Natural resource conflicts in the Western Amazon: Implications for community forest management

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Abstract:

Forest management decisions are strongly influenced by security of forest property rights, and best long-term management practices often hinge on strengthening control over forest resources through participatory engagement with local actors. Brazil nut (*Bertholletia excelsa*) is the most important non-timber forest product (NTFP) in the tri-national region of Pando, Bolivia, Acre, Brazil and Madre de Dios, Peru. This species simultaneously promotes forest conservation and forms the livelihood base for rural communities. The current development of the Interoceanic highway, an extension of the recently paved Brazilian BR-317 into Bolivia and Peru, will change the nature of this formerly remote region by providing regional access to Pacific ports. Within this dynamic context, it is essential to understand how property rights security affects short and long-term Brazil nut management linked to forest conservation and economic futures of this region. We evaluated Brazil nut collection and management practices in twelve communities in Bolivia and Brazil by conducting interviews with 190 extractivists and accompanying Brazil nut harvests in 2006 and 2007. Results of this comparative study show that unclear property rights, coupled with the dominant role of Brazil nut in the Pando household economy, creates an extremely high degree of conflict during the harvest season. Such conflict affects both the timing of Brazil nut collection, as well as management of the resource. Conversely, a secure land tenure system in Acre based on customary "tree tenure," along with more diverse livelihood options, have resulted in less conflict. Participatory mapping may be an important 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.

Keywords: *NTFPs, community forest management, property rights security, natural resource conflicts, participatory mapping, extractive reserves*

INTRODUCTION

Property rights, community forest management and participatory mapping

Forest management decisions are strongly influenced by the security of forest property rights, and best long-term forest management practices often hinge on strengthening local control over forest resources. Property rights regimes can be conceptualized as bundles of rights that range from access, withdrawal, management, exclusion, and finally, to alienation (Schlager and Ostrom 1992). The holders of certain rights in the bundle can be considered along a spectrum: "authorized users" are those who can both access and withdraw a particular resource, but do not have management authority to decide when or how to operationalize these rights; however, "claimants" also hold the right of management, allowing them greater decision-making power in regards to the use of land and resources; "proprietors" can exclude others; and "full owners" will have all rights in the bundle, including alienation, which is the right to sell or lease other rights, such as exclusion, management or withdrawal (Schlager and Ostrom 1992). Since property rights over natural resources are a key determinant in how people interact with their environment, they must be well-defined, reflect the social goals of the resource base and be well-enforced to promote natural resource management and conservation (Hanna et al. 1996, Stroup 2003, Gibson et al. 2005).

Since local communities are an important stakeholder in managing approximately 25% of the world's tropical forests, a significant and growing figure (White and Martin 2002, Scherr, White and Kaimowitz 2004), it is essential to promote property rights security of forest-dwelling communities towards long-term forest management and conservation. This is justified by arguments that those who are highly dependent on a resource are more likely to place greater emphasis on ensuring its long-term management (Gibson 2001, Colfer 2005), and that the transfer of property rights away from local resource users and towards higher levels of governance generally eliminates local incentives for resource conservation as a means of deriving maximum long-term livelihood benefits (McKean 2000). Given that communities manage natural resources both as common-pool and private resources (Ostrom 2003) and that these customary rights are often governed by local institutions (Gibson et al. 2000), it is essential to help communities formalize customary property rights systems in order to empower them in forest management and conservation.

Participatory mapping is considered an important tool for empowering communities to better understand and negotiate customary property rights (Peluso 1995, Alcorn 2000, Chase Smith et al. 2003). This simple, flexible tool is often used by NGOs and research organizations to facilitate the spatial representation of real-world features by individuals or groups of people through maps drawn on paper or on the ground (Lynam et al. 2007). Formal recognition of customary rights through participatory mapping may help forest-dwelling communities: 1) clarify boundaries, which may operationalize the right of exclusion and decrease conflicts; and 2) improve planning, which may allow better access to government support (Cronkleton et al. 2007). However, the facilitation of the

mapping process and the context in which mapping occurs, may be more significant in either empowering or disempowering participants than the skills learned or maps generated (Anau et al. 2003, Chambers 2006). That said, working with forest-dwelling communities to better understand and articulate their property rights through participatory mapping may allow communities to further the sustainable management of their forests and forest resources.

Brazil nut as bridging forest conservation and livelihood development

Brazil nut (*Bertholletia excelsa*) is the most important non-timber forest product (NTFP) in the tri-national region of Madre de Dios, Peru, Acre, Brazil and Pando, Bolivia. This species simultaneously promotes forest conservation and forms the livelihood base for rural communities. Brazil nut is somewhat unique in this balance, since increased market demand for NTFPs often leads to trade-offs in biodiversity conservation (Belcher et al. 2005). Brazil nut seeds are collected almost exclusively from wild Amazonian populations; experimental plantations of Brazil nut have been largely ineffective, producing negligible fruit yields (Ortiz 2002). Optimal natural regeneration of the species depends on forests that support large-bodied bee pollinators and the scatter-hoarding agouti (*Dasyprocta spp.*), a rodent that serves as both the main seed disperser and predator (Mori and Prance 1990, Ortiz 2002, Zuidema 2003), highlighting this species' value in promoting the conservation of intact Amazonian forests. Brazil nut trees are dominant, long-lived canopy trees in the Amazon and are often found in 20-50 ha stands of 50-300 individuals per stand (Mori and Prance 1990). 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. There is high variability in fruit production between Brazil nut trees, although far less variability at the population level across harvest years. Variability in fruit production among trees can be explained by a number of ecological factors, namely diameter at breast height (dbh), crown attributes and soil and nutrient variability (Kainer et al. 2007). Better producing trees are found in the medium diameter range (100 cm ≤ dbh ≤ 150 cm), and higher fruit production is strongly correlated to larger crown areas, as well as to higher Cation Exchange Capacity (CEC) (Kainer et al. 2007).

