Açaí Palm Management in the Amazon Estuary: Course for Conservation or Passage to Plantations?

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*In the late 1980s, the açaí (*Euterpe oleracea*) fruit and palmito extraction system of eastern Amazonia was heralded as a promising alternative to deforestation that could simultaneously provide income to rural producers and protect forest integrity. We tested these claims in five communities located along a distance gradient from the largest regional market in Belém, Brazil. We evaluated the market accessibility and management strategies of açaí producers, and assessed the impacts of management on forest characteristics. In contrast to other NTFP systems, we found that distance to the major market is not a limiting factor for açaí sales because throughout the region intermediaries are readily available to transport açaí from producer to market. Demand for açaí fruit is increasing, leading to intensification of palm management, which results in the conversion of native floodplain forests into açaí-dominated forests that closely resemble plantations. We conclude that the açaí system is not typical of other NTFP and should not be regarded as a model for merging forest conservation with rural development. However, the increased demand for açaí, especially from educated consumers, together with the ease of production and marketing, present an opportunity to develop the açaí system into one in which both rural livelihoods and forest integrity are supported.*

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Chegou a Pará, parou; Tomou açaí, ficou
(Arrived in Pará, stopped; Ate açaí, stayed)

Common saying in Pará, Brazil

É a planta que alimenta
A paixão de nosso povo . . .
que eu sou muito mais que um fruto
sou sabor Marajoara

It's the plant that nourishes
The passion of our people . . .
I am much more than a fruit
I'm the flavour of Marajó

Nilson Chaves, from the song, *Sabor Açaí* (The Flavour of Açaí)

Introduction

Non-Timber Forest Products as a Strategy for the Conservation of Biodiversity

Over the past fifteen years, enthusiasm over the conservation and development potential of non-timber forest products (NFTP) has waxed and waned. Early reports suggested that NTFP might support rural livelihoods while simultaneously protecting forest cover and biodiversity (Arnold and Pérez 1998; Fearnside 1989; Panayotou and Ashton 1992; Peters et al. 1989a, 1989b; Plotkin and Famolare 1992). Moreover, it was proposed that as markets for NTFP developed and grew, the forests that provide these products would be increasingly valued intact and be less subject to deforestation for timber or agricultural production. As researchers have delved into studies of the social, economic and ecological aspects of the NTFP harvest, however, it has become increasingly clear that these lofty goals may be more difficult to achieve than initially envisioned. In some cases there is inadequate demand for the NTFP; in others markets are inaccessible to rural communities and the forests from which they harvest (Browder 1992; Godoy and Bawa 1993; Guimarães and Uhl 1997; Padoch 1992; Pendleton 1992; Shanley et al. 2002; Wallace 1999). A significant hindrance to marketing NTFP is the distance harvesters must travel to markets to sell their products. The cost of getting a product to market increases with distance, because fuel for transport is expensive. In some regions intermediaries, or middlemen, buy NTFP from harvesters and transport them to markets, but reliability of intermediary transport decreases with distance. If intermediaries fail to show up, or if harvested areas are too far from markets (that is, requiring several travel days), then perishable NTFP such as fruit may spoil before ever reaching markets. If markets are reached with viable products, the income earned may be too low to offset the costs of production and transport. Finally, market prices of NTFP can fluctuate greatly, and this can affect the ability of NTFP producers to effectively manage and harvest their products. The importance of these 'access to markets' issues suggests they may play a pivotal role in the future of NTFP development.

In addition to economic difficulties, NTFP enterprises have also faced challenges on ecological grounds. Some NTFP are harvested in destructive ways, such as collecting fruits by cutting down the tree (Peña Claros 1996; Peters 1996; Vasquez and Gentry 1989), or are harvested at intervals or intensities that have a negative impact on the health or recruitment of the resource (Anderson 1999; Gould et al. 1998; Hall and Bawa 1993; Peters 1994, 1996; Robinson and Redford 1994). Increased household income obtained in NTFP sales does not necessarily guarantee the maintenance of forest resources, as it is sometimes invested in technology that facilitates deforestation (Godoy 1995). Also, when an NTFP becomes economically important, the nature of its utilisation often changes. As an NTFP increases in value, the forest may be increasingly enriched with NTFP species to augment their production (Anderson et al. 1995; Ricker et al. 1999; Schulze et al. 1994) or the resource may be planted in home gardens and agricultural plots (Smith et al. 1992), and eventually in plantations where the yield and harvest is more efficient (Homma 1992, 1994).

Thus, there exists a tension between the socio-economic and ecological aspects of NTFP development (Lawrence 2003). On the one hand, overcoming obstacles to market access (for example, distance to market) can boost rural incomes, but may lead to intensification of forest management, destructive harvesting and the creation of plantations (Arnold and Pérez 2001; Struhsaker 1998). On the other hand, prioritising forest integrity can help ensure the long-term conservation of biodiversity, but may do little to alleviate rural poverty (Browder 1992). Resolving this tension is a necessary step to achieving the multiple goals of NTFP development.

In the late 1980s data began to emerge on a so-called model for conservation in the Amazon basin: the açaí palm, *Euterpe oleracea*. Research suggested that forests managed for *Euterpe oleracea* (hereafter 'açaí'; pronounced ah-sigh-EE) closely resembled native forests yet provided substantial income for rural people (Anderson 1988; Anderson and Ioris 1992). More recently, açaí has been a focal species in extractive reserves (areas designated specifically for the long-term sustainable harvest of forest resources) and other rural communities (Allegretti 1990), where people actively manage forests for production. Markets for NTFP from açaí (primarily fruit and palm heart) have greatly expanded, as have strategies for its production. One proposal calls for the planting of 5 billion açaí plants in the next ten years (O Liberal 2000). These recent developments beg the question of whether the açaí system truly strikes a balance between conservation and development.

In this article, we present results of detailed socio-economic and ecological studies of the açaí system across a range of sites in the Amazon estuary. Our research addressed two main questions: (*a*) How does household distance from a major market centre influence açaí palm management decisions? and (*b*) What are the ecological effects of açaí palm management? To address the former, we collected information on açaí palm management strategies and household production, sales and transportation of açaí NTFP in interviews with açaí-producing households at sites along a distance gradient from the major centre of açaí commerce. We evaluated the ecological effects of açaí palm management at two levels: (*a*) açaí populations; and (*b*) forest composition and structure. We analysed açaí density and demography from forest areas managed for açaí to address how management affects açaí populations at sites throughout the Amazon estuary. We evaluated the effects of açaí management on forest vegetation composition and structure by comparing canopy height, vegetation density and stem diameters of vegetation in forest stands managed for açaí production with stands not managed for açaí production. By understanding the factors that influence management decisions and the ecological effects of that management, a more comprehensive strategy to promote forest conservation and rural incomes can be developed.

The Açaí Palm: A Model NTFP for Conservation in the Amazon?

The quotations at the opening of our article offer a glimpse into the importance of açaí in the eastern Amazon. Archaeological evidence indicates that the fruit of the açaí palm has been a component of the diet of estuarine inhabitants since ancient times (McCann 1999; Roosevelt et al. 1996), and today açaí is venerated in popular songs and festivals, which are held in its honour in scattered villages during the fruit harvesting season. As traditional forest management systems have attracted increased attention from scholars and conservationists, research has documented the various current and potential uses of açaí (Pollak et al. 1995; Strudwick and Sobel 1988); the ways in which it is managed and harvested (Anderson 1988, 1990; Anderson et al. 1995); its role in household, local and regional economies (Anderson and Ioris 1992; Hiraoka 1995; Muñiz-Miret et al. 1996; Warren 1992), and the potential for increased production and more efficient management (Anderson and Jardim 1989; Jardim and Rombold 1994). In many ways, açaí is considered a model NTFP for conservation of floodplain forests of the Amazon delta because it overcomes many of the challenges often attributed to other NTFP systems: (*a*) unlike many tropical forest trees, açaí occurs at high densities along accessible river margins; (*b*) local inhabitants have a long history of extractivism and the palm has traditionally provided products that are a major part of their subsistence; (*c*) the extensive network of rivers and streams throughout the region provide access to markets and towns, including Belém, the largest city in the Amazon basin; (*d*) the açaí palm has two commercially valuable products, its fruit and palm heart; and (*e*) other land uses, such as timber extraction or agricultural production, are considered less profitable than NTFP extraction in the flooded estuary environment (Anderson and Ioris 1992).

While the açaí palm provides many useful products to local inhabitants (called ribeirinhos or caboclos), it is most known for its commercially valuable products: its fruit (açaí fruit) and palm heart (palmito). Açaí fruit is harvested by climbing the tree and cutting off the ripe bundles of fruit (the infructescence; Figure 1).

