Measuring the resilience of Brazil nut production to landscape-level change in the Western Amazon

Amy Duchelle, School of Forest Resources and Conservation, University of Florida
Rainforest Alliance Kleinhans Fellow 2005-2007

Dedicated to the unwavering spirit of Vanessa Sequeira (1970-2006)

Abstract
Understanding complex socio-ecological systems and their resilience to external shocks is essential for promoting sustainable management of natural resources. The MAP tri-national frontier region, comprised of the states of **M**adre de Dios, Peru, **A**cre, Brazil, and **P**ando, Bolivia, provides an exceptional opportunity for exploring the resilience of Brazil nut production to landscape-level change. Brazil nut (*Bertholletia excelsa*) is the most important non-timber forest product (NTFP) in the region, simultaneously promoting forest conservation and forming the livelihood base for rural communities. The current development of the Interoceanic highway is radically changing the nature of this formerly remote region. In this context, I hypothesize that Brazil nut production is most resilient when: 1) local extractivists actively manage Brazil nut stands; 2) Brazil nut provides adequate income for communities to discourage investment in alternative land uses; 3) property rights are secure for Brazil nut producers; 4) deforestation and fire are minimal in Brazil nut stands; and 5) seedling recruitment assures long-term population viability. Combinations of these variables were measured in 22 Brazil nut producing communities in Bolivia, Brazil and Peru using socioeconomic, spatial and ecological research methods. Preliminary results show that participatory mapping of Brazil nut stands and product certification are two strategies that promote the resilience of Brazil nut production in forest-dwelling communities. Findings were returned in innovative ways to communities and other stakeholders in the MAP region. This research is essential for understanding the changing role of NTFPs in bridging conservation and sustainable development in dynamic landscapes.

Brazil nut production in the MAP region

Understanding complex socio-ecological systems and their resilience to external shocks is essential for promoting sustainable management of natural resources. The MAP tri-national frontier region, comprised of the states of **M**adre de Dios, Peru, **A**cre, Brazil, and **P**ando, Bolivia, provides an exceptional opportunity for exploring the resilience of Brazil nut production to landscape-level change. In this approximately 220,000 km^2 region in the southwestern Amazon, traditional extractivist communities share the land with indigenous groups and more recently settled farmers, cattle ranchers and loggers.

Fig. 1. MAP region and Interoceanic highway (red line)

The development of the Interoceanic highway, an extension of the newly paved Brazilian BR-317 into Bolivia and Peru, is changing the nature of this formerly

remote region, by providing regional access to Pacific ports (Fig 1). In Acre, forest conversion has been fast, extensive, grouped and dominated by the establishment of cattle ranches. In Madre de Dios, the deforestation process has been slower, less extensive, patchy, and dominated by small farms. In Pando, deforestation has been minimal, with most land conversion in close proximity to population centers and along the shared border with Brazil. Brazil nut (*Bertholletia excelsa*) can be considered the most important non-timber forest product (NTFP) in the MAP region, promoting forest conservation and forming the livelihood base for many rural communities. Within the dynamic MAP context, forest fires, deforestation to pasture, insecure land tenure, and fluctuating prices for Brazil nuts threaten the future of this important NTFP. My comparative research in the three countries explores under what conditions Brazil nut production is most resilient to such large-scale change.

Brazil nut is a unique non-timber forest product, because its seeds are primarily collected from wild Amazonian populations, and optimal natural regeneration of the species depends on intact, healthy forests to support large-bodied bee pollinators and ground-dwelling mammal seed dispersers (Mori & Prance 1990, Ortiz 2002, Zuidema 2003). Brazil nut trees are dominant, long-lived canopy trees in the Amazon and are often found in 20-50 hectare stands of 50-300 individuals per stand (Mori & Prance 1990). There is current debate over whether this spatial distribution is the result of Amerindian planting regimes (Baleé 1989) or clumped seed dispersal patterns by agoutis (*Dasyprocta sp.*) (Peres 1997). In open areas, Brazil nut trees produce fruit at 12-16 years of age, and reach maximum production levels at 100 years or more (Zuidema 2003). The large, woody Brazil nut fruits, which contain the edible seeds, generally fall to the ground during the wet season, where they are collected by humans, eaten or buried by agoutis, or left to rot. Experimental plantations of Brazil nut have been largely ineffective, producing negligible fruit yields, highlighting this species' value in promoting the conservation of intact Amazonian forests (Ortiz 2002).

