A PROFILE OF PALM HEART EXTRACTION IN THE AMAZON ESTUARY

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ABSTRACT

Most of the processed palm hearts consumed in the world are derived from the Acai palm (Euterpe oleracea Mart.), which grows abundantly in forests of the Amazon estuary. Palm heart extraction began in the estuary in the 1970s and there are now hundreds of canning factories and some fifty distribution firms in this region. Annual profits of the canning factories range from $30,000 to $50,000 while profits for distribution firms frequently exceed $500,000/year. But, there are several indications that this economic boon will be short-lived: factory closings are frequent; palm hearts are much smaller now than in the past; and mortality of palm trees is high in stands subjected to frequent palm heart harvest. However, the Acai palm is well suited for management because of its abundance, rapid growth and multi-stemmed life form (individuals are constantly producing new sprouts). Under management, palm hearts can be harvested from the same clump over many years through a sort of regimented thinning process and management could result in significant long-term savings when compared to the cost of purchasing wild palm hearts from extractors. Indeed, Acai management may offer one of the best opportunities to date for protecting Amazonian forest while at the same time deriving benefits from its riches.

KEY WORDS: Amazon; palm hearts; heart-of-palm; non-timber forest product; resource economics; sustainability

INTRODUCTION

For the past several years, environmentalists, scientists and politicians have discussed the possibility of promoting the use of and developing markets for non-timber forest products to maintain rain forests intact while bolstering the economy in rain forest countries (Plotkin and Famolare, 1992; Nepstad and Schwartzman, 1992; Peters et al., 1989). However it has been difficult to find economically attractive non-timber forest products. To be successful, a non-timber forest product must have a lasting market appeal (i.e., not be merely a "novelty item"), the extractor must receive a good income from working with the product (to avoid resorting to non-sustainable extraction techniques or abandoning the product all together), and distributors must be guaranteed a consistent supply of the product (Pendleton, 1992; Homma, 1992).

A non-timber forest product that potentially meets these criteria, yet has received little attention from the conservation community, is palm heart. Palm hearts, which are derived from the apical meristem (growing tip) of certain palm species, are a delicacy served in all parts of the world. Brazil has been the world's primary source of palm hearts since the 1950s, when palm hearts were first introduced on the international market (Urpi et al., 1991). Palm hearts were originally extracted in the forests of southern and southeastern Brazil from the palm, Euterpe edulis Mart. This species is single-stemmed and, therefore, does not survive palm heart-extraction. Intensive harvesting of E. edulis led to the collapse of the palm heart industry in southern and eastern Brazil by the end of the 1960s (Ferreira and Paschoalino, 1987).

Beginning in the 1970s, palm heart companies, faced with depleted palm heart reserves in the south and east of Brazil, relocated to the Amazon estuary, where vast populations of the Acai palm (Euterpe oleracea Mart.) occur. This palm grows naturally in flood plain forests covering more than 40% of the 25,000 km^2 Amazon estuary (Calzavara, 1972). Acai is multi-stemmed, meaning that one individual consists of a "clump" of many stems. This permits the removal of palm hearts from selected stems, year after year. The species is also widely cultivated by estuary inhabitants, owing to the importance of the Acai fruit as a staple of the local diet (Anderson and Ioris, 1992). By 1975 Pará State accounted for 96% of Brazil's palm heart production (IBGE, 1975). Presently, the palm heart industry provides nearly 30,000 jobs in the estuary and generates an estimated cash flow of $300 million/year (Diário do Pará, 1993).

But since the beginning of the 1980s, there have been several indications that palm heart extraction, at current levels, is not sustainable. For example, the average palm heart today is smaller than it was 20 years ago, meaning that smaller, younger stems are being cut today. There are also far fewer factories operating today in areas where palm hearts were exploited intensively in the past, suggesting that palm heart supplies have declined in these areas. While there is no evidence that the Acai palm is endangered as a species, these, and other signs of pressure point to potential difficulties in supplying the local industry with palm hearts in the future.

In this paper, we present an economic and ecological profile of Acai palm heart production in the Amazon estuary. We begin by analyzing costs and profits in palm heart extraction, palm heart canning, and palm heart distribution. In so doing, we reveal the factors that lead players in each sector to unwittingly pursue non-sustainable practices. Then, we examine how the frequency of palm heart harvest might affect Acai population structure and palm heart productivity. Finally, we assess the economic potential of forest management approaches designed to guarantee a constant supply of palm hearts.

METHODS

Structure and Economics of the Palm Heart Industry

We focused our research on the Amazon estuary, and particularly on the island of Marajó (Fig. 1), where most of the palm hearts in Pará are produced (IBGE, 1975-1989). The palm heart industry in the Amazon estuary is divided into three sectors: 1) extraction--conducted by estuary inhabitants who harvest wild palm hearts and sell them to processing plants; 2) processing--executed in small factories along riverbanks throughout the estuary; and 3) distribution--carried out by firms, located mostly in Belém, that purchase canned palm hearts from factories and sell them in Brazil or abroad (Fig. 2). We studied the activities and economics at each of these three levels. Throughout the paper, monetary values obtained in Brazilian currency are adjusted for inflation and converted to American dollars, using the official exchange rate in July, 1992 (US$1.00 - Cr$3830).

Palm heart extraction: We spoke to more than 50 extractors in nine counties in the estuary about harvesting techniques, daily production, marketing arrangements, and earnings. We also accompanied three extractors to observe their daily work (one complete day spent with each extractor). All three were subsistence-type forest dwellers. We divided harvest work into travel (by canoe) to and from the work site, searching for and cutting palm hearts, carrying palm hearts to canoe, loading and unloading palm hearts, sharpening the cutting knife, and resting.

Palm heart processing: We visited more than 30 palm heart factories in nine counties in the estuary, and conducted intensive interviews in nine factories. Data collected included year the factory opened, previous owners and/or locations of the factory, work force, rate of production, source of raw materials, chemical products used, production costs, and the sale price and destination of processed palm hearts.

Palm heart distribution: We applied questionnaires to owners or managers of ten distribution firms in Belém that handle 50 to 450 tons of processed palm hearts each month. Data collected included the source and destination of canned palm hearts, number of supplier factories, work force, operating costs, and freight costs.

Sustainability of Palm Heart Extraction

Relationship between the palm heart yield and plant size: We considered that palm heart weight and diameter would be related to the size of the stem furnishing the palm heart and that this relationship might be useful in monitoring pressure on Açai populations. To establish the relationship between palm heart size and plant size, we selected 68 wild Acai stems in a variety of sizes, and measured their diameter at breast height (dbh) and height, as well as the palm heart weight and diameter (in the middle).

Palm hearts are assigned different end uses. To better understand the utilization and classification of palmhearts, we hired experienced palm heart factory workers to simulate the canning process on 175 palm hearts. For each palm heart we recorded weight and diameter of whole palm heart (with and without leaf-sheaths), weight and number of export and domestic market pieces, weight of palm heart used for other uses or discarded, and the number, diameter, and total weight of pieces used to fill a 1 kg can.

Impacts of harvesting palm hearts on Acai populations and on palm heart yield: We compared Acai populations in the southern part of Marajo Island in stands that have been harvested every 1-2 years (high extraction pressure) to sites subjected to low extraction pressure (harvested at 4-5 year intervals). "High extraction pressure" sites were abundant; "low extraction pressure" sites were difficult to find. For the "high extraction pressure" sites, surveys of Acai were conducted in five regularly-spaced 10 m x 100 m plots in five different forest sites. For the "low extraction pressure sites", we surveyed two 10 m x 100 plots in each of two sites. Palm hearts had been recently extracted from all stands. We also established two 10 m x 50 m plots in a forest where palm hearts had never been harvested, as a "control". In all plots, we recorded the number of Acai clumps with stems taller than 2 m, and for each of these clumps we measured the DBH of stems $\geq$ 2 m tall. We also counted the number of recently cut stems in each clump and measured the diameter of these stems to determine how many palm hearts had been harvested during the most recent harvest and, using our correlations, the size of these palm hearts.

One sign of excessive extraction pressure is the presence of dead Acai clumps. We measured clump mortality in three sites: one where palm hearts had been harvested at one to two-year intervals, another where extraction was at four to five-year intervals, and a third where Acai had never been extracted. Clump mortality was assessed in two randomly-placed 25 m x 50 m plots in each site, and the number of dead and living Acai clumps was recorded in each plot.

Economic Potential of Forest Management for Palm Heart Production

We assessed the costs and benefits of Acai management in natural forest stands to determine if management is a viable alternative for supplying palm hearts to the industry. In this analysis, we considered the projected costs and yields of two similar types of management. The first was a compilation of techniques described by Lopes et al. (1982) and Calzavara (1987), for which we estimate costs based on the number of man days required for each management step and the average Brazilian minimum wage. The resulting analysis reflects what companies might pay if they took responsibility for management. The second analysis reflects management costs if a forest engineering firm were contracted to supervise management. We obtained the firm's fees from the owner.

RESULTS

Structure and Economics of the Palm Heart Industry

Palm heart extraction: Most palm heart extractors are riverside inhabitants who harvest from the forest within 5-10 km of their homes. Some men will harvest only very ocassionally, others harvest during 50-100 days each year, and still others are employed by factories to harvest palm hearts on a continuous basis.

