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Social Geomatics: Participatory Forest Mapping to Mediate Resource Conflict in the Bolivian Amazon

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Abstract This paper describes a participatory mapping method field tested with agro-extractive settlements in the Bolivian Amazon. A regional transition from customary to formal property rights resulting from sweeping 1996 land tenure reforms has led to confusion and conflicts over resource rights, a problem compounded by recent high market prices for Brazil nuts. In response to community requests to clarify resource rights to Brazil nut trees, CIFOR offered to train community members to map trees, trails and other key features themselves. This experience indicates that local residents can map their resources in an effective and efficient way and in the process gather necessary information to mediate competing claims, demonstrate their legitimate resource claims to external stakeholders and make management decisions. We argue that maps and properties are more likely to be seen as legitimate reflections of de facto rights if local stakeholders are involved as a group from the outset.

Keywords Participatory mapping · Brazil nuts · Bolivia · Community forestry · Resource tenure

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Introduction

A fundamental precondition for assuring the viability of community forestry management is secure property rights, especially clearly defined access rights to forest resources. Similarly, strengthening property rights of forest peoples is a key step in addressing rural poverty, promoting human well-being and even addressing global concerns such as climate change (Clay and Clement 1993; Chomitz 2007; Sunderlin *et al*. 2008). The issue of how to secure property rights has gained growing prominence in forest policy debates (Forest Trends 2003; Roldán Ortega 2004; Fitzpatrick 2005; Stocks 2005; Sikor and Nguyen 2007). However, more effort is needed to test tools and approaches in the field to develop practical steps for supporting the property rights demands of community level forest stakeholders and involving them in the process. This paper discusses a participatory mapping methodology that was developed to document customary forest property rights in an agro-extractive community in the Bolivian Amazon and to mediate conflict driven by intensified competition to gain access rights to Brazil nut (*Bertholletia excelsa*) trees on community land. The results of this fieldwork, while focused on a regionally specific topic, provide general lessons that could guide efforts to strengthen agrarian and forest rights by more actively involving forest dependent people in the process.

With the recognition that significant portions of the world's tropical forests are occupied and used by rural peoples who depend on them for their livelihoods, national governments are increasingly formalizing the rights of these forest stakeholders (White and Martin 2002; Molnar *et al*. 2004; Sunderlin *et al*. 2008). The granting of formal titles to the forestlands controlled by community level actors is a positive step, but all too often, such legal processes in and of themselves are insufficient to truly strengthen and stabilize local control over forest resources (Stocks 2005; Sikor and Nguyen 2007; Larson *et al*. 2008). Frequently, when governments opt for various types of communal tenure systems, emphasis is placed on defining the outer boundary of a polygon, which creates a "tenurial shell" without addressing the internal dynamics of owners within the shell (Alcorn and Toledo 1998; Ankersen and Barnes 2004). Such approaches assume that internal norms, rules or boundaries already exist or will be developed spontaneously by the landowners and disregard the potential impacts of change on customary systems that occurs parallel to formal tenure reforms. Typically, there are major incongruities between the formal de jure rights granted and the complex pre-existing mosaic of de facto rights, patterns of use and indigenous perceptions of local forest users (Meinzen-Dick and Mwangi 2008). The imposition of formal rights over customary systems can strain existing resource governance systems creating, as Fitzpatrick (2006) noted, a "worst-case scenario: the partial disintegration of a viable resource governance mechanism without the provision of effective substitutes by the State," leading to degradation normally associated with open access regimes. In such situations, stakeholders losing out may decide that they are better off extracting what they can while they can, rather than continuing to cooperate with collective norms.

