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Managing Amazonian palms for community use: A case of aguaje palm (*Mauritia flexuosa*) in Peru

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ABSTRACT

Amazonian palms are prime candidates for sustainable management of non-timber forest products and yet useful species are often harvested destructively. This paper examines a promising management initiative for one of the most useful Amazonian palms – *Mauritia flexuosa* – in a rural community of northeastern Peru. Based on data from household surveys ($n = 57$), filmed in-depth interviews, focus groups and participant observation, we identify the factors that influence: (1) the adoption of a locally developed climbing device for wild-harvesting of aguaje palm fruit; (2) the continued practice by some households of palm felling for harvesting fruit; and, (3) investment by households in planting and cultivation of aguaje palm. Our findings identify key conditions for palm management and point to the particular importance of the adoption of palm-climbing devices, not only for reducing wild palm felling but also for stimulating broader community-level conservation as well as efforts to cultivate the palm.

1. Introduction

Palms are one of the most important plant groups in the Amazon basin, with 34 genera, 151 species and 189 taxa listed, of which about 75% are endemic (Henderson, 1995). In Amazonian forest ecosystems, palms serve as habitat for a wide range of fauna, as keystone species, as providers of famine foods, and as litter collectors, among other functions (Kahn and De Granville, 1992). Rural people throughout the basin rely upon palms for subsistence and for cash income through the sale of fruit and other products, and considerable interest exists in the economic potential of palms (e.g., Anderson, 1988; Anderson et al., 1991; Clement, 1993; Campos and Ehringhaus, 2003; Zambrana et al., 2007). Many Amazonian palm fruits though are harvested destructively (with notable exceptions, e.g., açai, *Euterpe oleracea*; babasu, *Attalea speciosa*), and the incidence of palm cultivation and domestication remains low (Coradin and Lleras, 1988; Byg and Balslev, 2006). Although most species remain abundant, some increasingly suffer from regional depletion (Vasquez and Gentry, 1989). A key challenge facing local communities, researchers, and NGOs is how to promote alternative ways of managing socio-economically important palms.

A prime candidate for sustainable management in Amazonia is the aguaje palm (*Mauritia flexuosa* L.f.) (Padoch, 1988; Peters et al., 1989; Vasquez and Gentry, 1989; Carrera, 2000; Delgado et al., 2007). Known by a variety of vernacular names (Peru: *aguaje*; Brazil: *buritĺ* and *miritĺ*; Venezuela: *moriche*; Colombia: *cananguchа*; Ecuador: *moretes*; Bolivia: *palma real*), the aguaje palm provides food, fiber, oil, medicinals, materials for construction and fishing equipment, and fallen stems serve as a substrate for raising of edible larvae of the palm beetle (*suri*, *Rhynchophorus palmarum*) (Mejia, 1988; Padoch, 1988; Hiraoka, 1999). Particularly appreciated in Peru, aguaje fruit is consumed directly or processed into ice cream, popsicles and cold drinks, and is the richest natural source of vitamin A yet known (Pacheco Santos, 2005). Fruit harvesting brings significant cash income for rural families, with estimates of market demand in Iquitos ranging from 22 to 150 mt/month (cf. Guzmán Castillo, nd; Delgado et al., 2007). Poor urban and peri-urban women in Iquitos derive significant income from the sale of the fruit (Padoch, 1988).

Despite considerable promise, initiatives aimed at sustainable management of the aguaje palm face significant impediments, including limited knowledge of the population dynamics of this dioecious species; depletion of its important seed dispersers; harvesting by felling of the female palm to secure the fruit; and, limited success in cultivation (Kahn and De Granville, 1992; Pacheco Santos, 2005; Delgado et al., 2007). In Peru, the fruit is harvested by felling the towering palm with an axe, which though

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laborious, is sufficiently safe and productive to be the dominant manner of harvesting the fruit. Pervasive cutting has lead to a significant reduction in the availability of fruiting palms around urban centres in Amazonian Peru. Delgado et al. (2007) estimate that at least 24,000 palms are cut down each year to satisfy demand for aguaje palm fruit in Iquitos. Recognition of growing local scarcity has spurred efforts to manage the palm in traditional agroforestry systems (J. McCann, unpublished thesis; J.W. Penn, unpublished thesis; RCF, 2007; TNC, 2007; Delgado et al., 2007; Goulding and Smith, 2007) as well as to identify the factors, more generally, that influence palm cultivation and use (see Byg and Balslev, 2006; Byg et al., 2007).

In this paper, we report on a promising initiative to promote more sustainable palm management among forest peasant households in northeastern Peru. Our study focuses on a small rural community that depends heavily upon aguaje palm fruit extraction but which faces growing scarcity due to palm felling. This community engaged actively in an NGO-sponsored palm management program that promoted wild-harvesting through the use of a locally developed palm-climbing device and the integration of aguaje palms into agroforestry systems. The case study provides an opportunity to examine the adoption of alternative harvesting and management practices among rain forest dwellers. Here, we describe the palm management program and analyze household socio-economic characteristics to ascertain which features shape households' decisions regarding palm management practices. Specifically, we seek to identify the factors that influence: (1) the adoption of palm climbing as an alternative to felling for wild-harvesting of aguaje palm fruit; (2) the continued practice of palm felling by some households; and, (3) the investment in cultivation of aguaje palm. Importantly we find that the adoption of palm climbing, which effectively permits more sustainable harvesting, is also an important incentive not only for wild palm stand conservation but also for palm cultivation.