Brazil nut has a relatively high economic value on local, national and international markets. In the MAP region, it is the cornerstone of the extractive economy, employing tens of thousands of families. Because of this, Brazilian, Bolivian, and Peruvian legislation prohibit its felling. However, recent studies have shown that both small and large-scale producers overexploit Brazil nuts (Peres et al. 2003) and that environmentally-destructive timber and agricultural activities often accompany Brazil nut harvesting in the Western Amazon (Escobal & Aldana 2003). Brazil nut trees are often left standing alone, scorched by fire, in pastures that have been completely cleared around them (Ortiz 2002).

Interdisciplinary Research Approach

My hypotheses are that Brazil nut production is most resilient to landscape-level change when: 1) local extractivists actively manage their Brazil nut stands to secure property rights, enhance yield and promote regeneration; 2) property rights are secure for Brazil nut collectors; 3) Brazil nut provides adequate income for Brazil nut collectors to prevent investment in alternative land uses; 4) deforestation and fire are minimal in protected

Brazil nut stands; and 5) seedling recruitment is sufficient to provide for the long-term population viability of this species.

An interdisciplinary research approach, including socioeconomic, spatial and ecological research methods, was used to measure the variables in this complex socio-ecological system (Fig 2).

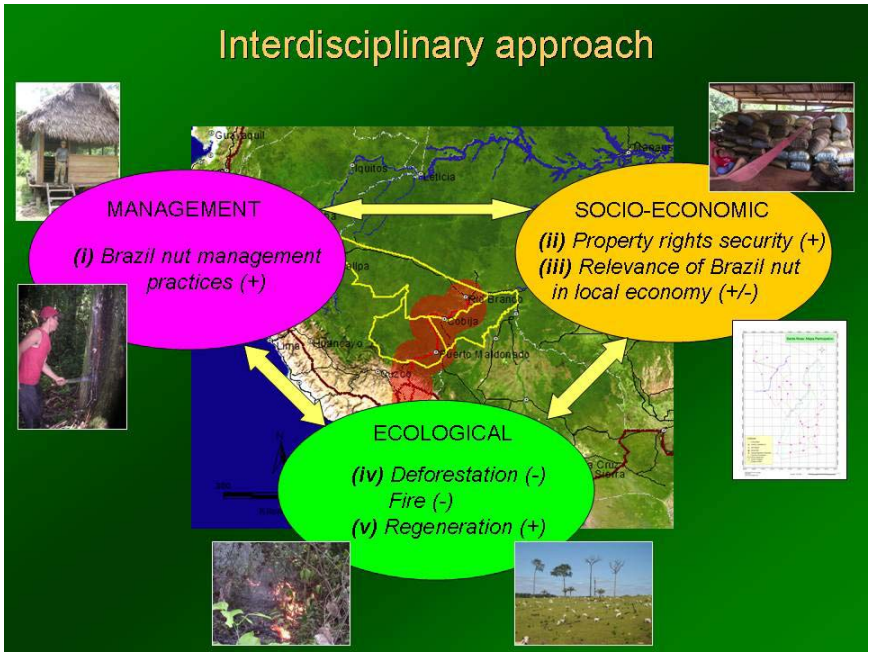

Fig. 2. Diagram of multi-disciplinary variables both positively and negatively affecting the resilience of Brazil nut production

(i) Local extractivists actively manage their Brazil nut stands to secure property rights, enhance yield and promote regeneration:

Management of Brazil nut by producers demonstrates the importance of the resource in the livelihood system. We evaluated Brazil nut collection and management practices in 22 communities in Bolivia (12), Brazil (5) and Peru (5) by conducting interviews with extractivists and accompanying Brazil nut harvests in 2006 and 2007. Management practices were categorized by those activities designed to secure resource rights (e.g. mapping Brazil nut stands), to enhance fruit yield (e.g. vine cutting) and to promote regeneration (e.g. clearing around seedlings). All practices were quantified by the degree (amount of time, spatial extent) to which they are performed at the individual tree and/or stand level. A lack of management in Brazil nut stands, along with intentional or unintentional management practices that have an adverse affect on the species, were also recorded, since this is pertinent to understanding the resilience of Brazil nut production over time.

