacos de farinha. Eles calcularam que levariam 1 dia para colher e vender as frutas, que renderiam R$ 40 (200 frutas x R$ 0,20 a unidade). Para fazer os mesmos R$ 40 de farinha, levariam aproximadamente 1 semana. O bacuri tem vantagens para comercialização, pois sua casca grossa protege a polpa durante a viagem para a feira. Além disso, a fruta pode durar até 7 dias caída embaixo da árvore.

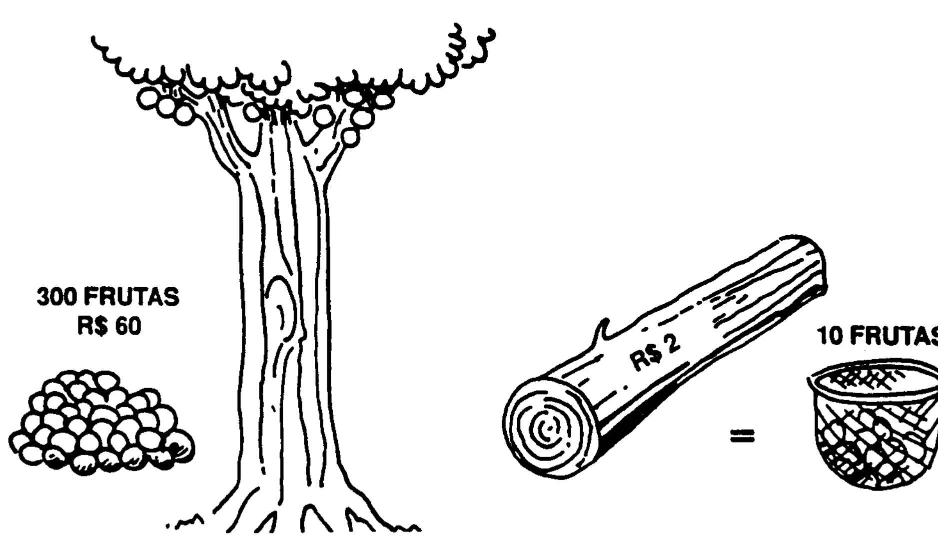


Fruta ou madeira?

Vamos comparar o valor das frutas do bacurizeiro com o valor da sua madeira. Uma tora da madeira nas matas de algumas comunidades do Pará foi vendida por R$ 2. Na mesma época, 10 frutas renderam os mesmos R$ 2 (10 frutas x R$ 0,20 a unidade). Curumi e Antoninho, caçadores do Rio Capim, pensaram sobre isso. Com base em suas experiências, eles sabem que uma árvore de bacuri joga em média 400 frutas por ano. Calcularam que sua família, seus vizinhos e a caça comem uma parte dessa produção (100 frutas), deixando ainda 300 frutas de bacuri no chão.

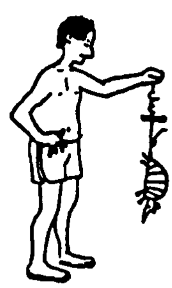
Curumi e Antoninho decidiram colher essas frutas e mandá-las para a feira. Mesmo com a variação dos preços durante a safra, eles obtiveram um lucro entre R$ 40 e R$ 60 pelas 300 frutas de uma árvore! A mão-de-obra envolvida na colheita e venda das frutas também foi bem pequena, comparada com a mão-de-obra necessária para ter o mesmo lucro fazendo farinha. Para ganhar essa mesma quantia de dinheiro com a venda da madeira, eles precisariam vender de 20 a 30 árvores. Eles entenderam que a venda de uma árvore é feita uma vez só, enquanto uma frutífera pode produzir frutas todos os anos de sua vida produtiva.

É certo que muita gente não pode chegar até as feiras por causa do trabalho na roça, falta de transporte, alguém doente na família ou falta de rancho para se sustentar na feira. Mas mesmo sem vender qualquer fruta é importante lembrar da "renda invisível" e da excelente nutrição das frutas consumidas em casa. As frutas da mata podem fornecer vinhos, sucos, cremes e doces.