Figure 1
Ribeirinho Harvesting Açaí Fruit

Note: This teenager is holding a single infructescence of açaí, weighing several kilograms. Most of the stems of the palm in the foreground are from the same genetic individual. Açaí fruit is harvested mainly by men, children (typically boys, beginning around 8 years of age), or single women who are the head of their household. Reproductive stems of the palm range in height from 5 to over 15 m, depending on light availability and other ecological conditions. Although the timing of the açaí fruit harvest season varies among sites in the estuary, the majority of açaí fruit is harvested in the dry season from July to December. Ribeirinhos may collect over 100 infructescences in a single day during the harvest season. (Photo taken near Igarapé Miri in 1999 by S. Weinstein.)

The rind (mesocarp) of the açaí fruit is ground and mixed with water to form the thick, purple vinho, which forms a staple part of the ribeirinho diet. In towns and cities, açaí is processed into vinho at small stands or shops and sold by the litre, or it is made into ice cream or other desserts. Palmito is generally not eaten in the estuary but is exported principally to southern Brazil, France and the United States.

Ecologically, *E. oleracea* is considered to be an ideal source of NTFP because an individual palm grows as a multi-stemmed clump (Figure 1). In biological terms, these clumps are called 'genets', and they consist of genetically identical stems, each of which is called a 'ramet' (hereafter we will refer to a genet as a clump and a ramet as a stem). Although stems of the palm are felled in order to harvest palmito, the entire palm is not killed because of its growth form, whereby other stems and sprouts remain in the clump. Not only does the palm survive the palmito harvest, but the selective harvest of stems has been shown to increase fruit production in the remaining stems (Anderson and Jardim 1989). Thus, ribeirinhos can benefit economically from management strategies that allow them to harvest both palmito and açaí (Anderson 1988; Anderson and Ioris 1992). Ribeirinhos actively manage açaí for fruit and palmito production in forests that have been described as being 'almost indistinguishable from the native floodplain forests' (Anderson 1990: 70).

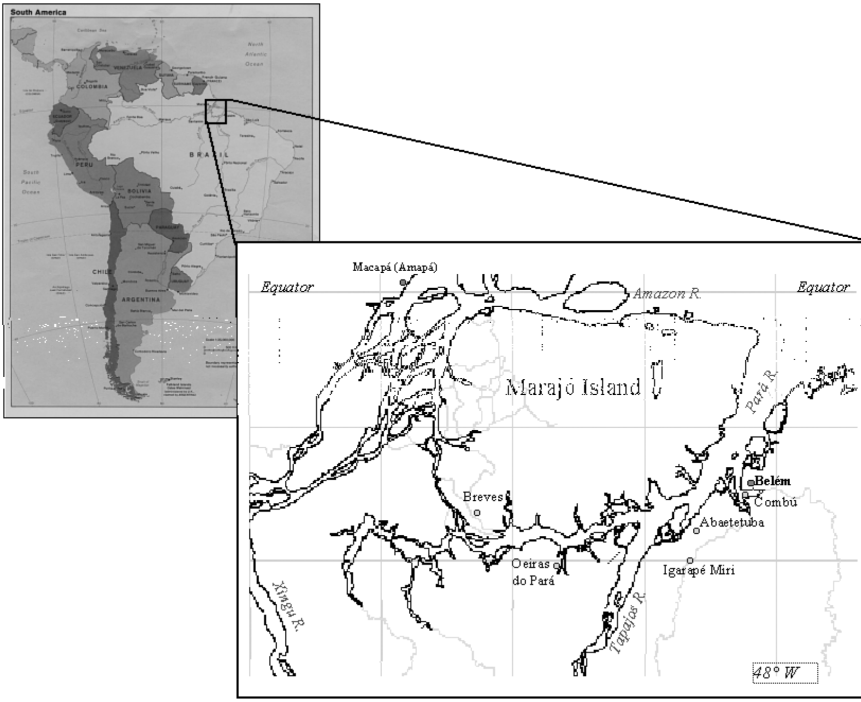
Despite the potential for sustainable use of açaí for both palmito and fruit, over-harvesting of palmito has been reported in parts of the estuary, resulting in the demise of some palm populations and threatening the subsistence needs of locals (Clay 1997; Pollak et al. 1995). One factor that may influence harvest and management decisions is the distance that ribeirinhos are from markets. Although most ribeirinhos are fairly accessible to towns and cities via waterways, açaí fruit is highly perishable and must reach market and be processed within twenty-four to forty-eight hours of harvest to retain its unique flavour (Smith 1999). In contrast, palmito is the apical bud of the palm and is protected by leaf sheathes. Palmito remains fresh for four to five days and is processed in factories in towns and cities as well as in small backyard processing facilities scattered along river margins. Thus, ribeirinhos living close to cities might be expected to focus on açaí fruit production, while those at greater distances might be predicted to focus on palmito production.

Study Area

Ecology of the Amazon Estuary

The Amazon estuary extends from the mouth of the Xingu river to the mouths of the Amazon and Pará rivers, which merge on the eastern side of Marajó, a 50,000 sq. km island (Figure 2). Most of the Amazon estuary is within the Marajó *várzea* ecoregion, which is distinct from surrounding areas by its seasonal and tidal flooding and poorly-drained clay soils consisting of Holocene (less than 10,000 years old), and slightly older and higher tertiary deposits (WWF 2001). The region receives an average of 2,300 mm of annual rainfall, three quarters of which falls during the rainy season from December to June (Calzavara 1972). Tides inundate the estuary twice daily, pushing a large volume of river discharge onto the landscape and raising the water level an average of 1.2 m. The tides and seasonal flooding create an interconnected network of rivers, streams and channels surrounding abundant sedimentary islands. These waterways and landforms are dynamic landscapes, with constantly changing stream margins, vegetation and drainage. There are over 25,000 sq. km of floodplain forests (also called *várzea*) in the estuary, including 10,000 sq. km that are dominated by *Euterpe oleracea* (Lima 1956). The vegetation of the ecoregion is characterised by low plant diversity and dominance by plant species that are adapted to extreme flooding, shallow

Figure 2
The Amazon Estuary and Study Sites



Note: The Amazon estuary is characterised by floodplains that are inundated both seasonally and by twice-daily tides. The Amazon estuary extends from the western edge of Marajó Island and the mouth of the Xingu river over 250 km to where the Amazon and Pará rivers empty into the Atlantic Ocean. The estuary includes portions of the Brazilian states of Pará and Amapá, including the state capitals Belém and Macapá. Study sites were located in floodplain forests centred around Combú, Abaetetuba, Igarapé Miri, Oeiras do Pará and Breves.

soils, low soil oxygen levels and frequent disturbance. Species that are well-adapted to these conditions include *aninga* (*Montrichardia* sp.; Araceae), the *mirití* palm (*Mauritia flexuosa*) and the açaí palm, which are considered important in colonising and stabilising riverbanks and island margins (Strudwick and Sobel 1988). The *várzea* forests perform important ecological functions such as nutrient cycling, and the ecoregion has a high diversity of birds, freshwater fish and aquatic mammals (WWF 2001).

All of our study plots were located within floodplain forests in the Amazon estuary. From prehistoric times to the present, these forested areas have been shaped to varying degrees by human activities, including NTFP extraction, logging, and agriculture (for example, Anderson et al. 1999; Dean 1987; Roosevelt et al. 1996). None of the forest areas where data collection took place could be considered 'pristine'. However, aside from differences in management, our study plots were located in ecologically similar environments on tidally inundated lands where the açaí palm is a native and conspicuous component of the forest systems.

Ribeirinho Livelihoods

The lives of ribeirinhos are intricately linked to the ebb and flow of the river. They live in scattered settlements in towns or along rivers and island margins where their homes are built on stilts to avoid the twice-daily tidal inundations (Figure 3). The existing pattern of ribeirinho settlement heralds back to at least as early as the nineteenth-century rubber boom, when ribeirinhos were the primary labour force for European landholders (Brondízio and Siqueira 1997). Today the majority of ribeirinhos live on small areas of land (1–50 ha). Although most do not have legal title to their land, these smallholders are free to decide how to manage their lands, including how and where NTFP and/or agricultural products are managed, when they are harvested, and where and to whom they are sold (ibid.). Owners of medium to large landholdings (50–200 ha) are primarily urban entrepreneurs who do not live in the floodplain forests and instead rely on ribeirinho sharecroppers or lessees (ibid.). Ribeirinhos who are sharecroppers on these larger properties have little control over natural resource management, and in particular

Figure 3
Ribeirinho Home in the Amazon Estuary

Note: Palms in the foreground and background are *Euterpe oleracea*. (Photo taken near Igarapé Miri in 1999 by S. Weinstein.)

over the harvest and marketing decisions for açaí and palmito (ibid.). We limited our study (and the description of ribeirinho land uses, below) to include only those households that have full control over forest management decisions.

