Unsustainable Management of Arumã (*Ischnosiphon polyphyllus* [Poepp. & Endl.] Körn.) by the Novo Airão Artisans Association, Rio Negro, Amazon, Brazil[1]

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Non–timber forest products (NTFP) represent potentially sustainable economic alternatives for traditional peoples. However, exploiting NTFPs involves challenges, including successful insertion of products into conventional markets, accommodating legal or traditional–use restrictions, and negotiating access to traditionally occupied territories. Some of these restrictions are due to the creation of conservation units. Here we present information on the effects of creation of a conservation unit on the viability of an NTFP–extraction initiative by the members of the Artisans Association of Novo Airão (AANA), Amazonas State, Brazilian Amazon. Those artisans make vegetable fiber handicrafts using the leafstalks of arumã (*Ischnosiphon polyphyllus* – Marantaceae), which is common in seasonally flooded areas near Novo Airão. Conservation areas surround the town of Novo Airão and AANA members are prohibited from harvesting arumã leafstalks in these areas. In 2000, alternative areas for harvesting were suggested by environmental institutes, and management of arumã was concentrated along four rainforest streams close to Novo Airão. Harvest sites were monitored for three years, but there was no increase in growth rate as a result of harvesting, and leafstalk density did not completely recover between samples. High growth rates of arumã leafstalks suitable for handicraft manufacture are found only in areas where people manage the tree cover, but these practices are not permitted by current legislation, even in areas outside conservation units. To obtain arumã using traditionally sustainable methods, AANA requires the right to work and manage forests in protected areas. The lack of regionally appropriate public and environmental policy has resulted in a major impediment to a sustainable and locally run development activity.

Produtos florestais não madeireiros (PFNM) representam potenciais alternativas econômicas sustentáveis para povos e comunidades tradicionais. No entanto, além dos desafios quanto à inserção em mercados convencionais, constatam–se restrições de uso e acesso aos territórios tradicionalmente ocupados. Umas destas restrições é a criação de Unidades de Conservação. Neste trabalho, apresentamos informações sobre uma iniciativa de artesanato em fibras vegetais da Associação dos Artesãos de Novo Airão (AANA), Amazonas, Brasil. Os membros da AANA foram impossibilitados de extrair talos de *arumã* em áreas que foram delimitadas como Unidades de Conservação de uso indireto. No ano de 2000, alternativas de uso foram sugeridas por institutos ambientais para realizar o manejo de *arumã* em áreas de quatro *igarapés* próximos ao município de Novo Airão. Os resultados da densidade média de talos extraídos de *arumã*, ao longo de três anos, demonstram que não houve um incremento na taxa de aumento intrínseco, uma vez que

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o crescimento dos talos de *arumã* nessas áreas indica que não foram renovados completamente em relação à densidade inicial amostrada. Fatores biofísicos, como luminosidade e água são fundamentais para favorecer o adensamento das plantas. Neste caso, é necessário que haja manipulação do meio ambiente para adensar os talos de *arumã*. E para que isso seja realizado a AANA requer o reconhecimento ao direito de uso dos territórios para que possa realizar estratégias de manejo que sejam adequadas à sua atividade tradicional. A falta de políticas públicas e ambientais adequadas à região acarreta os principais empecilhos para desenvolvimento da atividade.

Key Words: Non–timber forest product, handicrafts, resource rights, traditional peoples, ethnobotany.

Introduction

The use of non–timber forest products (NTFP) is a favored form of tropical land use (Stanley et al. 2012), especially because alternatives, such as logging and commercial agriculture, have been responsible for high rates of deforestation in recent decades (Fearnside 2005; Margulis 2003). Mapping by the Brazilian National Institute for Space Research (INPE) shows that about 60% of Amazonian deforestation has occurred where land was converted to pasture (INPE 2011). In the southern and eastern parts of the Amazon basin, expansion of agricultural activities and logging have led to changes in carbon stocks and regional rainfall patterns, altering energy and water cycles (Davidson et al. 2012).

An alternative form of land use with lower impacts on existing forest cover than logging or commercial agriculture is the commercialization of non–timber forest products (NTFPs), such as vegetable fibers, oils, resins, fruits, medicinal plants, and seeds. For rural people and traditional communities, the extractive practices associated with the use of these resources are often already an integral part of their livelihoods (FOIRN/ISA 2000; Leoni and Costa 2013; Macía and Balslev 2000; Nakazono 2007; Ruwanza and Shackleton 2015; Silva 2004). The right to use these resources and the traditionally occupied territories in which they occur has been legally recognized in Brazil in recent decades, especially in the 1988 Constitution (de Almeida 2008; Shiraishi Neto 2007). However, the difficulties in the effective conversion of such resources into environmentally sustainable income are many, especially since recognition and effective participation of communities in the conservation of natural environments has not been addressed by public environmental policies and government programs (PNCSA 2016). The legal recognition of rights to the use of traditional territories is critical to ensure physical and social continuity for these people and their communities (Alcorn 1993; Emperaire and Lescure 2000; Gibson et al. 2000; Ruwanza and Shackleton 2015).