In order to avoid the collapse of customary systems and maintain functioning norms and practices in the face of increased resource competition driven by the expansion of agrarian frontiers and land reform, communities need to generate more detailed information about their traditional tenure rights and develop the necessary skills to adapt these regimes to changing conditions (Ankersen and Barnes 2004). The livelihoods of forest dependent people often reflect decades if not generations of acquired experience through resource use. Property rights frame customary practices adapted to local conditions and address such topics as resource access rights, rules for use and the operation of commercial networks and linkages with markets. They reflect the abundance and distribution of natural resources and respond to local subsistence needs, market demands, demographic pressure and available technology. These systems are complex, heterogeneous due to local adaptation, and are not readily apparent to outsiders. Although not perfect, they provide the de facto frameworks that allow families to manage their resources to meet subsistence and income needs, to coordinate activities with neighbors, and to maintain the forest. They should be understood and used as a point of departure for attempts to support local people.

While customary forest property rights systems are relatively resilient, the forest communities that hold them are increasingly subjected to rapidly changing conditions driven by forces outside their control. Efforts to support forest communities need to actively involve community level stakeholders to improve their capacity to respond and adapt. This is especially true as customary systems underlying forest livelihoods are difficult for outsiders to perceive and understand without local knowledge and guidance. Residents of communal properties have a vested interest in strengthening their resource management systems and can generate detailed information about customary tenure because they understand the existing rules, rights and practices; and they know what aspects are ill-defined or contested. However, they often lack the tools or methods they need for doing so and policy makers usually have limited interest in their input (Eghenter 2000; Forest Trends 2003).

Participatory mapping is a diverse field encompassing a wide variety of facilitation approaches and cartographic methods that involve local people, empowering them to generate maps that graphically reflect their perceptions of the landscapes where they live. Participatory mapping has emerged out of a broader interest in participatory methods (Chambers 2006) and has proven particularly useful in assisting indigenous and other rural forest dependent people to illustrate and defend their traditional rights to land and natural resources (Peluso 1995; Chapin and Threlkeld 2001; Fox 2002; Herlihy and Knapp 2003; Warren 2005). Although participatory methods for mapping natural resources and customary property rights systems have existed for years, the challenge is how to document these systems accurately, efficiently and at a low cost.

This paper examines a collaborative project between the Center for International Forestry Research (CIFOR), a municipal government in the Bolivian Amazon and residents of an agro-extractive community that developed and implemented an approach for mapping a customary property rights system defining access to Brazil nut trees as a point of departure for mediating resource conflicts. It responded to local concerns that unfamiliar communal land rights granted by the State, coupled with sudden increases in Brazil nut prices, the basis of the region's forest economy, were undercutting customary practices used by the community to allocate resources, and as a result were generating conflicts among neighbors.

Brazil Nut Extraction in Communal Forest Property in Pando

The research described in this paper took place in Bolivia's northern Amazon in the department of Pando (Fig. 1). The landscape in Pando is dominated by lowland tropical forests and up until 1990 only 2.6% of the region had been deforested (Llanque 2006), although rates have increased over the last decade and a half. Pando's population is small: only 52,525 people in the last census (INE 2001) with 60%