Every ribeirinho household has some form of watercraft, whether a dugout canoe or motorboat, which is used for transportation to school, markets and to access NTFP in the surrounding forests. The *várzea* environment is rich with aquatic and terrestrial resources used by ribeirinhos. Ribeirinhos catch fish and shrimp from the rivers and streams, and are able to cultivate some crops, including beans and manioc on higher ground. Forest gardens surrounding ribeirinho homes (homegardens) include a diverse assortment of exotic, native and semi-domesticated plants, which are important sources of food, medicine and construction materials (Smith 1999). In the Amazon estuary, homegardens also include an intensively managed area of the açaí palm, called an *açaízal*. Floodplain forests are farther from ribeirinho homes and are managed to varying degrees. Areas closest to the home are often managed to increase production of açaí; in this study we refer to these areas as 'açaí-enriched' forests. Other forest areas, usually more distant from the home, may be used by ribeirinhos for hunting, selective logging, fishing, and gathering of wild fruits and other NTFP as a source of food, medicine or construction materials. These areas have sometimes been called 'mature floodplain forests' (for example, Anderson et al. 1995) because they are late-successional forests that are less intensively used than other forest areas. In our study we refer to these forest types as 'non-enriched' to emphasise that they are not enriched for açaí production, although they may be used by ribeirinhos for other purposes. Because the majority of ribeirinhos rely on NTFP for some of their income, ribeirinho activities are seasonal and depend on market demands (Anderson et al. 1995; Hiraoka 1999; Jardim 1996).

Markets

Ribeirinhos in the estuary are integrated at various levels into the market economy. Villages with markets, shops, churches, hospitals and other institutions are scattered throughout the estuary and ribeirinhos have links to these populated centres. The largest city in the Amazon basin is Belém, located at the mouth of the Pará river, with almost 2 million inhabitants. The largest market in Belém is the Ver-o-Peso ('see the weight'), where boats from all over the Amazon converge every morning before dawn and unload a diverse array of products including fish, cultivated fruits and vegetables, and numerous NTFP gathered by ribeirinhos from the surrounding floodplain forests. The Ver-o-Peso has an enormous market for açaí fruit, the Feira do Açaí, where an estimated 70 to 120 vendors sell approximately 204,000 kg of fruit per day during the peak harvest season from July to December (Warren 1992). Belém also has numerous other smaller markets for agricultural products and NTFP, including four smaller-scale açaí fruit markets (ibid.). Some of the scattered towns throughout the Amazon estuary have small markets where NTFP and agricultural products are sold. Although these markets may also serve as the final destination for ribeirinhos' NTFP, demand is substantially lower in these areas than in Belém, particularly in the case of açaí. For example, although Abaetetuba is one of the largest towns in the estuary, its population of approximately 64,000 (FIBGE 1997) is significantly smaller than that of Belém. Consequently, the demand for açaí in Abaetetuba is substantially less than in Belém, with ten to twenty vendors selling approximately 45,000 kg of fruit per day during the peak harvest season (Stephanie Weinstein and Susan Moegenburg, personal observations).

Palmito factories are scattered throughout the estuary. They range in size from simple makeshift structures on ribeirinhos' properties that are used as seasonal operations, to larger factories that are registered with IBAMA, the Brazilian environmental protection agency. Palmito is processed at these factories and then transported to Belém where it is exported to regions outside the Amazon.

Methods

Açaí Palm Management Strategies

Semi-structured interviews were conducted with twenty-five ribeirinho households from May to August 1999. Interviews took place in ribeirinho homes, homegardens and managed forest areas. The purpose of the interviews was to gather information on the types of açaí palm management strategies used by ribeirinhos, and the frequency and intensity of their use at sites throughout the estuary. We also wanted to determine if ribeirinhos focused açaí palm management on palmito or açaí fruit production, and if this focus varied among study sites.

Households were located on islands or in rural areas surrounding five main sites: Combú Island ($n = 5$ households), Igarapé Miri ($n = 5$), Abaetetuba ($n = 6$), Oeiras do Pará ($n = 5$) and Breves ($n = 4$). These sites were chosen in order to have a sample of households found along a distance gradient from Belém; sites are located 1.5, 52, 70, 150 and 250 km from Belém respectively (Figure 2). Within each study area, households were selected using a snowball sampling method in which a key consultant is located and this person then leads the researcher to other appropriate consultants (Bernard 1995). Study households were limited to those possessing the right to make all decisions regarding the harvest, marketing and transport of açaí fruit and palmito from the property (that is, not sharecroppers), and to those that produced açaí fruit to sell (that is, in addition to household consumption).

Market Influences on Açaí Palm Management and Sales

In each of the twenty-five households sampled using the methods described in the previous section, we also conducted interviews to determine if a household's distance to Belém influenced açaí management decisions and the annual sales of açaí fruit and palmito. As the largest population centre and the site of the largest

NTFP markets in the Amazon basin, we hypothesised that Belém exerts a disproportionate influence on ribeirinho forest management decisions throughout the Amazon estuary and that this influence varies along a distance gradient from Belém. We expected that açaí palm management decisions would depend largely upon the household production of açaí fruit and palmito, transportation opportunities to bring açaí NTFP to markets, and the prices received for these products. Because açaí fruit is highly perishable and its greatest demand is in Belém, we expected that households located closer to Belém would focus açaí palm management on fruit production and sales whereas those farther from Belém would concentrate on palmito production. Additional informal interviews were conducted at each site with palmito factory workers, açaí fruit vendors and middlemen in açaí markets to develop a better understanding of the palmito and açaí fruit industry throughout the estuary.

Ecological Impacts of Açaí Palm Management

Açaí Palm Density and Recruitment Differences in household management activities might be reflected in differences in açaí population structure, including açaí clump density and açaí stem demography. Açaí clump density is an important measurement because it gives an indication of açaí enrichment planting activities. Açaí stem demography data allow us to assess if sufficient recruitment is occurring from each life stage of the açaí palm, from seedling to adult. It is important to evaluate recruitment in studies of NTFP systems because the harvest of the NTFP could impact particular life stages of the plant. For example, areas with intensive açaí fruit harvesting might have fewer seedlings, whereas areas with intensive palmito harvesting might have a high number of younger stems of açaí but fewer larger, reproductively active stems.

Data on açaí populations were collected along transects in the floodplain forests at each of the twenty-five households where interviews took place. Transects began at a point in any area of the forest where the harvest of NTFP from açaí occurred, outside of the homegarden. The direction of the transect was selected such that the length of the transect could be walked without crossing the household land boundary or fording any rivers. Density of açaí clumps was estimated using the point-centred quarter method (Greig-Smith 1983). Starting at the chosen point within the açaí-managed forest area, a quadrant was formed in a random orientation by tossing a stick in the air and laying another stick perpendicular to the first. In each of the four quadrants, the distance (r) from the sticks' intersection point to the centre of the nearest clump of açaí was measured. In each quadrant we recorded the number and height of each seedling and adult stem of açaí and categorised each into one of six size class categories: (*a*) seedlings without stems; (*b*) seedlings with stems up to 2.5 m in height; (*c*) juveniles 2.5–6.0 m; (*d*) adults 6.0–10.0 m; (*e*) adults 10.0–15.0 m; and (*f*) adults greater than 15.0 m. Size categories are based on personal observations of heights at first fruiting in managed floodplain forests (usually over 6 m) and the recorded height limits for this species (Henderson 1995). At each quadrant we also recorded data on the amount of vegetation cleared around a clump of açaí. A second point-centre was laid 20 m directly ahead in the predetermined direction. Between six and eight quadrants were laid on a transect (transect length 120–160 m, n = 24–32), depending on household land area or land constraints, such as rivers cutting across landholdings.

The density of açaí clumps at each household forest area was determined by measuring r, the distance in metres from the point-centre to the clump, and n, the number of quadrants sampled on a transect. Açaí clump density was calculated using the following equation: density = $1/(\Sigma r/n)^2$ (Greig-Smith 1983). We calculated the density of açaí stems in each size class by multiplying the result of the equation above by the mean number of stems in a size class per clump on a transect.