Development based on large–scale agriculture is not considered sustainable in the Amazon because the changes that it brings about reduce the fertility of the soil and the climatic conditions necessary for continued production (Fearnside 2003). In contrast, use of NTFPs may be more ecologically sustainable because their extraction does not necessarily change the ecosystem processes on which production depends. However, NTFPs generally generate less income per unit area in the short term, and their long–term economic sustainability may depend on community access to traditional territories and their associated natural resources. For this to happen, traditional communities must have effective participation in the management of their territories (Ostrom 2002). Therefore, involvement of local people in management decisions is important to increase the chances that industries will be ecologically and economically sustainable (Silvius et al. 2004). Many conservation reserves in Brazil allow people to live within their boundaries and are called sustainable–use conservation units (Sousa et al. 2011). Sustainable–use is defined as activities that do not interfere with the processes that sustain the natural ecosystem, and that is the sense in which we use ecological sustainability here.

In this paper, we describe the social and environmental circumstances of an Amazonian rural collective, the Association of Artisans of Novo Airão (AANA). The association was created in 1996 by artisans who had previously individually commercialized products based on arumã without being involved in collective activities. The families of the artisans had previously engaged in subsistence agriculture and fishing, and the handicrafts based on plant fibers were their principal source of income (Fig. 1).

In 2000, the association inaugurated headquarters in the township of Novo Airão. The principal

Fig. 1. (A) Arumã, *Ischnosiphon polyphyllus*, growing beside a stream on the right margin of Rio Negro. (B) Artisans weaving mats from arumã stalks at Novo Airão in 2000.

fiber used in handicrafts was the arumã, *Ischnosiphon polyphyllus* (Poepp. & Endl.) Körn.), Marantaceae, and the area from which arumã collection was allowed was restricted by the creation of conservation units (UCs), especially the Anavilhanas National Park.

The criteria for creation of UCs in Brazil are based on data on the geomorphology, hydrology, soils and vegetation, and the National System of Conservation Units (SNUC – Law No. 9.985/2000) includes approximately 1.5 million square kilometers. Presently, there are 310 federal, 397 state, 60 municipal, and 973 privately owned UCs. The SNUC defines two categories of UCs: Integral–Protection Units (UPIs) and Sustainable–Use Reserves (UUSs) (Sousa et al 2011). UPIs, such as ecological stations, biological reserves, national parks, natural monuments, and wildlife refuges do not allow resident human communities.

The municipality of Novo Airão is surrounded by the following UCs: Anavilhanas National Park, Jaú National Park, the Environmental Protection Area on the right bank of the Rio Negro, and the Waimiri–Atroari Indigenous Reserve. Paradoxically, while the actions of the rural cooperative were legally restricted, clandestine illegal logging in the Anavilhanas National Park was not contained by the environmental institute (Scabin et al. 2012).

Areas traditionally used for collecting arumã leafstalks were situated in flooded forest on the islands of the Anavilhanas Archipelago. In 1988, this previously unprotected river archipelago became a conservation unit, the Anavilhanas Ecological Station. In 2008, its status was changed to the Anavilhanas National Park (Law No. 11.799 2008), mainly to attend to demands for access by tourists, many of which come from the state capital, Manaus. Extractive activities are prohibited in both categories of UC, and AANA had to look elsewhere for sources of arumã in areas outside the boundaries of the protected area. After several meetings between the artisans and the environmental institutes, rules were put in place that regulated the extraction of arumã using a management plan initially authorized in 2003. The mediation of negotiations with environmental institutes had the support of the NGO Fundação Vitória Amazônica.

A new way of collecting, restricted to a limited area and distant from the islands, changed the traditional ways of obtaining arumã stalks and the areas from which AANA members gathered them. Under the traditional system of management, arumã collection occurred during family trips that were combined with other economic activities, such as fishing and collection of other NTFPs for household use. Although the management plan was approved in 2000, the artisans were only officially permitted to collect in 2003 (Diário Oficial 2003). A harvesting group formed and initiated a new form of organization among weavers using arumã that interfered with the existing social links, because weavers had traditionally collected their own leafstalks. With the new rules, the harvesters became responsible for the control of arumã–collection activities and access to the areas where these extractive activities occurred (Nakazono 2010).