2. The aguaje palm (*M. flexuosa* L.f.)

The aguaje palm is one of the most widespread fruiting palms in Amazonia. The palm grows in permanently or temporarily flooded areas – from depression swamps and seasonally inundated floodplains to irregularly flooded *terra firme* and savannas – in mono-dominant stands or in association with palms such as *Mauritiella* and *Euterpe* (Goulding and Smith, 2007). High densities of near monospecific stands – of over 300 palms/ha – can stretch over thousands of hectares as aguaje swamp forest, providing a food source and habitat for large ungulates, such as lowland tapir, peccaries, and deer as well as fish and birds, particularly macaws (Kahn and De Granville, 1992; Bodmer, 1990; Brightsmith and Bravo, 2006).

A massive, single-stemmed palm with a spherical crown, aguaje can reach heights of over 30 m with a stem diameter of 50–60 cm (Goulding and Smith, 2007). The plant has 8–25 costapalmate leaves, each with 120–236 segments and a petiole of 1.4–4 m in length (Delgado et al., 2007). Roots of the palm extend down into the waterlogged, acidic soil to a depth of about 60 cm before reaching out horizontally, as far as 40 m. Aerial roots allow respiration in hydromorphic conditions (Pacheco Santos, 2005). The palm is dioecious, with staminate and pistillate flowers on separate plants. A female aguaje palm produces 4–8 infructescences, and each raceme bears 500–2000 fruits (Goulding and Smith, 2007). The fruit is a reddish brown elliptic drupe, the size of a plum, and the edible part – a thin layer of oily yellow-orange pulp – covers a very large pit. Reported fruit yields range from 6.5 mt/ha (Ucayali river, Peru) to 9.07 mt/ha (Colombian Amazon) (Kahn and De Granville, 1992). Seeds are dispersed by large ungulates, rodents and primates, and by water.

3. Study area and methods

3.1. Site description and setting

This study was conducted in 2003 in the peasant community of Roca Fuerte (4°31′48′S, 74°45′06′W), located along the left (north) bank of the Marañón river, in the Peruvian Amazon, approximately 30 h upriver by riverboat (*lanchas*) from Iquitos. The village comprises 63 households of mixed Spanish and Amerindian descent (*ribereños*) and the community's territory encompasses 10,545 ha of floodplain, including extensive aguaje palm stands (*aguajales*). The San Luis river joins the Marañón at Roca Fuerte, which the residents use for transport, access to aguaje palm stands, and for fishing (Fig. 1).

Residents of Roca Fuerte are economically poor and highly reliant upon local natural resources. In 2002, a typical household earned an annual total income of US$1751 (mean), held 3.26 ha of agricultural land and owned US$543 of non-land assets (i.e., livestock, fishing material, extractive material, consumer durables). Residents earn their living from swidden-fallow agroforestry, floodplain agriculture, fishing, hunting, and the extraction of non-timber forest products, particularly aguaje palm fruit and chonta – *Euterpe precatoria*.

Roca Fuerte was founded in 1940 and originally sited on the right bank of the Marañón river, within what today is the Pacaya Samiria National Reserve. In 1998, a major riverbank slump forced residents to relocate across the river at the community's current site. Instrumental in the process of relocation was the assistance of a Lima-based NGO called CEDIA (*Centro para el Desarollo del Indígena Amazónico* – http://www.cedia.org.pe), which helped identify the site and secure community title to the land through the Ministry of Agriculture's land titling program (*Proyecto Especial de Titulación de Tierras*). Since 1998, residents have been working with CEDIA to develop and implement initiatives to reduce pressure on local natural resources, including fish and aguaje palm stands. Aguaje palm swamps in Roca Fuerte extend over 6300 ha or 60% of community land, primarily along inland watercourses and around oxbow lakes (Valderrama et al., unpublished report) (Fig. 1). Fruit from the aguaje palm are harvested seasonally up to 8 months of the year, usually from September to April.

Palm fruit is sent to market in Iquitos on riverboats traveling along the Marañón. Extractors sell to buyers within the community, to traders on riverboats or directly to traders/wholesalers in Iquitos. In 2002, aguaje palm extraction was the third most important economic activity for households in Roca Fuerte, making up 31% of market income and involving 75% of households (Fig. 2). A total of 7063 sacks (~124 sacks/household) of wild aguaje fruit was sent to market, worth an estimated 14,832$US.

3.2. From palm felling to climbing

Palm felling around Roca Fuerte has led to local depletion of female aguaje, especially the most valued variety, "*shambo*". As a result, increasing time and effort is spent on the transport of a lower quality product – *aguaje común* – over longer distances, making harvesting significantly less profitable. In 1999, when the community was resettled on the left bank, extractors had immediate access to fruit-bearing palms by canoe, along the San Luis river. Four years later, when interviews were conducted, the average time spent to reach extractive sites beyond the river was close to 3 h. Older residents reported that depletion of aguaje palm stands at the previous settlement site had also put stocks there in