A typical palm heart extractor begins his day by sharpening his machete or ax (depending on the size trees to be harvested) and paddling to the area where he will harvest palm hearts. He moves through the forest from one Acai clump to another, cutting one or more Acai stems per clump, and lopping off the top 50 to 100 cm with the ensheathed palm heart. He then removes the first two or three leaf-sheaths, leaving the inner sheaths to protect the palm heart during transport to the factory. The cutting done, the extractor returns by the same path to pick up the palm hearts, and stacks them in his canoe. He then delivers the palm hearts to a factory or takes them to his house, where they are picked up for delivery to the factory.

Most of the extraction time (56%) is spent finding and cutting the palm stems and striping the outer leaf-sheaths from the palm heart, with much of the remaining time spent in gathering, carrying, and loading and unloading (28%), and canoe travel (11%) (n = 3 days of observation).

The productivity of an extraction episode varies with the size and abundance of Acai palms in the forest, which, in turn, depends largely on the interval between extraction episodes at that site. Interviews with extractors indicate that in a seven-hour work day, if an extractor cuts exclusively small, medium, or large-sized palm hearts, he can cut approximately 200, 175, or 150 palm hearts, respectively. When palm hearts are delivered to a factory, which an extractor does if he lives close enough (up to approximately 2 hours away), the extractor receives $0.039/small palm heart, $0.052/medium palm heart, and $0.065/large palm heart (these prices may fluctuate somewhat during the year). When he sells palm hearts to an intermediary, which is more often the case, he receives approximately half this price. In accordance with the size of palm hearts harvested, therefore, an extractor earns between $8/day (200 small palm hearts x $0.039) and $10/day (150 large palm hearts x $0.065) when he sells directly to a factory, and about half this much if he sells to an intermediary.

Palm heart processing: Palm heart factories are located along rivers and streams in the estuary. A factory contains a dock and a building, approximately 300 m^2, where 15 to 30 workers cut and can the palm hearts (Fig. 2). Upon arrival at a factory, all remaining leaf-sheaths are removed and palm hearts are cut into export and domestic market pieces (differentiated by their texture -- the most tender pieces are designated for the export market). The palm heart pieces are then placed in cans (export palm hearts) or jars (domestic palm hearts), and covered with a water-based preservative solution of salt and citric acid. The open cans and jars are heated in a double-boiler and then sealed (Brabo, 1979).

In our survey, the average palm heart production in canning factories was 29 tons/month (n=9 factories; s.d.=8.3; range=15 to 40), which we round to 30 tons/month for our financial profile of a typical factory . It takes between 60,000 and 122,000 palm hearts, depending on their size, for such a factory to produce 30 tons of processed palm hearts/month (Table 1).

Our results from simulating the canning process on 175 palm hearts show that a palm heart, independent of its size, yields an average of 1.8 pieces for the export market (36% of total palm hearts' weight) and 0.9 pieces for the domestic market (23% of total weight; Fig. 3). The remaining, more fibrous part of the palm heart is either cut and sold on the local market as palm heart chunks, which we do not consider in this analysis owing to their small role in a factory's total production (less than 10%, when produced at all), or included with the waste. Considering that 36% of a palm heart's weight is appropriate for export pieces and 23% is suitable for domestic pieces, and that there are 500 g (drained weight) of palm hearts in a 1 kg export can and 300 g in a 1 kg domestic jar, approximately 48% (14.4 tons) of a typical factory's total monthly production (30 tons) would go to export-quality cans, and 52% (15.6 tons) would be for domestic-quality jars.

In July, 1992, distribution firms paid factories $0.44 for a 1 kg can of export-quality palm hearts, and $0.28 for a 1 kg jar of domestic-quality palm hearts, giving our "typical" factory a gross monthly income of approximately $10,700 (Table 1). Production costs are roughly $7400/month; 58% of these costs are to purchase palm hearts from extractors. The average monthly net income is $3315. If the factory were to work exclusively with large, medium or small palm hearts, profits would be $3745, $3343, or $2858/month, respectively, with profit margins of 35%, 31% or 27%. A reduction of profits occurs when using medium and small palm hearts because the cost per unit weight of palm hearts is greater for smaller palm hearts than for larger palm hearts (e.g., 0.24/kg for small palm hearts vs. 0.19/kg for larger hearts; Table 1, footnotes 2 & 3).

Palm heart distribution: After processing, cans and jars of palm hearts are packed into boxes and sent by boat to a distribution firm in Belém (Fig. 2). There are 28 distribution firms in Belém that purchase more than 50 tons of processed palm hearts/month (Oliveira and Nascimento, 1991). Combined, these firms handle approximately 85% of all palm hearts produced in Pará.

Most distribution firms supply a limited number of factories with a steam furnace and canning machine, and with empty cans and jars, in exchange for exclusive purchasing rights to the factories' production. Since the average production in the ten firms where we interviewed was 138 tons/month (s.d.=104), we estimate that a typical distribution firm will contract some five factories (each producing approximately 30 tons/month). This would provide a firm with 150 tons of palm hearts/month, which is what we consider in our analysis (Table 2). In accordance with our typical factory's production, we consider that 72 tons, or 48%, is destined for the export market, and 78 tons, or 52%, is for the domestic market.

A firm purchases processed palm hearts from factories for $0.44 for each 1 kg can and $0.28 for each 1 kg jar (Table 2). The firm sells the palm hearts for $1.94/can and $1.11 per jar, for monthly gross returns of approximately $230,000. The firm's monthly profit is nearly $60,000, or 28% of the gross returns. While returns are robust, these are capital intensive enterprises, requiring some $160,000 in operational costs each month.

Sustainability of Palm Heart Extraction

Relationship between palm heart yield and plant size: We developed equations that correlate the height and dbh of an Acai stem with the weight and diameter of its palm heart (Table 3). These equations could be used to predict the size of a palm heart that a living stem might contain. Alternatively, knowing the size of a palm heart section in a can, the equations could be used to determine the size of the stem that was cut to produce that palm heart. For example, a 1.5 cm diameter palm heart would come from an Acai tree about 7 cm in diameter and 6 m tall (Table 3); whereas a 3.5 cm diameter palm heart section would have been associated with an Acai tree that was 14 cm in dbh and 18 m tall.

Impacts of harvesting palm hearts on Acai populations and on palm heart yield: Using these equations it is possible to reconstruct recent harvest episodes simply by surveying all Acai clumps in plots of known dimensions and measuring the diameter of all cut stems . We did this on recently-harvested sites that had been subjected to regular harvests at 4-5 year intervals and at 1-2 year intervals over a 15-year period. An average of

1.2 palm hearts/clump (considering all clumps) were extracted in the areas subjected to harvests every one to two years (Table 4). The average dbh of the harvested stems was 6.2 cm, and the estimated height of the cut stems was 5.2 m. The palm hearts from these stems were, on average, 1.3 cm in diameter and weighed 76 g (using equations in Table 3). Combining the average palm heart weight with the number of harvested palm hearts in these areas, the total palm heart yield was estimated at 44 kg/ha [(481 Acai clumps/ha x 1.2 palm hearts/clump x 76 g/palm heart) / 1000]. Meanwhile, harvesters extracted 1.0 palm heart/clump in areas subjected to harvests every four to five years. The average dbh of the harvested stems was 10.6 cm and the estimated height was 13.0 m. Palm hearts derived from these stems had, on average, a diameter of 2.6 cm and weighed 262 g. The total palm heart yield in these areas, therefore, was approximately 192 kg/ha [(734 Acai clumps/ha x 1.0 palm hearts/clump x 262 g)/palm heart /1000] or 4.5 times greater than for sites subjected to more frequent harvests.

We also noted big differences in the characteristics of the Acai populations in the areas subjected to low and high extraction pressure. For example, we found that there were, on average, 481 Acai clumps/ha with stems > 2 m tall in areas that have been harvested at one to two-year intervals, but 734 clumps/ha in areas harvested at four to five-year intervals (Table 4). Following the most recent harvest, only 4% of the Acai stems remaining in the frequently-harvested plots were ≥ 4 m tall. In less-frequently harvested plots, 22% of the remaining stems were ≥ 4 m tall. Moreover, 25% of all clumps in areas subjected to frequent harvests were dead, compared to only 11% in areas harvested every four to five years, and 12% in the control site. Overall, the population structure in the "low extraction pressure' site was quite similar to that in the control forest (Table 4).

Economic Potential of Forest Management for Palm Heart Production

Managing Açai palms in the flood plain forests of the estuary requires very little equipment or technical expertise: the primary requirement for good Açai growth in this environment is an ample supply of light and growing space. Management measures to improve growing conditions for Açai include clearing undergrowth and girdling canopy trees with no economic value or household utility. Açai seeds may also be scattered on the forest floor to encourage regeneration. Plots are thinned periodically of weeds and vines, and Açai clumps are groomed to contain approximately three large, three medium and three small-sized stems. In this management regime, three large palm hearts (i.e., three large stems) are harvested from each Açai clump every third year.

We considered the economic potential for palm heart management given natural densities of Açai and also in stands with elevated Açai densities resulting from enrichment planting (the forest engineering firm that oversees most of the palm heart management projects in the estuary utilizes the latter form of management). For the "natural density" case (referred to as "low intensity management"), we considered an average clump density to be 625/ha (similar to the value reported in Table 4 for control forest). Hence, the "natural density" model provides an average annual yield of 625 palm hearts/ha (i.e., 3 stems/clump harvested once every three years). The elevated density model, referred to as "high density management" is designed to provide an annual production of 1000 palm hearts/ha (Table 5). In both cases, yields are estimated to average only 32% of full capacity for the first six years, before a project reaches its full production potential (Lopes et al., 1982).

