Brazil nut harvesting in Peruvian Amazonia from the perspective of ecosystem services

RISTO KALLIOLA AND PEDRO FLORES

Kalliola, Risto & Pedro Flores (2011). Brazil nut harvesting in Peruvian Amazonia from the perspective of ecosystem services. *Fennia* 189: 2, pp. 1–13. ISSN 0015-0010.

Brazil nuts are harvested from the primary rainforests in the Amazonian lowlands as a direct form of sustainably using the region's biological resources. We analyze the ecological economics of Brazil nut production in the Peruvian region of Madre de Dios where nut extraction occurs on hundreds of small-holder concessions operating under long-term agreements. This activity sustains locally important economies that suffer from small volumes and high seasonality. The size and the remoteness of the NTFP concession determine much of its profitability to concessionaires. Seasonality of the harvest generates short-term income peaks for the majority of collectors. The fragility of the Brazil nut economy in the region is compounded by volatile market prices and the overall development pressures in Amazonia, which usually involve deforestation. Although the current regulatory mechanisms in Peru encourage long-term Brazil nut production in concessions, the income level is seldom high enough to help concession-owners to rise from poverty. Auxiliary financial support based on compensations for the non-valued ecosystem services provided by the forest-covered Brazil nut concessions could change the picture. Funds for these could come from international instruments like those of carbon emission control or debt for nature swaps. Green marketing could be developed to consider payments supporting ecosystem values as well as mechanisms supporting indigenous communities working with Brazil nuts. Appropriate indicators are needed to optimize those management, policy and trading conditions that best help to preserve the invaluable ecosystem functions and services.

Keywords: non-timber forest products concessions, Brazil nuts, Peruvian Amazonia, payment for ecosystem services, capture of carbon, REDD

Risto Kalliola (corresponding author), Department of Geography, University of Turku, 20014 Turku, Finland. E-mail: riskall@utu.fi.
Pedro Flores, ACCA- Asociaciòn para la Conservación de la Cuenca Amazónica, Madre de Dios-Perú. E-mail: pedroaft@gmail.com.

Introduction

Ecosystem services refer to the many different contributions of nature to human welfare, providing such necessities as food, shelter, medicines, clean water and atmospheric gas exchange among others (De Groot et al. 2002). In many cases they provide primarily local benefits to local people yet some products have been exploited commercially for centuries. In megadiverse regions such as the Peruvian Amazon lowlands, many different forest products have become important even in the world level. For example the first effective drug against malaria was made of the bark of the cinchona (quinine) tree, and also the resin of the rubber three has contributed significantly to our modern lifestyle. The potential of Amazonia's biodiversity resources is huge due to the wide extension of these poorly-known forests and their high species richness, but it is challenging to realize this potential into the form of viable persistent economy.

URN:NBN:fi:tsv-oa4307

This paper focuses on one of Amazonia's eminent Non-Timber Forest Products (NTFP), the Brazil nut (local name castaña in Perú and Bolivia). The large-sized seeds ("nuts") of the Brazil nut tree (*Bertholletia excelsa*, Lecythidaceae) have an established market demand around the world, comprising 1,5% of the international edible nut trade (Clay 1997). The tree that produces this crop is a true rainforest giant that may live for centuries – one individual has been estimated to be 1600 years old (Clay 1997) – and reach up to 40–50 meters high. Its populations are dense enough for commercial nut extraction only in Brazil, Bolivia and Peru, yet the total distribution area of the species covers most of the Amazon Basin. As attempts to produce Brazil nuts in plantations have not been successful, nut extraction from the natural stands is the only way of its commercial exploitation (Mori 1992).

Brazil was the main producer and exporter of Brazil nuts until the 1990s but its production levels have now decreased. The Brazil nut tree is nowadays considered vulnerable in Brazil according to the IUCN Red List of Threatened Species (IUCN 2007). However, the protection of the species only is not enough because the viability of its populations rely on an intricate set of ecological interactions. In consequence Brazil nut populations are susceptible to environmental changes associated with deforestation in the surrounding areas, leading into ceasing tree reproduction (Clay 1997). Long term nut exploitation may also change the age structure of the populations, as shown by the reduction in the juvenile age class in intensely harvested areas (Zuidema & Boot 2002; Peres et al. 2003). Keystone species, decreasing Brazil nut populations imply capricious ecological and social consequences in the forest (Camargo et al. 1994).

Policy options to promote healthy Brazil nut stands and sustainable nut extraction should be considered in terms of the entire production chain from the forest to the market. Dedicating some lands for the Brazil nut production implies that the forest of these areas shall not be altered too much overall, which in turn contributes to the persistence of the vigorous rain forest. It is hoped that the Brazil nut based economies would therefore help to preserve some of the Amazonian forests with their enormous biological values, climatic influences and contribution to atmospheric gas exchange. However, cattle ranching and other activities involving deforestation may appear even more appealing uses of the same areas. As deforestation tends to follow the improvement of road connections in Amazonia (Mäki et al. 2001), any time the Brazil nut production forests get to occur in the development front of the expanding road network and agricultural activities, their economic return and consequently also longevity will be questioned.

We here examine the ecological economics of the Brazil nut extraction and economy using the Madre de Dios region in south-eastern Peru as a case study region. Each year the harvest season (zafra) that mainly occurs between January and March is an active period in the forest, involving numerous concession holders, their families and contracted workers. Parallel to this, road improvement projects near the Brazil nut production areas go together with advanced timber logging, deforestation other land use pressures. In the following, we will analyze the current state of the Brazil nut economy in the region by using a holistic approach that combines geographical, socio-economic, market and ecosystem service perspectives.

Materials and methods

Our study draws from a combination of wide-ranging information sources, both literature based, remote sensing and field work. Academic literature and maps of the Peruvian Amazon as well as government and NGO reports and data were reviewed to appraise the general geographical realities that correspond to the Brazil nut production in Peru. We applied a mosaic of Landsat TM satellite imagery (Kalliola et al. 2008; SIAMAZONIA 2008) to reveal the environmental heterogeneity of the study area. This part of the study was backed by R. Kalliola's biogeographical research activities in the region (e.g. Salo et al. 1986; Tuomisto et al. 1995; Kalliola et al. 1999; Toivonen et al. 2007). The spatial data about the Brazil nut concessions are from Instituto Nacional de Recursos Naturales (INRENA, the name of this institution was changed in 2008 ATFFS, Administración Técnica Forestal y de Fauna Silvestre). The national statistical data comes from the year of 2005 and is from the Instituto Nacional de Estadística e Informática (INEI 2005). Supporting statistical and descriptive data are from the Food and Agriculture Organization (FAOSTAT 2006).