Vegetation Clearing Around Açaí Palms We estimated the amount of clearing of mid- and overstorey vegetation around the açaí clumps using the point-centred quarter method described above. Within each quadrant, we measured the distance between the açaí clump and the closest tree (not açaí) with diameter at breast height (DBH) greater than or equal to 5 cm. Distances were grouped into four categories: (*a*) 0–3 m; (*b*) >3 and <5 m; (*c*) >5 and <10 m; and (*d*) >10 m. For each transect, the number of measurements in each of the four categories was converted to a percentage. These percentages were then averaged for all transects within a site (that is, Combú, Abaetetuba, Igarapé-Miri, Oeiras do Pará and Breves) to give an estimate of clearing.

Vegetation Composition and Structure in Açaí-enriched and Non-enriched Forest Areas In addition to affecting açaí palm populations, management might also affect overall structure and composition of the forest. To evaluate this, a detailed analysis was done of vegetation structure and composition in forest stands on islands near the town of Abaetetuba. Data were collected from September to November 1997 in ten forest stands: five enriched with açaí (hereafter 'enriched') and five not enriched with açaí (hereafter 'non-enriched'). These forests were identified through conversations with local people. Enriched stands had been so managed for at least twenty years and were approximately 4–5 ha in size. The sizes of the non-enriched stands ranged from 10 to 100 ha. Although some of the enriched and non-enriched stands were adjacent to each other, the locations at which data were collected within the stands were all greater than 500 m apart. Aside from differing in management activities, the ten forests were in close proximity and were similar in soils, topography and vegetation. Non-enriched forests have long been subject to subtle management, in which people selectively remove trees for timber and remove other products, such as palm leaves for thatch, bark for medicines and fruits for food. Nevertheless, they differ from enriched forests by not being managed specifically for açaí production.

Vegetation variables, including canopy height, canopy cover, and the number and diameter at breast height of all plant stems were evaluated in each of the ten sites along a 50×1 m transect. Fifty metres was chosen as the minimum transect length that allowed a characterisation of the vegetation while remaining within a homogeneous stand of each forest type. Within such stands, transect starting points and orientations were located randomly. Along each transect canopy height and cover were estimated at 5 m intervals for a total of ten points per transect. Canopy cover was measured using a spherical densiometer, an instrument for measuring forest overstorey density (Lemmon 1957). Canopy height was visually estimated after practising with a clinometer at known distances from trees. All stems within each transect were counted and recorded as belonging to one of the following categories: *E. oleracea*, other palms (for example, *Mauritia flexuosa, Raphia taedigera*), aninga (*Montrichardia linifera*), non-woody vine, woody liana or hardwood tree. DBH of all stems was measured using either a DBH tape or dial calipers.

Result and Discussion

Açaí Palm Management Strategies

A summary of ribeirinho management strategies for açaí is found in Table 1. Data were pooled for all households because of small sample sizes at each individual study site. Sample sizes less than twenty-five signify that ribeirinhos at one or more households were not certain if a particular management strategy was used.

Ribeirinhos generally divided management activities into three main categories: enrichment, cleaning and stem cutting. These three general categories of açaí management are described in more detail later. In addition to these commonly employed management strategies, we also describe two other practices that were infrequently used by ribeirinhos: cutting off the inflorescence, and tying the leaves of juvenile stems into knots.

Enrichment Enrichment strategies include planting açaí palm seeds and/or seedlings and relocating seedlings to areas of the forest where more açaí palms are desired. Fifteen of the twenty-five households interviewed, representing households from all study sites, regularly engaged in enrichment activities. Those that did not plant açaí seeds and seedlings stated that the palms were already at sufficient densities, indicating that enrichment activities had likely occurred at sometime in the past. After making *vinho*, the staple food from açaí, households are left with a tall mound of discarded seeds, which serves as food for domestic animals as well as a source of açaí seeds and seedlings (Strudwick and Sobel 1988). Seedlings are transplanted to areas with more available sunlight, or farther from other açaí clumps where they do not compete for light or nutrients and are sufficiently spaced such that they are easier to climb. Some households plant seeds of rare varieties of açaí, such as 'white açaí' (açaí *branco*), which sells at higher prices in markets (approximately US$ 0.60 more per 15 kg in 1999). Nine of the ten households that planted significant number of açaí seeds and seedlings were from areas surrounding Abaetetuba and Igarapé Miri. This region has recently undergone a transition from

Table 1
Euterpe oleracea *Management Strategies Used by Households in Five Study Sites in the Amazon Estuary*

Category	*Management strategy*	*Level*	n *(%)*
Enrichment	Plant *E. oleracea* seeds and/or seedlings	No	10 (40)
		Yes, few	5 (20)
		Yes, many	10 (40)
	Relocate seedlings	No	10 (40)
		Yes	15 (60)
Cleaning	Add mulch around *E. oleracea* clumps	No	14 (56)
		Yes	11 (44)
	Weed understorey vegetation	No	2 (8)
		Yes	23 (92)
	Cut or girdle trees	No	2 (8)
		Yes, selective	14 (56)
		Yes, leave only if tree will fall on açaí	9 (36)
Stem cutting	Cut stems from *E. oleracea* clump	No	2 (8)
		Yes, leave stems in forest to rot	1 (4)
		Yes, sell palmito	22 (88)
	Age of stem when cut	Up to 4 years	4 (17)
		5–10 years	2 (9)
		Only cut when stem is very old or too tall to climb	17 (74)
	Palmito harvest frequency	Every 1–2 years	10 (50)
		Infrequently (every 3 or more years)	7 (35)
		Never	3 (15)
Other	Tie knots in leaves of *E. oleracea*	No	24 (96)
		Yes	1 (4)
	Cut inflorescence of *E. oleracea*	No	24 (96)
		Yes	1 (4)

sugarcane production and swidden-fallow agriculture to açaí-managed floodplain forests (Brondízio et al. 1994; Brondízio et al. 1996; Brondízio and Siqueira 1997; Hiraoka 1995).

Cleaning A second group of management activities is termed '*limpeza*' (literally meaning 'cleaning') by ribeirinhos. The most commonly practised cleaning activities were weeding understorey vegetation, such as various species of grasses, seedlings and tree saplings, and cutting or girdling vines, woody lianas and trees from the area surrounding an açaí clump (Figure 4). Households from all sites took part in cleaning activities, which generally begin at the end of the rainy season in May before the fruit has ripened, and continue throughout the duration of the açaí harvest. Ribeirinhos stated that cleaning activities encourage açaí to grow faster, improve access to the palms, make the palms easier to climb, and make them safer to climb (for example, by removing poisonous snake habitats).

Figure 4
Cleaning Understorey Vegetation from Açaí-enriched Forest

Note: This forest area, near Igarapé Miri, is managed intensively for açaí. All trees shown are *E. oleracea.* (Photo by S. Weinstein 1999.)

Those households that refrained from weeding did so because they claimed they lacked the time or labour required. Only two households did not cut trees from the forest; these households already had a mature and well-established açaí-enriched forest, and one explained that cutting other trees would cause increased light penetration and the spread of unwanted understorey vegetation. To this person, lower fruit production was offset by lower labour needs. Of the twenty-three ribeirinhos that removed trees, fourteen were selective about the trees that they cut, leaving certain species that are economically important, such as virola (*Virola surinamensis*) and andiroba (*Carapa guianensis*), both valuable timber species. Nine of twenty-five households, representing all sites except for Combú and Breves, aimed to turn as much of their forest as possible into a virtual monocrop of açaí, and only refrained from cutting or girdling those trees that might fall on the palms.

Stem Cutting Ribeirinhos distinguished between the above-mentioned activities and stem cutting (called '*manejo*' by ribeirinhos, literally meaning 'management'), which was reserved to describe cutting adult stems of açaí from clumps. Ribeirinhos remove stems from açaí clumps to harvest palmito, particularly during the winter (January to May) when açaí production is scarce (Anderson and Ioris 1992). In addition to providing needed seasonal income, ribeirinhos gave other reasons for removing açaí stems, including: to stimulate younger stems to develop faster; to increase fruit production, especially during the winter (rainy season) when açaí fruit is typically scarce; to clear an area of the forest that will be used for another purpose, such as agricultural production or cultivation of other fruit trees; and to prevent neighbours from stealing fruit and/or palmito. In experimental forest plots, Jardim and Rombold (1994) corroborated ribeirinhos' assertions that removing stems from a clump of açaí does indeed serve to increase fruit production in the remaining stems. Twenty-three out of twenty-five households interviewed removed açaí stems, and all but one sold the palmito from the cut stems. Those that did not harvest palmito were only found at Combú and Oeiras do Pará, and stated that it was not worth the time and effort to do so for the low wages received. However, all households had harvested palmito at some point in the past, and most spoke of indiscriminate harvesting of palmito on their properties when the industry first arrived in the estuary in the late 1960s. Today, households are divided on how frequently they harvest palmito. Ten out of twenty-three households cut many stems from portions of their landholdings every one to two years, whereas seven out of twenty-three harvested less frequently, usually every five to seven years. However, because of the importance of açaí fruit in household subsistence and economics, seventeen out of twenty-three households cut only those açaí stems that no longer serve in açaí fruit production because they are too tall to climb safely or they are older and have diminished fruit yield.