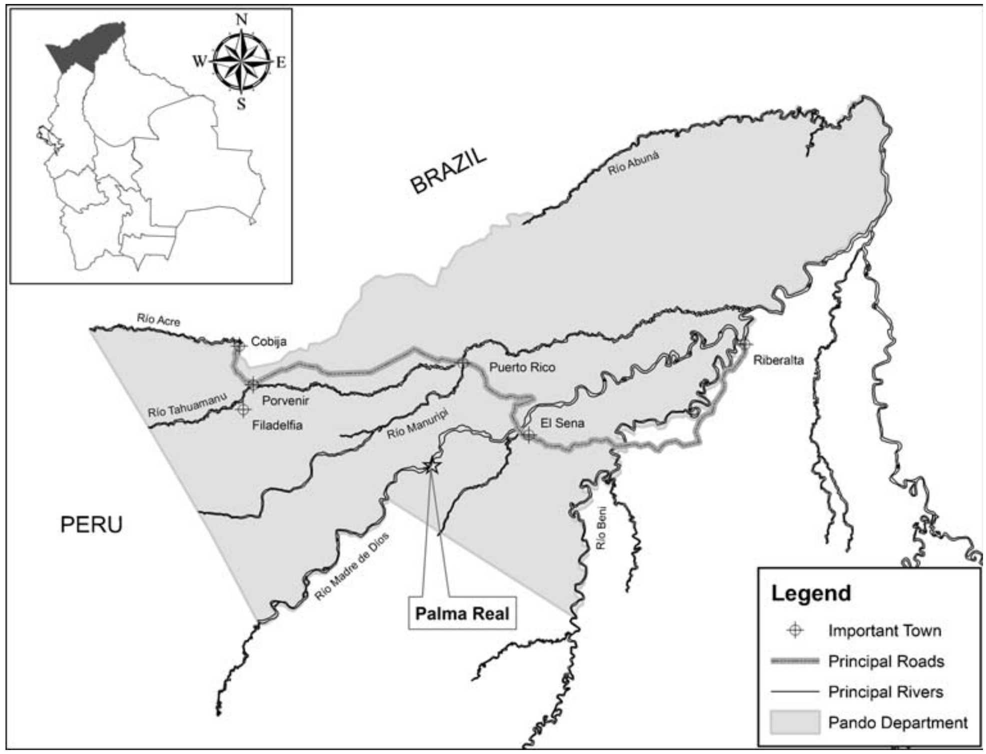


Fig. 1 The department of Pando and location of project site

sparsely distributed across the department's 63,827 km^2. Human settlements are widely dispersed along rivers and the few roads in the region. Throughout Pando forest resources, primarily non-timber forest products (NTFPs), have provided the basis for rural livelihood strategies and the regional economy for generations. The underlying system defining the traditional property rights and commercial networks used by the region's people has evolved over time.

Initially, Bolivia's occupation of the region was driven by the rubber boom in the late nineteenth century but later shifted to other NTFPs, especially Brazil nuts, which have become the foundation of the regional economy (Stoian 2000). In fact, since 2003 Brazil nuts have generated Bolivia's top forest export income (Cámara Forestal 2007). Since 2000, Bolivia has accounted for over 50% of the world's Brazil nut exports and over 70% if only the processed shelled nuts are considered (FAOSTAT 2007).

Brazil nut trees are found throughout the Amazon, but are most concentrated in Brazil, Bolivia and Peru. Although the trees are found throughout Bolivia's northern Amazon, 80% of Bolivia's Brazil nut production comes from Pando (Cámara Forestal 2006). The Brazil nut tree, locally known as *castaña*, is a giant among rainforest trees and can reach a height of nearly 60 m, a diameter of over 2 m, and live for more than 1,000 years (Ortiz 2002). The trees are sporadically distributed in the forest with about one to five individuals per hectare (DVH 1993). They produce a large woody fruit containing from 15 to 25 seeds or nuts (Ortiz 2002). The fruit begins to drop in November and by January most of the crop has dropped to the forest floor. Rural people or hired labor harvest the fruits, normally through March. Most nuts are shelled by Bolivia's highly developed processing industries and almost all production is exported.

For many rural families in Pando, the income generated during these months provides most of the cash they will have throughout the year. Recently household income has increased dramatically as the Brazil nut price paid to rural producers jumped from US$3.00 dollars per 22-kg box (a standard measure used in the region) in 2002 to US$ 14.80 dollars per box in 2005, an increase of almost 500%![1] Prices have remained at these levels driving increased competition and conflict during the harvest (El Deber 2005). Historically, the forest livelihoods of rural producers in the region were not based on formal property rights. However, Bolivia's on-going tenure reform is bringing legal land rights to rural communities. Whether their forest livelihoods are secured depends on how existing customary property rights are accommodated within the new property rights.