Socio-economic data include interviews made by P. Flores with Brazil nut collectors, middlemen

and exporters on two different occasions. The first interviews were made in late 2001 when the concessions for the NTFP extraction were about to be defined. The second set of interviews is from spring 2007, after the concessions had been operational for a few years. A total of 107 interviews were conducted in the city of Puerto Maldonado, the capital of the department of Madre de Dios, and in the production zones of Las Piedras, Alerta, Alegria and Tahuamanu. A questionnaire was filled during the interviews, focusing on the working conditions in the Brazil nut concessions and the corresponding income generation process. The main body of raw primary data has been reported by Flores (2002).

The following analysis presents a combinatory review of the above described materials. We furthermore present scenarios to estimate the income generating potential of selected area-based ecosystem service payments in support of viable Brazil nut production within the region.

Results

Geographical perspective

The indigenous people Ese'Eja living in Madre de Dios are considered to be among the first to use Brazil nut seeds as food, but commercial Brazil nut extraction started in the region not until after the "rubber" boom in the early 20th century. The current Brazil nut collection areas cover an area of 2,500,000 hectares and are mainly located in the department of Madre de Dios that borders with Brazil and Bolivia (Fig. 1A). The climate in this area is humid tropical with an annual average precipitation of approximately 2200 mm, and temperature of nearly 26 °C. A distinct dry season occurs between June and August, but the Brazil nut fruits fall mostly during the rainy season in January and February.

The physical landscape of the Brazil nut collection areas is flat, made of river floodplains, alluvial terraces and dissected low-lying non-flooded areas with variable soil characteristics (Osher & Buol 1998). Madre de Dios has an almost uninterrupted cover of rain forest vegetation with some deciduous emergent trees. These forests are well known for their high levels of biological diversity (Lamas 1994; Phillips et al. 2003), though also extensive thickets of species-poor arborescent bamboo are widespread. Brazil nut trees often grow in small stands made by a few tens of individuals in non-flooded areas, separated from one another by distances of a few hundred meters (Mori & Prance 1990; Peres & Baider 1997). The low density of the Brazil nut trees (10 or 20 trees per hectare) may be beneficial for the species, as the nut production capacity depends on a variety of complex interactions between the Brazil nut tree and other species of the forest; for example bees, bats and rodents that contribute to pollination and see dispersal (Mori 1992; Gustafsson 1998).

The environment and natural resources of the Madre de Dios region were focused in the 1970s by the Peruvian government in connection to plans to integrate the Amazonian lowlands into the national economy (ONERN 1972). The region was shown to have significant natural resources, particularly timber, NTFP, alluvial gold, gas and agricultural products. The Peruvian Amazonian Research Institute (IIAP) made a proposal of ecological-economic zoning for this region and identified areas suitable for extractive forest uses (SIAMAZONIA 2008). The institute suggests that as much as 40% of the department's area is suitable or modestly suitable for Brazil nut extraction (IIAP 2002).

The Brazil nut trees in Peru are owned by the state, which may provide concessions to individuals with the exclusive right to harvest the nuts in a given area (Peruvian law of Forestry and Wildlife from year 2002, No.27308; with updates in 2008). Currently, there are around 1,200,000 hectares of NTFP concessions in Peru, including 60,000 hectares in titled indigenous people territories. There are almost one thousand separate concessions with their sizes ranging between 100 and 1 200 hectares, the smallest of them usually belonging to the indigenous people. The concessions occur side by side with each others as a dense cluster of free-shaped land units in eastern Madre de Dios, being significantly distinct from the larger-sized quadrangular shaped timber production concessions in the same region (Fig. 1). Considering the puzzle-like composition of the Brazil but concessions across the region, spatial accuracy is critical in the field. The precise locations of the concessions are considered carefully by national and regional planning authorities with help of satellite positioning. Sometimes big Brazil nut trees are tagged to designate their ownership.

Logistics and accessibility constitute another critical spatial factor. The nut harvest is made manually on forest floor after the extremely hard-