(ii) Property rights are secure for Brazil nut producers:

Forest management decisions are strongly influenced by the security of forest property rights, and best long-term management practices often hinge on strengthening control over forest resources. In order to understand the differing land tenure systems for forest-

dwelling communities in Madre de Dios, Acre and Pando and quantify conflicts over natural resources, interviews were conducted with all households, association leaders and policy-makers in the three countries. Participatory maps were elaborated with select communities to visualize forest use systems and build capacity among community members (discussed further below).

(iii) Brazil nut provides adequate income for Brazil nut producers to prevent investment in alternative land uses:
Brazil nut must provide adequate income for producers in order to maintain its position in the livelihood system of extractivist communities, and not be abandoned for competing land uses, such as cattle ranching. Participation in the Center for International Forestry Research Poverty and Environment Network (CIFOR's PEN) as a research partner (http://www.cifor.cgiar.org/pen/_ref/home/index.htm) allowed for an in-depth comparison of the financial importance of Brazil nuts in rural household economies between Brazil and Bolivia. A total of 135 households in 8 communities in Bolivia, and 60 households in 4 communities in Brazil, from my larger sample of Brazil nut producing families in the MAP region, comprised this in depth socioeconomic analysis, which involved application of quarterly socioeconomic surveys developed by the PEN program at the household level. This data will be part of a global database and analysis on the role of tropical forests in poverty alleviation.

(iv) Deforestation and fire are minimal in protected Brazil nut stands:
The ecological resilience of Brazil nut trees can be adversely affected by deforestation and fire, both of which are common disturbances in the MAP region. Landsat and Aster images from 1985, 1991, 1996, 2001, 2006 were acquired and pre-processed in collaboration with the University of Florida's NSF Amazon Roads Project # 0527511. A total of approximately 420 field training samples for different land cover classes, namely mature forest, secondary re-growth, agriculture, pasture and built areas (i.e. village centers) were performed during the dry seasons of 2005-2007 that will be used to ground-truth satellite imagery through supervised classifications. Satellite image analysis will be used to evaluate forest change, including disturbance by fire, along roads and rivers in selected Brazil nut landholdings from 1986-2006 and correlate such change to socioeconomic and management variables.

(v) Seedling recruitment is sufficient to provide for long-term population viability:
Although fire is assumed to be a threat to Brazil nut-rich forests and population viability, the effects of fire on Brazil nut regeneration are still unknown. To measure the effect of fire on Brazil nut regeneration, 9-hectare plots were established in the Chico Mendes Reserve in Acre Brazil in two areas burned in the fires of 2005. Brazil nut seedling, sapling and adult tree densities were measured in the plots, as well as in two control plots of unburned forest from a previous study on Brazil nut regeneration (Cotta *et al.* 2006). 25x25m subplots, within each 9 ha plot, were established to sample for recruitment of seedlings (individuals < 1.5 m in height) and saplings (1.5 m in height ≤ individual < 10 cm dbh). Individuals were geo-referenced, using a Garmin XL GPS unit and information collected on basal area, light and water availability, and soil type. These results will be

compared with data from other *Bertholletia* regeneration studies (Wadt *et al. In Press*, Cotta 2007, Zuidema & Boot 2002).

Preliminary results: Natural resource conflicts in the Western Amazon and implications for Brazil nut management

Preliminary results of this comparative study show that the dominant role of Brazil nut in the Pando household economy, coupled with unclear property rights, creates an extremely high degree of conflict during the harvest season – primarily theft of nuts. Conversely, a secure land tenure system based on traditional "tree tenure" in Acre, along with more diverse livelihood options, have resulted in less conflict (Fig 3). In Pando, the actors involved in conflicts over Brazil nuts vary, but thousands of temporary workers during the harvest season who immigrate into large private forested landholdings, known as *barracas,* likely account for the vast majority (Fig 4).