Arumã of the quality used for mats occurs only in flooded areas, and harvesting originally occurred on the islands of the Anavilhanas Archipelago, which have relatively fertile soils derived from the sediment–rich waters of the Rio Branco (Scabin et al. 2012) and frequent disturbance due to bank erosion and flooding. However, under the new system, harvesting was transferred to locations outside the boundaries of Anavilhanas National Park. These collection areas are on the margins of black–water streams where soils are poorer than those of the Anavilhanas islands. The stream banks are lined by forest that is denser than that on the islands, and less subject to disturbance. Forests flooded by black–water rivers are generally infertile (Prance 1980). The lower soil fertility and lower light penetration to the understory may be associated with lower growth rates of arumã, which is more common in regrowth forest. Harvesting along the streams followed strict criteria defined in the management plan approved by the environmental authority (see methods). Previous studies had evaluated only the collection of arumã in Anavilhanas National Park. The objective of this study was to evaluate the ecological and economic viability of arumã collection along the streams. Based on their experience in Anavilhanas, the AANA collectors had assumed that a three–year cycle of cutting would be sufficient to sustainably exploit the arumã along the streams, and that is the hypothesis that we explore here.

Methods

Study Area and Species Investigated

The town of Novo Airão is located on the lower part of the Rio Negro, 180 km from Manaus, Amazonas (AM). Anavilhanas National Park is adjacent to the town, and has an area of 350,000 ha, spread over approximately 400 islands. Outside the park, areas along creeks with especially dense concentrations of arumã are preferred locations for harvesting by AANA members. The four sites outside the park used for harvesting are located near the Community of Sobrado, 19 km from Novo Airão. Along each of the four streams, an area was set aside for arumã extraction: Dinheiro (15.9 ha), Dinheirinho (12.6 ha), Sucurijú (6.4 ha), and Água Branca (6.4 ha) (Fig. 2).

Ischnosiphon polyphyllus is a perennial monocot (Anderson 1977). In the Anavilhanas, the average height of arumã thickets is about 4.17 m but some leafstalks can reach up to 7.0 m tall (Nakazono and Piedade 2004). The mode of reproduction is predominantly asexual, with the species forming extensive clones in some locations, leading to the formation of monospecific stands. It is most abundant in well–lit locations in the forest understory (Costa et al. 2002). The species occurs from the upper Rio Orinoco, through the entire Rio Negro basin, and along the Amazon River from Tefé to the Atlantic Ocean.

Data Collection

Data presented in this paper are derived from a research program by Erika Matsuno Nakazono (EMN) undertaken between 2000 and 2007. From 2000 to 2003, EMN was hired by the Brazilian NGO Fundação Vitória Amazônica (FVA) to advise AANA on the implementation of arumã management. At the end of the FVA contract period, EMN continued monitoring arumã management along the streams as part of her doctoral thesis. The last field visit occurred in November 2006. Comparisons are also made with previously published data collected by EMN between 1998 and 2000 in Anavilhanas National Park.

Information on the traditional forms of arumã collection, leafstalk–quality categorization, cut criteria, and areas used were obtained from artisans who used arumã and from arumã harvesters. Both open and guided interviews were used, combined with intense periods of fieldwork using participant observation.

Arumã monitoring plots were distributed throughout the whole area in which AANA members conducted arumã harvesting. Because arumã occurs only in seasonally flooded areas, study sites varied in size. The timing and extent of the period of the year in which the forest is not flooded varied, according to the year and stream. The dry period usually begins in August and extends until April of the following year. There were no collections of arumã in November or December because the channel of the creek was too shallow for navigation by canoe to the harvest sites.

The number and length of plots varied during the study and among stream sites, and plots were pooled to take into account the natural variability of each stream site, which are considered individual management units by the AANA collectors. Data