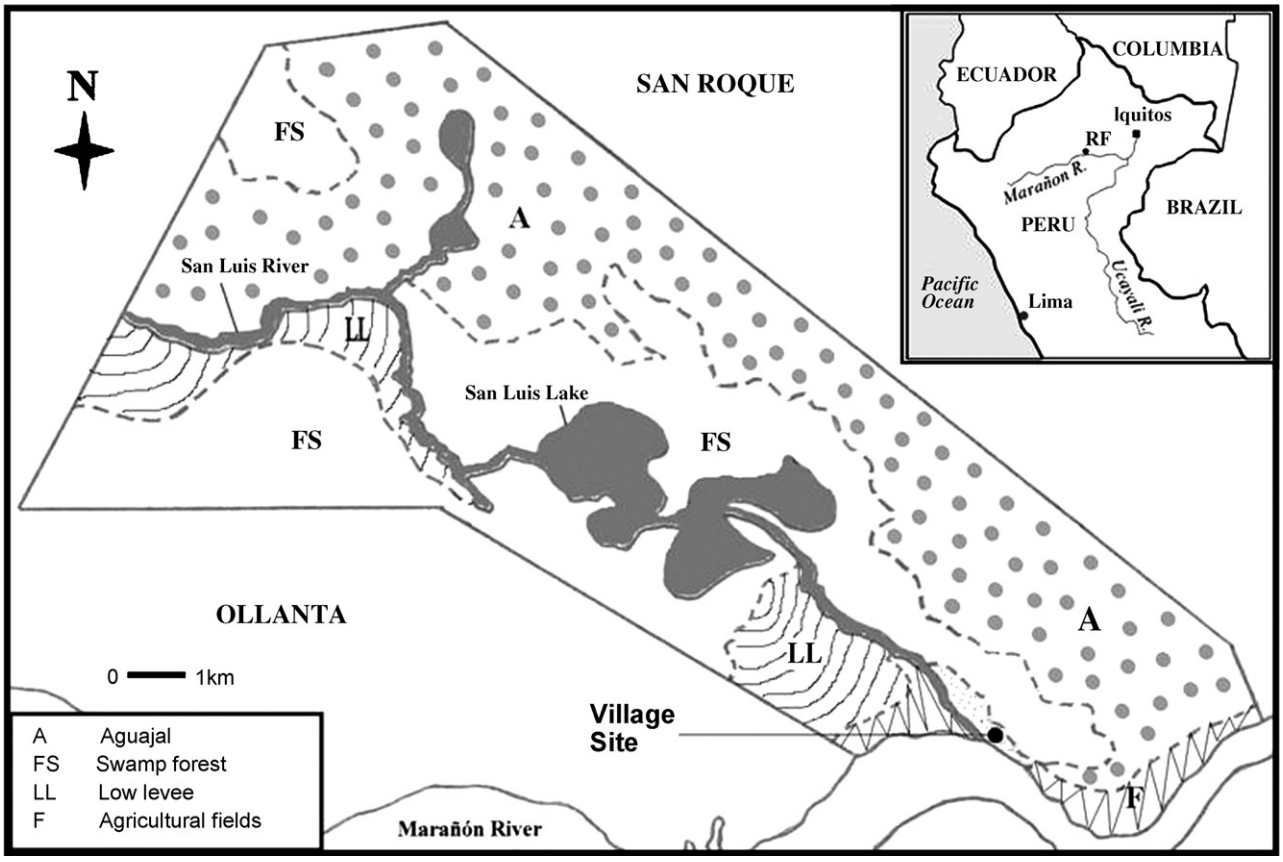
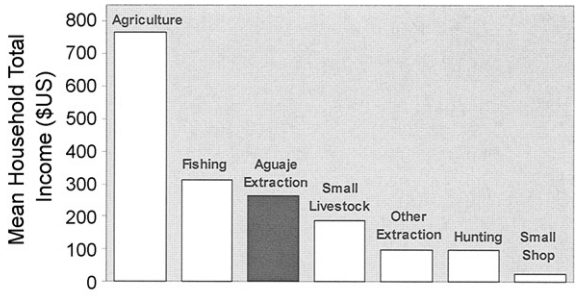


Fig. 1. Territorial boundaries and land classifications for the community of Roca Fuerte, Peruvian Amazon, 2003. *Source*: based on Landsat Imagery (acquired from CEDIA).

peril. Although harvesting by felling palms continued, increasing scarcity and knowledge from past experience of the consequences of depletion motivated households in Roca Fuerte to work with CEDIA. The granting of communal land title in 1999 and the community's re-establishment on a new site with privileged access to rich stands of aguaje palms provided ideal conditions for community-based resource management initiatives.



Total income share (%)	44	18	15	11	6	6	1
Market income share (%)	30	14	31	12	7	4	3
Participation (%)	100	98	75	86	54	75	7
Market Participation (%)	84	70	75	72	44	18	7
Gini coefficient	0.37	0.47	0.58	0.53	0.83	0.70	0.96

Fig. 2. Mean household total income by source, January–December 2002, Roca Fuerte, Peru. *Notes*: mean household total income measures household total annual production (i.e., consumption and market income). 'Other Extraction' measures income from all other aquatic and terrestrial extractive activities besides aguaje palm fruit extraction (i.e., paiche fishing, aquarium fish collection, timber, firewood, and heart of palm extraction, *chonta*, etc.). Gini coefficient measures income distribution across households. A low Gini coefficient indicates more equal income distribution, whereas a high Gini coefficient indicates more unequal distribution.