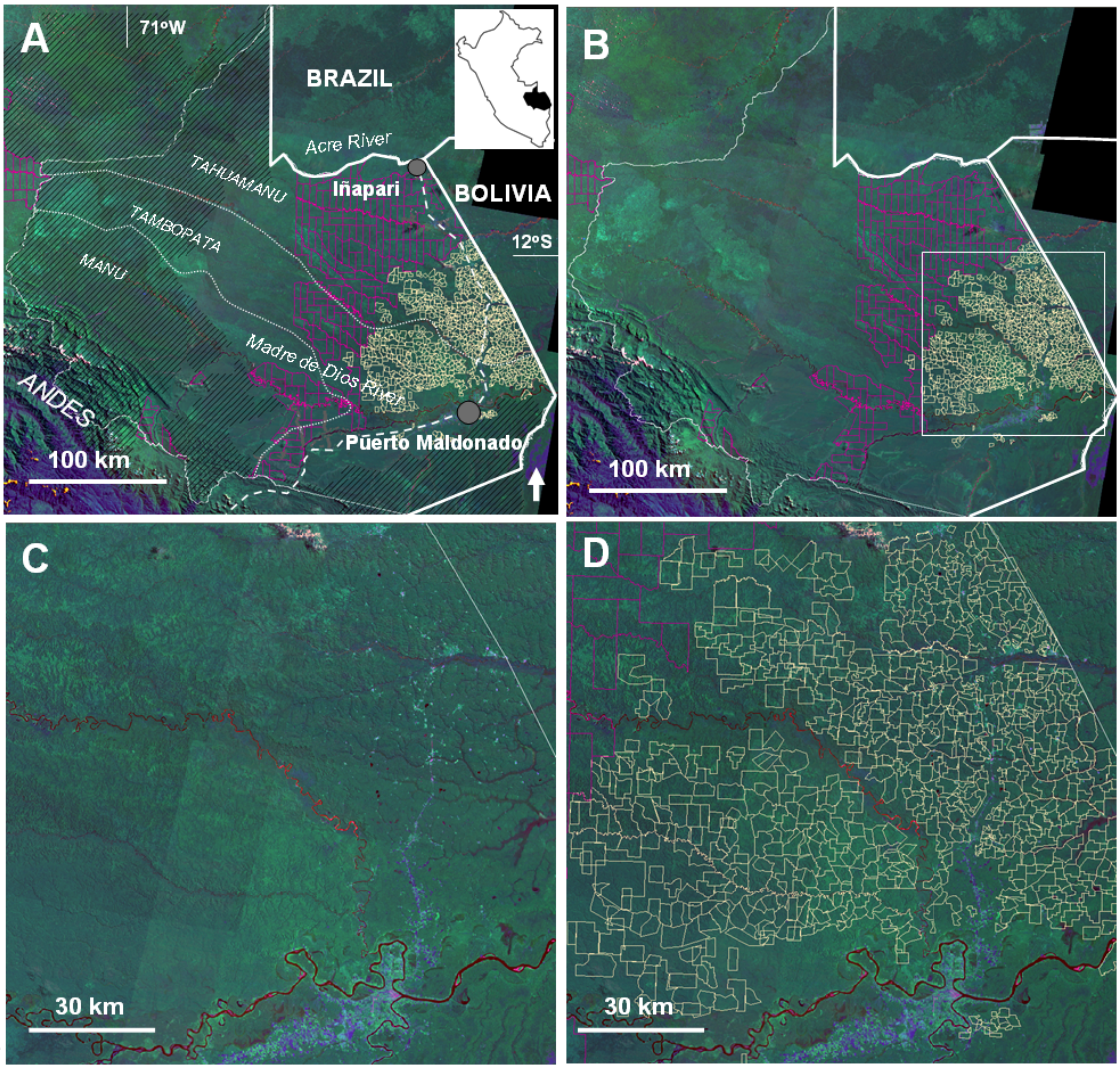


Fig. 1. Maps from the Brazil nut production areas in Madre de Dios, Peru. The bottom layer is formed by Landsat TM mosaic with data from 1985–86 (BIODAMAZ 2004), expressing the natural environmental variability of the region when deforestation was still limited to the vicinity of Puerto Maldonado. Green colours and tonalities indicate tropical rainforests and their local variations; the palest green areas are bamboo forests. Water areas are black and deforestation appears in pale and blue colours. A. Names of the provinces, major population centres and rivers. The main roads are shown by dashed line and protected areas are hatched with black. B. Distribution of concessions of Brazil nut extraction (pale yellow) and forestry (purple). C and D. Magnification of the satellite image from the area of Brazil nut concessions (quadrangle shown in B).

covered fruits of the Brazil nut trees have fallen down. Both the collection and the subsequent transportation are laborious. The seeds must be removed from the fruits and carried to the collection centers in heavy bags. After sun-drying the nuts must be further transported to the city of Puerto Maldonado, which has some 100,000 inhabitants and is the main economic center of the region. Sometimes entire Brazil nut fruits are transported instead of forest-dried seeds, adding to the transport load and diminishing the revenue. Most transports in the forest are by foot, but also waterways

are used whenever possible. As the northernmost rivers in Madre de Dios drain to Bolivia or Brazil, the crop may have to be carried overland from one river to another. Whenever roads are available the nuts are finally taken to the city by car. In Puerto Maldonado, they get re-dried and sorted, after which they are exported over the Andes – mainly to the international market through the seaports of Callao (Lima) and Matarani (Arequipa).

Socioeconomic perspective

The gathering of Brazil nuts is important for many indigenous and immigrant communities living in Madre de Dios (Lawrence et al. 2005). All concessionaires are requested to develop annual operating plans and present a management plan every fifth year. The latter includes basic information about the production process and forest quality, including the numbers of existing Brazil nuts trees and their management plans. The current regulations are mainly ecological and overlook cultural values such as indigenous communities. By fulfilling all requirements, the concession holder can establish a planning horizon of up to 40 years. Such assurance provides a strong predictability element that can be considered as an incentive to invest in and maintain the sustainability of the nut production. The obligation to regularly update the operation and management plans also promotes bidirectional interaction with the national authorities that are in charge of this natural resource. This linkage reinforces the implementation of sound environmental practices in the country, yet the required paper work may be overwhelming for some concession-holders.

The Brazil nut collection areas in Madre de Dios are among the least populated and poorest areas in Peru. The livelihood of these people is however contributed by the direct use of the regions natural resources. The majority of concessions are located in the Tahuamanu province that borders with Brazil and Bolivia (see Fig. 1A), having one of the smallest populations in the country. According to a recent census (INEI 2005), its total population is 7429 people, which makes on average 0,4 inhabitants per square kilometer. The province has three districts, the Brazil nut concessions being situated in the Tahuamanu district (21,196 km^2). Socioeconomic indicators from this district as well as the other major Brazil nut collection areas confirm low living standard, one largely dependent on forest resources for housing and energy, and with extremely limited infrastructure (Table 1).

Table 1. Selected welfare indicators in the two districts of the Madre de Dios department with Brazil nut concessions (Tahuamanu district in the Tabuamanu province and Las Piedras district in the Tambopata province). Data from INEI (2005).

Categories / Districts	**Tahuamanu**		**Las Piedras**	
	Number	%	Number	%
Dwellings				
Rural area	313	59	1157	65
Urban area	218	41	635	35
Main building material				
Brick	23	6	37	3
Timber	316	78	1340	91
Other	66	16	100	6
Type of lighting system				
Electricity	2	0,4	430	29
Kerosene	129	31,8	738	50
Oil-gas(lamp)	38	9,3	18	1
Candle	171	42,2	158	11
Electric Generator	38	9,3	111	8
Other	25	6,1	20	1
Do not have	2	0,4	2	0
Primary cooking fuel				
Electricity	0	0	1	0
Gas	70	17	183	12
Kerosene	0	0	2	0
Coal	106	26	306	21
Fire wood	223	54	940	64
Other	12	3	0	0

The total number of people working with Brazil nut harvesting, processing, and commerce in Peru is about 30,000 (Collinson et al. 2000). In native communities, the decision to harvest Brazil nut is communal, allowing some members to harvest Brazil nuts from their reserved area. The majority of the Brazil nut collectors are however urban dwellers from mainly Puerto Maldonado, who come to work in the forest only during the harvest period, living in rudimentary camps in the woods. Most concessionaires have been working as gatherers for a long time already, sometimes being descendants of people who have a few decades ago

migrated into the lowlands mainly from the Andean regions of Cusco or Puno. The additional gatherers they employ are typically recent male immigrants in the region or local people living in the nearby areas. As the population in Madre de Dios grows fast, attention toward Brazil nut jobs is increasing. This may reduce the prize paid of the harvest, salaries of the hired collectors and also widen the harvest activities into previously unexploited areas (Stoian 2004).