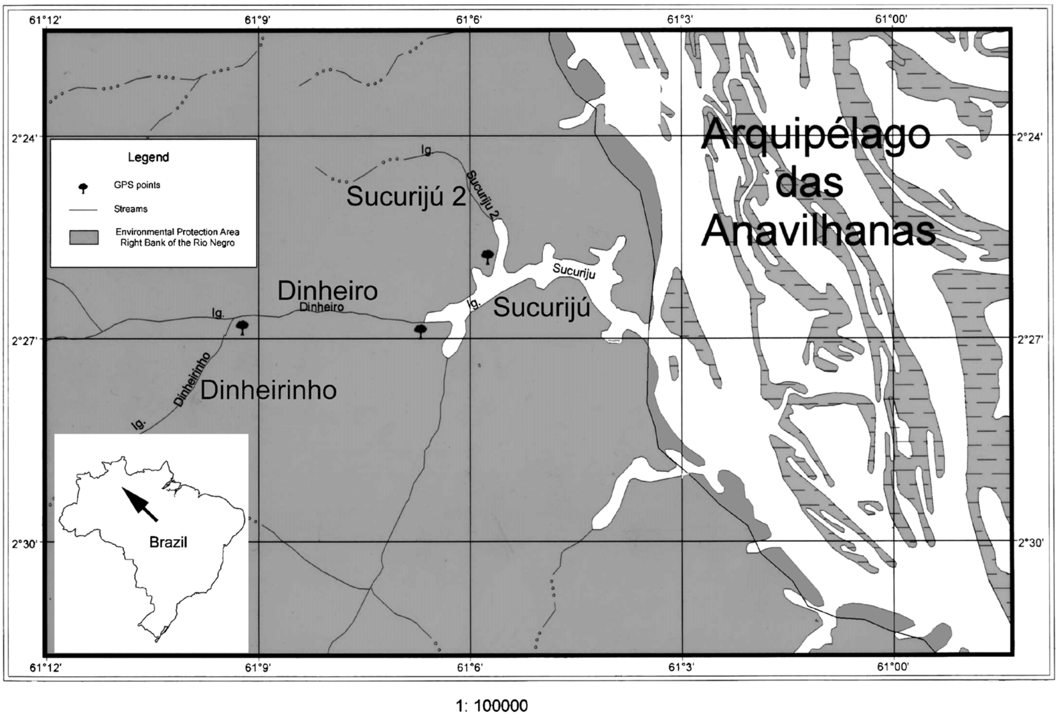


Fig. 2. Location of arumã (*Ischnosiphon polyphyllus*) collecting sites provided by the Instituto de Proteção Ambiental do Amazonas (IPAAM). Igarapé Água Branca was not initially included and we added this site to the IPAAM map.

presented in this paper refer only to a single three–year arumã cutting cycle, the period that the AANA harvesters originally considered to be sufficient to permit a second cycle of harvesting.

Information on the density of arumã leafstalks suitable for harvesting was obtained prior to the initial extraction (year zero) and then monitored annually (years 1, 2, 3). Monitoring generally took place between the months of December and February after annual harvesting.

Harvest sites were areas with dense stands of arumã selected by AANA collectors for harvesting. To quantify leafstalk density, plots were established within each harvest site (Table 1). Each plot was 52 m long and 2 meters wide (104 m^2), and the distance between plots depended on the extent of the arumã stand along the stream. Before harvesting (year 0), the collectors marked the areas that would be collected based on the density of arumã. Within the areas in which the arumã would be collected, they systematically distributed plots along the stream. Plots were arranged perpendicular to the creek channel, traversing the annually flooded area and ended at the limit of the area flooded by the stream at high water. Because of the requirement to submit a management plan to the environmental agency, there was not sufficient time to sample all of the plots and sampling was done only on both margins of Dinheiro Stream and the right margin of Dinheirinho Stream in October 2000. The plots were sampled across their entire width (3 m), but only at the following distances from the stream (total area 60 m^2): 0 m to 2 m (6 m^2); >2 m to 12 m (30 m^2); 20 m to 22 m (6 m^2); 30 m to 32 m (6 m^2); 40 m to 42 m (6 m^2); and 50 m to 52 m (6 m^2).

Plots were marked every 5 meters with colored plastic tape attached to stakes along the plot centerline. Aluminum tags were attached to trees to facilitate relocation of the sites on subsequent surveys. The tags were located 2 m and 7 m from the edge of the creek.

The distance between plots varied among harvest areas. Within each plot, clumps of arumã leafstalks were counted by harvesters. As arumã has underground rhizomes, we do not know whether or not

TABLE 1. SAMPLE PLOTS IN THE AREAS OF ARUMÃ (*ISCHNOSIPHON POLYPHYLLUS*) COLLECTION BY THE MANAGEMENT OF ARTISANS ASSOCIATION OF NOVO AIRÃO (AANA).

	Arumã management of AANA				Plots sampled (ha)					
Stream (unit)	Side of stream: (ha)	Extraction period	Mature stem	Eye Stem	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Dinheiro (2)	Left: 6.41	10/2000 to 03/2001	18.815	879	0.052	0.177	0.177	0.239		
Dinheiro (3)	Right: 9.46	09/2001 to 02/2002	29.165	1.463	0.066	0.156	0.156	0.156	0.534	
Dinheirinho (4)	Right: 1.40	03/2001	6.505	320	0.018	0.156	0.156	0.146	0.146	0.146
Dinheirinho (5)	Right: 5.12	09/2001 to 03/2002	6.280	150	0.036	0.166	0.166	0.156		
Dinheirinho (7)	Left: 6.10	02/2003 to 04/2003	18.185	820	0.166	0.177	0.177	0.177		
Água Branca (10)	Right and Left: 6.40	08/2003 to 09/2003	8.200	575	0.208	0.198	0.208	0.229		
Sucurijú (8)	Left: 0.10	04/2002	4.300	150	0.114	0.114	0.114	0.104	0.104	0.104
Sucurijú (9)	Right: 0.29	04/2002			0.094	0.094	0.094	0.094	0.094	0.094
Sucurijú (11)	Right and Left: 5.98	09/2003 to 05/2004	8.330	260	0.281	0.27	0.25	0.156		

clumps represented individual plants. In locations with high stem density, such as at the stream edge, it was difficult to distinguish individuals. In such circumstances, a clump was defined as a group of leafstalks with ≤ 20 cm of open soil between any pair of stalks.