To provide a firmer informational base for local palm management, CEDIA undertook a participatory forest inventory program. A mean of 90 aguaje palm stems/ha was found within an inventoried area of 6 ha of *aguajal*, of which 52% were unproductive (males), 32% were of undetermined sex and only 16% were productive (female) individuals. In the inventoried plot, a mean of 58 racemes per hectare was found, suggesting a standing crop of 73,208 racemes, equivalent to about 36,604 sacks of palm fruits with a total market value of 55,461$US (CEDIA, unpublished report). Elsewhere in northeastern Peru, the aguaje palm is found naturally at higher densities (e.g., 130–200 adult stems/ha, Kahn and De Granville, 1992) and the ratio of male to female palms is approximately 50:50 in areas without collecting (see Kahn and De Granville, 1992, Table 67 for Colombia). These results suggest a high level of pressure on and depletion of local aguaje palm stands.

In 2001, CEDIA organized workshops in Roca Fuerte on alternative harvesting practices during which they introduced and provided training to promote the use of a climbing device for aguaje palm fruit harvesting. The palm-climbing device and technique was developed by two brothers (Flores Simón) in the community of Parinari (Bejarano and Piana, 2002), some 4 h downstream on the Marañón by riverboat (4°34′19′S, 74°27′49′W). Harvesting palm fruit by the climbing method is easily learned (Fig. 3a–d). Climbing generally requires no more than 30 min of work per palm, depending on the amount of trimming needed, the number and accessibility of the racemes, and the obstacles encountered (e.g., bad weather, snakes, insects). In December 2003, the community owned four climbing devices, all purchased by CEDIA; each device cost 75$US (fabrication cost: 52$US), well beyond the means of most households. The climbing

Fig. 3. Climbing of aguaje palm and harvesting of fruit, Roca Fuerte, 2003. *Note*: aguaje harvesting comprises the following steps: (a) using the stirrup to ascend; (b) sliding the upper strap upward and tightly clutching the strap around the palm; (c) sliding the lower strap upward while sitting in the harness and tightly clutching the strap around the palm; (d) locating one foot in the stirrup and repeating steps (a)–(d) until reaching the crown; (e) cutting down the racemes with the machete or saw; (f) stripping the fruit from each raceme (*desgranar*) and filling the sacks; (g) transporting the sacks (photos M. Manzi).

devices are in high demand and serve only the most experienced and confident climbers. This material constraint encouraged some residents to work as 'climber assistants' when extractive trips are planned. Groups of five to eight men work with a climber and their main tasks consist of stripping the racemes of fruit, filling the sacks, and carrying the fruit out (Fig. 3f–g). To encourage climbing, the community declared the palm stand located behind the settlement as a protected area, prohibiting harvesting by palm felling. By 2003, Roca Fuerte was protecting 40 ha of *aguajal* in three areas on community land. Community patrols visit the *aguajales* monthly to promote protection and monitor the quantity of palm fruit harvested from community lands, charging a tax to both residents (3 cents/sack) and outsiders (6 cents/sack). The revenue raised is used for communal investment and expenses in conservation and community services.

3.3. Aguaje palm cultivation

Aguaje palms tend not to be cultivated in agroforests as long as palm fruit are readily available nearby in the wild. Residents began introducing aguaje palms in their home gardens and fields only recently and particularly since 1999, with community re-establishment in the newly titled territory and the arrival of CEDIA (Fig. 4). In 2002, CEDIA undertook two initiatives, one to reforest public land near the community with aguaje palm and the other to promote palm cultivation. Palm cultivation includes: (1) tending of wild varieties (mainly *aguaje común*) that occur naturally within private agroforestry systems as a result of intentional or unintentional seed dispersal (discarded seeds); (2) transplanting and tending of wildlings or seedlings – or planting seeds – of a wild

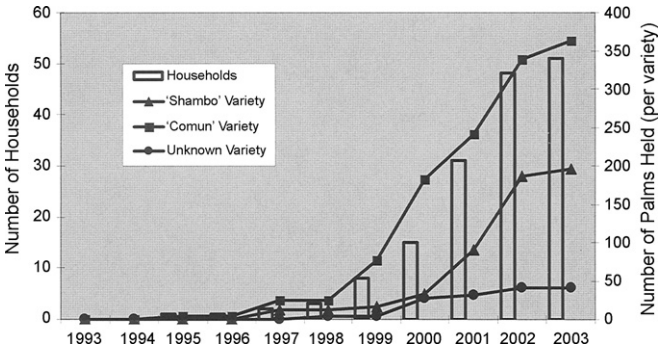


Fig. 4. Number of households holding aguaje palm, and number of palms by variety, planted or growing as volunteers in gardens or fields, Roca Fuerte (1993–2003). *Note*: this figure was created based on data gathered from household surveys. Each household was asked to indicate the number of each variety of aguaje in their home gardens and fields, reporting the age of each palm and whether it was planted or naturally occurred.

(*in situ*) variety (*aguaje común*); and, (3) transplanting and tending of *ex situ* seeds or seedlings of a selected variety (*shambo*). We consider naturally occurring wild varieties of aguaje palms within private agroforests as an integral part of cultivation since it entails purposeful tending, an essential part of agroforestry. Studies elsewhere demonstrate that aguaje palm cultivation is challenging but feasible (J. McCann, unpublished thesis; J.W. Penn, unpublished thesis; RCF, 2007); the palm generally only fruits at the age of 7–8 years (or later) (Flores Paitán, 1997) and juvenile palms remain vulnerable to flooding and predation. For reforestation, CEDIA established a nursery of *shambo* aguaje palm, which produced 5000 seedlings of which 4000 were planted in the newly protected area. Most households participating in the reforestation project also received seedlings of *aguaje shambo* for planting in their own gardens and fields.