A "renda invisível"

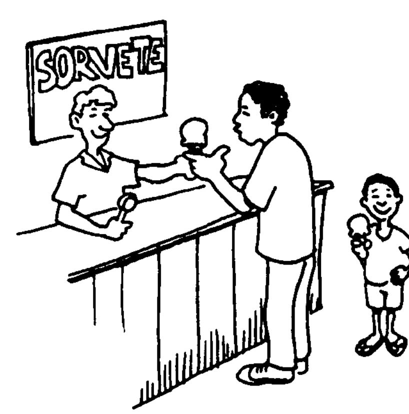
A mata oferece remédios, comida, fibra e caça - tudo de graça; mas é bem fácil esquecer disso. Para medir a importância da mata na economia doméstica, 30 famílias da comunidade de Quiandeua, no Rio Capim, pesaram todos os produtos florestais que elas extraíram. Os resultados mostraram que, durante um ano, os cipós, a caça as frutas que uma família média consumiu foi o equivalente a 25% da renda de um agricultor da comunidade. Bons caçadores ganharam mais que a metade de sua renda com as caçadas. Se eles tivessem que comprar esses produtos, gastariam tempo, transporte e dinheiro que eles não têm. E de onde você acha que eles extraíram a maioria dos produtos? Da mata fechada foram extraídos 85% dos cipós, 87% das frutas e 82% da caça. É importante fazer esses cálculos quando queremos vender madeira ou terra. Devemos lembrar que é possível negociar e guardar algumas partes de nossa floresta onde existem árvores úteis. Com planejamento, é possível manejar a mata e extrair tanto produtos madeireiros quanto frutas, cipós, óleos e caça.



NUTRIÇÃO

Doze por cento da fruta é polpa, 18% caroço e 60% casca. Suas sementes fornecem 65% de uma gordura castanho-avermelhada escura. O aroma do bacuri tem sido extraído e usado em iogurtes.

Você sabia que a casca de bacuri tem um sabor delicioso? Então por que deixar tantas cascas apodrecerem quando podem ser comidas? Principalmente porque uma grande porcentagem (60%) do peso da fruta é casca. Pode-se comer a casca do bacuri pura sem nenhum outro ingrediente. Para isso, é necessário cozinhá-la, eliminando as resinas abundantes. Porém, a casca fica mais saborosa se adicionarmos 20 a 30% da polpa. Também existem outras receitas mais complicadas, que levam leite e açucar. Experimente!



Doce da casca de bacuri

Quebre 6 bacuris, lave as cascas e ferva até amolecerem. Derrame na peneira. Em seguida, retire as películas das cascas, deixando só a massa. Misture 250 gramas de açúcar e 1 litro de água. Ferva até virar calda. Quando a calda engrossar, acrescente a massa. Ferva e mexa por 30 minutos até atingir o ponto.

Creme da casca de bacuri

As cascas devem ser cortadas, lavadas, fervidas até amolecerem, em seguida raspadas com uma colher. Para cada 5 a 7 cascas junte uma lata de leite condensado, uma lata de creme de leite, ¼ da lata de açúcar e ¼ da lata de polpa. Coloque a mistura numa forma de torta e leve ao congelador. Sirva uma hora depois.

Vinho da casca de bacuri

Raspe a casca, deixe de molho por 1 ou até 24 horas. Adoce e beba.

MANEJO

germinação
1 a 2 anos

crescimento
rápido no sol:
50 cm a 1 metro por ano

produção
8 a 10 anos

O bacurizeiro é uma árvore de múltiplos usos (fruta, madeira, resina) e com alto valor econômico. Esse valor significa que essas árvores devem ser protegidas no seu ambiente e que também devem ser plantadas ou manejadas em áreas degradadas. O bacurizeiro cresce bem em solos pobres, com melhor produção de frutas em áreas abertas com muito sol. Mesmo em áreas de fazenda, as árvores devem ser conservadas. Por causa do alto valor das frutas no início e no fim da safra, quem tiver árvores que produzem na entressafra deve mantê-las cuidadosamente, pois são valiosas.