Brazil nut has a relatively high economic value on local, national and international markets. In the Western Amazon, it is the cornerstone of the extractive economy, employing tens of thousands of families during the primary wet season collection from January through March (Bojanic 2001). Because of this, Brazilian, Bolivian, and Peruvian legislation prohibit its felling. Although one study suggests that persistent harvest over decades may result in insufficient juvenile recruitment to maintain the population (Peres et al. 2003), populations in the Western Amazon are generally observed to be viable over the medium-term under a range of harvest intensities (Zuidema and Boot 2002, Wadt et al. 2007). Still, Escobal and Aldana (2003) reported that environmentally-destructive timber and agricultural activities often accompany Brazil nut harvesting in the Western Amazon. Nonetheless, deforestation and fire are

possibly the most severe environmental threats to Brazil nut production as observed in visually striking scenes of Brazil nut trees left standing alone, scorched by fire, in pastures that have been completely cleared around them. Within this dynamic context, it is essential to understand how property rights security affects short and long-term Brazil nut management in order to envisage the future sustainability of this important NTFP.

Through comparing community-based Brazil nut management systems in Acre, Brazil and Pando, Bolivia, we first highlight important historical processes and policy changes that have shaped property rights security for forest-dwelling communities in the Western Amazon. We then present preliminary results of fieldwork that show the effects of both property rights security and livelihood system diversity on Brazil nut management in forest-dwelling communities, highlighting the ecological and economic trade-offs of such management systems. Finally, we explore participatory mapping of Brazil nut stands as a potential way to strengthen customary rights and promote sustainable forest management within this context. This comparative study is illustrative of broader issues related to the role of property rights security and livelihood system diversity in sustainable management of tropical forests by rural communities.

STUDY SITE

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 comparative opportunity for understanding how property rights security affects long-term management of forest resources, specifically Brazil nut rich forests in this region. In this approximately 220,000 km^2 region in southwestern Amazonia, traditional forest extractivist communities share the landscape with indigenous groups and more recently settled farmers, cattle ranchers and loggers. Although the entire MAP region is grossly characterized by lowland wet tropical forest habitat, settlement histories, patterns of deforestation, public policy and socio-economic development vary considerably from one country to the next. 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, concentrated and dominated by 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 occurring in close proximity to population centers and along the shared border with Brazil. Within the MAP region, we focus our comparison on Acre, Brazil and Pando, Bolivia. These two areas were chosen because of their particularly contrasting property rights systems and degree of dependence on Brazil nuts by

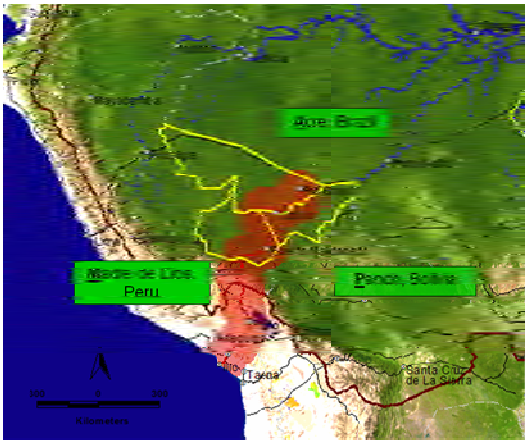


Fig. 1. MAP region and Interoceanic highway (red line). Map: A. Alencar, IPAM.

extractivist populations.

History of extraction and relevant forest policy in Acre, Brazil and Pando, Bolivia

History of forest extraction

The history of colonization and settlement of non-indigenous extractive populations in Acre, Brazil and Pando, Bolivia began in the late 19th century during the first price boom of natural rubber (*Hevea brasiliensis*) and has since been shaped by distinct changes in policy and market demands (Table 1). During the first rubber boom, there was heavy immigration to the Western Amazon, including Pando and what is now Acre (which at the time was officially Bolivian territory) (Barham and Coomes 1996). Settlement of the region exploded after the 1870s, when Bolivian entrepreneur Nicolas Suarez began his dominance of the Bolivian rubber industry. Although his headquarters was established at Cachuela Esperanza on the Beni River, he constantly traveled up the Madre de Dios River into Pando and present-day Acre where supply posts were established at portage points between key rivers (Fifer 1970). The war between Brazil and Bolivia, in which the Brazilian rubber tappers in Acre had a major role in Brazil's victory, finalized the boundaries between the two countries, and the territory of Acre was ceded to Brazil in 1903 (Fifer 1970). When the price of rubber fell in 1912, after establishment of rubber plantations in Malaysia, former rubber estates in Brazil and Bolivia began to diversify their production to include Brazil nuts and agriculture (Fifer 1970, Barham and Coomes 1996, Stoian 2000, Cronkleton et al. 2007, Cronkleton and Pacheco *forthcoming*). In 1931, the Suarez Company introduced Brazil nut shelling, a labor force that became dominated by women and girls, as the Chaco war drained male labor in Bolivia (Fifer 1970). During World War II, there was a second, smaller rubber boom in which the U.S. partnered with Brazil through the Washington Accords, and subsequently Brazilian "rubber soldiers" were recruited to Acre (Sobrinho 1992). Although Acre and Pando were legally separated, the border was porous, such that more than 2000 Brazilian rubber tappers were employed by *Suarez and Hermanos*, who at the time controlled 80% of rubber production in Brazil-Bolivia border region (Sobrinho 1992). Brazil nuts continued to be a complementary seasonal activity to rubber, although in the 1950's, nut exports surpassed rubber production, with the first "official boom" of the Brazil nut sector in the