Adult Brazil nut trees produce some 24–36 kg of raw nuts per season (Clay 1997) but fruit production varies among individuals and years (Kainer et al. 2007). Usually the nuts are sold by the concessionaires sun-dried in bulk to traders working as buyers for the exporting companies. Preference is given to high quality nuts that are delivered punctually in the desired quantities and quality. Being closer to the market, middlemen and exporters have ways to guarantee their own profit, particularly as there is only a low degree of competition among the Brazil nut buyers. Some gatherers have long-term contracts with buyers with trust-based relationships which can involve credits to cover the harvest period costs. This situation may create obstacles for new firms that would like to enter to this business. Additionally, when a middleman credits a collector prior to the harvest, little price negotiation power remains when the nuts are sold (Collinson et al. 2000). The situation is even worse for those who transport their harvest laboriously in shell until Madre de Dios, facing rude trading conditions: "sell it or bring it back". This situation is commonly met by the indigenous people who generally get lower price of their harvest than the non-indigenous people. Those working in remote areas tend to get only poor returns due to the high costs of transportation and a smaller number of buyers working in these areas. The best alternative for a Brazil nut collector would be to sell his product to a fair trade certified buyer, in which case the maximum payment may reach half of the export price (Collinson et al. 2000).

In the most remote areas with difficult access to the market, a minimum of 800 hectares or 320 productive Brazil nut trees is considered sufficient to support one gatherer and his family. This concession size allows the Brazil nut collectors to obtain a net income within a range of some 500 to 2000 USD annually (Flores 2002). Some urban interviewees considered the Brazil nuts collectors as "rich" but this generalization comes from temporary impressions from the selling period when money is moving. In most cases Brazil nuts merely provide temporary contribution to the economy of rather poor households. Combined activities such as agriculture, fishing and hunting provide some buffer against occasional drops in the market price that may otherwise lower the collector's share near the threshold of overall profitability and lead into withdraw of the harvest for the lack of realistic economic incentives. As the majority of the concessionaires have practically no access to bank credit, opportunities for investments and improvements in the concession are limited and must be funded through alternative means.

Unsecure conditions hardly encourage concession owners in laborious or long-term management of this renewable resource. Even simple management efforts like vine cutting from juvenile individuals could, however, be beneficial for Brazil nut production in the long run (Wadt et al. 2005; Kainer et al. 2007). The potential for bigger harvest is lost as most concessions are finally treated as immediate and short term cash money generators and otherwise neglected. This is particularly so in the small remote concessions that are near the threshold of profitableness. The populations of the Brazil nut trees in the Tambopata and Tahuamanu provinces may already be decreasing below the density of 0,5 individuals per hectare in consequence of long lasting seed harvesting (Cornejo 2001). Other evidence of possible population decline is provided by the natural resource inventories made in the region, which reported that Brazil nut production forests should typically have a density of some four to five big trees per hectare (ONERN 1972), which is notably more than it is today (see also Peres et al. 2003). Worse, according to our interviews some Brazil nut trees have been cut due to their valuable timber.

Market perspective

The present world production of Brazil nuts is roughly at levels seen already in the 1970s but the production levels of different countries vary a lot (Fig. 2A). Brazilian production has dropped to about half of its peak time, whilst Bolivia has compensated for that drop maintaining the annual world production at levels between 70,000 and 80,000 tons (FAOSTAT 2006). The Bolivian increase was made by improved collaboration between the nut gatherers and the exporting firms acting in the country (Vinocur Coslovsky 2006), and also improving road conditions that have

made some remote production areas accessible. In contrast the Peruvian exports have suffered from a perception among importers that the quality of the nuts is lower than those from the neighboring countries. Much of the nut processing in Peru is made by hand whilst while in Brazil and Bolivia more industrialized processes prevail. Peru's share of Brazil nut production is less than one tenth of Brazil's and Bolivia's combined.

The main importer of Peruvian Brazil nuts is the United States, with its share growing from 49% to 80% between 1997 and 2007. However, the FOB (Free On Board) price paid by U.S. importers is not as attractive as that of others (Fig. 2B), making it strategically important for Peru to maintain a diversity of export destinations. The closest market is Colombia, which resembles the Peruvian national markets. The price paid by the Colombian importers is the lowest, but also the logistics and transactions costs are low. The best prices of the Peruvian exports come from Japan, Australia and some European countries, with FOB prices doubling that offered by the USA. Much of this import occurs with fare trade certification. Certificates of organic production (Nelson et al. 2002) could also be feasible for the Peruvian producers as the entire harvest comes from the natural forests. However, the administrative requirements needed for such certificates are complicated and not yet appealing to small export firms.

Sanitary certificates are demanded by most of the importing countries. Contaminating microorganisms and aflatoxins pose a continual threat, since Brazil nuts are kept for long times in bags in humid hot climate and they do not usually undergo any industrial processing before their consumption. The final product is most often sold in packages of either Brazil nuts alone or in nut mixtures. Sometimes nuts are used as an ingredient in commercial baking. Brazil nuts are a good source of selenium and may be preferred as functional food. Experiments with Brazil nuts in breakfast cereals or in hair conditioner are examples of potential expanded uses. In terms of price, the wholesale and retail markets of Brazil nuts vary less than they do for primary producers (Flores 2002).