3.4. Data collection and analysis

Data were gathered in Roca Fuerte during October–December, 2003, using participant observation, filmed in-depth interviews, focus group discussions, and household surveys. The surveys provided data on: (1) the history of aguaje palm fruit extraction in Roca Fuerte; (2) local aguaje palm conservation efforts; and, (3) cultivation of aguaje palm in private agroforests. Quantitative data were collected on household demographics, labor participation, kin affiliation, land and non-land assets, and on economic production for 2002. In-depth interviews with key informants provided detailed information on the harvesting and marketing of the aguaje palm fruit, the use of new extractive techniques and CEDIA's involvement in the community.

The data were analyzed using multiple regression modeling, guided conceptually by microeconomic theory and results of previous studies on economic livelihood among forest peasant households (Reardon and Vosti, 1995; Coomes et al., 2004; Pyhälä et al., 2006). Qualitative data from in-depth interviews and survey open-ended questions were used to guide our interpretation of the regression results. In addition to household demographic and labor characteristics, particular attention was given to the potential role of physical and non-physical assets in understanding resource use. Household physical assets include land (ha), productive capital (transport, fishing and extractive equipment), small livestock (poultry and pigs), and consumer durables (radio, sewing machine, etc.). Social network size was proxied by kin group size (i.e., affiliation with one of the three largest kin groups of the community). A proxy measure of forest knowledge was included, based on hunting expertise (i.e., assessed as the number and weight in kg of all animals killed in 2002) as hunters generally are more knowledgeable about the rain forest. Data analysis was conducted using the statistical package STATA™ on a sample population of 57 households, representing 91% of households in the community. Descriptive statistics for the independent variables are presented in Table 1.

4. Results

4.1. Palm climbing

Most households in Roca Fuerte (89%) consider palm climbing as a good alternative to harvesting by felling. Although palm felling would seem safer and faster than climbing, once the palm is felled, racemes can be difficult to access if buried underneath the palm, and many fruit are damaged by the impact of the fall. In addition to improving yields and the prospect for sustained harvesting over many years, climbing can increase the efficiency of harvesting: climbers can return to the same palm more than once during the season, following opened paths and harvesting from a previously trimmed crown; harvesting tasks can be readily partitioned among team members, e.g., assistants can strip and pack fruit while the climber works on another raceme; and, extractors can focus harvesting effort on the most productive and proximate palms. One year after the introduction of the climbing devices in Roca Fuerte, household use of this equipment showed encouraging results. Of the 22 households that learned the new method, 73% used it on one or more of their extractive expeditions. In 2002, the most experienced climber in the community earned 227$US from palm fruit extracted through climbing, which represented 38% of his total income earned from palm fruit extraction and 22% of his household income. High interest in the climbing device and strong rates of adoption, despite the constraint of few available climbing devices, suggest that this new harvesting technique holds considerable promise.

Who adopted this novel harvesting technique? In 2002, of the 37 households involved in aguaje extraction, 26 (70%) reported participating at least once in a palm harvesting expedition that involved the use of climbing devices (i.e., as climber or assistant) while only 18 (49%) did so by felling the palms. Our first Probit regression model predicts household harvesting by felling the palms (see Table 2). The results indicate that household holding fewer non-land assets and with less forest knowledge (i.e., less hunting expertise) are more likely to continue harvesting aguaje palm fruit by felling of the palm. Our second model reveals that participation in harvesting by climbing instead of felling tends to be higher among younger households and those with higher forest knowledge, as reflected by success in hunting large bodied animals (mainly ungulates). Hunters are well aware that large ungulates depend on the availability of aguaje palm fruit and that they play an important role in the regeneration of aguaje palm forests through seed dispersal. As such, hunters have a strong incentive to protect aguaje stands.

Table 1
Descriptive statistics for household characteristic variables, Roca Fuerte, 2003.

Variable	Units	Mean	Standard deviation	No. of observations
Age of head of household	Years	42.5	12.8	57
Active members in hhld	No. of person	3.3	1.47	57
Total land holdings	Hectares	3.3	2.97	57
Non-land assets	US$	543	897.56	57
Hunting expertise	Rating, 1–3*	1.6	1.2	43
More extensive kin network	0/1	0.51	0.50	29
Owns extractive asset (saw)	0/1	0.53	0.50	30

* *Note*: 1 = low expertise; 2 = medium; 3 = high (see Notes in Table 2).

Table 2
Regression models predicting participation and investment in aguaje palm management, Roca Fuerte, Peru.

	Model 1	Model 2	Model 3	Model 4	Model 5
	Harvesting by felling	Harvesting by climbing	Participation in climbing	Participation in assisting	Cultivation of *Aguaje Común*
Constant	−0.11 (0.12)	0.54 (0.63)	0.21 (0.20)	−0.98 (1.03)	3.05 (0.39)
Age of hhld head	0.03 (1.64)	−0.06 (2.31)**	−0.11 (3.11)***	−0.003 (0.15)	−0.25 (1.36)
Active members	0.03 (0.21)	0.09 (0.60)	0.20 (0.98)	0.001 (0.01)	2.35 (1.95)*
Total land (ha)	−0.02 (0.29)	0.06 (0.74)	0.29 (2.62)***	−0.25 (1.82)*	−0.28 (0.36)
Non-land asset ($US)	−0.23 (1.84)*	−0.013 (0.57)	−0.02 (0.60)	−0.02 (0.58)	−0.67 (1.55)
Hunting expertise	−0.47 (2.58)***	0.59 (3.20)***	0.67 (2.36)**	0.48 (2.19)**	−1.31 (0.80)
More kin	−0.61 (1.41)	0.53 (1.21)	0.07 (0.14)	1.09 (2.17)**	−0.11 (0.03)
Extractive asset (saw)	n.a	n.a	1.19 (2.11)**	−1.17 (2.05)**	n.a
Climber (0/1)	n.a	n.a	n.a	n.a	−3.22 (0.71)
Assistant (0/1)	n.a	n.a	n.a	n.a	12.90 (3.19)***
Number of Obs.	57	57	57	57	57
Uncensored Obs.	–	–	–	–	22
LR chi2(6)	18.35	20.98	30.50	15.63	22.18
Prob > chi2	0.0054	0.0019	0.0001	0.0288	0.0046
log likelihood	−26.3757	−28.8006	−18.5861	−23.9628	−98.2571
Pseudo R^2	0.2580	0.2670	0.4507	0.2459	0.1014