Acre, Brazil	Pando, Bolivia
1876-1910: Rubber boom (immigration to region)	
1903: Acre ceded from Bolivia to Brazil	1870s: Nicolas Suarez founded *Suarez Hermanos* rubber company
1910-1940: Decline in rubber; land use diversification	
Former rubber estates diversified production (Brazil nuts and agriculture)	1931-35: Suarez Co. introduced Brazil nut shelling by labor force of women and girls
1940-1945: New demand for rubber	
1942: Brazil-U.S. Washington Accords to recruit Brazilian rubber soldiers to Amazon	*Suarez and Hermanos* controlled 80% of rubber production in Brazil-Bolivia border
1950-90s: Brazil nuts replace rubber as main forest product	
1990s: New policies for extractivist communities	
1990: Extractive Reserves	1996: Forestry Law and Agrarian Reform Law

1990's (Stoian 2000, Cronkleton and Pacheco *forthcoming*).

Rubber industry sets the stage for Brazil nut production in Western Amazon

Although there has been analysis on why the rubber industry did not promote more long-term economic development in the Amazon (Weinstein 1983, Barham and Coomes 1996), this industry was critical in setting the stage for current Brazil nut production both in terms of extractivist settlement patterns and forest product market chains. In Acre and Pando, communities were formed by families of rubber tappers or worker groups that continued to live in the forests even after the price of rubber dropped. In Acre, forest extractivists maintained their traditional isolated distribution throughout the forest, large abar

Table 1. Significant historical events and relevant forest policy change in Acre, Brazil and Pando Bolivia. These events affect property rights, diversity of forest products currently exploited, and ultimately, degree of natural resource conflicts.

communities in Pando became more nuclear with the use of forests more concentrated spatially and seasonally during the Brazil nut harvest (Cronkleton et al. 2007) (Fig 2).

Fig. 2. Google Earth images of forest dwelling communities in Acre, Brazil (left) and Pando, Bolivia (right). Note contrast between dispersed pattern of household settlement in Acre's Chico Mendes Extrative Reserve (households circled) and concentrated community settlement in Pando (community circled).

In both situations, customary rights to land were largely based on "tree tenure" (Fortmann 1985). In Acre, these continued to be defined by the occurrence of rubber trees and trails through the forest, whereas in Pando, they were increasingly defined by the distribution of Brazil nut trees (Ankerson and Barnes 2003, Cronkleton et al. 2007). Brazil nut market chains from the forest to middle men to processors to international markets paralleled those of the rubber trade. As cattle ranching moved into Acre in the 1970 and 80's and forest extractivists asserted their rights to land they had settled in both Acre and Pando, several important policy changes occurred at the national level: the establishment of Extractive Reserves in Brazil in 1990, and the Forestry Law and Agrarian Reform Law in Bolivia in 1996, which were designed to allow for land devolution to communities with nearly a full bundle of rights, aside from the sale of communally-held land. How these different policies were manifested in Acre and Pando have important consequences for extractive activities in the region today.

National policies designed to support extractivist communities

Extractive reserves have been championed as a viable and sustainable alternative to widespread deforestation in the Amazon (Fearnside 1989, Allegretti 1989, 1990, Rosendo and Brown 2000). The government of Brazil established the Extractive Reserve system in 1990 in response to a combination of the Brazilian rubber tappers' struggle for secure land tenure under the leadership of Chico Mendes in Acre, the fall of the national military dictatorship and international pressure for increased conservation and development initiatives in the Brazilian Amazon (Schwartzman 1989, Hall 1997). Acre's rubber tappers used the prevailing environmental discourse at the time to their advantage, highlighting themselves as optimal forest stewards (Schmink and Wood 1992). The Extractive Reserve model guaranteed land tenure to extractivist populations who engaged in traditional livelihood strategies based largely on the extraction of NTFPs (e.g. rubber, Brazil nuts, various fruits, and palms) (Ehringhaus 2006), while maintaining at least 90% of their landholdings in forest cover as dictated by reserve utilization plans (Fearnside 2003). NTFP extraction was thought to be less ecologically destructive than other land-use practices, such as clearing land for agriculture and pasture, or harvesting timber (Arnold and Perez 2001), embedding conservation goals within the Extractive Reserve model (Fearnside 2003). An important difference between Extractive Reserves and other Amazonian protected areas is that they were created "not *despite* but *because* of people" (Ehringhaus 2006). Critics of this NTFP-based model emerged, highlighting the overexploitation of selected NTFPs (Peters 1996), their lack of economic viability (Browder 1990,1992) and their intensification or replacement by synthetic substitutes (Homma 1992), which may eventually cause reserve inhabitants to turn to ecologically-destructive land use activities, such as deforestation for cattle ranching, commercial agriculture and logging (Gomes 2001, Cardoso 2002, Salisbury and Schmink 2007). However, not all NTFP extraction based systems operate at an economic loss, particularly in the case of Brazil nut. With recent dramatic increases in Brazil nut prices from approximately $2.04/kilo for shelled Brazil nuts sold in the United States in 2000 to $4.38/kilo in 2005 (Red River Foods 2008), this NTFP clearly has the potential to contribute to rural poverty alleviation, although its financial value may not necessarily be captured by the producers themselves, but instead by those higher up the value chain, as often the case when a forest product accrues value (Dove 1993).