As sementes devem ser plantadas logo após terem sido retiradas das frutas. A raiz nasce e cresce rápido, mas demora para brotar. Se você corta a raiz depois de 60 a 90 dias ela brota logo e pode ser plantada depois de 6 a 10 meses. Quando a muda atinge cerca de 50 ou 60 cm pode ser levada ao campo.[4] O espaçamento recomendado para esse plantio é de 10 em 10 metros, atingindo assim 115 plantas/ha. Plantas enxertadas podem começar a produzir entre 3 a 5 anos, enquanto mudas não enxertadas demoram de 6 a 10 anos. Também pode-se plantar a raiz ou o galho enterrando-os no chão. As frutas podem ser transportadas por longas distâncias, porque sua casca grossa não quebra facilmente. Sua polpa permanece em condições de consumo por 5 a 7 dias dentro da fruta.

Para maiores informações veja os trabalhos de:
[1] B.B.G. Calzavara e P. Cavalcante.
[2] H. Villachica.
[3] R. Braga.
[4] Pesquisa em andamento na Embrapa, Belém, por J. E. Urano de Carvaho e C. H. Müeller.

APPENDIX C

SAMPLE PAGES OF

RECEITAS SEM PALAVRAS: PLANTAS MEDICINAIS DA AMAZÔNIA

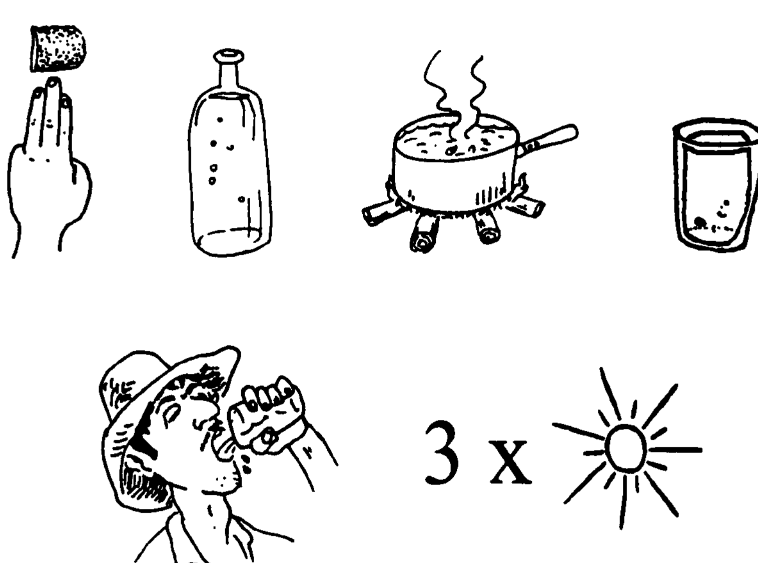
[RECIPES WITHOUT WORDS: MEDICINAL PLANTS OF AMAZONIA]

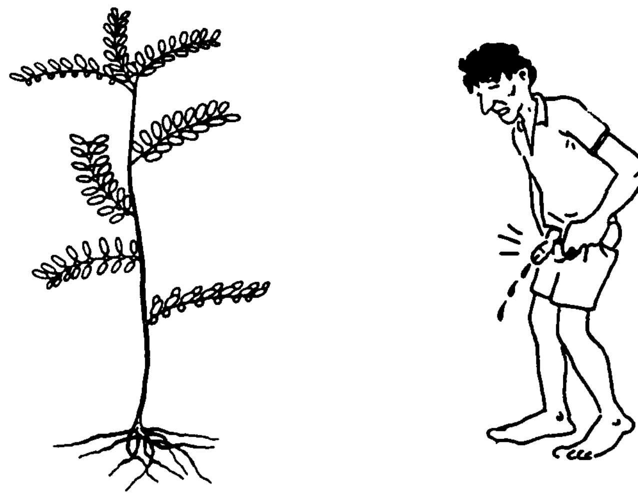
As dosagens mostradas são para adultos.
Para jovens (6-15 anos), usar metade da dosagem.
Para crianças (1-5 anos), usar um quarto da dosagem.