Notes: Models 1–4 are Probits (0/1) and model 5 is a Tobit. The first and second models predict whether or not (0/1) a household participates in harvesting palm fruit by felling or climbing. Models 3 and 4 predict whether or not a household participates in more sustainable extraction as a climber or as an assistant. Model 5 predicts the total number of local aguaje palms (*aguaje común*) held in home gardens and fields since 2001 (i.e., when CEDIA's resource management program began). Independent variables: *Active members*: are economically active in-house members (between 15 and 65 years old). *Non-land assets* ($US *100) is the value of household assets which include livestock, farming tools, fishing and extractive material, and consumer durables. *Hunting expertise* measures the number of animals hunted and the total number of kg of animals hunted in 2002 (codes 0 = 0 species hunted; 1 = less than 5 animals hunted and/or less than 70 kg of animal hunted; 2 = more than 5 animals hunted and between 70 and 200 kg; 3 = more than 10 animals hunted and over 200 kg); *More kin* (0/1) measures household affiliation to one of the community's three largest kin groups; *Extractive asset* is whether a household owns a saw (used in climbing expeditions); *Climber* measures household participation (0/1) in sustainable extraction as a climber; *Assistant* measures household participation (0/1) in sustainable extraction as an assistant.

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Which specific role in harvesting did households take on – palm climbing or assisting climbers? Of the 26 households involved in more sustainable harvesting, 16 households (62%) participated in climbing; 14 households (54%) assisted a climber on one or more expeditions; and, four households (15%) did both. Probit regression analyses were performed to explore which household characteristics correspond to the household decision to participate or not (0/1): (1) as a climber; and, (2) as an assistant (fruit stripping, packing, carrying, etc.). Our results indicate that households participating as climbers or as assistants exhibit similar yet contrasting characteristics. Household physical asset holding is a significant predictor for participation in both roles but in distinct ways: whereas asset holding is positively related to participation in climbing, it is negatively related to participation as a climber assistant; as such, assistants tend to be asset-poorer than climbers, in terms of land and extractive capital. Age is only significant among climbers, for climbing requires strength and agility, whereas social network access is only significant among assistants who have higher chance of participating in extractive expeditions if they belong to a more extensive kinship network. Finally, forest knowledge is positively significant in both models and thus a key feature in the choice to practice more sustainable use of the palm.

Table 3
Household participation in agroforestry by method and by variety of aguaje palm, Roca Fuerte, Peru, 2003.

Method	HH (%)	Variety	HH (%)
Planted	27 (60)	Aguaje shambo	12 (27)
Natural	15 (33)	Aguaje común	25 (55)
Both	3 (7)	Both	8 (18)
Total hhld participation	45		45

Notes: 'Planted' means aguaje palms planted as seeds, seedlings, or wildlings; 'Natural' means volunteers from discarded palm seeds (intentional or non-intentional).

4.2. Cultivation of aguaje palm

In 2003, 79% households held a total of 637 aguaje palms in their home gardens and fields. Of those 45 households, 60% held palms as a result of planting seeds or seedlings, 33% held palms only from tending natural occurring palms as a result of human dispersal, and 7% held palms from planting and tending seedlings (Table 3). The role of CEDIA in promoting aguaje palm cultivation is evident in the high share (31%) of *aguaje shambo* found in households' agroforests; prior to 1998, this high-value variety was absent in the agroforests of Roca Fuerte (Fig. 4). The balance of aguaje palm planted (i.e., 69%) is of the *in situ* variety – *aguaje común* – and reflects the initiative of individual households rather than CEDIA's intervention. Not all households though planted the palm (21%, 12 households); when asked why not, they reported reasons including long maturation time (34%), insufficient or inadequate land available for planting (17%), lack of knowledge of how to cultivate (17%), availability in the wild (8%), recently arrived (8%), not profitable (8%) and not working with CEDIA (8%).

What factors influenced household decisions to invest in palm cultivation in their agroforests? A Tobit regression model was developed to predict household's initiative to cultivate the *aguaje común* in home gardens and/or fields since the beginning of CEDIA's involvement in the community (2001). Model 5 in Table 2 indicates that households cultivated more aguaje palm when they had access to more in-house labor and someone in the household who had participated in one or more climbing expeditions as an assistant (but not as a climber).

5. Discussion and conclusions

Our case study of palm management in a remote riverine community of the Peruvian Amazon described a recent initiative to

manage a socio-economically important species, the aguaje palm. The initiative resulted in positive changes in peoples' perception and use of the palm some 4 years after initiation. Of particular interest in our study were the conditions and household characteristics associated with decisions to protect wild stands and to cultivate the aguaje palm. Based on our results, we draw four principal findings of broad relevance to the issue of sustainable use and management of palm species in Amazonia and beyond.