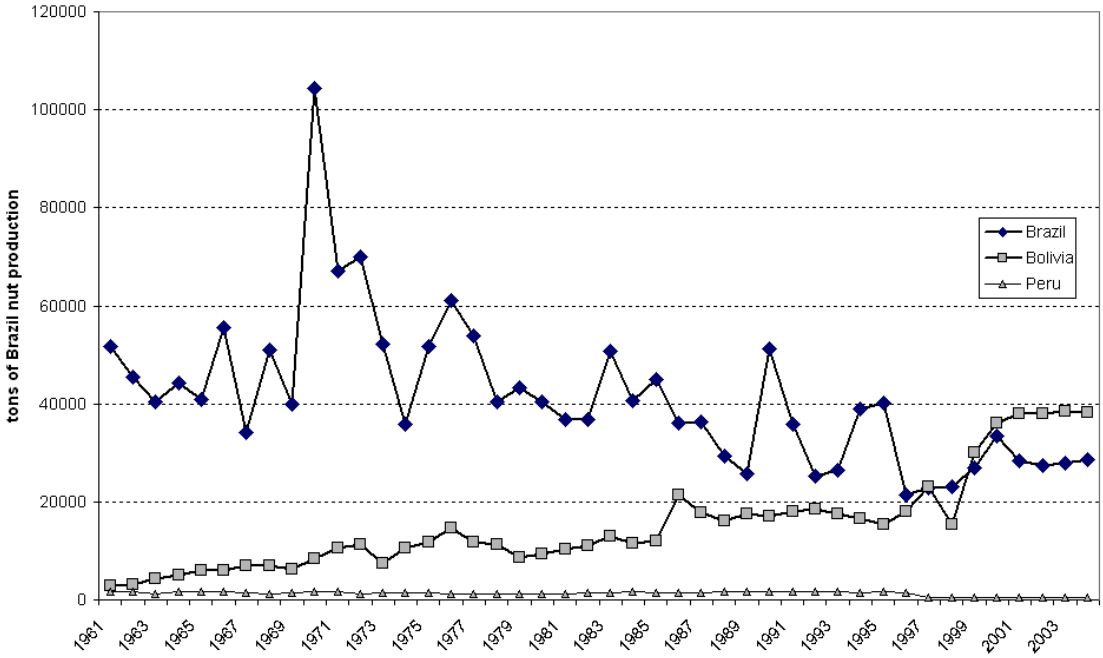
Ecosystem service perspective

The existence of an established international market for Brazil nuts gives an opportunity to support forest maintenance in the long run through relatively light additional incentives. Paying for the co-occurring ecosystem services in the Brazil nut concessions would ensure that the holders of these concessions would stay over the threshold of minimum profitability. A way to recognize the value of the preserved forest is to pay for the ecosystem services they provide according to a sensible mechanism. The economic valuation of these services aims at linking the use values in the existing markets with the non-the use values of the missing markets for values such as biodiversity, supporting ecosystem services or preserved indigenous cultures. The cash equivalent payments to the providers of such services naturally depend on a number of different variables, both general and local.

In organic production, the sustainability of the harvest is in focus and in fair trade, buyers contribute to the producer's socioeconomic conditions. As none of these mechanisms recognize the functional value of the diverse forest, new approaches need to be considered. To examine the feasibility and potential of the recognition of the indirect ecosystem values, we take the compensation levels to of 6 and 12 USD per hectare as reasonable basis to explore.

Scenarios A to F represent different surface areas to focus by these payments (Table 2). In A, the area to consider (115,190 hectares) corresponds to the total area of the smallest forest concessions in Madre de Dios covering also the native communities of the region. At the level of 6 USD per hectare the extra annual income would be around 3000 USD for a concession of 500 hectares, which would double the concession holder's income. The total funds needed for this scenario is about 700 thousand USD annually, and nearly 21 million USD during a 30 years period, which roughly coincides with the remaining time of the first 40-year long concession allowances in Madre de Dios. In the subsequent scenarios we increase stepwise the total area of concessions to consider until scenario F, which includes the total area of all the Brazil nut concessions registered by Regional Forestry Authority in 2007. With the compensation rate of 12 USD per hectare, the range of needed annual payments according to the different scenarios is between about 1.4 and 8.4 million USD. During a period of 30-years, the levels of the total needed payments range between about 21 and 251million USD.

A



B

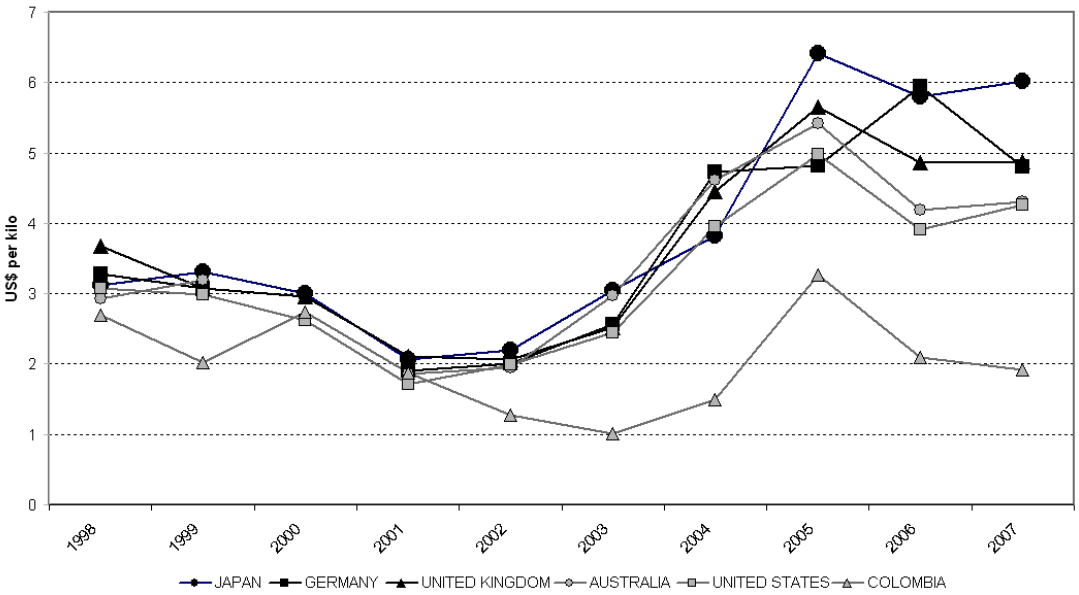


Fig. 2. International markets of the Brazil nuts. A. Amounts exported by different countries (in 103 kg). Source: FAOSTAT (2006). B. Average prize paid by the importing countries of Brazil nuts from Peru. Data from the year 2007 by INRENA.

Table 2. Exploration about the application of alternative area-based payment settings for the ecosystem services provided by the Brazil nuts concessions in Madre de Dios. Scenarios A to F consider stepwise increasing surface areas with payments calculated in the rates of 6 USD and 12 USD per hectare, respectively.

Scenario	Hectares included	Cost (10^3 USD) at level 6 USD ha^{-1}		Cost (10^3 USD) at level 12 USD ha^{-1}	
		Annual	Over 30 years	Annual	over 30 years
A	115,190	691	20,734	1382	41,468
B	231,821	1390	41,727	2781	83,455
C	348,452	2090	62,721	4181	125,442
D	465,083	2790	83,714	5580	167,429
E	581,714	3490	104,708	6980	209,417
F	698,345	4190	125,702	8380	251,404

Discussion

Brazil nut production in Madre de Dios is a prime example of an extractive ecosystem usage that is significant to the regional economy. However, its nature as a seasonal scale activity practiced mainly by poor disorganized concessionaires may make it antagonistic with some other development trends in the region. Heavy pressures are posed by the continual migration of farmers from the Andean highlands, illegal logging, bio-energy production and the spread of pastures for beef production. The integration of the Regional Infrastructure of South America (IIRSA) that involves highway construction through the major Brazil nut collection zones in Peru may ease the transportation of nuts to Puerto Maldonado and further on, but it simultaneously poses increasing threat of accelerated deforestation. To save the Brazil nut concessions, ways should be sought to convincingly integrate the Brazil nut based economy into the overall development priorities of the region.