Since the arumã collectors generally lacked basic education and could not record field data, recording was done by EMN or the literate artisans who coordinated the management of AANA. Leafstalk counts were made by arumã harvesters who had knowledge of leafstalk categories traditionally collected. They had also received training in the criteria adopted in the cutting management plan (see below), so they understood the purpose of the information they passed to the data recorders.

Initial leafstalk surveys were conducted before extraction (year 0). Year 0 data from Água Branca were collected only by arumã collectors with AANA managers recording data. EMN accompanied all other data collection.

AANA MANAGEMENT SYSTEM

The AANA management plan for arumã collection stipulated criteria for stalk use and cutting, which can be summarized as 1) determining where collection may occur, 2) defining the duration of the cutting cycle, 3) defining leafstalk and clump maturity categories, and 4) criteria for cutting. These criteria are elaborated below.

The criterion for extraction was based on categorizing the leafstalks in each clump (Table 2). The criteria for cutting "mature stems" (thin and thick leafstalks together) in the colony were considered when assessing the effect of extraction on overall

TABLE 2. CATEGORIES OF CLUMPS OF STEMS OF ARUMÃ (*ISCHNOSIPHON POLYPHYLLUS*). DAB = MEASURED AT 15 CENTIMETERS ABOVE THE SOIL. A "CLUMP" WAS DEFINED AS AN AREA OF STEMS SEPARATED FROM ANOTHER BY 20 CM OR MORE.

Stem categories	DAB	Stem length	Leaf branch	Number of leaves
Shoot	—	≤1 m	No	0
Eye	—	≥1 m	No	≤4
Mature-fine	≤1.5 cm	>1 m	Yes	≥4
Mature	≥1.5 cm	>1 m	Yes	>4
Thin branch[1]	≤1.5 cm	≤1 m	Yes	>4

[1] Clumps containing stems in the *thin branch* category are usually composed of a few stalks and are not used in handicrafts. Consequently, such clumps were not included in the census.

density. Collectors took up to 50% of "mature stalks" from each clump, along with an "eye" (a young leafstalk used when trimming or finishing craft products). If the sum of leafstalks resulted in an odd number, one more was added. In clumps with three collectable stalks, only one leafstalk was collected. Leafstalks were cut approximately 30 cm above the soil surface.

An arumã cutting and collecting trip lasted three to four days. Generally, such a trip had one coordinator with two to three assistants. The coordinating collector had the technical knowledge on how to collect and what areas were available for extraction, and the assistants were in charge of gathering the cut leafstalks into bunches of 100 for transport. The group paid all costs (Nakazono 2010).

Results

Structure and Distribution Of Arumã Clumps

For managed harvesting on each of the four streams, collectors selected the areas they considered to have the highest density of arumã. The highest frequency of these plants occurred in areas with an inundation gradient of between 2.0 and 4.0 meters, as reported for arumã in Anavilhanas National Park by Nakazono and Piedade (2004).

Arumã clumps had their highest concentrations in areas closest to the stream channels (Figs. 3 and 4). Arumã clumps along the four streams had an average of 91% of mature stems, 6% young growth and 2% "shoots" (Table 3).

Sustainability of Arumã Harvesting

The initial stocks of arumã along the Dinheiro and Dinheirinho streams were high, but had decreased by the second cutting cycle three years later. There was little increase in the number of mature stalks over the post–extraction period (Fig. 5). However, on Água Branca Creek, the number of leafstalks was relatively stable, indicating either high recovery or a low impact of the initial harvest. The initial leafstalk–density survey (year 0) on Água Branca Creek was undertaken only by artisans, so possible errors in recording cannot be ruled out. There was also an increase in the total number of clumps over the three years, which did not occur in any of the other plots. However, the small size of this stream, plus high canopy openness and good water availability appeared to produce near–ideal growing conditions, and this may have facilitated an exceptionally high density of arumã within the stream channel.