First, we find that the success of the palm management initiative depended on key prevailing conditions in the study community. Specifically, palm fruit is an important source of cash income for asset poor households who are remote from urban markets, and palm felling gave rise to growing concern over local scarcity. Studies elsewhere in the neotropics also point to the importance of perceived scarcity as an incentive for palm management initiatives, particularly where the product is pervasively important for subsistence or broadly accessed commercially (see Coradin and Lleras, 1988; Coomes, 2004; Byg and Balslev, 2006). Interestingly, resettlement of the community opened new opportunities for sustainable palm management, as residents moved across the river from a site where the palm forest had been extensively degraded to a new site, where the aguaje palm initially was more plentiful. Land tenure and rights to the palms on the new community lands were clarified and secured, and a locally developed technology – one that is more effective for harvesting palm fruit than felling of the palm – became available to residents. Support of the community by an NGO – which was actively sought out by community leaders concerned about the future of the resource and their village – was critical in assisting the community in securing communal tenure, inventorying the availability of the palm as a resource and setting aside a protected area, purchasing the climbing equipment and establishing a palm nursery for replanting in the communal protected area as well as in households gardens and fields. Importantly, a large proportion of the community was committed to more sustainable palm management. Such conditions would seem necessary (though perhaps not sufficient) for successful management of aguaje but also other Amazonian palms.

Second, we find that palm-climbing devices can be successfully adopted and provide users with the direct benefit of earning sustainable income while conserving local wild stands of aguaje palm. This outcome stands in contrast to previous experience in Amazonia where technology transfer for palm climbing and sustainable non-timber forest product harvesting, though often called for (Kahn and De Granville, 1992; Phillips, 1993; Delgado et al., 2007), has been largely unsuccessful (Pacheco Santos, 2005; Goulding and Smith, 2007). By employing a palm-climbing device which is simple in design, safe in use and robust in manufacture, harvesters found that fruit collection was more productive than felling palms. The primary constraint on higher participation rates was the initial cost of climbing devices and their limited availability. Subsidization of the production of climbing devices for rural poor households combined with demonstrated effectiveness relative to traditional techniques would both seem to be vital to household adoption of more sustainable harvesting practices.

Third, we observed that – in addition to reducing wild palm felling – the use of palm-climbing devices had two important indirect effects, by stimulating: (a) the adoption of community-level palm conservation measures; and, (b) the cultivation of palms in household agroforestry plots. The perceived benefits of climbing over palm felling were sufficient for residents to invest in longer term conservation and cultivation. The community set aside areas to be protected from felling, established management rules over harvesting, and initiated a planting program to increase the density of a high-value variety of the palm. As well, households saw that investments in planting the palm on their own land would be worthwhile, now that the fruit could readily be harvested for many years, without having to fell the palm. Importantly, more households took to planting aguaje on their property than those adopting palm climbing, indicating the importance of the 'demonstration effect' of the feasibility and advantages of palm climbing. While the use of climbing devices and the planting of the high-value *shambo* variety on community land and in home gardens were part of the NGO's program, other activities – such as assisting climbers or integrating the common palm variety into agroforestry systems – were the indirect result of the NGO's influence. As aguaje palm takes many years to mature, wild-harvesting with the climbing method provides a viable alternative; once mature, residents will have the opportunity to harvest from both cultivated and wild stands. As such, our findings suggest more generally that wild palm conservation and species cultivation can be complementary activities, with benefits for both, rather than strict substitutes as is sometimes argued, once wild stocks have diminished sufficiently to sharpen incentives to act.

And finally, the important decisions made by forest dwellers who rely on palm fruit – as to how it is harvested and whether or not to invest in palm cultivation – depend heavily on the socio-economic characteristics of their households. To date, few studies specifically identify the demographic, social and economic features of households that practice more sustainable palm use. Byg and Balslev (2006) found that households in Amazonian Ecuador who depend more on palm products, are wealthier and those who were born outside the community tended to cultivate palms. Households in an Amazon river community in northeastern Peru that planted *Astrocaryum chambira* tended to be those with larger land holdings, younger in age and those belonging to larger kin groups (Coomes, 2004). In the present study, we find that participation in more sustainable harvesting is related to household age, physical wealth, kin network, and forest knowledge whereas investment in aguaje palm cultivation is predicted by the availability of in-house labor and the participation in climbing expeditions as an assistant – suggesting again a positive synergy between more sustainable wild-harvesting and the integration of the palms within agroforestry systems. These findings offer potentially helpful insights to researchers, NGOs, and local people in the Peruvian Amazon and elsewhere in the neotropics, who face similar challenges in working towards more viable ways of managing the palms and other non-timber forest resources upon which much of their livelihoods depend.

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References

Anderson, A.B., 1988. Use and management of native forests dominated by açaí palm (Euterpe oleracea Mart.) in the Amazon estuary. Advances in Economic Botany 6, 144–154.