The potential Brazil nuts have in the long-term welfare of the region is limited. The current concession system provides tenure security, rights and other incentives that support stable nut extraction as well as the objectives of the Peruvian Amazon biodiversity strategy (BIODAMAZ 2001). However, the socio-economics of sustainably managing Brazil nut extraction is challenging (Wadt et al. 2008). In their analysis of Brazil nut extraction in Peru, Escobal and Aldana (2003) show a clear negative relationship between natural resource based income and family's total income; the poor depend more on natural resources than the wealthy. To make extractive forest use a real choice in the long run, the value of the standing forest should be high enough to make this forest use attractive at the household level (Wunder 2001; Shone & Caviglia-Harris 2006). This demand calls for holistic approach to the Brazil nut economy and forest valuation as a whole.

As minor exporter, Peru is a "price taker" in the world market of Brazil nuts where the price level is set largely by Bolivian and Brazilian firms and their clients. Many buyers in importing countries have little awareness of the origin of these nuts and their linkage to rainforest preservation. A better prize could be obtained voluntarily like in the case of fair trade or organic labels that already exist in the market of Brazil nuts. With better information provided, some customers could appreciate the purchase of Brazil nuts as an environmentally conscious choice (Kengen 1997). In the Mediterranean region the marketing of some products upon ecological values have got positive reaction from consumers (Croitoru 2007). The application of these kinds of mechanisms require sound product certification criteria that should be defined jointly among the producers, firms trading with the Brazil nuts, scientists, non-governmental organizations, and the governments of exporting and importing countries (Shanley et al. 2003).

For additional stability, payments for the associated value of the standing tropical forest that hosts the Brazil nut concessions could be considered (Farber et al. 2002). Researchers have attempted to determine the economic potential of the diverse natural forests by valuing all of the found extractable resources (Peters et al. 1989; De Groot et al. 2002), but such analyses may lack market realism. Alternative approach is to account for ecosystem services using avoided deforestation as a proxy. Many services provided by the standing

forest have thus far been operating free of charge, but now we may have to consider paying for them. This approach could lead into concrete earnings by those who have a choice in the forest floor and who may be inclined into logging or slash and burn agriculture. Considering that the Brazil nut concessions smaller than some 500 hectares are economically instable (Escobal & Aldana 2003), only a third of the current concessions in Madre de Dios are sufficiently large. In other concessions illegal logging may become tempting but even a small regular compensation of the standing forest could make a difference. Long-term earnings and conservation goals could be reached simultaneously and encourage concessionaires for long-term management efforts (Arnold & Ruiz 2001; Gavin & Andersson 2007; Zilberman et al. 2008).

In Peru, payments for the ecosystem services have received little attention compared to some other Latin American countries like Costa Rica, Ecuador and Colombia (see Wunder et al. 2008). Our calculations suggest that payments that remain well under 10 million USD per year for the entire Madre de Dios would significantly improve the economic situation of the nut concessionaires in Madre de Dios. This level of funding is not much when compared to for example the funds allocated by many individual countries to combat global warming. In the United Nations Climate Change Conference in Cancún in December 2010, the so called REDD mechanism for compensating tropical nations that succeed in reducing carbon emissions from deforestation and forest degradation took a step forward. It is expected that REDD could help to provoke ecological damages and promote ecological co-benefits in the Amazon (Stickler et al. 2009). The mechanisms of REDD set a number of conditions for the concessionaires to fill, requiring concerted efforts at the regional scale. Such activities have already been initiated by some indigenous communities and WWF in Madre de Dios.

Another source of potential international funding for the ecosystem service payments is provided by the debt-for-nature swap. By the year 2006, Peru's national organization FONDEBOSQUE had agreed upon this mechanism for 14 million USD with the governments of Germany, Canada and Finland (Flores 2006). A proportion that is less than one percent of Peru's public debt in 2008 would mean a capital of some 100–200 million USD that would contribute the profitability of the Brazil nut concessions in Madre de Dios for up to thirty years.

Also diverse side economies can help concessionaires to survive but care should be taken not to damage the standing Brazil nut trees. Even reduced-impact logging may cause significant damage to the Brazil nut trees (Guariguata et al. 2009). At places, ecotourism can be developed along with viable Brazil nut production (Gössling 1999). In the Tambopata National Reserve south from Puerto Maldonado Brazil nuts are collected in the same lands that attract tourists. Also many other side economies may be considered but importantly, the financial incentives that correspond must be predictable, stable and sufficient. In their absence at the local level the argument of preserving the non-valued ecosystem services by viable "soft" economies remains empty.

Market fluctuations constitute a constant challenge for the NTFP extractors in the Amazon (Kengen 1997). Stable area based compensations like those experimented in this paper (Table 2) could help to buffer the influences of these variations, but the allocation of such incentives should not be made too easy. It is necessary to define objective criteria for the ecological sustainability of the concessions and for their assessment using undisputable indicators. Also the associated socio-economic mechanisms need much attention. As an example, prospected earnings from future ecosystem service compensations might induce some concession holders to incur debts in anticipation of the expected income. This and other risks alike should be minimized by appropriate planning and regulatory mechanisms. An initial set of possible long term evaluation criteria for Brazil nut production and ecosystem service valuation is presented in Table 3.

Conclusions

The extraction of Brazil nuts from the primary rainforest is an important source of livelihood in the Madre de Dios region of Peru. The current national legislation supports long term extraction activities. However, due to endemic poverty of the region, small size of most of the concessions (especially those of the native communities), strong income fluctuations and underdeveloped production chains, this economy is vulnerable to forces beyond their control.

The design of appropriate policies to sustain long term viability of the Brazil nut concessions

Table 3. Possible criteria to support the development of policies toward stable Brazil nut production in Peru.