In 1990, the Chico Mendes Extractive Reserve (CMER) was created in Acre as the second federal Extractive Reserve. Former rubber estates (known as *seringais*) were reoriented into associations comprised of extractivist households who have concessionary rights to the land. There are 42 *seringais* in the Chico Mendes Extractive Reserve, which encompass approximately one million ha of mostly forested land. Individual property holdings are defined by the number and distribution of rubber trails through the forest with one trail equaling approximately 100 ha of land (Ankerson and Barnes 2003). The average size of an individual holding in the CMER is 475 ha with large variation between households (Duchelle and Gomes, *unpublished data*). Households are spread throughout the forest, their locations based on traditional access to rubber trails. Through the creation of the RESEX, the unique "tree tenure" legacy

from the rubber age became formalized. When residents of the CMER are asked how much land they have, they refer to the number of rubber trails since this is what defines the extent of their properties, even though Brazil nut has replaced rubber as the most important forest product in the CMER (Wallace 2004, Ehringhaus 2006). Notably, while land in the CMER is *de jure* communal, land and resources are customarily managed in a private way by individual extractivist families.

In Bolivia, the Forestry Law and the Agrarian Reform Law, which were both passed in 1996, have had their greatest impact on forest-dwelling communities in Pando within the last few years. Although the Forestry Law focused on timber production, it had several important implications for community forest management of NTFPs, as well as timber. Large landholdings of former timber companies were discouraged through the creation of a patent fee based on area, thus making more forested land available to communities (Cronkleton and Pacheco *forthcoming*). Access to forests was democratized by recognizing indigenous subsistence rights and creating several avenues through which communities could participate in commercial forestry, which previously had been prohibited (Ruiz 2005). A modification of the Agrarian Reform Law in the Northern Amazon resulted in forest-dwelling communities being given *de facto* rights to a minimum of 500 ha per family, which continues to be implemented within larger communal titles (Ruiz 2004, Cronkleton and Pacheco *forthcoming*). However, in many cases, communal titles implemented by the Bolivian agrarian reform agency (*hereafter* INRA) are incongruent with the traditional boundaries of communities' forest use. Unlike the owners of the rubber estates in Brazil, large landowners in Pando actively tried to maintain their privileged position (Cronkleton and Pacheco *forthcoming*, Cronkleton et al. 2007). Throughout the 1990s and early 2000s there was a contested struggle between these large landholders and peasant and indigenous communities to control forest resources (Cronkleton et al. 2007). As the price of Brazil nut began to rise significantly in 2003-04, invasions by migrant workers onto communally held lands led to severe conflicts over Brazil nuts, which in a few cases turned violent when the price of Brazil nut increased dramatically in 2005 (El Deber 2005). In response to property rights insecurity and conflict in Pando, community-initiated measures emerged to more clearly define property rights, including organized protests to INRA and inventories and mapping of Brazil nut stands (Cronkleton et al. 2007).

There is also a very large protected area in Pando, the Manuripi National Wildlife Reserve, whose land is managed both communally and privately. The Manuripi Reserve encompasses 1.8 million ha of mostly forested land and was officially created in 1973 for biodiversity conservation, although it was not officially managed as a national protected area until 1999 (Miserendino et al. 2003, Kühne 2004). Unlike in the CMER, the majority of land in the Manuripi Reserve is held in large, private concessions (*barracas*) with eight communities managing land along main roads. Only one community in the Manuripi Reserve lacks road access as it is located the middle of the reserve along the Madre de Dios River. Similar to communities that live outside of the Manuripi Reserve, forest-dwelling families within the reserve live clustered together and only during the Brazil nut harvest season do they relocate to their Brazil nut areas to make collection more efficient. Although cattle ranching among communities is still rare