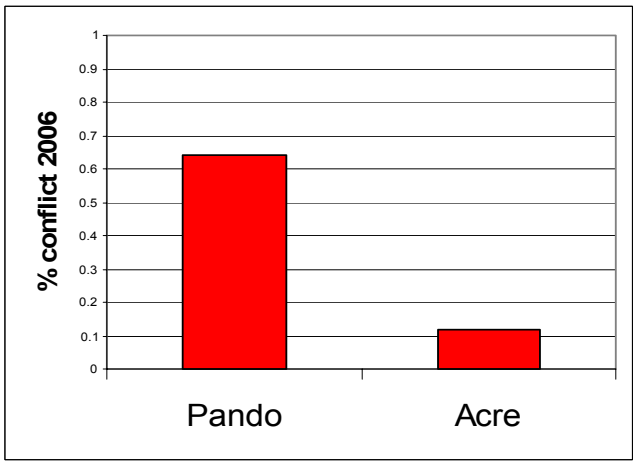

Fig. 3. Percentage of families experiencing theft of Brazil nuts during the harvest season (n=135 in Pando; n=60 in Acre)

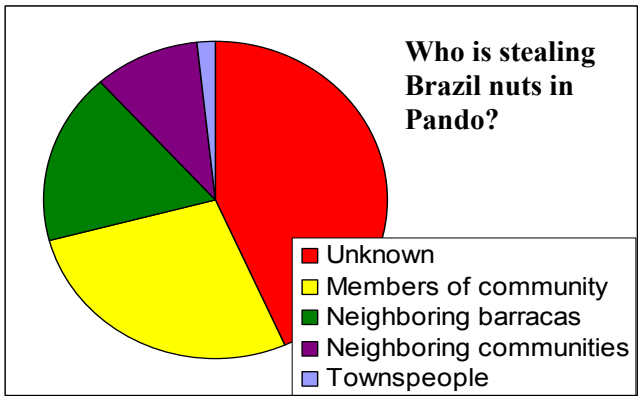

Fig. 4. Breakdown of sources of theft of Brazil nuts in communities in Pando, Bolivia.

Such conflict affects both the timing of Brazil nut collection, as well as management of the resource. In Pando, a lack of property rights security leaves little option for people in terms of management decisions. As soon as Brazil nuts hit the ground in early December in Pando, they are collected and carried out of the forest that same day for fear of theft. This is a dangerous practice for Bolivian collectors as the heavy fruits are still falling. Also, the method of collection is relatively inefficient in that individual trees must be revisited multiple times over the course of the season and the Bolivians must gather, break open and transport the nuts all at once to prevent theft. Conversely, the low incidence of conflict over Brazil nuts in Acre leads extractivists to enter the harvest later in the season (February) and collect the nuts all at once. They are also able to spend several days gathering all fruits in the forest, and another few days breaking them. Once all nuts are collected, the Brazilian extractivists transport them out of the forest using animals, which overall is an easier and more efficient practice.

In Pando, the Brazil nut harvest lasts much longer than in Brazil (until April, or occasionally July), because Brazil nut is such a central product for rural households in

northern Bolivian. Aside from the cultivation of rice, manioc, some fruit trees and a few chickens, there are very few other subsistence or commercial options available for forest-dwelling people. In contrast, forest extractivists in Acre engage in diverse production systems, from the seasonal extraction of Brazil nuts, açai palm fruit and subsidized rubber to the cultivation of agroforestry systems and investment in a diversity livestock. While traditional extractive activities are alive among forest-dwelling families in the Chico Mendes Extractive Reserve, they also now compete with cattle, a land use that the Reserve was designed to impede (Gomes 2002). There is clearly a trade-off between these two systems: While extending the Brazil nut harvest season for many months in Pando in order to collect all fallen fruits may not promote optimal Brazil nut regeneration, the clearing of Brazil nut-rich forest for pasture, as seen in the Acre context, may be even less sustainable for the future of Brazil nut production. The resilience of Brazil nut production in the Western Amazon depends on both secure property rights and a healthy balance of livelihood activities to allow for sustainable management of the resource.