In sum, although twenty-two out of twenty-five households harvest palmito, all households balanced the palmito harvest with management to maintain sufficient açaí production for subsistence needs and income. This finding did not support our hypothesis that households farther from Belém would concentrate açaí management on palmito production. Many households admitted that they once cleared their forests of açaí to sell the palmito and that, as a result, they suffered from a lack of açaí fruit for consumption. Today it appears that, at least at the household level, ribeirinhos generally do not engage in indiscriminate palmito harvest on their own properties due to their negative experiences with overharvesting in the past. Nonetheless, ribeirinhos complained of theft of both açaí fruit and palmito from their properties, and one motivation for some households to harvest palmito was to attempt to pre-empt theft of either palmito or açaí. Because households in the estuary are in relative proximity to one another and are easily accessible by boat, theft of NTFP is a common occurrence and is difficult to control. Predatory palmito harvesting from large landholdings, especially with absentee landowners, is also likely to still occur in parts of the estuary (O Liberal 2002).

Other Management Strategies In addition to the commonly used strategies noted above, some ribeirinhos described other açaí management practices, including climbing trees to cut off the inflorescence before the fruits develop and tying the leaves of juvenile stems into knots. The technique of cutting the inflorescence was described by households in the vicinity of Oeiras do Pará. Cutting off the inflorescence when it first emerges in the summer apparently causes the tree to produce a new inflorescence that will produce fruit by winter, when açaí is normally scarce and expensive. This management practice was experimentally tested by Jardim and Rombold (1998). The authors found that cutting early inflorescences resulted in an extended fruiting season (that is, into the winter), but did not result in increased fruit yield. Tying knots in the leaves purportedly produces a shorter and stouter adult tree that has a fatter palm heart and fruits that grow lower to the ground. Many ribeirinhos had heard of this technique, but only one household encountered actually practised it. We never observed this management practice, nor do we know if or how tying knots in leaves produces the described effects.

Market Influences on Açaí Palm Management and Sales

Because there is such great demand for açaí fruit in Belém and it is highly perishable, we expected that there would be significant differences in household sales of açaí fruit and palmito, market values and household income from açaí NTFP among sites across the distance gradient to Belém. However, this hypothesis was not supported by data gathered in household interviews.

The Palmito Industry As discussed in the previous section, twenty-three of the twenty-five households harvest palmito and there was no relationship between the frequency of harvest or number of stems harvested and the distance of a household to Belém. Palmito prices vary primarily depending on the size and texture of the palmito. Prices are slightly higher in the summer, when most ribeirinhos are harvesting açaí fruit rather than palmito. Palmito prices are lower and fluctuate less than açaí fruit. For example, in Igarapé Miri in 1999, fifty first-quality stems of palmito were sold for US$ 7.50, which is approximately as much as one to two baskets of açaí fruit (about three to ten infructescences; 15–30 kg). Although palmito provides a valuable source of income for açaí producers when açaí fruit is scarce, the future of the palm heart industry in the estuary is uncertain. One household in this study cut stems from açaí to promote increased fruit production, but did not harvest the palmito from cut stems. This may signal a decrease in the importance of palmito production from the Amazon estuary and other households may follow suit, particularly if açaí production during the winter increases. French and United States imports of palmito extracted from plantation-grown *Bactris gasipaes* (called *pupunha* in Brazil, *chonta* in Ecuador and *pejibaye* in Costa Rica) from Costa Rica and Ecuador have been increasing steadily since the 1990s and will likely overtake imports of Brazilian palmito (Library of International Trade Resources 2000; SICA 2003). Heart of palm from plantation-grown *B. gasipaes* offers what the industry considers to be a higher quality product than the palmito produced from *E. oleracea* in forest stands. In 1999 three palmito factories visited near Breves were struggling to stay in business. Numerous makeshift factories in ribeirinhos' homes that were once common sights around Igarapé Miri had disappeared by 2001, allegedly because of a crackdown by IBAMA. Recent deaths in southern Brazil from botulism from canned palmito also brings into question the health standards of the largely unregulated industry in the estuary.

Household Production and Sales of Açaí Fruit In the açaí fruit trade, a standard unit of measurement of açaí fruit quantity is the '*lata*'. A *lata* is a large can that holds approximately 15 kg of fruit. The estimated number of *lata*s of açaí sold per harvest season by a household ranged widely, from a low of twenty-six (on Combú) to a high of 5,000 (in Igarapé Miri), with a mean ± standard error of 1,300 ± 252 *lata*s for all households. The volume of açaí fruit sold during the main summer harvest season for açaí from June to December was not significantly different among sites or with distance from Belém (ANOVA $F_{4,19} = 1.50$, $p > 0.2$). The price received per kilogram during the summer harvest season was also not significantly different among sites (ANOVA $F_{4,19} = 1.27$, $p > 0.2$) with a mean ± standard error of \$2.0 ± 0.1 and a range of \$1.2 to \$2.7 per *lata*.[1]

The data presented above are for household production and sales of açaí limited to the summer harvest season, when the fruit is most abundant and all households have surplus açaí fruit to sell once household consumptive demands are met. However, during the winter (rainy) season few households have sufficient quantities of açaí fruit to sell and during this season most must dilute vinho with water to stretch their supplies to meet consumptive needs. Because of its relative scarcity during the winter, the market demand for açaí fruit is greater and prices increase—doubling or increasing up to almost ten-fold that of the summer prices, ranging from \$5.40 to \$11.10 per *lata*. In years of notable scarcity, a *lata* of açaí fruit regularly sold for as much as \$15 in the winter. Only twelve out of twenty-five households were able to sell açaí fruit during the winter, but those that did derived a significant portion of their yearly income from açaí fruit sold at this time (a mean of 18.2 per cent up to a maximum of 57.2 per cent of their yearly income). Households from Combú sold significantly more açaí fruit during the winter harvest (ANOVA $F_{4,19} = 4.23$, $p < 0.02$; mean=107 ± 39 *lata*s) than households from all other sites except Igarapé Miri. Households from Combú did not seem to manage açaí differently or more intensively than households from other sites and did not have significantly higher densities of açaí palms. However, the commercialisation of açaí fruit in the Amazon estuary began in the region around Belém in the early 1970s, so it is possible that households from Combú have more experience with *E. oleracea* management and marketing than in other localities and have managed to increase winter production in ways that were not detected in this study. Alternatively, the higher volume of açaí fruit sold in the winter from Combú might be attributable to natural variation in açaí fruit ripening periods throughout the estuary.

Based on estimates of volume sold during the harvest and price received per *lata*, we calculated a rough estimate of income derived from the sale of açaí in each household. Household income from açaí during the açaí harvest season ranged from \$70 to \$8,100, which was equivalent to \$1.70 to \$702 (mean ± SE = 135 ±40) per ha of household land. In contrast, when açaí fruit sales from the winter harvest are included in calculations of annual income, it increased to a maximum of \$951 per ha (mean ± SE = \$159 ± 50), with a range from \$16.60 to

$951 per ha of household land, when including only those households with winter income ($n = 12$). Although data represent ribeirinhos' estimates of their production and income rather than direct measures of these variables, interviews with açaí vendors and middlemen on açaí prices were used to confirm the accuracy of household estimates. Also, the range in açaí fruit production and income from açaí-enriched forests are comparable to that described in other studies (Table 2). Because there was no significant difference between the volume of açaí fruit sold and prices by site, factors other than the household distance from Belém account for the range in household sales of açaí fruit. Although we found that households practised many of the same management strategies (Table 1), there may be differences in the intensity of management between households that account for the variation in household production of açaí. Other factors that might influence açaí production are the number of years since açaí palm enrichment (as seen in Table 2) and household labour availability, which is required to engage in management activities and to climb palms to harvest açaí fruit. It is clear that ribeirinhos can benefit from sales of açaí fruit when demand and prices are high during the winter season, but the factors that contribute to increased winter productivity of açaí are not known. Although cutting the inflorescence of the açaí palm in the summer is a means to have winter fruit production, few households engaged in this activity.