A management project with an average yield of 625 large palm hearts/ha/year would require an area of 1144 ha to supply a typical factory, producing 30 tons/month (Table 1), with a steady supply of palm hearts. Meanwhile, a project with yields of 1000 palm hearts/ha/year would require an area of only 715 ha to supply the typical factory.

It takes approximately ten work days/ha to prepare an area for the low intensity management model. We estimate that an additional four work days/ha/year are necessary during the first six years, and two work days/ha/year in following years, to maintain favorable growing conditions for <u>Acai</u> in these "low intensity" management areas. Considering a daily minimum wage of $2.50, a 1144 ha project would cost a total of $42,442 to implement in the first year, $16,702/year from the second to sixth years, and $20,706/year beginning in the seventh year (Table 5). Revenues from management are calculated as the price paid by factories for large palm hearts ($0.065 for each large palm heart). Subtracting costs from revenues (Table 5) shows a net loss of $27,570 in the first year [($13.00/ha - $37.10/ha) x 1144 ha] for this type of management, a loss of $1830/year in the second through the sixth years, and a net profit of $25,774/year after the seventh year. The net present value of a 1144 ha low-intensity <u>Acai</u> management project over the first twenty years, at a 6% discount rate, is estimated at $119/ha, or $135,610 for the entire 1144 ha project.

The costs for "high intensity" palm heart management are much higher than these low intensity cost estimates, partly because the forest engineering firm charges for additional items, and partly because the firm is the only one doing this kind of work in Belém, and does not need to price competitively. Estimated costs of this project are $110,989 in the first year ($155.23/ha x 715 ha), $26,326/year from the second to sixth years, and $25,390/year from the seventh year on (Table 5). Subtracting the value of palm hearts shows a net cost of $96,117 in the first year and $11,454/year from the second through sixth years, and a net profit of $21,085/year after the seventh year. The net present value of a 715 ha high-intensity management project over 20 years (6% discount rate) is $2.75/ha, or $1966 for the entire 715 ha management area.

DISCUSSION

Signs of Non-sustainable Palm Heart Extraction

Our findings indicate that palm heart yields diminish significantly if palm hearts are extracted too frequently from the same areas. At the rate we observed, areas harvested every one to two-years would yield fewer palm hearts over the course of four extraction episodes than stands harvested every four to five-years would yield in one. In fact, over time, the frequently-harvested areas might yield even less, because, as our population structure data indicate, harvesting palm hearts so frequently leaves <u>Acai</u> stands with few mature stems and a relatively high proportion of dead clumps. If this occurs on a widespread basis, as we observed to be the case, then wild palm hearts, and especially large-sized palm hearts, should become increasingly difficult to obtain.

In fact, there are already several indications that palm hearts are being over-exploited. For example, palm hearts processed today are generally smaller than palm hearts processed twenty years ago, when the industry first arrived in the estuary. Brabo (1979) reports that in the 1970s, two palm hearts were sufficient to fill a 1 kg can. Today, such large palm hearts are rare. The industry currently aims for palm hearts from four Açaí stems per can (i.e., 7-8 pieces/can), but we frequently saw cans in factories with pieces from more than ten stems. Another indication of pressure is the declining work load for employees in palm heart factories. When factories were first established in the region, they operated six or seven days/week, and even evenings. Many of the factories we visited, however, operate only three or four days/week, which factory owners and managers attributed to shortages of palm hearts. Many estuary inhabitants with whom we spoke agreed that too much palm heart extraction over the past two decades has depleted the population of wild Açaí palms.

Pressure appears to be greatest in counties closest to Belém, which initially experienced quicker intensification of the palm heart industry. On the island of Marajó, for example, the counties closest to Belém produced only 1% of the state's palm hearts in 1989, compared to 64% in 1975 (IBGE, 1975 and 1989). During this same period, the more distant counties on Marajó increased their share of the state's palm heart production from 12% to 96% (IBGE, 1975 and 1989). Indeed, in 1992 these more distant counties contained 91% of all registered factories on Marajó (n=88) (Secretária da Fazenda, unpublished document).

The Logic Behind Resource Over-exploitation of Açaí Palm Hearts

To maintain palm heart productivity, recovery periods of several years are necessary between harvest events. The smaller-sized palm hearts that result from harvesting too frequently cause extractor and factory profits to decline and ultimately could lead to sharp declines in forest palm heart production . Nevertheless, in the short term, there is either little incentive or capacity at any level of the industry to avoid working with small palm hearts.

Consider the extractor, who has to wade through mud, hacking away vines and other undergrowth, to reach the base of an Acai clump. Once there, he is inclined to cut all stems, even the small ones, before trudging through the forest in search of the next clump. In fact, there are certain advantages to cutting small stems. For instance, young, tender Acai stems are easier to cut than older, thicker stems. There are fewer leaf-sheaths surrounding a small palm heart as well, reducing the time and effort necessary to prepare small palm hearts for delivery to a factory. Furthermore, harvesting small palm hearts requires less work at the carrying and loading/unloading stages (28% of the work involved in palm heart extraction), when most of the leaf-sheaths still have not been removed from the palm hearts. For example, an extractor earns $12.21 for each 100 kg of small palm hearts that he carries out of the forest, compared to $9.56 for each 100 kg of large palm hearts.

Overall, an extractor's income is higher from harvesting palm hearts of any size than from other available income-generating activities in the region (IMAZON, internal document); daily earnings from harvesting palm hearts, even small ones, are two to three times higher than the Brazilian minimum wage.

Factory profits decline by as much as 24% from working exclusively with small palm hearts (Table 1). Nevertheless, most factories we visited purchase small palm hearts. Similar to the case of extractors, there is a rational explanation for this. Palm hearts of all sizes generally arrive at the factory mixed together, and a seller would be reluctant to separate out the medium and large palm hearts and be left with only small palm hearts. In this case, he would be more likely to sell all his palm hearts to another factory, resulting in the first factory losing its supply of palm hearts. Another important consideration is that, even when using small palm hearts, palm heart processing is a relatively lucrative activity; profits from palm heart processing are more than five times higher than profits from the two other predominant small industries in the Marajo region -- saw mills and brick factories (IMAZON, internal document).

Distribution firms also lack incentives to insist on large palm hearts from their suppliers. In the first place, although excessive pressure on wild palm hearts has repeatedly forced firms to shift their activities to new areas over the past several decades, they continue to realize impressive profits (greater than $500,000/year) (Table 2). Furthermore, the only extra cost a distribution firm may incur from purchasing cans with small palm hearts is a slight risk of being fined by the Brazilian Environmental Agency (IBAMA) for breaking minimum-size regulations (see below). In fact, firms may even have an incentive to work with small palm hearts. Some consumers seem to be wary of palm hearts that are too thick, since thick palm heart pieces may (but do not necessarily) still contain the more fibrous outer sheaths (Urpí et al., 1991). As long as consumers associate thick palm hearts with a fibrous product, instead of with a rationally-harvested product, then small palm hearts will have more consumer appeal and firm owners will not discourage factories from processing them.

Combined with the individual reasons at each level for working with under-sized palm hearts, there is a "tragedy-of-the-commons" effect that exacerbates the problem (Hardin, 1968). Land in the estuary is frequently divided into large, unmarked plots. Many families may live, spread along river or stream banks, on the same property. These families plant and manage useful species, including Acai, in clearings and in the forest immediately surrounding their houses (Anderson and Ioris, 1992). However, all families generally share access to the rest of the forest, from which they extract timber, rubber, palm hearts, fruits, and other products. In addition, outsiders often negotiate directly with the absentee land-owner for extraction-rights to resources in these larger holdings, such as palm hearts and timber. Hence, delaying palm heart harvests does not necessarily result in higher palm heart yields for the individual. Instead, it may mean losing the palm hearts all together to another interested party. Extractors are therefore inclined to harvest palm hearts as soon as possible, instead of waiting for the palm hearts to reach a larger size. In this way, the extractor guarantees his own income at the shared cost of other extractors with access to the same areas (Pendleton, 1992).

Approaches to Developing a Sustainable Palm Heart Extraction Industry

Minimum-size regulations for palm hearts: To discourage palm heart extractors from harvesting young Acai stems, the Brazilian Institute of the Environment (IBAMA) has established minimum-size regulations for palm hearts. A palm heart must weigh at least 250 g after all leaf-sheaths are removed, and have a diameter of at least 2.0 cm. Unfortunately, these figures were not determined through systematic testing (IBAMA, personal communication) and are in need of revision. A palm heart that weighs 250 g has a diameter closer to 2.5 cm than to 2.0 cm (Table 3). Considering that it is far more practical for an enforcement officer to measure a palm heart's diameter, which can occur after the palm heart has been cut into pieces and canned, than it is to weigh the whole, uncut palm heart, it is important that

IBAMA correct this underestimate of a small palm heart's maximum diameter.

Furthermore, we observed that these regulations, even in their present form, are not adequately enforced. We opened 19 cans destined for the export market (obtained from factories in six counties on Marajó Island), and found that 49% of the palm heart pieces (n=314) had a diameter < 2.0 cm . The average diameter of all 314 pieces was 2.1 cm (s.d.=0.58), meaning that they were derived from whole palm hearts that weighed, on average, 180 g (Table 3). According to IBAMA's minimum-weight regulations, the "average" palm heart in these cans was illegal and should not have been harvested.