Agro-Extractive Communities and Tenure Reform

The origin of Pando's forest property rights system is found in the late 1800s when Bolivian commercial interests first expanded into the northern Amazon in search of NTFPs (Fifer 1970; Pacheco 1992; Stoian 2000). To exploit the

[1] With high prices in recent years the harvest continues 3 or 4 months longer, an extension locally called the *zafrilla* or little harvest.

region's rich reserves of wild rubber (*Hevea brasiliensis*), the owners of forest estates, known as *barraqueros*,[2] contracted rural laborers from other regions to gather rubber. The laborers were held in debt peonage and had no claim to the property. The system developed spontaneously in response to the needs of landowners to control forests, the rural workforce and transportation infrastructure; apart from these strategic assets, territorial limits of property remained nebulous. With the fall of international rubber prices in the early twentieth century, the regional economy collapsed diminishing the ability of *barraqueros* to restrict access to forests and control the population, and allowing independent communities to form (Ormachea and Fernández 1989; Stoian and Henkemans 2000; Assies 2002). Access and use rights for forest resources diffused to individual households replicating the earlier system, but without the oversight of a patron.

The customary property rights claimed by these families are based on a type of "tree tenure" (Fortmann *et al*. 1985) which recognizes access rights to individual trees and related infrastructure by households or family groups. Access rights to Brazil nut trees are organized by "*castañal*," which is a cluster of trees connected by a network of forest trails and a simple base-camp called a "*centro*." Typically, a *castañal* can have anywhere from a few dozen to over several hundred trees, spread unevenly over hundreds of hectares. The system does not emphasize control of contiguous territory but is centered on the key resource (Brazil nut trees) and related infrastructure (trails and storage areas). In newer communities, the system may be less clearly defined, but in established communities the customary tree tenure system is well developed and incorporates quite specific mosaics of resource rights, even though no formal written record of these rights exists (Cronkleton *et al*. 2008). Though lacking a clear legal foundation, the system has been sufficiently resilient to allow NTFPs to drive the regional economy and until recently define resource access to maintain a very lucrative and important forest industry.

The Bolivian government began to address the country's chaotic land rights system in 1996 with a broadly focused land reform policy which was put into law through the *Ley de Servicio Nacional de Reforma Agraria* (popularly known as the INRA law because of the agrarian reform institution that it created—*Instituto Nacional de Reforma Agraria*). This law was an ambitious attempt to reorganize Bolivia's complex and contradictory land rights system, to resolve competing land claims and to distribute and title undocumented or unclaimed lands throughout the country.

The reform process was particularly contentious in the country's northern Amazon where the general lack of formal land documents led to tensions among competing interest groups, particularly *barraqueros* and communities (Ruiz 2005; de Jong *et al*. 2006). Eventually a coalition of peasant and indigenous organizations supported by regional NGOs succeeded in pressuring the national government to issue decrees that recognized community land rights in the region (Aramayo 2004; Ruiz 2005; Cronkleton and Pacheco 2010).

The decrees stated that in Pando and portions of the La Paz and Beni departments—the source of most Brazil nuts—the minimum area provided to peasant and indigenous communities would be 500 ha per family (previously legislation allowed only 50 ha for peasant families). The 500-ha measure corresponds roughly to the territory traditionally used by extractivist families to harvest NTFPs, and effectively recognizes their de facto hold over extensive forest properties. However, rather than attempting to title individual properties, INRA policy gave communities properties more or less equivalent to 500 ha times the number of resident families, thus defining only the external boundary of the polygon. Internal resource distribution was left to residents to determine. Once all community polygons were titled the State would grant NTFP concessions to *barracas* in the remaining forests up to 15,000 ha.

A review of unpublished INRA data from mid-2008 shows impressive results in the titling of lands in favor of agro-extractive communities in Pando (Cronkleton and Pacheco 2010). Out of 163 communities, 139 have been titled, receiving a total of 1,807,320 ha. The claims of an additional 24 communities were being processed at that time which, once finished, would add another 112,384 ha of forest. The advances in land titling are laudable; however the process has produced unexpected complications and tensions among the beneficiaries. Observations of such problems provided the impetus for the participatory work described in this paper.