Market Distance and the Role of the Middleman As we have shown, açaí fruit prices were not significantly different between sites and did not vary across a distance gradient from Belém. Despite the large size of the Feira do Açaí in Belém, smaller local markets scattered throughout the estuary were more commonly the destination of ribeirinhos' açaí fruit. The time required for ribeirinhos in this study to arrive at the local market (defined as the market closest to the household) varied from five minutes to three hours (one-way) (mean = 51 minutes; $n = 25$). No differences in household açaí management were apparent based on the amount of time to reach local markets. Table 3 presents information on where ribeirinhos sell açaí and how they transport it to the market. Fifteen out of twenty-three households sold surplus açaí fruit at a local market, and all of these households used their own source of transportation (canoe or motorboat) for açaí transport. Only three out of twenty-three households sold açaí fruit at a market more distant than the local market ('regional markets'), and five additional households sold açaí to both local and regional markets, depending on the time of year or quantity of fruit harvested. Seven out of twenty-three households relied on middlemen to transport açaí fruit to regional markets at least at some times of the year. As a result, households that are distant from the Feira do Açaí in Belém or from local açaí fruit markets still have numerous opportunities to transport and sell açaí fruit because of the availability of middlemen.

Although the Feira do Açaí is clearly the largest açaí market in the Amazon, other smaller markets are significant in local trade. A web of trade networks exists between the many small and medium-sized towns throughout the estuary and

Table 2
Summary of* Euterpe oleracea *Densities and Associated Income from Managed Açaí Forests Reported in Different Studies

Forest type	*Product*	*Number of açaí palm clumps (per ha)*	*Income (yearly per ha) (US$)*	*Location (closest town)*	*Source*
Non-enriched forest	–	0–600	–	Abaetetuba	This study
Floodplain forest, unmanaged	–	156–208	–	Ponta de Pedras	Brondízio and Siqueira (1997)
Açaí-enriched forest	Açaí fruit	600–1,600	–	Abaetetuba	This study
Açaí-enriched forest	Açaí fruit and palm heart	220–2,080	1.70–702	Belém, Igarapé Miri, Abaetetuba, Oeiras do Pará, and Breves	This study
Açaí-enriched forest	Açaí fruit	550	480–934	Ponta de Pedras, Abaetetuba, and Muaná	Muñiz-Miret et al. (1996)
Homegardens	Açaí fruit	650	939–1,511	Ponta de Pedras, Abaetetuba, and Muaná	Muñiz-Miret et al. (1996)
Açaí agroforests	Açaí fruit	444–872	–	Ponta de Pedras	Brondízio and Siqueira (1997)
Low-intensity management	Palm heart	625	119	Muaná, São Sebastião de Boa Vista, Curralinho, and Limoeiro	Pollack et al. (1995)
High-intensity management	Palm heart	1,000	2.75	Muaná, São Sebastião de Boa Vista, Curralinho, and Limoeiro	Pollack et al. (1995)

Table 3
Transportation and Marketing of Açaí Fruit by Households in the Amazon Estuary

	Source of transportation to market		
Market where sold	*Household-owned boat*	*Intermediary*	*Total (%)*
Local	15	0	15 (65)
Regional	1	2	3 (13)
Mixture	0	5	5 (22)
Total (%)	16 (70)	7 (30)	23 (100)

Note: Numbers reported are the number of households and the percentage of all households is in parentheses. Local markets are those that are closest to the household whereas regional markets are those that are farther from the household, such as the Feira do Açaí in Belém, or markets in other towns more distant than the local market.

middlemen transport açaí fruit between these markets in addition to Belém's Feira do Açaí. Despite the reputation that middlemen have in the Amazon for exploiting local producers (for example, Gray 1990), they perform a valuable service for ribeirinhos who are unable or reluctant to transport açaí fruit to market themselves. Furthermore, intermediaries often struggle to earn a meager living. Interviews with middlemen revealed that they try to gain a profit of $0.60 per *lata*, but they usually pay ribeirinhos beforehand and market prices are notably unpredictable. Açaí fruit prices fluctuate not only between years and seasons based on overall fruit availability, but also between days or even the time of day, based on the number of vendors in the markets or the quality of the fruit. Consequently, middlemen often lose money. Several middlemen claimed that they often lost more than they gained, and one energetically characterised his career as an adventure because of the unpredictability of the financial rewards and losses. Any delay in the middleman's journey to regional markets increases the amount of time between the harvest and sale of açaí, which jeopardises açaí quality and price received for the fruit. Where an intermediary buys and sells açaí fruit depends on his or her social connections in the estuary and on the differences in the timing of fruiting at different sites. Local peaks in fruit ripening times throughout the year encourage trade between communities and regions within the estuary. Middlemen transport açaí fruit between these regions with different açaí fruit ripening times in order to meet market demands.

Because household interviews were limited to those that had surplus açaí to sell after meeting consumptive needs, it is possible that our small sample size was biased to those with market access. However, households represented a large range in the distance from the home to Belém and the time that it took to arrive at the local market, minimising this possibility. The market situation for açaí described above is atypical for many NTFP systems where transportation to markets and/or market demand is at a premium (Marshall et al. 2003). Even in the Amazon estuary, where river travel and transportation is available, there is a lack of market demand for numerous other NTFP, limiting the ability of ribeirinhos to derive economic benefits from forest products (Shanley et al. 2002).

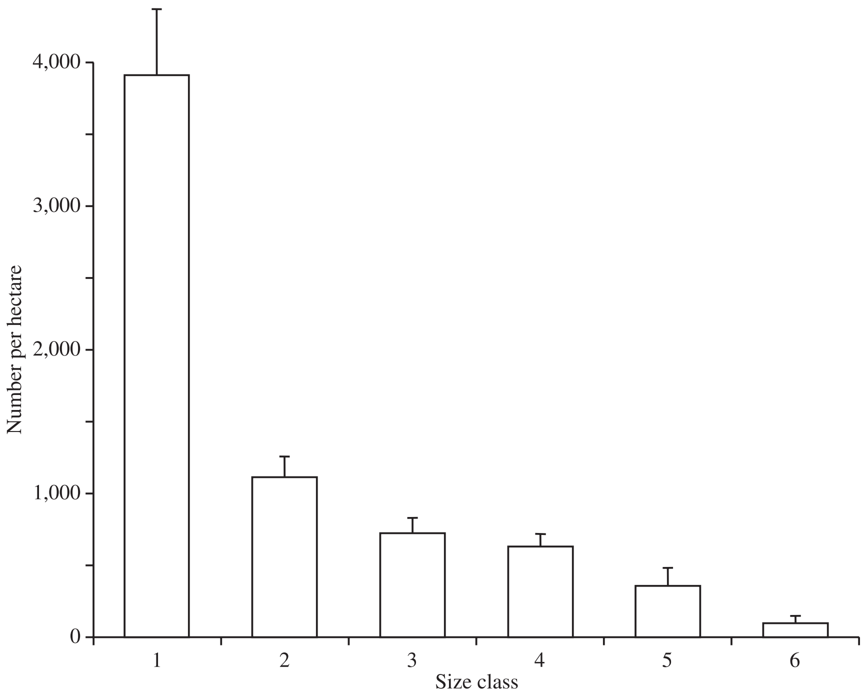
Ecological Impacts of Açaí Palm Management

Açaí Palm Density and Recruitment The management strategies employed by ribeirinhos result in a wide range of açaí clump densities with no differences among sites (ANOVA $F_{4,20} = 0.89$, $p > 0.48$). Clump densities ranged from 220 to 2,080 per ha, with a median density of 1,250 per ha. Although household interviews revealed that similar management strategies were used to promote the açaí palm, future studies could be designed to look more closely at whether management intensity, land use history or the time since açaí palm enrichment accounts for differences in açaí clump density. In comparison to other studies, the low density of açaí clumps is comparable to *várzea* that is not managed or is managed at low intensities for açaí and the highest clump densities are comparable to açaí agroforests that have been managed for close to twenty years (Table 2). Among all households, the mean number of stems of açaí in a clump was 6.28 and the mean number of adult stems in a clump was 2.76 ($n = 586$).