We have elaborated a simple technique which allows an enforcement officer, or, for that matter, a consumer, to determine the average size of palm hearts used to fill a 1 kg can of export palm hearts simply by counting the number of pieces in the can. Suppose an enforcement officer opens a can of palm hearts and finds 12 pieces inside. He could measure the diameter of each piece, or, more simply, he could refer to the Harvest Pressure Index (Fig. 4), which was created from the information presented in Table 3. The Harvest Pressure Index indicates that for this can with 12 pieces, the average size-category of these palm hearts is "medium," and that approximately six stems were harvested to fill the can. According to the agency's minimum-size regulations, the palm hearts that went into producing this can were, on average, acceptable (≥ 2.5 cm diameter). If, however, the enforcement officer found 15 or more pieces inside the can, he could infer that at least eight Acai stems were harvested to fill the can. It would be reasonable to assume, given the number of palm trees affected and the small size of the palm hearts, that the pieces in this can came from an area where extraction of palm hearts was not sustainable.

Forest management regulations for Acai palm trees: IBAMA's second strategy to protect Acai populations is to require that factories or distribution firms establish management projects in which one stem is managed or one Acai seedling is planted for each harvested palm heart (Regulation Nº 439, 1989). A distribution firm shares responsibility with its supplier factories for complying with this law, and usually assumes the responsibility entirely. In 1990, there were 62 palm heart management projects (average size = 870 ha) registered with IBAMA, of which approximately 80% were sponsored by distribution firms in Belém (IBAMA, unpublished document). Nevertheless, we observed that projects registered with IBAMA often exist only on paper. Not a single factory that we visited works with palm hearts obtained through management.

This is surprising, since management could result in significant long-term savings when compared to the cost of purchasing wild palm hearts from extractors. We compared the net present value of using management to supply a factory with palm hearts over 20 years (estimated lifetime of a management project) vs. meeting the palm heart needs of the factory by purchasing wild palm hearts (Table 6). A factory requires approximately 14,300,000 large palm hearts over 20 years in order to produce 30 tons of processed palm hearts/month (59,600 large palm hearts/month x 12 months x 20 years; see Table 1). The net present value of supplying this many palm hearts through "low-intensity" or "high-intensity" management, considering a 6% discount rate, is -\$19,792 and -\$153,436, respectively (the negative values signify that these are costs). These estimates include the discounted cost of purchasing additional palm hearts during the first six years, when a management project produces at only 32% of full-capacity (Lopes et al., 1982). In contrast, the net present value of purchasing all of a factory's palm hearts over twenty years is -$533065. Dividing these net present values by the number of palm hearts obtained over 20 years (14,300,000) shows that the average price per palm heart, in terms of present-day dollars to be spent over this period, is $0.001 using low-intensity management, $0.011 using high-intensity management, and $0.037 without management. Hence, this analysis reveals that it may be 3 to 37 times more expensive over 20 years to purchase palm hearts from extractors than it would be to implement a management project.

In spite of the viable management alternatives and a legislative mandate to implement Acai management projects, palm heart producers continue to depend on native Acai stands for raw materials. Factory owners are wary of Acai management because of the relatively high investment (net expenditures over the first six years to implement the low-intensity management project are 15% of a factory's average profits during the same period) and because of the six-year delay before the project reaches full production capacity. Distribution firm owners are also reluctant to invest in management, even though the more expensive, high-intensity management would only represent 3% of a firm's profits during the first six years. Firms do not currently pay for a factory's raw materials, and, considering their faith in an inexhaustible supply of wild palm hearts, they see no advantage to obtaining lower-priced raw materials through management. From their perspective, this would be equivalent to subsidizing factories' raw material costs (J. Nascimento, personal communication). Another important factor that works against palm heart management is that it is extremely difficult to prevent unauthorized extractors from entering an area and removing palm hearts. This reduces the project's anticipated yield and disrupts the planned extraction schedule, and may render a project ineffective.

After completing our financial analysis of palm heart factories and distribution firms, we returned to five firms and three factories to ask the owners whether they have invested in palm heart management. While they all claimed to be conducting management projects, none anticipated that management will replace wild palm heart extraction. In fact, 88% of them invest most of their profits from working with palm hearts in other activities, such as cattle ranching (four firm owners and one factory owner), timber processing (three firm owners), and fluvial transport (one firm owner and one factory owner). Evidently, they do not consider palm heart management a necessary or wise investment.

Social considerations: Laws that mandate size regulations for palm hearts and require Açai palm management projects are examples of how, through a top-down approach, the government can impose standards on the palm heart industry geared toward making the industry sustainable. In the forest, however, it is the extractor who, upon deciding which stems to cut and which to leave for future harvests, exercises the ultimate control over whether or not the activity is sustainable. Conditions must be made favorable for the extractor to carry out that task in a way which, ultimately, protects the natural resource against over-extraction.

We estimate that, by far, most of the profits realized on the sale of a can of palm hearts go to factories and distribution firms, even though much of the labor behind each can is from the local extractors. One way for extractors to receive a larger share of the benefits from working with palm hearts would be for them to operate their own management projects. This would make it easier to produce more large palm hearts in a shorter amount of time, thereby increasing the amount of income an extractor could earn in a day. With clear title to land, access to investment capital, and an effective means of community organization, inhabitants would be well-position to responsibly manage the Acai palm. For example, twenty families, with 50 ha each (i.e., 1000 ha total), could produce enough palm hearts, in managed forest tracts, to supply a typical factory (Table 5). If the families also ran the factory, they could receive an even greater portion of the profits.

To be truly sustainable, social criterion, as well as environmental and economic criterion, must be satisfied. Palm hearts offer a unique opportunity for this to occur. Measures are called for that promote technical, legal, financial, and community assistance for families that live in the estuary. These people have an important role to play in making the palm heart industry sustainable.

CONCLUSION

In this paper, we have shown that: 1) palm hearts from Euterpe oleracea are a lucrative non-timber forest product, 2) harvesting palm hearts too frequently could lead to declines in palm heart production, and 3) E. oleracea management is an economically viable alternative for guaranteeing a supply of palm hearts into the future. These conclusions are largely based on our own observations and on data collected during visits to many parts of the estuary. To make sense of our results, we have had to make certain generalizations. For example, we describe a "typical factory" and a "typical firm," as if all factories and firms were the same, which is certainly not the case. Similarly, we characterize the impacts of harvesting palm hearts on Acai stands based on limited sample in a restricted geographic area. However, over the course of this research we have become familiar enough with the palm heart industry to feel confident that our results capture the essence of palm heart activities in the Amazon estuary.

We intend this paper to draw attention to palm hearts and to serve as a spring board for future research. While virtually every aspect of the palm heart industry could use some further investigation, we suggest that the following topics receive top-priority. First, nobody knows exactly how many palm hearts are produced in the estuary, nor how many factories there are, since official data are incomplete. This information is important for estimating the full potential and impacts of palm heart extraction. Second, studies that measure the industry's response to seasonal or long-term changes in production costs and palm heart prices would be a valuable supplement to our "snap-shot" portrayal of the industry. Third, it is important to understand more about the Acai palm itself, and about its responses to palm heart extraction. We recommend more extensive surveys of harvesting practices and Acai population structure, as well as experimental plots in which Acai response to a variety of cutting treatments is assayed. Finally, there are important social factors associated with the palm heart industry which must be considered, to compliment the economic and ecological focus of this paper. Research should be encouraged that examines the living and working conditions of extractors and factory-workers, land-tenure issues that influence palm heart harvest-behavior, and opportunities for organizing palm heart processing and distribution activities so that rural communities receive greater financial benefits.

In conclusion, we wish to address those readers who may come away from this paper reluctant to buy canned palm hearts, owing to the signs of pressure and lack of initiatives to adopt the sustainable management strategies which we have discussed. Indeed, palm hearts are no different than any other renewable resource, in that the greatest profits are realized in the short-term through indiscriminate harvesting. We have shown, however, that palm heart management is a feasible, albeit initially expensive, way to guarantee a supply of palm hearts. Furthermore, under the right conditions estuary inhabitants could assume the responsibilities (and rewards) of palm heart management. Rather than dismissing palm heart extraction as an unsustainable activity, consumers may play a constructive role by demanding higher quality (i.e., larger) palm hearts. They can act by using the simple technique, described in this paper (Fig. 4), of counting the pieces in a palm heart can. If this occurs, palm heart producers may be persuaded that palm heart management is a worthwhile investment. Although the challenges are great, creating a sustainable palm heart industry offers one of the best opportunities to date for protecting the Amazon forest while at the same time generating benefits from its riches.

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REFERENCES

Anderson, A. B. and Ioris, E. M. (1992). The logic of extraction: resource management and income generation by extractive producers in the Amazon estuary. In Redford, K. H. and Padoch, C. (eds.), Conservation of Neotropical Forests: Working from Traditional Resource Use. Columbia University Press, New York, pp. 175-199.

Brabo, M. J. C. (1979). Palmiteiros de Muaná - estudo sobre o processo de produção no beneficiamento do açaizeiro. Boletim do Museu Paraense Emílio Goeldi 73: 1-29.

Calzavara, B. B. G. (1972). As possibilidades do açaizeiro no estuário amazônico. In Faculdade de Ciências Agrárias do Pará, Belém, Boletim 5: 165-206.

Calzavara, B. B. G. (1987). Açaizeiro. Recomendações básicas 3. Empresa Brasileira de Pesquisa Agropecuária, Belém, Pará.

Diário do Pará (1993). May 13, A-11.

Ferreira, V. L. P. and Paschoalino, J. E. (1987). Pesquisa sobre palmito no Instituto de Tecnologia de Alimentos (ITAL). In Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Proceedings from the First National Conference of Researchers on Palm Hearts, May 26-28. EMBRAPA, Curitiba, Brazil, pp. 45-62.