Enhancing the resilience of Brazil nut production for the future

1) Mapping Brazil nut stands in Bolivia to secure property rights

Participatory mapping can be used as a tool for communities to deal with tenure conflict, visualize traditional forest use systems, and leverage integration of traditional practices into formal land titling processes and decision-making. A participatory mapping method developed by CIFOR was used on communally-held Brazil nut stands in this research to both envisage forest use systems and build mapping capacity among local residents. In each community, the method began with a workshop beginning with an explanation of "what is a map?" Discussions followed in which community members drew the most important features and land cover types in the community on a large official polygon of the communal landholding. Then, through a series of hands-on activities, participants were trained in the use of GPS units and compasses and understand the workings of an X-Y coordinate system. Over several days, significant map features were then geo-referenced in the field by community members themselves. The original maps drawn by the community were then compared to the geo-referenced map. The geo-referenced maps were remade in a GIS and given to community leaders as a base to pursue mapping of their individual Brazil nut trees with local supporting organizations. This mapping method was adopted by a local cooperative and other community outreach organizations and followed-up through mapping individual Brazil nut tress. In Pando, such maps are extremely important since official government polygons of communally-titled lands are often incongruent with traditional use areas, which is often the source of conflict between

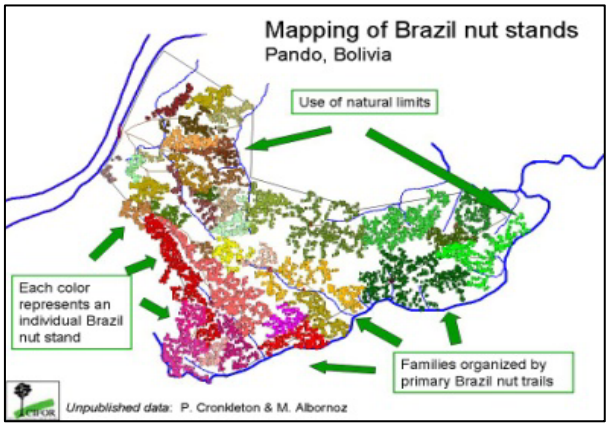

Fig. 5. Example of a participatory map of individual Brazil nut trees in Pando. Official polygon incongruent with traditional use areas

communities and their neighbors (Fig 5).

Additionally, mapping individual Brazil nuts trees in a participatory way can decrease conflicts between members of the same community as producers are better able to both visualize and negotiate their traditional property rights. Although the incidence of conflict over Brazil nuts generally decreased between 2006 and 2007 in communities studied in Pando, this decrease is greater in communities that mapped their Brazil nut stands prior to the 2007 harvest (Fig 6).

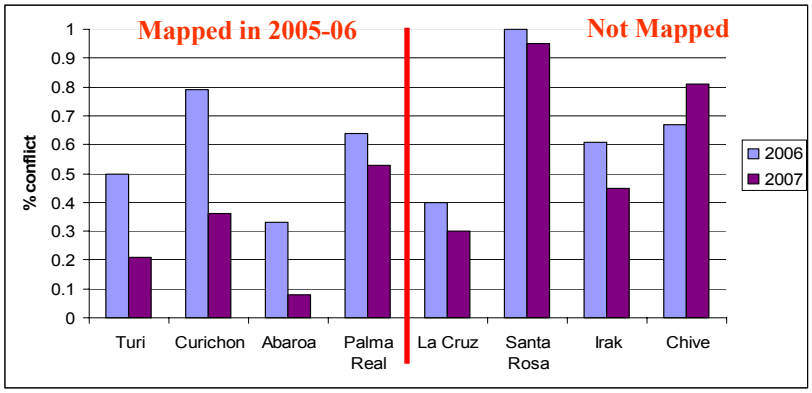

Fig. 6. Comparison of conflict over Brazil nuts between 2006 and 2007 in communities that mapped their Brazil nut stands and those that did not map their stands.

2) Promoting certification of Brazil nuts to enhance value and encourage management
Specialized markets play an important role in affecting the sustainability of Brazil nut in the MAP region. Certification of Brazil nuts has proven essential for maintaining the price of this NTFP. Cooperatives and non-governmental organizations in Bolivia, Peru and Brazil have tapped into certified markets for Brazil nuts in Europe, allowing producers to gain increased benefit for their product. Essentially, there are three types of certification for Brazil nuts: 1) Organic, which is a healthy (aflotoxin-free) product; 2) Fair Trade, signifying that producers are socially organized in a cooperative and benefits are distributed fairly among members; and 3) Forest Stewardship Council, which promotes ecological benefits, along with social and economic.