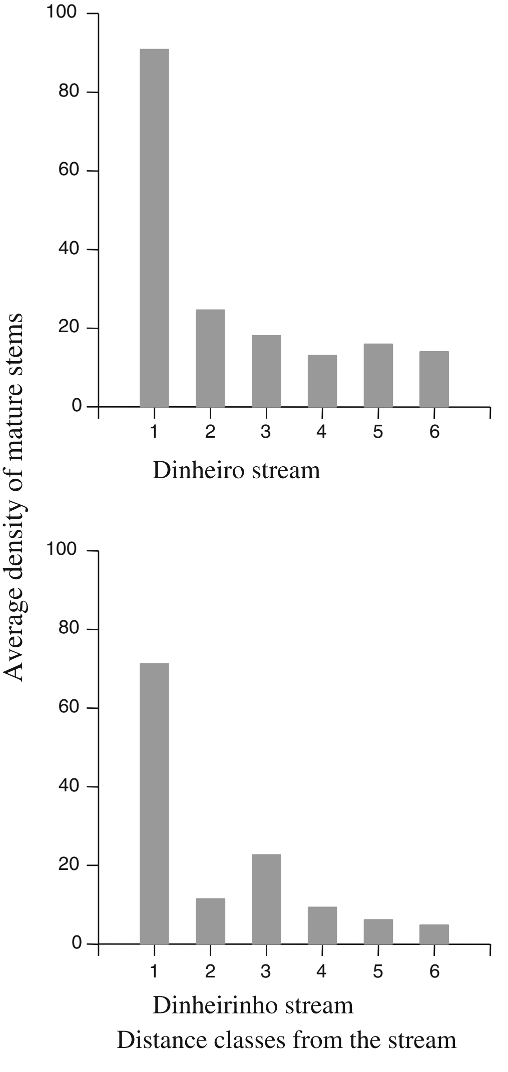
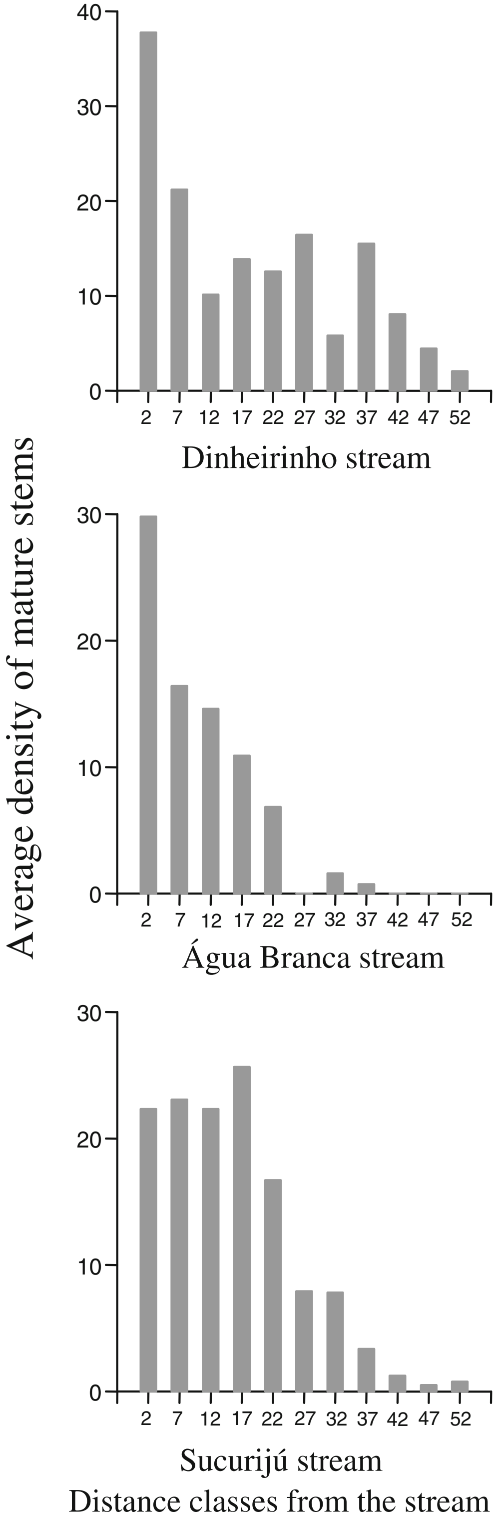


Fig. 3. Average density of "mature stem" arumã (*Ischnosiphon polyphyllus*) found along transects sampled in the flooded forest of the creeks Dinheiro (in 2000) and Dinheirinho (right bank in 2000), in relation to the distance of plots from the creek channel towards higher ground. Distance ranges: 1 = 0–2m; 2 = >2–12m; 3 = 20–22 m; 4 = 30–32 m; 5 = 40–42 m; 6 = 50–52 m. Data were collected before harvesting.

At Sucurijú Creek, there was a slight decline in the number of stems the second year after cutting. In subsequent years, this stabilized at between 40% and 80% of the initial pre–cut leafstalk density, and



◀Fig. 4. Average density of "mature stem" arumã (*Ischnosiphon polyphyllus*) found along transects (2 x 52 m) sampled in the flooded forest of the creeks, Dinheirinho (left bank in 2002), Água Branca (in 2003), and Sucurijú (in 2001) in relation to the distance of plots from the creek channel towards higher ground. Data were collected before harvesting.

a similar pattern as recorded along other streams, except Água Branca in which leafstalk density recovery exceeded 100%.

Despite some indications of recruitment in arumã colonies on one stream, the amount of arumã available for a second extraction was overall no greater than what was available immediately after the first collection (Fig. 5). That is, there was no evidence of recovery of arumã stocks over a period of three years, and there was no recovery at Sucurijú and Dinheirinho creeks even after five years.