Hardin, G. (1968). The tragedy of the commons. Science 168: 1243-1248.

Homma, A.K.O. (1992). The dynamics of extraction in Amazonia: a historical perspective. Advances in Economic Botany 9: 23-31.

Instituto Brasileiro de Geografia e Estatística (IBGE) (1975-1989). Producão Extrativa Vegetal. Fundação Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro, Brazil.

Lopes, A. V. F., Souza, J. M. S. de, and Calzavara, B. B. G. (1982). Aspectos econômicos do Açaizeiro. Superintendência do Desenvolvimento da Amazonia, Departamento de Setores Produtivos, Belém, Pará, Brazil.

Nepstad, D. and Schwartzman, S. (eds.) (1992). Non-timber products from tropical forests: evaluation of a conservation and development strategy. Advances in Economic Botany, Vol. 9.

Oliveira, P. H. B. de and Nascimento, M. J. M. (1991). Os trabalhadores rurais de Gurupá (PA) em busca de alternativas econômicas: as estratégias e o mercado do palmito em conserva Paraense. Reforma Agrária 21: 91-120.

Pendleton, L. H. (1992). Trouble in paradise: practical obstacles to non timber forestry in Latin America. In Plotkin, M. and Famolare, L. (eds.). Sustainable Harvest and Marketing of Rain Forest Products. Conservation International, Island Press, Berkeley, pp. 252-262.

Peters, C. M., Gentry, A. H. and Mendelsohn, R. O. (1989). Valuation of an Amazonian rain forest. Nature 339: 656.

Plotkin, M., and Famolare, L. (1992). Sustainable Harvest and Marketing of Rain Forest Products. Conservation International, Island Press, Berkeley.

Rossetti, C. F., Berger, R. and Duarte, J. (1987). Considerações sobre a produção e comercialização do palmito. In Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Proceedings from the First National Conference of Researchers on PalmHearts, May 26-28. EMBRAPA, Curitiba, pp. 125-136.

Urpí, J. M., Bonilla, A., Clement, C. R. and Johnson, D. V. (1991). Mercado internacional de palmito y futuro de la explotación salvaje vs. cultivado. In Universidad de Costa Rica, Boletím Informativo 3: 6-27.

Table 1. Financial analysis of a palm heart processing plant that produces 30 tons of palm hearts per month, July, 1992, Pará, Brazil.

		US$
1. MONTHLY RAW MATERIAL COSTS [1]		
Large palm hearts [2]		3,872
Medium palm hearts [3]		4,274
Small palm hearts		4,759
	AVERAGE:	**4,302**
2. MONTHLY PRODUCTION COSTS		
Wages [4]		1,650
Chemical products [5]		453
Maintenance [6]		223
Freight [7]		191
Firewood [8]		111
Boat [9]		377
Electricity [10]		26
Depreciation [11]		56
	TOTAL:	**3,087**
3. GROSS MONTHLY RETURN		
Export palm hearts [12]		6,336
Domestic palm hearts [13]		4,368
	TOTAL:	**10,704**
5. MONTHLY NET PROFIT [14]		
Using large palm hearts		3,745
Using medium palm hearts		3,343
Using small palm hearts		2,858
	AVERAGE:	**3,315**

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[1] A factory requires 11,880 kg (drained weight) of palm hearts to produce 30 tons (net weight) of processed palm heart cans and jars. Of this 11,880 kg, approximately 7200 kg are export quality pieces that fill 14,400 one kg cans (500 g of palm hearts/can). The remaining 4680 kg are domestic quality pieces that fill 15,600 one kg jars (300 g of palm hearts/jar).

[2] We consider that "large" palm hearts have a diameter of 3.0 cm (Calzavara, 1972) and weigh approximately 338 g (Table 3). A total of 59% of total palm heart weight is actually used to fill cans and jars (36% for export pieces and 23% for domestic pieces) (Fig. 3). Hence, for large palm hearts, approximately 199 g would actually go into cans and jars (338 g x 0.59). A factory relying exclusively on such large palm hearts to meets its 30 ton/monthly production quota would require approximately 59,600 hearts (11,880 kg/0.199 kg). The cost to purchase these palm hearts would be some $3,872 ($0.065/palm heart x 59,573 palm hearts).

[3] We consider that "medium" palm hearts have a diameter of 2.5 cm and weigh 245 g, while small palm hearts have a diameter of 2.0 cm and weigh 165 g (Calzavara, 1972) (Table 3). A factory relying exclusively on medium palm hearts would need to purchase 82,186 hearts. At $0.052/palm heart, the total cost would be $4274. Meanwhile, a factory relying just on small palm hearts would require 122 034 hearts. At $0.039/palm heart, the total cost would be $4759.

[4] A typical factory employs one manager (four minimum wages/month), a manager's assistant (two minimum wages), a palm heart purchaser, a furnace operator and canning machine operator (1.5 minimum wages each), and 17 other workers (one minimum wage each), for a total of 27.5 minimum wages/month (minimum wage = $60.00/month) (27.5 minimum wages x $60.0 = $1650). We do not include workers' benefits in our analysis, since workers in palm heart factories are rarely registered and receive no benefits.

[5] 120 kg of citric acid ($167 for a 50 kg sack) and 600 kg of salt ($2.60 for a 30 kg sack) are used to process 30 tons of palm hearts ((2.4 sacks x $167) + (20 sacks x $2.60) = $453).

[6] Maintenance costs of a factory include maintaining the building, grounds, equipment, machinery and, often, a boat. These costs add up to approximately $670/month. We consider that a factory pays for 1/3 of these costs ($670 / 3 = $223). A factory's sponsoring distribution firm pays the remaining costs.

[7] It costs, on average $6.35/ton to freight palm heart cans and jars to Belém (based on the price of freight from Muaná, Breves, and Limoeiro de Ajurú to Belém) ($6.35/ton x 30 tons = $191) (Fig. 1).

[8] Two cubic meters of firewood are used to heat water to sterilize and seal each ton of cans and jars. Firewood costs approximately $1.85/m^3$ (30 tons x (2 x 1.85) = $111).

[9] Factories usually own at least one boat to pick up palm hearts at extractors' houses. We estimate that the boat makes eight 12-hour trips/month, for a cost of $377. This includes the cost of 240 litters of diesel fuel, wages and food for a two-person crew.

[10] Factories receive electricity from the local power authority or they use a diesel generator. Energy costs, on average, \$0.87/ton of palm hearts produced (n=9) (\$0.87/ton x 30 tons = \$26).

[11] The initial investment for a factory is approximately \$20,000, including the building, steam furnace, boiling tank, canning machine, boat, and all other equipment. We consider that a factory owner pays one third of this (the other two thirds are paid by the factory's sponsoring distribution firm), for an investment of \$6667. We estimate the life expectancy of a factory and associated equipment as 10 years. Monthly depreciation is 10% of the initial investment ((0.10 x \$6667)/12 = \$56).

[12] Forty-eight percent of the factory's production (14.4 tons) is export cans of 1 kg each, which the factory sells to a distribution firm for \$440/ton (14.4 tons x \$440/ton = \$6336).

[13] Fifty-two percent of the factory's production (15.6 tons) is domestic jars of 1 kg each, which the factory sells to a distribution firm for \$280/ton (15.6 tons x \$280/ton = \$4368).

[14] Average monthly net profit = gross monthly returns - (cost of palm hearts + production costs).

Table 2. Financial analysis of a palm heart distribution firm that sells 150 tons of palm hearts per month, July, 1992, Pará, Brazil.

	US$
1. MONTHLY PRODUCTION COSTS	
Purchase price: export-quality palm hearts [1]	31,680
Purchase price: domestic-quality palm hearts [2]	21,840
Packaging materials [3]	48,848
Taxes [4]	31,750
Freight [5]	10,662
Wages [6]	6,317
Maintenance [7]	7,233
Office and warehouse rental [8]	2,000
Communication (phone/fax/telex)	1,310
Electricity and water	637
Port fees [9]	518
Business fees [10]	249
Depreciation [11]	**556**
TOTAL:	**163,600**
2. GROSS MONTHLY RETURN	
Export palm hearts [12]	139,680
Domestic palm hearts [13]	86,580
TOTAL:	**226,260**
3. MONTHLY NET PROFIT [14]	**62,660**

[1] The firm purchases 72,000 1 kg cans (export) of processed palm hearts from its supplier factories for \$0.44 each (72,000 x \$0.44 = \$31,680).
[2] The firm purchases 78,000 1 kg jars (dometstic) of processed palm hearts from its supplier factories for \$0.28 each (78,000 x \$0.28 = \$21,840).
[3] Each month, the firm sends 72,727 empty cans (\$0.38/can) and 78,788 empty jars (\$0.23/jar) to its supplier factories (the extra cans and jars are to compensate for a 1% breakage rate). Cans and jars come in boxes, but the firm purchases an additional 6000 special boxes (\$0.32/box) that hold 12 cans each for export palm hearts. Labels are pre-printed on cans, but 78,000 labels must be purchased for jars (\$0.015/label). Total

packaging costs are $48,848/month (($0.38 x 72,727) + ($0.23 x 78,788) + ($0.32 x 6000) + ($0.015 x 78,000)).