Cooperatives in all three countries have tapped into the organic and fair trade markets, although the greatest financial benefit to Brazil nut producers is seen in Pando. When Brazil nuts are transported out of the forest early in the season or just after fruits have fallen to the ground, such as in the Bolivian case, they are less likely to be infected by aflotoxins, a fungus which enters the nuts and damages them. However, in order to further decrease the incidence of infection by aflotoxins, there are a series of good management practices that must be put into effect, namely removing the inedible parts of the Brazil nut fruits upon collection, drying the nuts in an elevated storage area, and taking care to avoid contamination by petroleum products or livestock during any part of the collection or transport process.

In Pando, the Cooperativa de Trabajadores Agro-extractivistas de Pando (COINACAPA) has supported hundreds of Brazil nut producers in accessing organic and fair trade

markets in Europe. As the conventional price for Brazil nuts rose significantly in 2005, but dropped during the 2006 and 2007 harvest seasons, Bolivian collectors selling certified Brazil nuts were able to maintain a high and stable price for their product, which has increased steadily over the past three years. COINACAPA also supports collectors in building storage areas for drying their Brazil nuts and mapping their Brazil nut trees, along with providing health insurance and other financial benefits for their members.

In Acre, government price supports for Brazil nuts tripled the price between 2002 and 2003 (Kainer et al. 2003), and a cooperative in Xapuri was able to open a large, new processing plant to enhance local production of Brazil nuts through accessing organic and fair trade markets. Unfortunately, corruption in Acre, led to the closing of a separate cooperative in 2006, and many Brazil nut producers never receiving the promised return on their certified product.

Ecological certification of NTFPs is promoted as a way to enhance a forest product's commercial value, through its sustainable use and management and conservation of the forest in which it is embedded (Shanley et al. 2002). In Madre de Dios, one NGO has supported hundreds of Brazil nut producers in achieving certification of their product by the Forest Stewardship Council, through mapping their Brazil nut stands and encouraging best management practices. This type of certification promotes the health of the Brazil nuts, similar to organic certification, but also focuses on the sustainability of the forest, such as limiting hunting in Brazil nut stands. Although FSC-certified producers have been well-trained and supported in undertaking best management practices, they have not yet seen a financial benefit from the production of FSC-certified Brazil nut in Peru.

Dissemination of Preliminary Research Results

In May of 2006, I participated in the "Knowledge Train" whose objective was to return the results of scientific research in an innovative format to rural producers, policy-makers and academic communities in the tri-national MAP region (Mendoza et al. 2007). A group of 17 researchers from Brazil, Peru, Bolivia, and the United States traveled together over a two-week period, visiting eight municipalities in Brazil, Peru and Bolivia to present research results in evening and day-long meetings. More than 500 people participated in a total of ten meetings during the two-week period (Fig 7). Laminated posters of individuals' research results were left in each municipality. The "train" was received with enthusiasm by participants and was an inspiring experience for the researchers involved. This experience could be considered a paradigm shift in that it involved diverse groups of stakeholders in socializing scientific research results and could serve a model for similar regional initiatives in the future.

Fig. 7. Brazil nut producer expressing himself at a Knowledge Train meeting in Puerto Maldonado Peru. Photo credit: Stephen Perz

Preliminary research results were also presented to participating communities from March-July 2007. In final community meetings and workshops, large land cover maps were presented depicting each community in 1991 and 2006 to show land cover change in this 15-year period. This served as the basis of a discussion with each community about land transformation in the Western Amazon. Presentation of comparative PEN results between Brazil and Bolivia. Community members were divided into small groups and asked to comment on similarities and differences between the forest, agricultural and aquatic resources that were found to be used in Brazil and Bolivia in the PEN study. The presentations of each group's observations served as a base for a subsequent discussion in the community meeting. Workshops were also held with schoolchildren, in collaboration with school teachers, in which children broke into small groups to draw primary forest products in the following land cover categories: mature forest, secondary forest, agricultural areas and water. Their drawings were then compared to preliminary findings from the study. At final communities meetings, personalized certificates and photos were presented to each family as an additional way of thanking them for their participation in the research project. The certificates were signed by me and my primary field assistant and included logos of the University of Florida, Rainforest Alliance and CIFOR (Fig 8).