The distribution of açaí stem densities in all samples by size class resembles an inverse J-shape, with high densities of seedlings and lower densities of adult stems (Figure 5). Size class distribution data were pooled for all samples because the pattern was similar among all households. This size class distribution pattern is common for many species of tropical trees that produce many seedlings, with few surviving to adult sizes due to competition for resources (Peters 1996). The high density of açaí seedlings and saplings (size classes 1 and 2) indicates that at this point in time, the palm is readily regenerating in forest areas managed by ribeirinhos for açaí fruit and palmito production. Unlike many other NTFP systems where there is concern that extraction threatens the future production of the NTFP itself, regeneration of açaí is not threatened by the palmito and açaí harvest. Açaí is fast-growing, so areas where overharvesting for palmito occurred in the past may have since regenerated naturally or via enrichment planting. The relative significance of açaí fruit in household consumption and the recent increases in market demand likely influence management strategies at the household scale such that the palm is not overharvested.

Vegetation Clearing Around Açaí Palms Ribeirinhos revealed in interviews that they clear vegetation from around açaí clumps to facilitate movement through the forest for NTFP collection, and they cut and girdle trees from around the clumps to encourage açaí growth and increased fruit production. These management strategies were apparent in measures of the distance between the palm clumps and the closest tree ('clearing' values). Only a small proportion of any transect had less than 3 m cleared around a palm clump, and households from different sites had different clearing measures (Figure 6). In particular, transects in Igarapé Miri had more than 10 m cleared around 50 per cent of all palm clumps. Some ribeirinhos stated that their goal was to remove all other tree species and convert as much of their property as possible into a plantation of açaí. The clearing data

Figure 5
Density of* Euterpe oleracea *Stems by Size Class



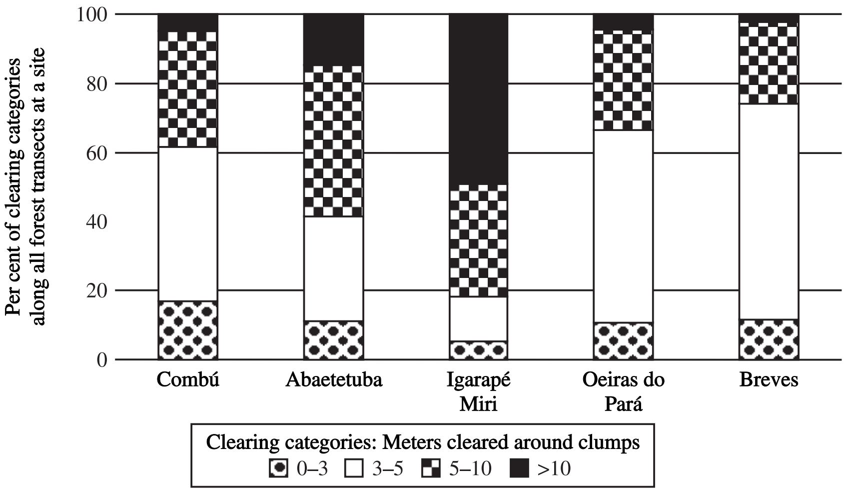
Notes: Data are from all 25 transects in the study area.
Size classes are defined as (1) seedling without a stem, (2) seedling with stem up to 2.5 m height, (3) 2.5–6 m, (4) 6–10 m, (5) 10–15 m, and (6) >15 m.

show that this is actually happening in parts of the estuary. Unlike what had been described for the açaí NTFP system in the early 1990s (for example, Anderson 1990), açaí management does not seem to be a subtle alteration of forest composition and structure. Instead, the clearing data demonstrate that some areas are being converted to plantation-like stands of the açaí palm. Hence, in the case of açaí, the dual goals of NTFP harvesting to promote biodiversity conservation and to support local livelihoods do not seem to be met.

Vegetation Composition and Structure in Açaí-enriched and Non-enriched Forest Areas In addition to increasing açaí clump densities, management activities also alter overall forest composition and structure, especially in forest stands where açaí palm enrichment was actively practised ('enriched' forest), compared with forest stands where açaí palm enrichment was not practised ('non-enriched' forest). Vegetation structure differed substantially between enriched and non-enriched forest (Figure 7). On average, the forest canopy was 6 m higher ($F_{1, 90} = 111.50$, $p < 0.01$) and 9 per cent more closed ($F_{1, 90} = 96.70$, $p < 0.01$) in non-enriched than

Figure 6

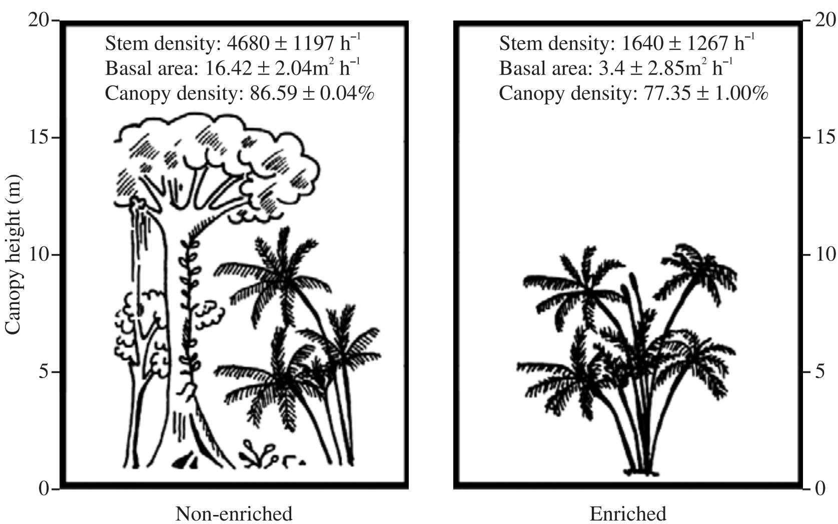
Cumulative Percentage of Categories of Vegetation Clearing from around Açaí Palm Clumps along Forest Transects in Five Communities in the Amazon Estuary



Note: Vegetation clearing was measured as the distance between an açaí clump and the closest tree that was not açaí with a diameter at breast height greater than 5 cm. Measures of vegetation clearing were grouped into one of four categories, as shown: 0–3 m, 3–5 m, 5–10 m, and >10 m.

Figure 7

***Typical Vegetation Profile in Five Forest Sites Enriched with* Euterpe oleracea *and Five Sites Not Enriched with* E. oleracea**

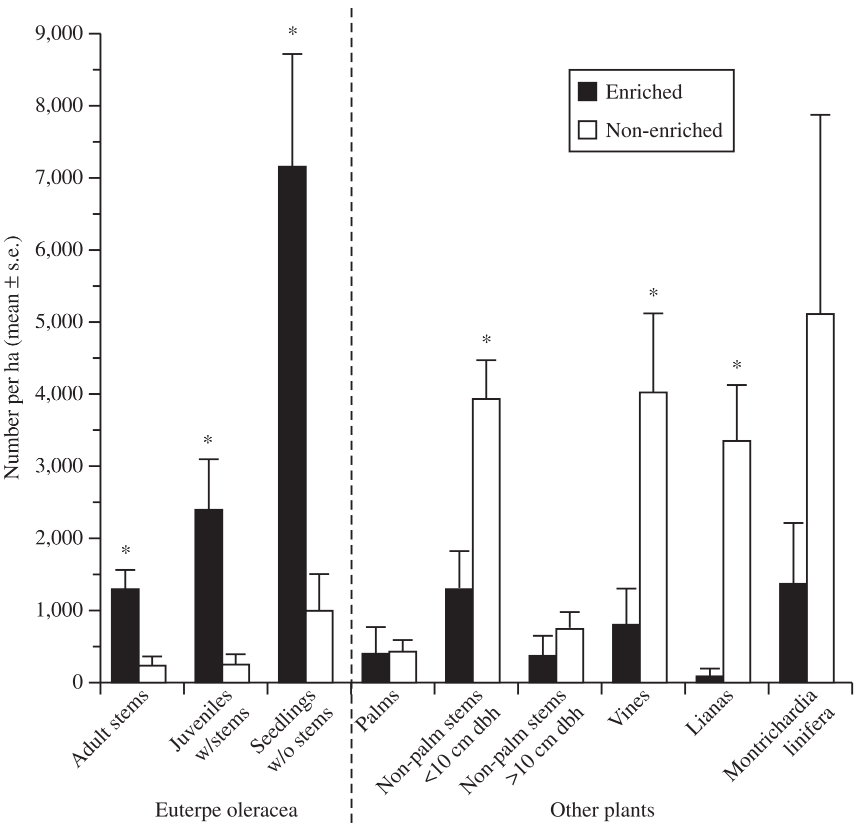


Note: All forest sites were near the town of Abaetetuba.

in enriched forest. Similarly, stem density of all species was 2.8 times higher ($t = 3.91$, d$f = 8$, $p < 0.01$) and basal area 4.8 times higher ($t = 3.72$, d$f = 8$, $p < 0.01$) in non-enriched than in enriched forest stands.