4 The state collects 13% of gross profit from export palm hearts and 12% of gross profit from domestic palm hearts in taxes (ICMS), for a total of $28,548 (0.13 x 139,680) + (0.12 x 86,580)). Federal taxes include 0.65% of the firm's total gross income (PIS) and 2% of the firm's gross income from domestic palm heart sales (FINSOCIAL), for a total of $3202/month ((0.0065 x 226,260) + (0.02 x 86 ,580)). Total state and federal taxes therefore equal $31,750/month.

5 The firm pays $10.50/ton to send the export palm hearts to the Belém port for shipping, and $127.00/ton to send the domestic palm hearts overland to other parts of Brazil (($10.50 x 72) + ($127 x 78) = $10,662).

6 The firm employs six administrative assistants (two minimum wages each), 36 workers (one minimum wage each), and a part-time chemical engineer to conduct quality tests (three minimum wages) for a total of 51 minimum wages (one minimum wage in July, 1992 = $60). The firm pays an additional 18.2% of wages as workers' benefits. In addition, the firm owner collects a salary of $2700/month, for total monthly wages of $6317 (($60 x 51) + (0.182 x 3060) + $2700).

7 Maintenance costs are estimated as two-thirds the total maintenance costs of a distribution firm's five supplier factories (Table 1, footnote 6), plus an additional $5000/month for maintaining the firm's facilities and equipment ((2/3 x $670/factory/month x 5 factories) + $5000 = $7233).

8 Most firms rent riverfront office and warehouse space in Belém. After conferring with four real estate agents in Belém, we estimated that it costs $2000/month to rent a 40 x 80 m Belém riverfront lot with buildings.

9 The firm pays a port fee of $7.20/ton for export palm hearts ($7.20 x 72 = $518).

10 Firms in Belém that sell more than 50 tons of palm hearts/month are members of the National Association of Palm Heart Producers and Exporters (ANFEP). ANFEP charges an annual fee of $2993, or $249/month ($2993 / 12).

11 Depreciation costs are considered as two-thirds the depreciation costs of a distribution firm's five supplier factories (2/3 x $2000/factory/year x 5 factories = $6667/year). Monthly depreciation costs are therefore $556/month ($6667 / 12).

12 The firm sells 72,000 1 kg cans of palm hearts on the export market, for $1.94/can (72,000 cans x $1.94 = $139,680).

13 The firm sells 78,000 1 kg jars of palm hearts on the domestic market, for $1.11/jar.

14 Monthly net profit = gross monthly return - (production costs + depreciation).

Table 3. Equations relating Açaí palm (Euterpe oleracea Mart.) stem dimensions with palm heart size and weight.

EQUATIONS

Palm heart weight (g) = [27.552 x **palm heart diameter** ^{2} (cm)] + [35.517 x **palm heart diameter**] - 16.603; r^2=0.66; n=180.

Palm heart diameter (cm) = [0.295 x **stem dbh** (cm)] - 0.513; r^2 = =0.78; n = 70

Stem DBH [cm] = [3.390 x **palm heart diameter** (cm)] + 1.739; r^2=0.74; n=70

Stem height [m] = [1.778 x **stem DBH** (cm)] - 5.849; r^2=0.83; n=59

Stem height [m] = [6.599 x **palm heart diameter** (cm)] - 3.905; r^2=0.74; n=59

EXAMPLES ILLUSTRATING USE OF EQUATIONS

	PALM HEART SIZE CATEGORIES				
	Very small	Small	Medium	Large	Very large
Palm heart diameter (cm)	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**
Palm heart weight (g)	99	165	244	338	445
Stem DBH (cm)	6.8	8.5	10.2	11.9	13.6
Stem height (m) [1]	6.3	9.3	12.3	15.3	18.3
Palm heart pieces required to fill a 1 kg export can [2]	22	17	12	7	3

[illegible]

[1]We used the equation correlating stem height with stem DBH (Table 3).

[2]We used the following equation to calculate the number of palm heart pieces of a given size category required to fill a 1 kg export can: **Number of pieces in 1 kg export can** = [-9.709 x **palm heart diameter** (cm)] + 36.583; r^2=0.86; n=36 cans.

Table 4. Characteristics of Açaí palm heart (Euterpe oleracea Mart.) extraction and Açaí population structure in stands harvested at one to two-year and four to five-year intervals in the Amazon esturary, Pará, Brazil Pará, Brazil.

	1-2 year harvest intervals (n = 5 sites)	**4-5 year harvest intervals (n = 2 sites)**	**No harvest control (n = 1 site)**
Characteristics Of Most Recent Harvest:			
Number of stems harvested per clump	1.2 (0.2)	1.0 (0.1)	--
Diameter of harvested stems	6.2 cm (1.0)	10.6 cm (2.1)	--
Height of harvested stems [1]	5.2 m	13.0 m	--
Diameter of harvested palm hearts [2]	1.3 cm	2.6 cm	--
Weight of harvested palm hearts [3]	76 g	262 g	--
Total harvest yield [4]	43,867 g	192,308 g	--
Post-Harvest Açai Population Structure:			
Density of clumps/ha with stem ≥ 2 m	481 (114) [5]	734 (339)	620 (113)
Average DBH (cm) of stems ≥ 2 m	4.9 (0.6)	6.3 (0.3)	8.5 (0.6)
Average height (m) of stems ≥ 2 m [6]	2.9	5.4	9.4
Percentage of stems with height:			
< 2 m	88%	64%	55%
2 - 3.9 m	8%	14%	13%
≥ 4 m	4%	22%	32%
Percentage of dead clumps	25%	11%	12%

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[1] The height of harvested stems was estimated from the diameter of the remaining stumps, which we considered equal to stem DBH.

[2] We calculated the diameter of harvested palm hearts from the diameter of the remaining stumps, which we considered equal to stem DBH: **Palm heart diameter** (cm) = [0.295 x **stem DBH** (cm)] - 0.513; r^2=0.78; n=70 (Table 3).

[3] The weight of harvested palm hearts was calculated from the diameter of harvested palm hearts, using the following equation: Palm heart weight (g) = [27.552 x **palm heart diameter**^{2} (cm)] + [35.517 x **palm heart diameter**] - 16.603; r^2=0.66; n=180 (Table 3).

[4] Harvest yield [g] = clumps/ha x harvested stems/clump x harvested palm heart weight.

[5] Numbers in parentheses are the standard deviation.

[6] The height of stems in all plots was calculated from the DBH of stems, using the following equation: **Stem height** (m) = (1.778 x **stem DBH** (cm)] - 5.849; r^2=0.83; n=59 (Table 3).

Table 5. Financial analysis of palm heart management in the Amazon Estuary, Pará, Brazil.

	"Low-intensity" Management [1] US$/ha	"High-intensity" Management [2] US$/ha
Costs (Year 1)		
Prepare project proposal [3]	--	3.76
Demarcate management plots [4]	--	2.56
Thin undergrowth and canopy trees [5]	25.00	97.00
Disperse seeds [6]	2.50	30.00
Trail maintenance [7]	--	0.51
Thin undergrowth [8]	5.00	14.40
Harvest palm hearts [9]	4.00	6.40
IBAMA fee [10]	0.60	0.60
TOTAL:	**37.10**	**155.23**
Costs (Years 2-6)		
Trail maintenance	--	1.02
Thin undergrowth	10.00	28.80
Harvest palm hearts	4.00	6.40
IBAMA fee	0.60	0.60
TOTAL:	**14.60**	**36.82**
Costs (Years 7 and on)		
Trail maintenance	--	0.51
Thin undergrowth	5.00	14.40
Harvest palm hearts	12.50	20.00
IBAMA fee	0.60	0.60
TOTAL:	**18.10**	**35.51**
Revenue from Harvested Palm Hearts [11]		
Years 1 to 6	13.00	20.80
Years 7 and on	40.63	65.00
Net Profit		
Year 1	-24.10	-134.43
Years 2 to 6	-1.60	-16.02
Years 7 and on	22.53	29.49
Net Present Value--20 Years [12]	118.54	2.75

1 "Low-intensity" management is a combination of management techniques described by Lopes et al. (1982) and Calzavara (1987). We estimated the costs of this type of management by multiplying the mandays required for each task by the daily minimum wage in July, 1992 ($2.50/hour). Low-intensity management yields 200 large palm hearts/ha/year during the first six years, and 625 large palm hearts/ha/year in following years. A 1144 ha low-intensity management project would supply 715,000 large palm hearts/year (1144 ha x 625 palm hearts/ha/year), which is approximately what a typical factory requires to produce 30 tons/month.

2 "High-intensity" management refers to the management techniques practiced by a forest engineering firm in Belém responsible for approximately 80% of the palm heart management projects registered with IBAMA. High-intensity management yields 320 large palm hearts/ha/year during the first six years, and 1000 large palm hearts/ha/year in following years. A 715 ha project would supply 715,000 large palm hearts/year.

3 The engineering firm charges a fee of $2687 to prepare and submit a project proposal to IBAMA. This is equivalent to $3.76/ha in a 715 ha project ($2687 / 715 ha).

4 For high-intensity management, the firm demarcates 100 ha sub-plots with 4 m-wide trails. A 715 ha project would require seven demarcated subplots, or 28 km of trails. Since management projects are normally implemented along a river or stream bank, and adjacent plots share boundaries, only 15 km of trails are necessary to demarcate seven management plots (no trails being required along waterways or shared boundaries). The firm charges $122/km, for a total cost of $1830 , or $2.56/ha ($122/km x 15 km / 715 ha).

5 Anderson and Jardim (1989) observed that it takes 10 mandays/ha to thin the understory and remove undesired canopy trees by girdling (conservative estimate), for a cost of $25/ha (10 mandays/ha x $2.50/manday). For a high-intensity management project, the firm charges $72/ha to thin the understory and $25/ha to remove undesired canopy trees for a total of $97.00/ha.