Fig. 8. Community members in Pando with certificates of participation

Acknowledgements

I am extremely grateful to the Rainforest Alliance Kleinhans Fellowship, William J. Fulbright Grant, Center for International Forestry Research (CIFOR) Poverty and Environment Network, and NSF-IGERT Working Forests in the Tropics Program that offered funding for this research. Faculty and graduate students at the University of Florida provided essential feedback in the development and implementation of these ideas. Fieldwork would not have been possible without the outstanding assistance of Gladys Guanacoma, Juceli Bezerra da Souza, Marciane de Araujo and Peter Groenendjik, among others. I also thank my institutional collaborators in the MAP region, namely Lúcia H.O.Wadt of Embrapa-Acre, Elsa Mendoza of IPAM Brazil, Peter Cronkleton and Marco Antonio Albornoz of CIFOR Bolivia, Juan Fernando Reyes and Sissy Bello of Herencia in Pando, and Luz Marina Velarde of the Asociación Para La Conservación de la Cuenca Amazónica in Madre de Dios. Angelica Almeyda and Eben Broadbent, of Stanford University, have been essential research partners. Most importantly, I am eternally grateful to the many Brazil nut producers who allowed me into their homes and into their lives while I resided in the Western Amazon.

Works Cited

Balée, W. 1989. The culture of Amazonian forests. In: Posey, D.A. and W. Balée (eds), Resource management in Amazonia: indigenous and folk strategies. The New York Botanical Garden, Bronx, NY, pp. 1-21.

Cotta, J. 2007. Shifting cultivation effects on Brazil nut (Bertholletia excelsa) regeneration. M.Sc. thesis. University of Florida

Escobal, J. and U. Aldana. 2003. Are nontimber forest products the antidote to rainforest degradation? Brazil nut extraction in Madre de Dios, Peru. *World Development* 31: 1873-1887.

Gomes, V. 2002. Dynamics of land use in an Amazonian extractive reserve: Case of Chico Mendes Extractive Reserve in Acre, Brazil. M.Sc. thesis. University of Florida.

Homma, A. K. O. 1992. The Dynamics of extraction in Amazonia: a historical perspective. In D.C. Nepstad and S. Schwartzman (eds.), Non-timber products from tropical forests: evaluation of a conservation and development strategy, pp. 23-33. New York: The New York Botanical Garden.

Mendoza, E., S. Perz, C. Aguilar, A. Chavéz, G. Cullman, A. Duchelle, J. Luzar, M. Marsik, G. Alarcón, H. Dueñas, I.F. Brown, J. Chávez, M. De los Ríos, V. Reis, C. Ehringhaus, J. Mayna, A. Muñante, and C. van Oosten. 2007. The 'Knowledge exchange train': a model for capacity building for participatory governance in the south-western Amazon. *Development in Practice*: 17(6) 791-799.

Mori, S.A. and G.T. Prance. 1990. Taxonomy, ecology, and economic botany of the Brazil nut (Bertholletia excelsa Humb.and Bonpl.: Lecythidaceae). *Advances in Economic Botany* 8: 130-150.

Ortiz, E. 2002. Brazil nut (Bertholletia excelsa). In: Shanley, P., A.R. Pierce, S.A. Laird and A. Guillen (eds.) Tapping the Green Market: Certification and Management of Non-Timber Forest Products. Earthscan.

Peres, C.A., Baider, C., *et al.* 2003. Demographic threats to the sustainability of Brazil nut exploitation. *Science* 302: 2112-2114.

Peres, C.A. and C. Baider. 1997. Seed dispersal, spatial distribution and population structure of Brazil nut trees (Bertholletia excelsa) in southeastern Amazonia. *Journal of Tropical Ecology* 13: 595-616.

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

Wadt. L.H.O., K.A. Kainer, C.L. Staudhammer, and R.O.P Serrano. *In Press*. Sustainable forest use in Brazilian extractive reserves: natural regeneration of Brazil nut in exploited populations. *Forest Ecology and Management.*

Zuidema, P.A. 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.

Zuidema, P. 2003. Ecology and Management of the Brazil Nut Tree (Bertholletia excelsa). PROMAB Scientific Series 6, Riberalta, Bolivia.