Tomar remédios depois da merenda, almoço ou jantar.

6. Jatobá *(Hymenaea courbaril)* Gripe, Fortificante

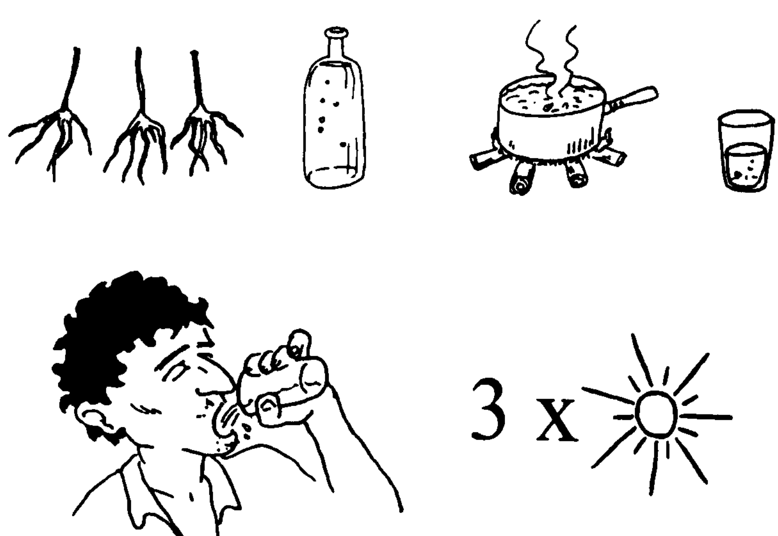
Ferver 3 dedos de casca (20g) em 1 litro de água por 15 minutos. Tomar 1 copo 3 vezes por dia.





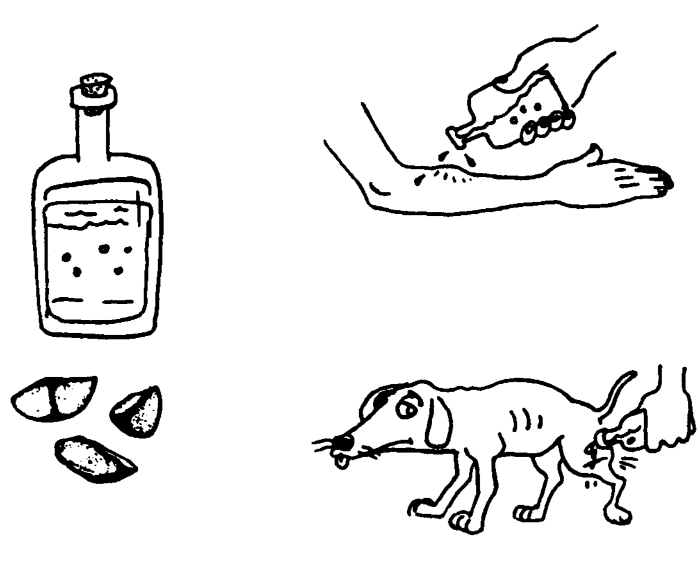
12. Quebra-pedra Branca *(Phyllanthus niruri)* Diurético, Problemas urinários

Pegar 3 raízes (20g) e ferver em 1 litro de água por 15 minutos. Tomar meio copo três vezes ao dia. Chá é anti-infeccioso das vias urinárias.



1. Andiroba *(Carapa guianensis)* Reumatismo, Machucaduras, Feridas de animais

Passar o óleo nas partes afetadas e fazer leve massagem. De preferência esquentar o óleo antes de usar e depois pode cobrir com um pano. Pode ser utilizado em baques e feridas de animais.



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