Impacts and Conflict at the Community Level

Building Capacity that Empowers Local People to Document Customary Rights

In 2005, CIFOR had planned to test a landscape mapping method with a community called Palma Real in the municipality of El Sena with the assistance of the Municipal Forestry Unit (UFM). Palma Real is situated on the south banks of the Madre de Dios River about 3 hours up river from the municipal capital El Sena (Fig. 2). It consists of a nucleated settlement along the Madre de Dios River and a forest property extending approximately 10 km inland to a stream called Saramano. The community was originally part of a *barraca* given to a Colombian employee of the powerful Suarez rubber baron family. The residents, most of whom are descendents of that owner, formed the community in 1997, with others forming the neighboring community of San Roque. There are 32 families in the

[2] This is derived from *barraca,* the local name for these estates.

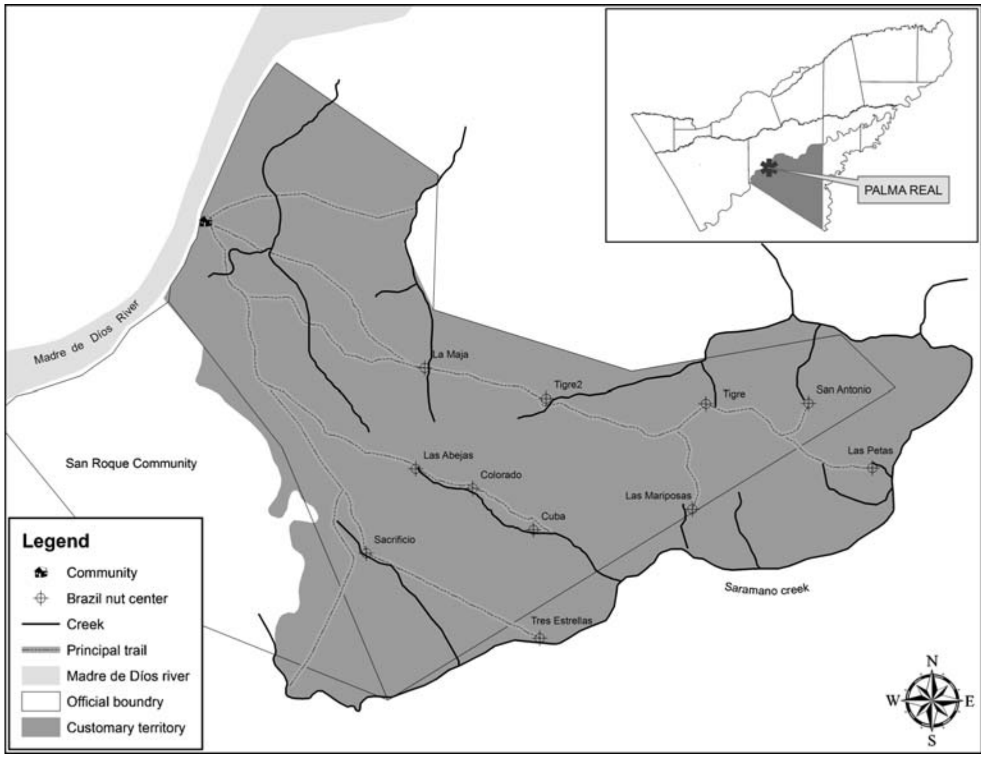


Fig. 2 Inside the polygon of Palma Real community (note discrepancies between boundaries of land unit and claimed Brazil nut boundaries)

community, although four are dependent households that work on their parents' *castañal*[3]. Palma Real is bordered on the southwest by the community of San Roque, and by two *barracas* on the southeast and northeast.

When CIFOR initiated the project, preliminary discussions with Palma Real community leaders revealed a high level of tension in the community. The families had just finished the Brazil nut harvest, which had been particularly lucrative due to high prices, but they were plagued by disputes. There were accusations of theft between neighbors as well as suspicion that outsiders had entered their territory to gather Brazil nuts. There also was growing resentment over the distribution of Brazil nut trees. Several individuals complained that they had too few trees to support their families, while five families had no trees at all and had to work for relatives or neighbors with large *castañales*. Our initial questions about resource use were met with cautious or evasive responses that gave little information as families were careful not to provoke jealousy from neighbors by providing details about their *castañales*.