Anderson, A.B., May, P.H., Balick, M.J., 1991. The Subsidy From Nature. Columbia University Press, New York.
Bejarano, P., Piana, R., 2002. Plan de Manejo de los Aguajales Aledaños al Caño Parinari. Junglevagt for Amazonas. WWF-AIF/DK. Programa Integral de Desarollo y Conservación Pacaya Samiria, Perú.
Bodmer, R.E., 1990. Responses of ungulates to seasonal inundations in the Amazon floodplain. Journal of Tropical Ecology 6, 191–201.
Brightsmith, D., Bravo, A., 2006. Ecology and management of nesting blue-and-yellow macaws (*Ara ararauna*) in Mauritia palm swamps. Biodiversity and Conservation 15, 4217–4287.
Byg, A., Balslev, H., 2006. Palms in indigenous and settler communities in south-eastern Ecuador: farmers' perceptions and cultivation practices. Agroforestry Systems 67, 147–158.
Byg, A., Vormisto, J., Balslev, H., 2007. Influence of diversity and road access on palm extraction at landscape scale in SE Ecuador. Biodiversity and Conservation 16, 631–642.
Campos, M.T., Ehringhaus, C., 2003. Plant virtues in the eyes of the beholders: a comparison of known palm uses among indigenous and folk communities of southwestern Amazonia. Economic Botany 57, 324–344.
Carrera, L., 2000. Aguaje (*Mauritia flexuosa*) a promising crop of the Peruvian Amazon. Acta Horticulturae 531, 229–235.
Clement, C.R., 1993. Native Amazonian fruits and nuts: composition, production and potential use for sustainable development. In: Hladik, C.M., Hladik, A., Linares, O.F., Pagezy, H., Semple, A., Hadley, M. (Eds.), Tropical Forests, People and Food. Man and the Biosphere Series. The Parthenon Publishing Group 13, pp. 139–152.
Coomes, O.T., 2004. Rain forest 'conservation-through-use? Chambira fibre extraction and handicraft production in a land-constrained community, Peruvian Amazon. Biodiversity and Conservation 13, 351–360.
Coomes, O.T., Barham, B.L., Takasaki, Y., 2004. Targeting conservation-development initiatives in tropical forests: insights from analyses of rain forest use and economic reliance among Amazonian peasants. Ecological Economics 51, 47–64.
Coradin, E., Lleras, L., 1988. Overview of palm domestication in Latin America. Advances in Economic Botany 6, 175–189.
Delgado, C., Couturier, G., Mejia, K., 2007. *Mauritia flexuosa* (Arecaceae: Calamoideae), an Amazonian palm with cultivation purposes in Perú. Fruits 62, 157–169.
Flores Paitán, S., 1997. Cultivo de Frutales Nativos Amazónicos: Manual Para El Extensionista. Tratado de Cooperación Amazonica, Lima, Perú.
Goulding, M., Smith, N., 2007. Palms: Sentinels for Amazon Conservation. Missouri Botanical Garden Press, St. Louis, MO.
Guzmán Castillo, W., (nd). Valoración económica de beneficios ambientales en el manejo sostenible de humedades: estudio de caso del manejo sostenible de "aguajal" en la comunidad de Parinari, Reserva Nacional Pacaya Samiria (Región de Loreto, Perú). Proyecto BIOFOR, Instituto de Investigaciones de la Amazónia Peruana, Iquitos, Perú.
Henderson, A., 1995. The Palms of the Amazon. Oxford University Press, New York.
Hiraoka, M., 1999. Mirití (*Mauritia flexuosa*) palms and their uses and management among the ribeirinhos of the Amazon estuary. Advances in Economic Botany 13, 169–186.
Kahn, K., De Granville, J.J., 1992. Palms in Forest Ecosystems of Amazonia. Ecological Studies 95. Springer Verlag, New York.
Mejia, K., 1988. Utilization of palms in eleven *mestizo* villages of the Peruvian Amazon (Ucayali River, Department of Loreto). Advances in Economic Botany 6, 130–136.
Pacheco Santos, L.M., 2005. Nutritional and ecological aspects of Buriti or Aguaje (*Mauritia flexuosa Linnaeus Filius*): a carotene-rich palm fruit from Latin America. Ecology of Food and Nutrition 44, 345–358.
Padoch, C., 1988. Aguaje (*Mauritia flexuosa* L.f.) in the economy of Iquitos, Peru. Advances in Economic Botany 6, 214–224.
Peters, C.M., Balick, M.J., Kahn, F., Anderson, A.B., 1989. Oligarchic forests of economic plants in Amazonia: utilization and conservation of an important tropical resource. Conservation Biology 3, 341–349.
Phillips, O., 1993. The potential for harvesting fruits in tropical rainforests: new data from Amazonian Peru. Biodiversity and Conservation 2, 18–38.
Pyhälä, A., Brown, K., Adger, W.N., 2006. Implications of livelihood dependence on non-timber products in Peruvian Amazonia. Ecosystems 9, 1328–1341.
RCF, 2007. Rainforest Conservation Fund – Project. http://www.rainforestconservation.org/projects.html. Cited June 8, 2007.
Reardon, T., Vosti, S.A., 1995. Links between rural poverty and the environment in developing countries: asset categories and investment poverty. World Development 23, 1495–1506.
TNC, 2007. Pacaya-Samiria National Reserve: protecting 5 million acres of Amazon rainforest. http://www.nature.org/wherewework/southamerica/peru/work/art17217.html. Cited June 8, 2007.
Vasquez, D., Gentry, A., 1989. Use and misuse of forest-harvested fruits in the Iquitos area. Conservation Biology 3, 350–361.
Zambrana, N.Y.P., Byg, A., Svenning, J.C., Moraes, M., Grandez, C., Balslev, H., 2007. Diversity of palm uses in the western Amazonia. Biodiversity and Conservation 16, 2771–2787.