Discussion

Handicrafts based on arumã (*Ischnosiphon polyphyllus*) contribute significantly to the income of families of artisans (Nakazono 2007, 2010, 2012). About 80% of the total production of AANA between 1997 and 2006 was obtained from the sale of artifacts made from arumã. Between 1997 and 1999, AANA members extracted 7,644 arumã stems for a total gross income of BRL 9,173 (USD 6,738), and between 2000 and 2005, they extracted 14,797 stems for a gross income of BRL 29,245 (USD 21,482). The increase was coincident with the formation of the association and an increase in quality of the mats produced. The price per handicraft increased 192% in this period, but it is not known whether this was due to increase in demand or difficulties in supply.

Between 1997 and 2006, the mean gross annual income of the families from handicrafts was 42% (29% – 63%) of the official minimum Brazilian salary. This does not reflect the importance of the activity for artisans; because most of their other activities are for subsistence, selling arumã products, fishing, and casual work provide the only opportunities they have for economic gain. Predictability of income is as important as the total amount received because opportunities for investment are limited in Novo Airão. If the extraction of arumã represents only reduction in capital, without renovation of stocks, it will be of little long–term benefit to the

TABLE 3. ARUMÃ (*ISCHNOSIPHON POLYPHYLLUS*) CLUMP STRUCTURE BEFORE THE FIRST EXTRACTION (YEAR 0), USING AANA STEM CATEGORIZATION TERMINOLOGY GIVEN TO MANAGEMENT, IN THE STREAMS DINHEIRO, DINHEIRINHO, SUCURIJÚ, AND ÁGUA BRANCA.

Stream	Shoot Mean± SD N (min–max)	Eye Mean± SD N (min–max)	Mature Mean± SD N (min–max)	Shoot % Mean	Eye % Mean	Mature % Mean
Dinheiro	0.05 ± 0.23 1188 (0–2)	0.33 ± 0.66 1188 (0–7)	3.70 ± 4.19 1188 (0–55)	1.2	8.1	90.7
Dinheirinho	0.08 ± 0.34 1135 (0–4)	0.25 ± 0.53 1135 (0–5)	3.60 ± 3.85 1135 (0–35)	2.0	6.4	91.6
Sucurijú	0.15 ± 0.44 754 (0–5)	0.23 ± 0.53 754 (0–5)	2.93 ± 3.87 754 (0–50)	4.5	6.9	88.5
Água Branca	0.04 ± 0.20 447 (0–1)	0.17 ± 0.43 447 (0–3)	3.62 ± 6.44 447 (0–97)	1.0	4.4	94.5

artisans. The efforts to monitor the effects of harvest were based on the assumption the industry would be long term. However, with the failure of the stocks to regenerate within a reasonable time, the artisans stopped collection and therefore monitoring. The artisans reported that they had drastically reduced their production of arumã products in 2006 (Nakazono pers. obs.) and had not recommenced as of 2015 (Magnusson pers. obs.).

The artisans and the management agency responsible for the extraction assumed that it would be

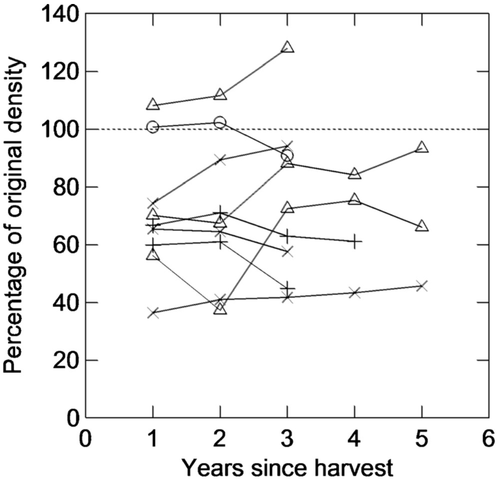


Fig. 5. Recovery of the mean density of "mature stalks" of arumã (*Ischnosiphon polyphyllus*) (%) relative to the average density before extraction in the sample units in the management areas of the Association of Artisans of New Airão located in the following streams: Dinheiro (+), Dinheirinho (X), Sucurijú (△) and Água Branca (O), in the Sobrado community, Novo Airão, Amazonas, Brazil.

possible to undertake a second harvest three years after the first. The management system, which prohibited the removal of all stems from a clump, was effective in maintaining the number of clumps. However, three years was not sufficient to replace the number of mature stems taken along the creeks within the Sobrado community.

The banks of the streams are relatively stable in comparison to areas on the islands of Anavilhanas where harvest took place previously and light is probably a limiting factor for arumã growth. The highest concentrations of arumã are found on the edge of the creek channel where more light is available than in the forest interior. We have some misgivings about the initial data collection on Água Branca stream, and this was the only site with close to 100% post–cut recovery. However, even if conditions for growth are better there than in other areas, it is too small to provide the needs of the AANA artisans.

The streams around the Sobrado community have been used for many generations by rural people, who regularly cut the forest around streams for agricultural activities. From what is known of arumã in the Anavilhanas Archipelago (Nakazono et al. 2004), it is likely that arumã requires clearings for establishment. Other streams in the Novo Airão area that potentially host arumã are also close to territories traditionally occupied by rural people and traditional communities.