INRA had visited the community in 2002 and demarcated an 8,955-ha polygon defining their communal property. However residents felt they had received few tangible benefits from the property polygon and were particularly concerned about differentiating their share of the property from their neighbors to make it easier to defend. They had received a small map from INRA showing only the outer land boundary of their community's polygon, but it lacked well-known reference points so that residents had a hard time relating it to their surroundings, and it did not address their concerns over internal division and distribution of resources.

A group of residents asked if it would be possible to change the landscape mapping test to focus on delineating their Brazil nut holdings. While that was outside the objectives of the CIFOR project, in such a tense climate, CIFOR offered to provide training so that they could do the mapping themselves. Rather than a generic test of landscape mapping methods, it was decided that research should be refocused to address property rights related to the resource generating the conflict, Brazil nuts. The result was a two stage participatory project that first trained community members in mapping methods and then allowed them to document their customary property rights for accessing Brazil nut stocks on their land.

Participatory Mapping Methodology for Mediating Resource Conflict

In response to the community's request CIFOR initiated a project to test methods for the mapping of customary forest rights involving collaboration with all Palma Real families

[3] In other Palma Real families sons that marry are provided a portion of the family *castañal* but such a division had not taken place in one family. Interestingly, their daughter, who married an outsider but remained in the community, would not have inherited a portion of the family *castañal*, given local custom. However, in this case the woman's family was given access to a *castañal* newly defined as a result of the mapping exercise described here.

and the local UFM. The main objective was to develop simple methods for mapping *castañales* that could (1) be implemented by rural people with limited technical assistance, (2) generate the necessary information to describe their forest management practices, (3) be verifiable and accurate from a technical standpoint, and (4) be used to generate information to mediate conflict. It was crucial that community members document the system themselves because only they had relevant information about the system and how it works. Through gathering and documenting the information, they would better understand the resulting maps and the process would give them ownership in the maps produced. And, because they would reflect local perceptions, community members would be more likely to agree on the results.

The Palma Real project took place over two stages. The first consisted of an initial training course and fieldwork to develop a geo-referenced sketch map of the community. This stage familiarized the residents with mapping techniques and tools, identified the main landscape features and reference points in the community, and demystified maps and their function for community members—an important step if they were going to mediate conflict or make management decisions. In the second stage, community members were trained in the use of a more elaborate mapping method called "direct connection," which they could use to collect information about individual Brazil nut holdings. The direct connection method allowed them to determine the extent and characteristics of each *castañal* by creating more detailed maps of forest trails and *centros*, generated census data on the Brazil nut tree population, and provided skills that would be useful for later management decisions.