Criteria	**Description**	**Evaluation approach**	**Source of verification**	**Measurement**
Ecologic value	Maintenance of the diverse tropical forest with low human impact	Status of the forest according to ecological and biodiversity criteria	Remote sensing, field verification; management reports collected by forest authorities	Long-term monitoring of changes
Economic value	Net economic benefits of exports with better prize for certified production and green marketing; payments for ecosystem services	Economic profitability of concessions, improved socio-economic welfare	Income statistics of the concession holders and regional welfare statistics by national authorities	Income level per unit area; statistics about welfare assets
Public acceptability	Agreed mechanisms of payments for ecosystem services; public support for NTFP concessions and economies	Stakeholders participate in a transparent process of negotiations and agreements	Reports and agreements about the process, opinions of stakeholders and public in general	Operational activities implemented and audited; stakeholder hearings
Fairness	Peoples living in the region have valuable cultural attributes to preserve	Brazil nut collection does not threaten the culture and future of the indigenous people	Indigenous people maintain their traditions and culture	Living language, communities and households evidenced by in situ surveys

must be knowledge based, including options and applying reasonable criteria of sustainability. Consumers in the importing countries should be given the chance to understand that their choice is critical. Furthermore, mechanisms leading to paying for the currently non-valued ecosystem services provided by the Brazil nut concessions could reinforce and stabilize the economic return of the concessionaires. These policy measures should be implemented upon a framework of many simultaneously pertinent criteria such as ecological, socio-economic and those supporting the indigenous cultures of the region. The financing of the ecosystem service payments could involve debt for nature swaps and/or mechanisms of compensation for the prevention of carbon emissions to the atmosphere.

ACKNOWLEDGEMENTS

The fundaments of this work lie in the researcher visit of PF in the University of Turku (2008) by the Coimbra Group Scholarship for Young Professors and Researchers of Latin America. We acknowledge also the KONE foundation for financial support. We thank our colleagues of the UTU-ART team for discussions, and Matti Salo and Paul Kaldjian for commenting versions of this manuscript. Data on the Brazil nut concessions and environmental conditions in the Madre de Dios region are from ACCA, National Direction of Forestry and Wildlife, IIAP and SIAMAZONIA.

REFERENCES

Arnold JE & Ruiz Pérez M 2001. Can non-timber forest products match tropical forest conservation and development objectives? *Ecological Economics* 39: 3, 437–447.

BIODAMAZ 2001. *Estrategia Regional de la Diversidad Biológica Amazónica*. Iquitos: IIAP-BIODAMAZ. <http://www.iiap.org.pe/publicaciones/CATALOGO/documentos/literatura_gris/ERDBAS/ERDB_Amazonas.pdf> 5.6.2010.

BIODAMAZ 2004. *Landsat image mosaic of the Peruvian lowland Amazonia*. Iquitos: IIAP-BIODAMAZ. <www.siamazonia.org.pe> 5.6.2008.

Camargo PBD, Salomao RP, Trumbore S & Martinelli LA 1994. How old are large Brazil-nut trees (Bertholletia excelsa) in the Amazon? *Scientia Agricola* 51, 389–391.

Clay BB 1997. Brazil nuts. The use of a keystone species for conservation and development. In Freese CH (ed). Harvesting wild species. Implications for biodiversity conservation, 246–282. John Hopkins Press, Baltimore.

Collinson C, Burnett D & Agreda V 2000. *Economic Viability of Brazil Nut Trading in Peru. Report*

2520, Natural Resources Institute, Kent. <*http://www.nri.org/NRET/brazilnuts.pdf*> 5.6.2008.
Cornejo F 2001. Historia natural de la castaña (Bertholletia excels (Humb and Bonpl.) y Propuestas para su Manejo. ACCA. Proyecto "Conservando Castañales".
Croitoru L 2007. Valuing the non-timber forest products in the Mediterranean region. *Ecological Economics* 63, 768–775.
De Groot R, Wilson M & Boumans R 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics* 41: 3, 393–408.
Escobal J & Aldana U 2003. Are nontimber forest products the antidote to rainforest degradation? Brazil nut extraction in Madre de Dios, Peru. *World Development* 31, 1873–1887.
FAOSTAT 2006. Food and Agriculture Organization. <*http://faostat.fao.org*> 5.11.2006.
Farber S, Costanza R & Wilson M 2002. Economic and ecological concepts for valuing ecosystem services. *Ecological Economics* 41: 3, 375–392.
Flores P 2002. *Identificación de Indicadores Económicos para Agentes Vinculados al Aprovechamiento del Bosque en Pie: Caso de la Castaña, Lima. Report prepared for BIOFOR Project.* International Resources Group, Winrock International and Harvard Institute for International Development.
Flores P 2006. *Identificación de requisitos para aprovechar las oportunidades para el financiamiento de programas de manejo sostenible de recursos naturales en los territorios rurales del Perú, a través del canje de deuda por naturaleza.* Unpublished report, Lima.
Gavin MC & Anderson GJ 2007. Socioeconomic predictors of forest use values in the Peruvian Amazon: A potential tool for biodiversity conservation. *Ecological Economics* 60: 4, 752–762.
Guariguata MR, Licona JC, Mostacedo B & Cronkleton P 2009. Damage to Brazil nut trees (Bertholletia excelsa) during selective timber harvesting in Northern Bolivia. *Forest Ecology and Management* 258, 788–793.
Gustafsson B 1998. Scope and limits of the market mechanism in environmental management. *Ecological Economics* 24: 2–3, 259–274.
Gössling S 1999. Ecotourism: a means to safeguard biodiversity and ecosystem functions? *Ecological Economics* 29: 2, 303–320.
IIAP 2002. Propuesta de zonificación ecológica económica de la region Madre de Dios. <*http://www.iiap.org.pe/publicaciones/literatura%20gris/ZEE_MadredeDios_Versi%F3ncorregida.pdf*> 13.6.2008.
INEI 2005. Instituto Nacional de Estadística e Informática, Peru. <*http://www1.inei.gob.pe/*> 13.6.2005.
IUCN 2007. 2007 IUCN Red List of Threatened Species. <*www.iucnredlist.org*> 13.6.2005.
Kainer KA, Waldt LHO & Staudhammer L 2007. Explaining variation in Brazil nut fruit production. *Forest ecology and management* 250: 3, 244–255.
Kalliola R, Jokinen P & Tuukki E 1999. Fluvial dynamics and sustainable development in upper Rio Amazonas, Peru. *Advances in Economic Botany* 13, 271–282.
Kalliola R, Toivonen T, Miyakawa V & Mavila M 2008. Open access to information bridges science and development in Amazonia: lessons of the SI-AMAZONIA service. *Environmental Research Letters* 3, 034004. <*http://www.iop.org/EJ/abstract/1748-9326/3/3/034004/*> 10.12.2010.
Kengen S 1997. Forest valuation for decision making. Lessons of experience and proposals for improvement. André Mayer Research Fellowship Report 1994/95. Food and Agriculture Organization of the United Nations Rome. <*http://www.citeulike.org/user/Flit/article/410734*> 10.12.2010.
Lamas G 1994. List of Butterflies from Tambopata (Explorer's Inn Reserve). In Barkley LJ (ed). *The Tambopata-Candamo Reserved Zone of Southeastern Peru´: A Biological Assessment.* Rapid Assessment Program Working Papers 6, Conservation International, Washington, DC, 162–177.
Lawrence A, Phillips OL, Reategui A, López M, Rose S, Wood D & Farfan JA 2005. Local values for harvested forest plants in Madre de Dios, Peru: towards a more contextualized interpretation of quantitative ethnobotanical data. *Biodiversity and Conservation* 14, 45–79
Mori SA 1992. The Brazil nut industry – past, present, and future. In Plotkin M & Famolare L (eds). *Sustainable harvest and marketing of rain forest products,*241–251. Island Press, Washington, DC.
Mori SA & Prance GT 1990. Taxonomy, ecology, and economic botany of the Brazil nut (Bertholettia excelsa Humb. and Bonpl.; Lecythidaceae). *Advances in Economic Botany* 8, 130–150.
Mäki S, Kalliola R & Vuorinen K 2001. Road construction in the Peruvian Amazon: process, causes and consequences. *Environmental Conservation* 28: 3, 199–214.
Nelson V, Tallontire A & Collinson C 2002. Assessing the benefits of ethical trade schemes for forest dependent people: comparative experience from Peru and Ecuador. *International Forestry Review* 4, 99–109.
ONERN 1972. *Inventario, Evaluación e Integración de Recursos Naturales en la Zona de los Ríos Inambari y de Madre de Dios.* Oficina Nacional de Evaluación de Recursos Naturales, Lima.
Osher LJ & Buol SW 1998. Relationship of soil properties to parent material and landscape position in eastern Madre de Dios, Peru. *Geoderma* 83: 1–2, 143–166.
Peres CA & Baider C 1997. Seed dispersal, spatial distribution and population structure of Brazil nut trees (Bertholletia excelsa) in southeastern Amazonia. *Journal of Tropical Ecology* 13, 595–616.