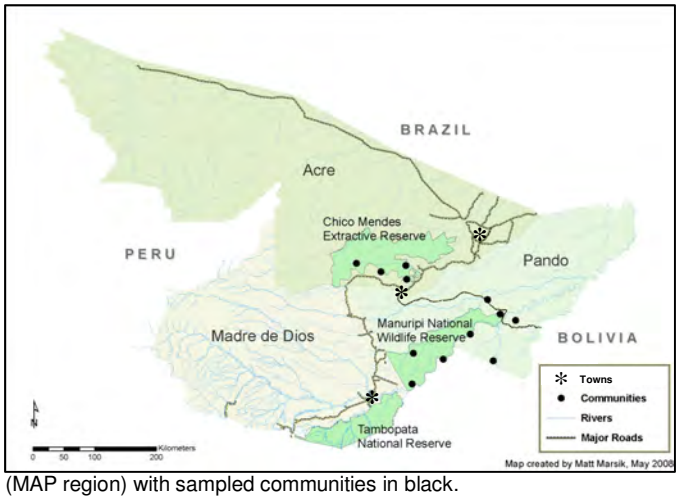
in Pando and found mostly closer to the urban center of Cobija, both large-scale cattle ranching and illegal logging are considered major problems within the reserve's *barracas* (Kühne 2004). Communities within the Manuripi Reserve have also experienced conflicts over Brazil nuts, but have generally received more external support in understanding and defining their land use rights due to their unique location within a national protected area (Carlo et al. 2000, Herencia 2000).

Participatory mapping to promote property rights security in Pando, Bolivia

Participatory mapping of Brazil nut stands by communities, with support of regional research organizations or NGOs, has been a recent focus for securing property rights and promoting forest management in forest-dwelling communities in Pando both within and outside of the Manuripi Reserve. The main goal of these efforts is to formalize customary property rights through mapping individual Brazil nut trees; however, there are two distinct methods that have been used by different organizations. The first takes a team-based approach, where community members lead an adaptation of the "direct connection" mapping method used in timber inventories with a technical support person simply accompanying and correcting the process (Ríos 2001, Cronkleton et al. 2007). The second method pairs an individual landholder with a technical support person who marks the location of individual trees using a GPS unit based on the knowledge of the landholder. The advantages of the first approach are that community members work together to determine agreed upon customary rights to trees, which allows conflict mediation over internal resource disputes to begin during the mapping process itself (Cronkleton et al. 2007). The disadvantage is that the error of actual geo-referenced tree location is cumulative, which actually may have minimal importance for communities negotiating their property rights in this context. In the second approach, the actual position of individual trees may be more spatially exact through the use of a GPS (error ± 20 m). However, more technical support is needed to accompany all landholders one-on-one, there is no communication between community members in the field, and the method does not capture the spatial location of Brazil nut trails, an important component of customary Brazil nut tree tenure. While both mapping methods have the basic outcome of helping formalize customary tree tenure – individual Brazil nut trees are numbered and their proprietor made explicit; maps are returned to communities to allow them to visualize and negotiate customary tree tenure – the difference in mapping process may have very important implications for communities to engage in conflict mediation towards securing property rights.

FIELD METHODS

We evaluated Brazil nut collection and management practices in twelve communities in Pando, Bolivia (8) and Acre, Brazil (4) by conducting structured interviews with 190 extractivists and accompanying seasonal Brazil nut harvests in both 2006 and 2007. In Pando, communities were chosen to represent variation in market access (river vs.



(MAP region) with sampled communities in black.

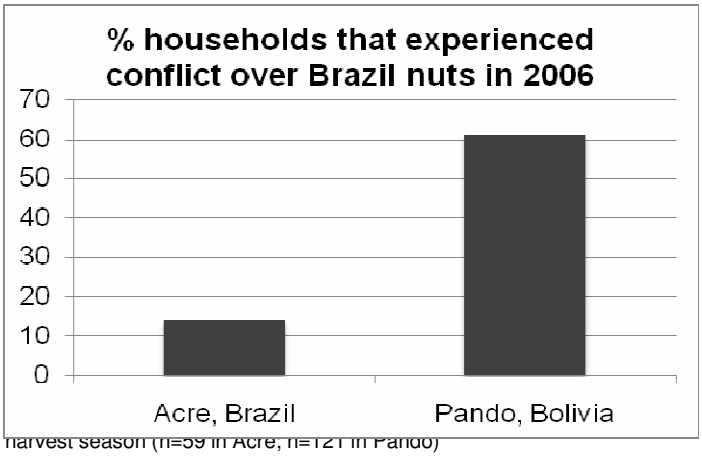
road) both within and outside of the Manuripi National Wildlife Reserve. In Acre, all four communities are located in the Chico Mendes Extractive Reserve, representing differences in river versus road access and variation in distance to major market centers (Fig 3). In smaller communities (<30 families), all available families participated in the study; in larger communities (>30 families), participating families were chosen randomly from a current list of total families in each community to represent the population. Harvest and management practices were categorized by: 1) initial harvest date, 2) harvest method and overall length, and 3) management practices designed to (a) secure property rights (e.g. mapping of Brazil nut stands), (b) enhance fruit yield (e.g. vine cutting) and (c) promote regeneration (e.g. clearing around seedlings). A lack of management in Brazil nut stands, along with intentional or unintentional management practices that have an adverse effect on the species, were also recorded since this is pertinent to understanding the sustainability of Brazil nut production over time. Conflict over Brazil nuts was defined as theft of nuts, and detailed conflict data collected during the 2006 and 2007 harvests, focusing on who, where, and how many nuts were stolen, along with what, if anything, was done to resolve the conflict. Additionally, community members' perceptions of the effects of mapping Brazil nut stands were evaluated in the three communities that had mapped their Brazil nut trees prior to the 2007 harvest in different ways; one community engaged in the team "direct connection" approach, a second in the individual GPS approach, and a third in a hybrid of the two, where the team direct connection" method was used, but with heavy dominance by outside technicians.