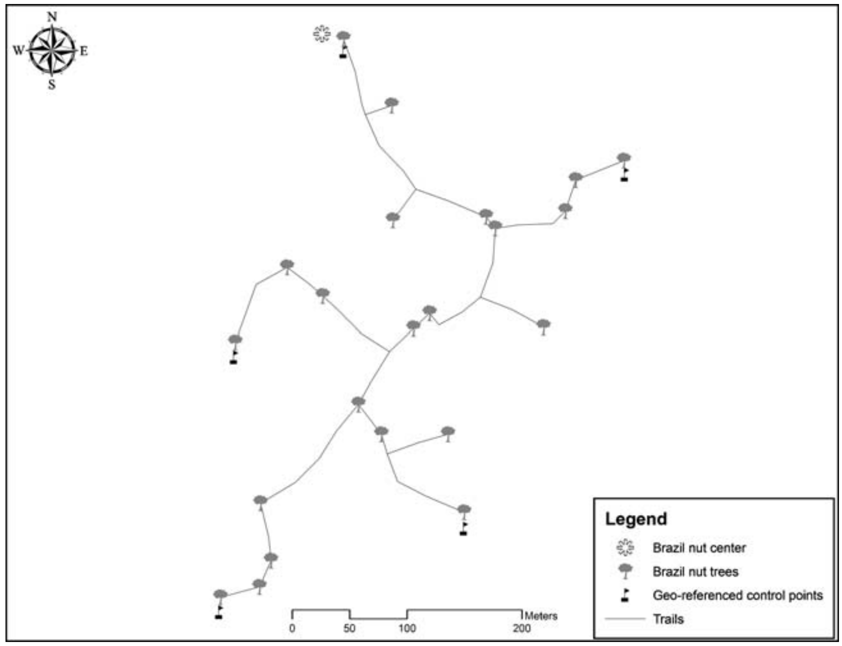
The first stage started in March of 2005 with a brief, one day training course, followed by several days of data collection. In the training course, community members were taught how to use a GPS and to plot the resulting coordinates on a map grid. One goal was for community members to understand how to use a GPS (none of them had ever held one before), but more importantly they needed to know how to use the information. Therefore, instead of storing measured coordinates in the GPS memory and generating a map using computer software, residents recorded the coordinates in notebooks and plotted them on a paper grid. In the following days community members measured and plotted coordinates of key reference points in the community and the forest, including all of their *centros*, primary trails, stream crossings, INRA boundary markers, and what they considered the outer limit of their territory until they had constructed and fleshed out the sketch map of their community. The geo-referenced sketch map provided a general overview of the forest areas traditionally used by community members. However, it did not provide information on specific trees and, consequently, the contested areas. More detailed information was needed to help community members mediate resource conflicts and make management decisions. To gather the necessary information, the CIFOR-El Sena UFM team returned later for a more intensive mapping exercise of the household *castaña* holdings.

The mapping of *castañales* is not new and there were several methods that could have been used (Rios 2001). However, it was important to develop an expedient way to gather information for mediating forest conflicts that was accessible and easily understood by rural people and that encouraged group participation. The community members needed to collect the information about the *castañales* as they were the only people that recognized customary boundaries and rights to individual trees. By promoting broad participation by groups of community members in the mapping process, it was expected that the results would have more chance of generally being regarded as legitimate.

To map the *castañales* a modified version of the "direct connection" method used by BOLFOR for timber censuses (Merlo *et al*. 1999) was utilized. This maps individual Brazil nut trees by measuring a series of sequential distances and azimuths from the closest geo-referenced control point (the triangles in Fig. 3). In geomatics (surveying discipline) this is known as a "link traverse" and is one of the most commonly used land surveying techniques (Wolf and Ghilani 2006). Ideally, all traverses should close on a known point or the point of origin in order to detect mistakes and determine the cumulative error in the traverse.

Although the measurement process in the direct method is simple, it requires careful organization and preparation. Where possible, *centros* are geo-referenced during the sketch map stage so that their coordinates are known. At each *centro*, the owner identifies the trailheads that correspond to his/her *castañal*. A tape, compass and clinometer are used to measure the distance, bearing and slope of each trail segment. The length of the segment is usually curtailed by the tape length (50 m), a curve in the trail, a sharp incline or decline in the topography, a trail branch, or reaching the next Brazil nut tree. Each Brazil nut tree is tagged with an identifying number on an aluminum plaque. Additional information for identifying the trees and for management planning was also recorded, such as diameter at breast height (DBH), estimated tree height, crown shape, whether or not it was emergent from the forest canopy, and liana infestation. This process is repeated until the main trails and all secondary trails (and the Brazil nut trees along them) are measured. In this way all trails and Brazil nut trees are mapped within each *castañal*.

Fig. 3 Distribution of Brazil nut trees, trail network and GPS control points



The community members formed brigades to gather and record the information. Because these groups needed sufficient people not only to use the tape measure, compass, clinometer and GPSs but also to measure, record data and clear trails to locate Brazil nut trees ahead of the measurement team, a brigade could be formed with as few as three people but it was easier with more and, in practice, brigades usually worked with five to ten people. The community members determined how to organize their brigades, including who worked and how often they worked. All participation was voluntary as neither CIFOR nor the UFM provided wages or food to participants during the fieldwork. Since the mapping had originated as a local demand, people were motivated to do it. The participation of the community members and neighbors is crucial in this process. Only community members can say when the entire property has been mapped, since only they know the divisions between *castañales* and tenure of individual trees. Forming brigades with neighbors allowed the community members to exchange labor but also assured that all claims to trees were validated.