6 Seeds are obtained free from local Açaí fruit processors. We estimate that obtaining and scattering seeds requires one manday/ha, for a cost of $2.50/ha. The firm charges $30/ha to scatter the seeds in a high-intensity management project.

7 The 4 m-wide trails that are part of a high-intensity management project must be cleared of new growth every six months during the first six years, and once every year

thereafter. Each maintenance episode costs 20% the original cost of opening the trails (0.20 x \$2.56/ha = \$0.51/ha).

8 In both types of management projects, new growth, including excess Açaí shoots, must be cleared two times during the first year, and once every year thereafter. For low-intensity management, this task requires four mandays/ha. For high-intensity management, the firm charges 20% the original cost of thinning undergrowth each time the forest is cleared of newgrowth (0.20 x \$72/ha = 14.40/ha).

9 Factory owners pay hired extractors \$0.02/palm heart to harvest large palm hearts. A low-intensity management project yields 200 palm hearts/ha/year for the first six years (200 palm hearts/ha/year x \$0.02/palm heart = \$4.00/ha/year) and 625 palm hearts/ha/year in following years (625 palm hearts/ha/year x \$0.02/palm heart = \$12.50/ha/year). The calculations are the same for high-intensity management, which yields 320 large palm hearts/ha/year for the first six years and 1000 large palm hearts/ha/year after the sixth year.

10 IBAMA charges an annual fee of \$0.60/ha to register a management project.

11 In this analysis, we consider the revenue as the value of the palm hearts produced on the project, considering the price paid by a factory for large palm hearts (\$0.065/palm heart).

12 Net Present Value is calculated for a twenty-year period, considering a 6% interest rate.

Table 6. Comparative analysis of the net present value of acquiring enough palm hearts to produce 30 tons of processed palm hearts per month for 20 years through low-intensity management, high-intensity management and without management in the Amazon Estuary, Brazil.

	Number of Palm Hearts [1]	Net Present Value [2]	Cost/Palm Heart [3]
Low-intensity management [4]			
Management yield	11,382,800	$135,610	
Purchased	2,917,200	-$155,402	$0.001
Total	14,300,000	-$19,792	
High-intensity management [5]			
Management yield	11,382,800	$1,966	
Purchased	2,917,200	-$155,402	$0.011
Total	14, 300,000	-$153,436	
No management			
Purchased	14,300,000	-$533,065	$0.037
Total	14,300,000	-$533,065	

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1 A factory requires 59,573 large palm hearts/month to produce 30 tons of processed palm hearts/month (Table 1). The factory therefore requires 14,297,520 palm hearts over 20 years (59,573 x 12 x 20), which we round to 14,300,000.

2 All net present value calculations consider a 6% discount rate. A negative net present value implies that this is a cost. The net present values of both types of management were calculated for the first 20 years of a project, using the costs and revenues of management shown in Table 5. In the absence of management, the net present cost of purchasing palm hearts was calculated from the price of a large palm heart in July, 1992 ($0.065 large/palm heart).

table 6, cont.

3 The cost per palm heart represents the average cost of each palm heart purchased over a 20-year period, and is derived by dividing the total net present value of producing and/or purchasing palm hearts by the number of palm hearts produced/purchased.

4 A "low-intensity" management project must be 1144 ha to provide enough large palm hearts for a factory to produce 30 tons of processed palm hearts/month (Table 5). A project of this size will yield approximately 200 palm hearts/ha/year for the first six years, during which time additional palm hearts have to be purchased, and 625 palm hearts/ha/year from the seventh year onward.

5 A "high-intensity" management project must be 715 ha to provide enough large palm hearts for a factory to produce 30 tons of processed palm hearts/month. A project this size will yield 320 palm hearts/ha/year for the first six years, during which time additional palm hearts have to be purchased, and 1000 palm hearts/ha/year from the seventh year onward.

LIST OF FIGURES

Figure 1. The study region in the Amazon estuary.

Figure 2. The pathway of a palm heart from the forest to the market.

Figure 3. The Acai palm (Euterpe oleracea Mart.) grows in "clumps," enabling its palm heart to be removed from selected stems without killing the individual. A palm heart is divided into categories: the most tender pieces are used to fill cans that are sold on the export market; other pieces are placed in jars that are sold in Brazil; the scraps may be cut into chunks and sold locally, used as pig feed, or simply discarded.

Figure 4. Using a "harvest pressure index" one can estimate the number and size of palm trees harvested to fill a 1-kg can of export palm hearts simply by counting the number of palm sections in the can. If a can has 15 or more pieces, then the average palm heart is "small" [below the current standards set by the Brazilian Environmental Agency (IBAMA).

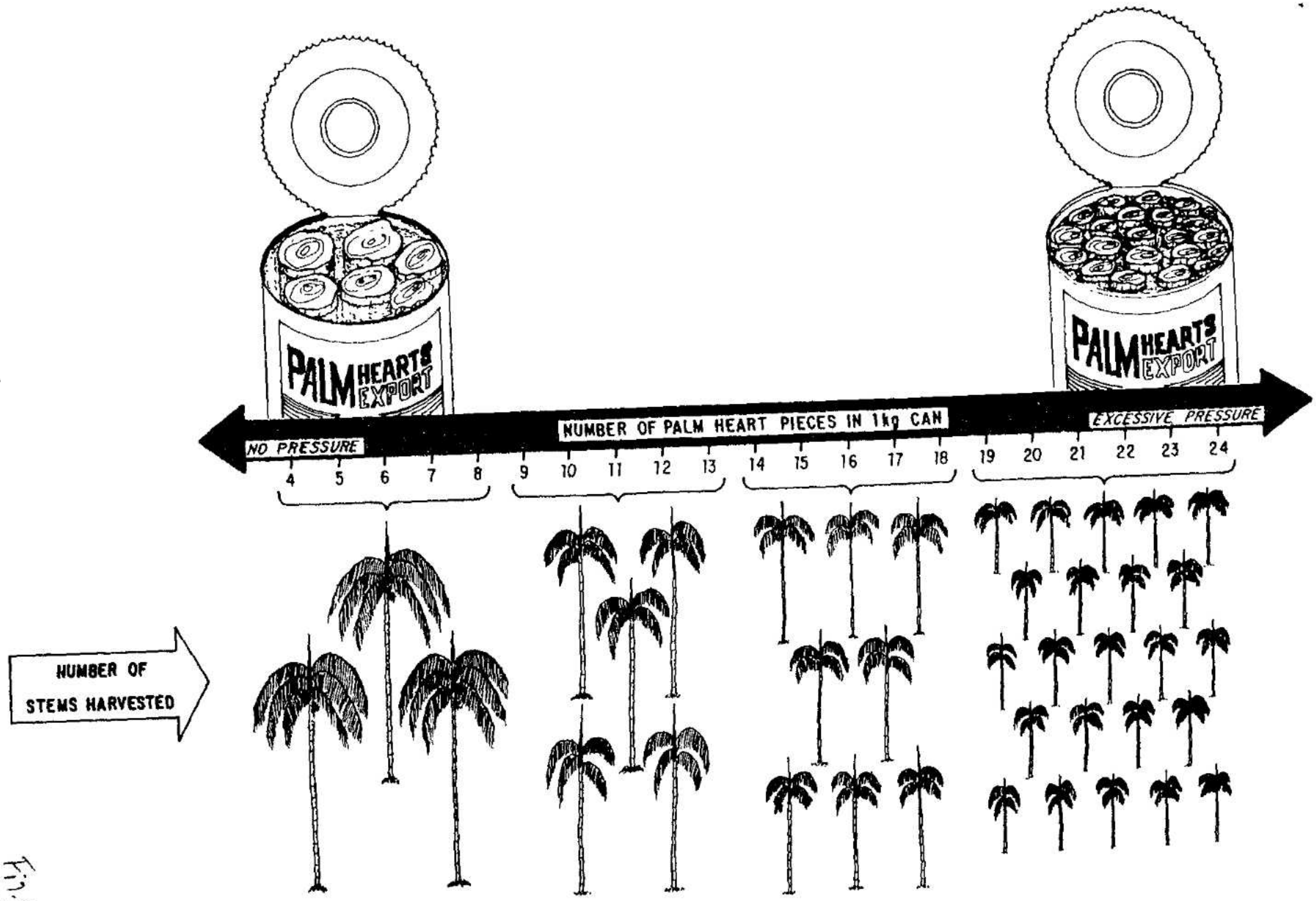

PALM HEARTS EXPORT
PALM HEARTS EXPORT
NUMBER OF PALM HEART PIECES IN 1kg CAN
NO PRESSURE
EXCESSIVE PRESSURE
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
NUMBER OF STEMS HARVESTED