Finally, quarterly economic interviews from June 2006 through August 2007, in collaboration with the Center for International Forestry Poverty and Environment Network (CIFOR PEN) (http://www.cifor.cgiar.org/pen/_ref/home/index.htm), were carried out with the 190 families to understand the general role of Brazil nut in subsistence and market-based livelihood strategies in these communities and, more specifically, to quantify the relative income derived from Brazil nut when compared to other land use activities.

PRELIMINARY RESULTS AND DISCUSSION

Comparison of property rights security and livelihood system diversity

Preliminary results of this comparative study show that unclear property rights, coupled with the dominant role of Brazil nut in the Pando household economy, create an extremely high degree of conflict during the harvest season – primarily theft of nuts.



harvest season (n=59 in Acre; n=121 in Pando)

Conversely, a secure land tenure system in Acre that continues to be based on customary "tree tenure," along with more diverse livelihood options, has resulted in less conflict (Fig 4). Residents of the Chico Mendes Extractive Reserve have had nearly twenty years to adjust to

the rights in the Reserve and have had some support of the Brazilian environmental protection agency, along with that of various NGOs and research organizations, in securing these rights. In contrast, communities in Pando have only recently emerged from the struggle with *barraca* owners to have their customary property rights recognized. Although INRA helps define community boundaries, there is no agency in Bolivia that helps enforce them. Additionally, the geo-referenced polygons that are presented by INRA are generally useless for community residents, since these maps lack any of the features with which they are most familiar, causing problems with the polygons to go unnoticed by residents and resulting greater property rights insecurity over the long term (Cronkleton et al. 2007). Although many communities in the Manuripi Reserve have received more attention and support from the Bolivian National Park Service and conservation NGOs, when compared with communities outside the Reserve, in the 2006 harvest, the incidence of conflict was actually greater among households sampled within the Reserve (67% experienced conflict, n=60) when compared with outside of the Reserve (56% experienced conflict, n=61). This illustrates that the national protected area status in Pando has done little to secure property rights for those forest dwellers who reside within its boundaries.

The dominant role of Brazil nut in the household economy in Pando, when compared with households sampled in Acre, clearly contributes to conflicts during the harvest season. In Pando, Brazil nut collection is the principal land use activity for communities. 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 seasonal extraction and sale of Brazil nuts, açai palm fruit (*Euterpe precatoria*) and subsidized rubber to the cultivation of agroforestry systems and investment in a diversity of livestock, including raising cattle for milk and use as an economic safety net (Wallace 2004). Because of greater livelihood diversity in Acre, the collection and sale of Brazil nuts is relatively less important and considered just one of many seasonal activities. Indeed, Brazil nut collection at two sites in the CMER in Acre was estimated at 45% and 71% (Wadt et al. 2007), which is much lower than an estimate of 93% of fallen fruits being harvested at sites in northern Bolivia (Zuidema and Boot 2002). Although in general a higher proportion forest dwellers' total income comes from forest products, an important reason to maintain diversified livelihood systems is to minimize risk (Vedeld et al. 2004, Sunderlin et al 2005).

Type and degree of conflict over Brazil nuts in Pando

In Pando, the actors involved in conflicts over Brazil nuts vary, but in our sample, members of the same community accounted for the majority, followed by temporary workers who immigrate to *barracas* during the harvest season and then neighbouring community members (Fig 5). Although communities theoretically hold the property right of exclusion, they lack the ability to enforce this right, since in many cases these rights are not considered legitimate by others. Since traditional use areas of communities may not coincide with new official INRA polygon boundaries, areas that lie outside of the community polygon, but have been used by community members for many years,