These changes in overall vegetation structure were accompanied by much higher densities of açaí in the enriched forests (Figure 8). Açaí-enriched forest stands contained six times the number of açaí adults ($t = 3.86$, d$f = 8$, $p < 0.01$), eleven times the number of juveniles ($t = 2.97$, d$f = 8$, $p < 0.02$), and seven times as many saplings as did non-enriched forest stands ($t = 3.96$, d$f = 8$, $p < 0.01$). The density of adult-sized açaí stems in enriched forests was similar to that found in other studies, whereas the density of adult-sized açaí stems in non-enriched forests was much lower (Table 2).

Figure 8
Numbers of Stems of Different Types in Five Forest Stands Enriched with* E. oleracea *and Five Non-enriched Stands



Note: Bars show standard error and asterisks indicate significant ($p < 0.05$) differences between stand types.

Enriched and non-enriched forest stands also differed in their densities of non-palm stems. Non-enriched forests contained four times more small trees (<10 cm DBH; $t = 3.84$, d$f = 8$, $p < 0.01$), five times more vines ($t = 2.95$, d$f = 8$, $p < 0.02$), and eighty-four times more lianas ($t = 4.51$, d$f = 8$, $p < 0.01$). Non-enriched forests also tended to have more large-diameter (>10 cm DBH) trees and *Montrichardia linifera*. In general, açaí stems and lianas tended to be larger in the enriched forest, while hardwood stems, vines, and *M. linifera* stems were larger in non-enriched forest.

The differences in vegetation composition and structure between açaí-enriched and non-enriched forest stands signify that ribeirinho forest management strategies are not only increasing açaí density across the Amazon estuary, but also that these activities are fundamentally changing the structure and composition of *várzea* forests. With a nearly complete loss of vines, lianas and large woody trees, and an accompanying opening and lowering of the canopy, heavily managed forests no longer resemble native *várzea*. In fact, the differences between non-enriched and açaí-enriched forest are comparable to differences between non-enriched forests and agroforests (Thiollay 1992), coffee and cacao plantations (Alves 1990; Greenberg et al. 1997), and logged forests (Johns 1988; Mason 1996). Nevertheless, forest enrichment is a popular and recommended strategy for increasing the economic value of forests in many regions (for example, Ricker et al. 1999).

Conclusions and Recommendations

Our study has shown that a variety of management activities are used throughout the Amazon estuary to promote açaí palm density, growth and production. Aside from the threat of theft, which caused some ribeirinhos to extract more palmito than they would ideally harvest, there was no evidence of conflict between palmito and açaí production or management on household landholdings. Management for açaí NTFP does not have a negative impact on the regeneration of the palm itself. The demand for açaí in household consumption and in local and regional markets serves to limit overharvesting of stems for palmito extraction. Although the fruit is highly perishable, household distance to Belém did not influence management activities because many households have boats and transport their own production of açaí to local markets and because middlemen facilitate trade to numerous other açaí markets throughout the estuary in addition to Belém. Açaí, and the estuary in general, is probably not typical of other NTFP systems where transportation is often unavailable or insufficient, and markets for the products are lacking (Browder 1992; Crook and Clapp 1998; Shanley et al. 2002).

The demand for açaí fruit continues to grow throughout the estuary and beyond. Although ribeirinhos appear to be benefiting financially from the industry, there are serious consequences for the ecological integrity and biodiversity of the *várzea*. Açaí is now available in cities and small towns throughout Brazil where it is marketed as a nutritious energy drink. A growing portion of the production from the estuary is exported internationally to Japan, Europe and the United States in the form of powder or frozen or pasteurised pulp (Brondízio, forthcoming; O Liberal 1999; Melo et al. 1988). As the demand for açaí continues to increase, the 'açaíza-tion' of the estuary (Hiraoka 1995) intensifies and expands. Açaí-enriched flood-plain forests once described as a subtle alteration of mature floodplain forests (Anderson 1988, 1990; Anderson et al. 1995) increasingly resemble açaí plantations. Not only are *várzea* forests being cleared to make room for açaí, but in some areas açaí plantations are being established in the terra firme uplands of the estuary (O Liberal 2003). Recent analysis has revealed that rates of deforestation in the Amazon floodplains is comparable to that occurring in the uplands, due in part to the expansion of açaí-managed forest areas (Zarin et al. 2001). Not only does vegetation structure and composition differ in enriched versus non-enriched forests, but the composition of the bird community also differs, as does the relative abundance of fruit-eating birds and native *várzea* bird species (Moegenburg and Levey 2002). Furthermore, within enriched forest stands, higher-intensity açaí harvests reduces the diversity of fruit-eating birds due to reduced fruit availability (Moegenburg and Levey 2003).

Given our findings, we question whether the açaí system is a 'win–win' system (see also, Uma Shaanker et al., this issue) for local development and floodplain forest conservation, as had been described in the past (Anderson 1990; Fearnside 1989; Peters et al. 1989a). However, our study offers some insights into how the açaí NTFP system could be improved upon such that local producers realise economic benefits and ecological impacts of management are minimised. Perhaps the most dramatic effect of açaí enrichment is the altered vegetation composition and structure due to 'cleaning' management strategies (including the removal of understorey vegetation, canopy trees, vines and lianas). Although the açaí palm typically responds to these treatments with increased growth rates and greater fruit output, cleaning activities could be used more selectively such that a better balance is achieved between açaí production and maintenance of characteristic *várzea* composition and structure. Some ribeirinhos interviewed in this study chose to minimise cleaning activities in açaí-enriched forests because they preferred to have a more diverse forest that offered numerous NTFP for subsistence use or supplemental income. More diverse forests may serve as 'insurance' in the face of rapidly changing market demands, which are characteristic of many Amazonian NTFP 'boom–bust' cycles. Selective cleaning strategies can also benefit açaí production itself. We encountered some ribeirinhos who had participated in an açaí management course where extension agents advised against transforming the forests into a monoculture of açaí, but recommended leaving numerous other species of trees to prevent erosion and maintain soil moisture and nutrients. There is a need to support similar efforts in other areas of the estuary to encourage sound management that also benefits ribeirinhos.

Another way in which ecological impacts of açaí enrichment could be minimised is to find ways to intensify production such that ribeirinhos can gain greater economic returns from a smaller area of land, thereby preventing enriched forest areas from spreading throughout the *várzea*. Rare varieties of açaí fruit have a potential niche market that could become profitable for ribeirinhos in some regions. Other households could realise financial gains from a smaller forest area by increasing production during the winter harvest season when prices for açaí fruit are much higher. Factors that influence seasonal variation in açaí fruit ripening times throughout the estuary should be investigated to determine the role of ecological conditions and/or management practices. We encountered few households that cut the inflorescence off açaí palms to increase off-season fruit production and this could be one means by which intensification could be achieved. Strategies to increase açaí production during the off season could become increasingly important if the palmito industry continues to suffer in the estuary and ribeirinhos lose this important source of winter income.

The growing interest in açaí internationally also presents opportunities to improve the açaí system to benefit ribeirinhos and floodplain forests. Açaí is being touted as a product that helps protect the Amazon rainforest—not one that contributes to floodplain forest conversion into açaí plantations. Certification of selected açaí production areas could be a tool to increase consumer awareness and promote açaí management systems that are more ecologically sustainable. Certification of açaí fruit and palmito harvesting exists in at least one area in the estuary (FSC 2003).[2] However, our results reveal that one must consider the ecological effect of açaí management on floodplain forest composition and structure instead of only evaluating the effect of the harvest on açaí palm recruitment.

Although the ecological impacts of açaí management may be less severe than other threats to biodiversity in the Amazon such as cattle ranching or logging (for example, Fearnside 1988; Uhl et al. 1993) it is clear from our study that açaí management will be insufficient to protect the biodiversity of the floodplain forests in the Amazon estuary over the long term. Fully protected areas do not exist in the Marajó *várzea* ecoregion (WWF 2001), but they may be necessary if biodiversity conservation is a goal. Insofar that açaí management protects major ecological processes and provides habitat for selected native species, this land use would be appropriate in regions surrounding protected areas. By understanding the markets for açaí and the ecology of the *várzea*, we can continue to work towards finding the balance between rural development and conservation.

Notes

1. Prices are quoted in US dollars based on an exchange rate in 1999 of US$ 0.60 to the Brazilian real.
2. The Forest Stewardship Council is an international non-profit organisation that certifies timber and NTFP as being sustainably harvested. The company certified for sustainable palmito and açaí production is Muaná Alimentos, which manages 4,012 ha on Marajó island.

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