The Baniwa indigenous people harvest arumã from areas that have previously been used for agriculture (Silva 2004). These activities provide well–lit areas and the greater abundance of *Ischnosiphon*. This is consistent with observations at Anavilhanas of higher density of *I. polyphyllus* clumps in areas during the early stages of secondary succession from open clearings within the forest (Nakazono et al. 2004). Although there are relatively dense stands of arumã in the forests around streams in the Novo Airão area, it is likely that they formed in previous times when shifting agriculture was practiced at those sites. This is in accordance with many other studies that have shown that humans have influenced the composition, structure, and plant species diversity of existing forest ecosystems in Amazonia (Anderson and Posey 1989; Balée 1989; Clement et al. 2015; May et al. 1985; Morán 2010), and changed the conditions for plant growth, as in the case of Amazonian "black earth" (Neves 2006).

Such associations with different forms of management used by traditional peoples and communities are linked to the biophysical requirements of species. Together, these form part of a broad framework of local knowledge that must be considered when putting protected areas in place. Some traditional communities along the Rio Negro have been severely impacted by the management requirements of environmental agencies, which have prevented access to natural resources in newly created conservation units (Farias 2013). This was the case in the area studied here. The ban on access to areas traditionally used by families of artisans and arumã collectors resulted in decrease in the area available for arumã extraction. Arumã naturally occurs on the 400 islands that comprise the Anavilhanas Archipelago, with an area of 350,000 ha. In these fluvial environments, higher light intensities are caused by treefall gaps. Such gaps are necessary for the maintenance of many understory species (Horvitz and Schemske 1994; Mulkey et al. 1991; Pfitsch and Smith 1988).

The light gaps, combined with the archipelago's more fertile soils, provide better growing conditions for clumps of arumã than creeks on the side of Rio Negro itself. Such favorable conditions also influence the quality of the arumã stems. AANA artisans and collectors reported that leafstalks from arumã plants from the Anavilhanas islands were thicker and better for production of mats.

As a result of the ban on collecting arumã on the islands, collection activity on the banks of local streams has intensified. Accordingly, AANA artisans began searching for streams with standing stocks of arumã sufficient to meet handicraft–production demands. This process requires great socio–political effort, resulting in additional costs and the creation of partnerships with other governmental and non–governmental institutions. Sustainable management of arumã on the four streams studied appears to require management that will encourage the plants to grow more quickly. Tree pruning and cutting–back of some types of plants could be an effective way to manage the stream environment to achieve this.

The arumã species studied occurs exclusively in flooded forests, which are classified as Permanent Preservation Areas by current legislation. Permanent Preservation Areas correspond to ridge tops, slopes, and the banks of water courses, where vegetation should be preserved. The Forest Code, Law No. 12.651 (2012) permits such management, but implementation would require a strong political collaboration among government, environmental, and scientific organizations.

Similar activities have been conducted in areas flooded by sediment–rich river water (*várzea*) in relation to the management of açaí palms (*Euterpe oleracea*), which also occur in clumps. Traditional management systems with açaí palms has been permitted in several municipalities in the states of Pará and Amapá, and several studies have shown the potential of this NTFP for use by rural inhabitants and traditional communities (Farias 2012; Jardim et al. 2004; Kouri et al. 2001).

The efficacy of NTFP use is enhanced in systems that combine management and cultivation, since these reduce the problem of resource shortages (Ruiz–Pérez et al. 2004). Indeed, such operations may be more viable when configured in the small groups that characterize traditional peoples and rural communities, and in the small units that they use in their management systems (Gibson et al. 2000). This is reinforced by the fact that such peoples possess the traditional knowledge relating to practices and forms of access and use, which expands the possibilities by which plans and effective strategies for sustainability may be implemented.

The environmental discussion around means of achieving sustainable development in the Amazon has intensified with the emergence of collective identities objectified in social movements (de Almeida 2008). The use of traditional territories has been recognized internationally, but often disconsidered in national and local political decisions (IWGIA 2012). The lack of implementation of national laws (1988 Constitution, Decree No. 6.040/2007) and international conventions (Convention 169/OIT, Decree No. 2519/1998 – Convention on Biological Diversity) that recognize traditional rights has resulted in conflicts between traditional communities and organizations responsible for conservation units (Almeida and Rezende 2013).

This study of arumã handicraft–related activities demonstrates a situation where traditional maintenance and conservation of resources by local communities depended on the continued use of traditional management practices. Management practices should be incorporated in the environmental legislation for protected areas, with recognition of the rights of rural people and traditional communities to access and use traditional resources. A combination of traditional and scientific knowledge can produce efficient results, and this synergy should be used to produce innovative conservation strategies for tropical countries with high biodiversity (Silvius et al. 2004). Scientific studies can show that extractive industries are sustainable (Ruwanza and Shackleton 2015); however, without the option to use traditional management practices, scientific study of the resource could not help the artisans of Novo Airão.

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