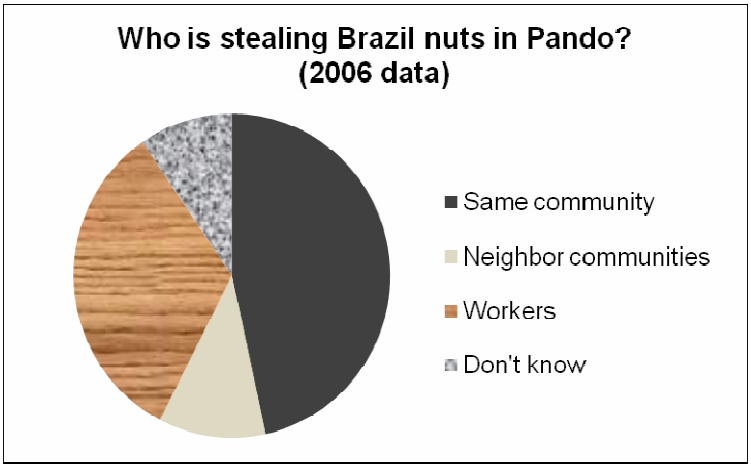


Fig 5. Breakdown of sources of theft of Brazil nuts in communities in Pando

are particular "hot spots" of conflict between communities and *barraca* workers. Also, conflicts among members of the same community occur as the 500-ha decree is introduced in communities that have managed their Brazil nut groves communally for many years as defined by internal norms and rules. Conflicts are also rampant in communities that have only recently had land rights devolved from a large landholder where there is less definition among residents over rights to Brazil nut trees. The 500 ha measure created the expectation in some communities that INRA would rearrange internal resource access so that everyone could have a 500 ha plot, undercutting the traditional tree tenure system. In the 2006 harvest, the majority of Brazil nuts were stolen from the forest floor (84%), as opposed to in sacks or storage areas, emphasizing that most conflict is less outright theft as opposed to genuine or purposeful confusion over customary land tenure. However, the theft of Brazil nuts in 2006 was not insignificant, with a mean (and standard deviation) of 63 *cajas* (±74), among the 53 Bolivian producers who estimated their losses. A *caja* equals approximately 23 kilos of nuts, and the loss of 3-6 *cajas* is equivalent to the loss of a day's labor. In 2006, the loss of one *caja* had a value of USD$11-12, a huge amount of money, especially for those forest extractivists at the upper end of the range who had 200-300 *cajas* stolen from their forested landholdings.

Conflict affects Brazil nut management

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 harvest and management decisions. As soon as Brazil nuts hit the ground in December, they are collected and carried out of the forest that same day for fear of theft. This is a dangerous and sometimes fatal practice for Bolivian collectors as the heavy fruits are still falling from trees up to 50m in height. Also, the method of collection is relatively inefficient in that individual trees must be revisited multiple times over the course of the season. Furthermore, Bolivian collectors must gather, break open and transport the nuts all at once to prevent theft. Conversely, the low incidence of conflict over Brazil nuts in the Chico Mendes Extractive Reserve in Acre allows extractivists to enter the harvest area later in the season (February) and collect all nuts within a few weeks. They are able to spend several days gathering all fruits in the forest and another few days breaking them open. Once all nuts are collected, the Brazilian extractivists transport them all at once out of the forest using draft animals, which overall is an easier and more efficient practice. In Pando, the Brazil nut harvest season

not only begins earlier, but also lasts much longer (often until April, with an extension of the harvest until June or July). The harvest is extended in Pando, because as mentioned earlier, Brazil nut is the sole commercial product for most forest-dwelling communities. Also, the price for nuts collected during the extension of the harvest is generally higher than the regular harvest as middle men and companies attempt to fill their yearly demand. Although speculative, the Brazilian harvest method may allow a longer period for the scatterhoarding agouti to both consume and disperse Brazil nut seeds. In turn, this effect on recruitment could influence long-term sustainability of the overall Brazil nut harvest system. In Pando, the insecurity of property rights and dependence on Brazil nuts clearly leave little option for people in terms of harvest and management decisions.

Ecological and economic trade-offs of differing harvest systems

Ecological and economic trade-offs exist between the Brazil nut harvest and management systems in Acre and Pando. While extending the Brazil nut harvest season for many months in Pando to collect all fallen fruits may not promote optimal Brazil nut regeneration over the long term, the clearing of Brazil nut-rich forest for pasture, as seen in Acre, may be even less sustainable for the future of Brazil nut production. Also, one of the main impediments to the sale of Brazil nuts on international markets is contamination by aflatoxins, caused by the fungus *Aspergillus* under hot and humid conditions, making them unhealthy for consumption, since aflatoxins are both a toxic and carcinogen (Hudler 1998). When European importers raised their quality standards for Brazil nuts in 1998, the potential to close European Brazil nuts markets became a concern (Newing and Harrop 2000). 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 contaminated by aflatoxins. In Acre, fruits that fall in December and are not be collected until February or March, appear to have higher risk of infection by *Aspergillus*. However, to further decrease the incidence of contamination by aflatoxins, a series of good management practices should be put into effect, namely removing the inedible parts of the Brazil nut fruits upon collection, and drying nuts in an elevated storage shed. The drying process is thought to the most important step in controlling aflatoxin contamination (Wadt et al. 2005). Additionally, producers are encouraged to avoid contamination by petroleum products or livestock during any part of the collection or transport process. Organic and Fair Trade certification of Brazil nuts, through the sale of a healthy (aflatoxin-free) product and affiliation with cooperatives, have proven to be an important way to stabilize and even increase the price producers receive for Brazil nuts and the implementation of better management practices throughout the MAP region (Duchelle *unpublished data*). As further research explores the effects of collection on Brazil nut regeneration and contamination by aflatoxins, property rights security is essential for extractivists to apply best management practices to ensure greater sustainability of Brazil nut production.

Community perceptions of participatory mapping process in Pando

In Pando, participatory mapping of Brazil nut stands has been viewed as an important tool for addressing conflicts over Brazil nuts and promoting long-term management of the species. Communities are better able to visualize "hot spots" of conflict and negotiate property rights, and the mapping process can serve as a communication tool since proprietors of individual trees and trails are clearly identified (Fig 6).