Peres CA, Baider C, Zuidema PA, Wadt LHO, Kainer KA, Gomes-Silva DAP, Salomao RP, Simoes LL, Franciosi ERN, Valverde FC, Gribel R, Shepard Jr GHh, Kanashiro M, Coventry P, Yu DW, Watkinson AR & Freckleton RP 2003. Demographic threats to the sustainability of Brazil nut exploitation. *Science* 302, 2112–2114.

Peters CM, Gentry AH & Mendelsohn RO 1989. Valuation of an Amazonian rainforest. *Nature* 339, 655–656.

Phillips OL, Vargas PN, Monteagudo AL, Cruz AP, Zans MEC & Sánchez WG 2003. Habitat association among Amazonian tree species: a landscape-scale approach. *Journal of Ecology* 91, 757–775.

Salo J, Kalliola R, Häkkinen I, Mäkinen Y, Niemelä P, Puhakka M & Coley PD 1986. River dynamics and the diversity of Amazon lowland forest. *Nature* 322, 254–258.

Shanley P, Pierce A, Laird S & Guillen A (eds) 2003. *Tapping the Green Market: Certification and Management of Non-Timber Forest Products*. Earthscan Publications, London.

Shone BM & Caviglia-Harris J 2006. Quantifying and comparing the value of non-timber forest products in the Amazon. *Ecological Economics* 58, 249–267.

SIAMAZONIA 2008. Zonificación Ecológica Económica. Sistema de información de la diversidad biológica y ambiental de la Amazonía Peruana. <*www.siamazonia.org.pe*> 13.7.2008.

Stickler CM, Nepstad DC, Coe MC, Rodrigues HO, McGrath MD, Davidson EA, Walker WS & Soares-Filho BS 2009. The potential ecological costs and cobenefits of REDD: a critical review and case study. *Global Change Biology* 15, 2803–2824.

Stoian D 2004. Cosechando lo que cae: la economía de la castaña (Bertholletia excelsa H.B.K.) en la Amazonia boliviana. In Alexiades MN & Shanley P (eds). *Productos forestales, medios de subsistencia y conservación de productos forestales no maderables,* 89–116. Cifor 3: 5.

Toivonen T, Mäki S & Kalliola R 2007. The riverscape of Western Amazonia – a quantitative approach to the fluvial biogeography of the region. *Journal of Biogeography* 34, 1374–1387.

Tuomisto H, Ruokolainen K, Kalliola R, Linna A, Danjoy W & Rodriguez Z 1995. Dissecting Amazonian biodiversity. *Science* 269, 63–66.

Vinocur Coslovsky S 2006. How Bolivia's Brazil-Nut Industry Became Competitive in World Markets While Brazil's Fell Behind: Lessons from a Matched Comparison. Massachusetts Institute of Technology, Unpublished working paper. <http://web.mit.edu/salo/www/BN-Salo%20Coslovsky-%2023%20Oct%202006.pdf> 10.8.2010.

Wadt LHO, Kainer KA & Gomes-Silva DAP 2005. Population structure and nut yield of a Bertholletia excelsa stand in Southwestern Amazonia. *Forest Ecology and Management* 211, 371–384.

Wadt LHO, Kainer KA, Staudhammer CL & Serrano ROP 2008. Sustainable forest use in Brazilian extractive reserves: Natural regeneration of Brazil nut in exploited populations. *Biological Conservation* 141, 332–346.

Wunder S 2001. Povery alleviation and tropical forests. What scopes for synergies? *World development* 29: 11, 1817–1833.

Wunder S, Engel S & Pagiolac S 2008. Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. *Ecological economics* 65: 4, 834–852.

Zilberman D, Lipper L & Mc Carthy N 2008. When could payments for environmental services benefit the poor. *Environmental and Development Economics* 13, 255–278.

Zuidema PA & Boot RGA 2002. Demography of the Brazil nut tree (Bertholletia excelsa) in the Bolivian Amazon: impact of seed extraction on recruitment and population dynamics. *Journal of Tropical Ecology* 18, 1–31.