Fig. 4

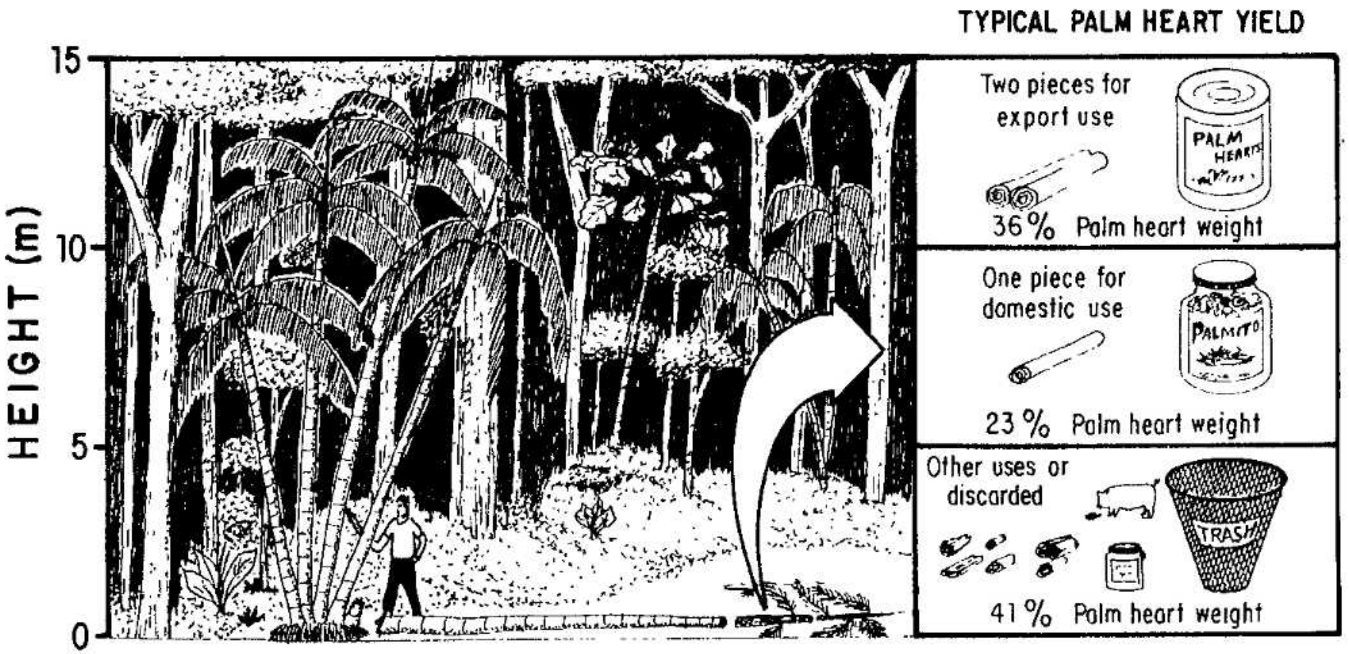

TYPICAL PALM HEART YIELD
HEIGHT (m)
15
10
5
0
Two pieces for export use
PALM HEARTS
36 % Palm heart weight
One piece for domestic use
PALMITO
23 % Palm heart weight
Other uses or discarded
TRASH
41 % Palm heart weight

Fig. 3

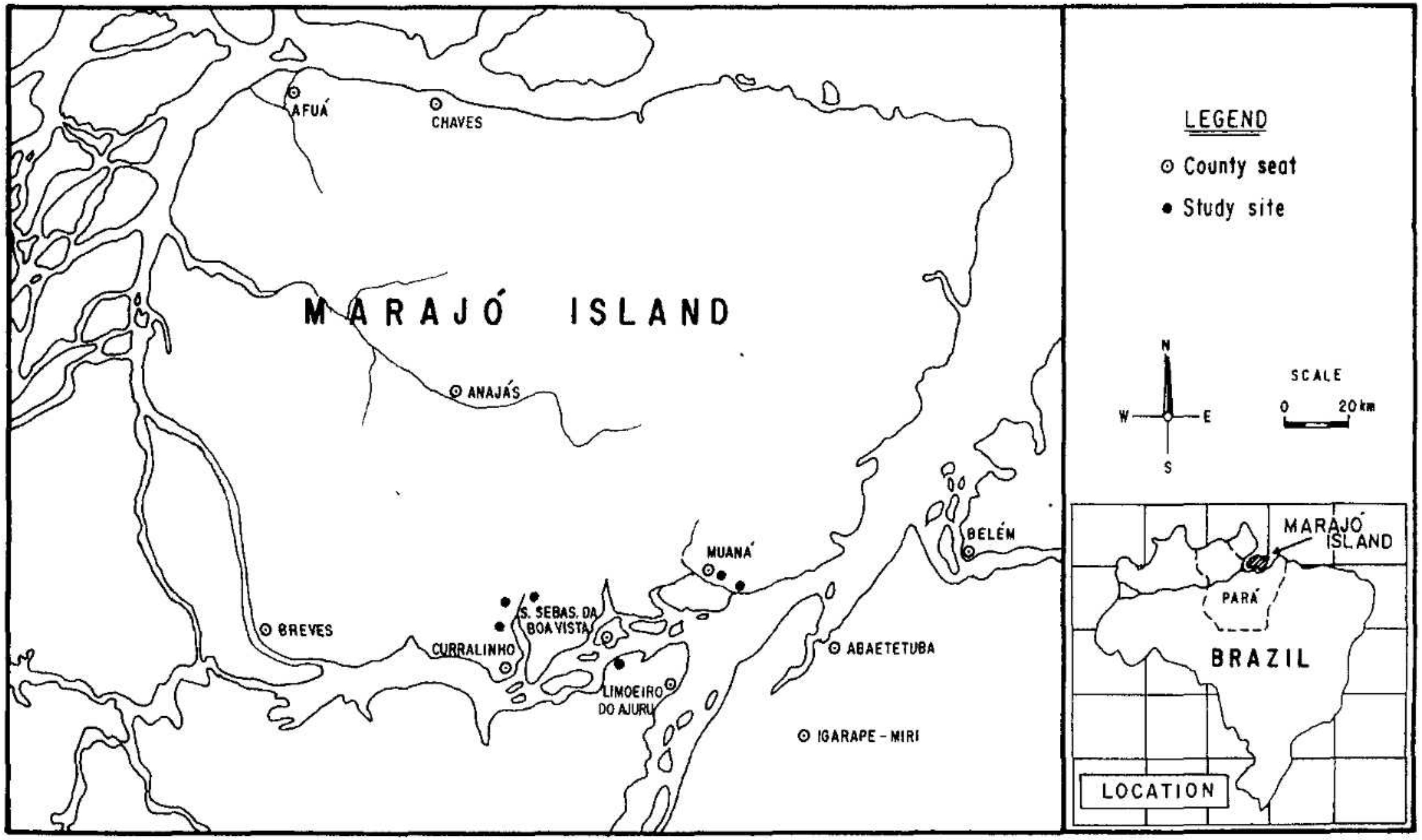
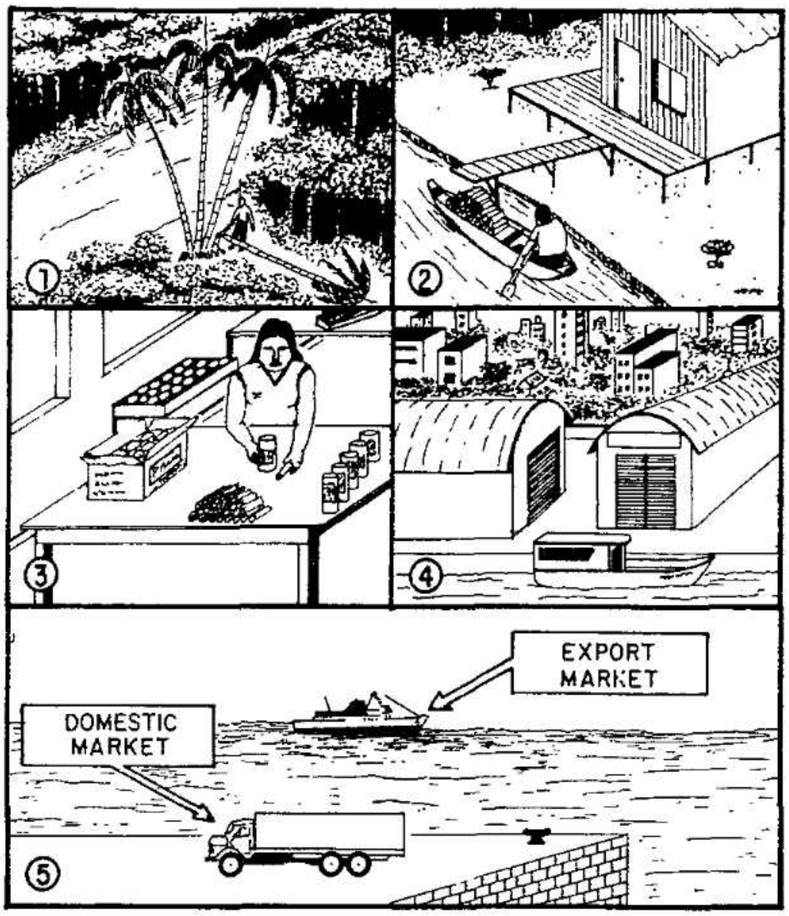

MARAJÓ ISLAND
AFUÁ
CHAVES
ANAJÁS
BREVES
CURRALINHO
S. SEBAS. DA BOA VISTA
MUANÁ
LIMOEIRO DO AJURU
ABAETETUBA
IGARAPE - MIRI
BELÉM
LEGEND
County seat
Study site
N
W
E
S
SCALE
0
20 km
MARAJÓ ISLAND
PARÁ
BRAZIL
LOCATION

Fig. 1

47



1- EXTRACTION OF WILD PALM HEARTS

2- ARRIVAL AT PALM HEART FACTORY

3- PROCESSING OF PALM HEARTS

4- ARRIVAL AT PALM HEART DISTRIBUTION FIRM

5- TRANSPORT TO FOREIGN AND DOMESTIC MARKETS

Fig. 2