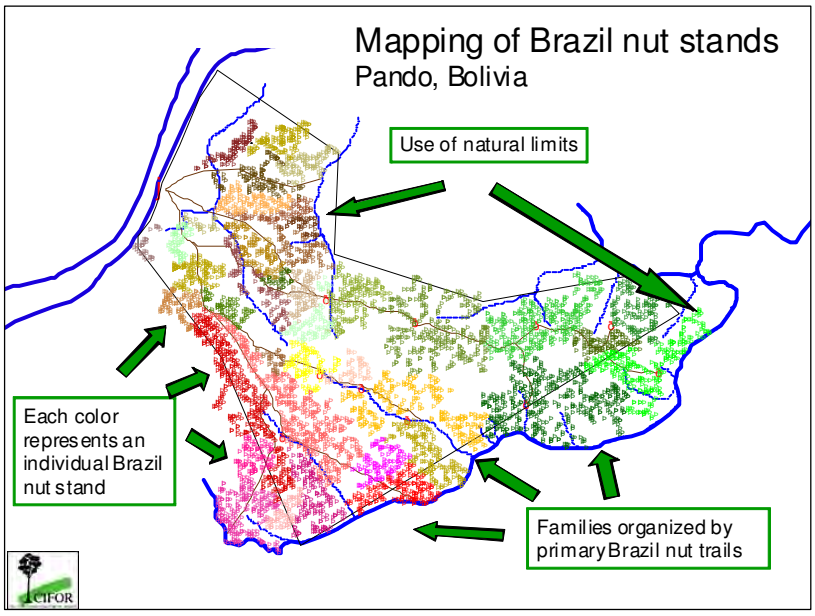


Fig 6. Example of a participatory map of individual Brazil nut trees in Pando. Note that official polygon incongruent with traditional use areas; conflicts occurred predominantly in these areas. *Courtesy of Cronkleton et al. 2008.*

In an analysis of community perceptions of the mapping process in three communities that had mapped their Brazil nut trees in 2005 and 2006, reduction of conflict was the primary reason given for engaging in a mapping process. In reality, the incidence of conflict over Brazil nuts decreased between 2006 and 2007 in nearly all communities sampled in Pando and statistically significant decreases were not necessarily seen in communities that had mapped their individual trees prior to 2007 (Table 2). That said, the goal of the mapping Brazil nut stands with communities was not necessarily to reduce conflict, but rather empower people to be able to better deal with conflict. The majority of those interviewed perceived mapping Brazil nut trees as somewhat to highly beneficial (76%, n=45). In addition to perceived conflict reduction, increased property rights security, and new knowledge of their Brazil nut stands (i.e. number of trees), producers cited that mapping provided a chance to learn new skills and help make the Brazil nut collection more efficient, since trails and trees were more clearly identified. Additionally, several producers noted that mapping was the first step needed in a management plan for Brazil nuts.

Twenty percent of those interviewed felt that mapping had no effect on securing property rights or reducing conflict. Although there were only a few producers who thought their mapping experience was negative (4%), several common negative

perceptions emerged, even among those who generally categorized the process as beneficial or neutral. These included the fact that newly cleaned and more visible trails made it easier for hired collectors, generally from outside the community, to enter into Brazil nut stands to steal nuts, actually increasing the incidence of theft as opposed to decreasing it. There was also criticism of the use of nails to secure numerical identification markers into trees. A natural decrease in Brazil nut production region-wide occurred in the harvest season of 2006 and became even more pronounced in 2007. Many community members felt that nailing of the identification marker prior to 2006 was to blame for this low fruit production and even the "drying up" and death of some Brazil nut trees. Since natural production rose to extremely high levels in the harvest of 2008 (Wadt, pers. comm.), this conception may likely have been subsequently debunked among those producers. Finally, producers who had customary rights to more trees and land felt that making relative wealth transparent throughout the community posed a greater risk of losing a portion of their holdings to those with fewer trees to make property rights more equitable throughout the community.

	% HH with conflict 2006	% HH with conflict 2007
Mapped (2005/2006)		
Community O-1 (n = 14)	21.4%	21.4%
Community O-2 (n = 17)	64.7%	52.9%
Community R-1* (n = 20)	70.0%	31.2%
Unmapped		
Community O-3 (n = 17)	88.2%	81.2%
Community R-2* (n = 10)	90.0%	44.4%
Community R-3 (n = 19)	57.9%	68.4%
Community R-4 (n = 12)	50.0%	33.3%
Community O-4* (n = 13)	38.5%	.0%

Table 2. Percent of households in 8 sampled communities that experience conflict during the 2006 and 2007 Brazil nut harvests; O = Outside Reserve; R = Inside Reserve.
* Statistically significant at .05 or lower

CONCLUSION

As Brazil nuts are increasingly managed more privately in communally-held forests, ensuring that producers have a nearly full bundle of property rights will allow them to respond to best management practices to ensure Brazil nut sustainability. Additionally, a diversification of livelihood activities must be encouraged in Pando if forest conservation is to be balanced with rural development. A full dependence on Brazil nuts not only puts immense pressure on the resource itself, but leaves forest-dwelling communities extremely vulnerable to fluctuations in Brazil nut prices. 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. However, its success in promoting property rights security will likely depend on how the process is facilitated and on the specific context in which mapping is performed. Producers' perceptions of distinct mapping experiences should be taken into account as mapping initiatives are expanded to communities throughout the region. This comparative study of Brazil nut management in the Western Amazon illustrates the importance of combining secure

property rights with a healthy balance of livelihood activities in promoting long-term forest management and conservation by communities.

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