The level of error in the mapped positions is related to measurement errors introduced by the GPS, taping and compass readings. If non-differential methods[4] are used for the GPS measurements, it is likely that the measured coordinates have an absolute positional error of 5–10 m. Tape errors arise due to different tension applied when pulling the tape or when it is extended over fallen trees or measured along sloped ground.[5] Most hand-held compasses measure to a resolution of 1–2°, with the possibility of interpolating to fractions of a degree. For example, an error of 1° in bearing will produce a positional error of 2 m over a distance of 60 m. As the network is extended, the errors in the bearing and distance are compounded with each additional segment that is measured. Isogonic charts are available to take into account magnetic declination and thus compute azimuth relative to true north (as opposed to magnetic north). These cumulative errors can be quantified by closing on a known geo-referenced point and comparing the computed coordinates of the closing point with the known coordinates.

Since the major objective of the mapping is to provide a general topological layout of the trail network and relative positions of Brazil nut trees, the accuracy achievable using a tape and compass is regarded as acceptable. Furthermore, the more sophisticated technologies and techniques required for higher accuracy would compromise the major value of the method—that it can be done by the community members themselves. For instance, we decided against using GPS more extensively along the trails as this would likely intimidate community members (at least initially) and give them the impression that conflict resolution requires high-tech solutions. In addition, satellite signals are often blocked under the canopy. If only trees are mapped, crucial

[4] Differential techniques involve having an additional GPS receiver collecting data at the same time over a point with known coordinates.

[5] Slope distances can be corrected by using the slope measurements: horizontal distance=slope distance×cosine (slope angle).

social–geographical information (i.e., trail networks, customary tenure rights, relationship with neighbors) would be ignored. Finally, the mapping method described here encourages group participation that is essential for resolving disputes within the community.

Field Test of the Participatory Mapping Methodology

Training in the direct connection method and fieldwork began in mid-July 2005. All individuals worked on mapping their own *castañal*, and most assisted their immediate neighbors and close relatives. The community started in the *centros* most distant from the settlement (a distance of about 10 km), moving back toward the settlement and the Madre de Dios River. Initially, forestry technicians from CIFOR and the UFM accompanied the process to assure that the brigades were following the mapping procedures and recording information correctly, and also to provide advice if needed. The technicians did not work directly in the data gathering. Over time, as the community members gained experience, they grew less reliant on this technical assistance and could carry out the fieldwork on their own. They worked at their own pace; for example two brigades started out working 6-day weeks over the first 3 weeks, then took 2 weeks off to devote to their agricultural activities. A similar pattern continued over the following months and a measure of local interest was that community members continued to map for several weeks when no CIFOR or municipal personnel were present. However, the residents were unable to finish in 2005. In mid-November families needed to prepare for the harvest and Brazil nuts began to fall so it was not safe to continue fieldwork. In June 2006, after the harvest was finished and agricultural chores during April and May were completed, the mapping resumed. It continued through September when residents finished surveying the remaining areas of their territory.

Once the fieldwork was completed, the information gathered by the community members was entered into an MS Excel spreadsheet, and ArcView 3.2 software was used to generate maps of the customary property rights. These activities were beyond the capacity of community members at this time so the work was done by CIFOR and UFM technicians. Although our goal was to develop methods that were accessible to local people and that would not require dependence on outside assistance, it was still necessary to provide technological support to process the mapping data.

Results

The geo-referenced sketch map revealed in impressive detail the social geography of the community and the detailed knowledge people use to define their territory. Although the families work mostly on their own, their *castañales* are organized into three extended kin groups clustered along three roughly parallel trails named *Sacrificio*, *Cuba* and *San Antonio*. Clustering in contiguous areas facilitates labor exchange and cooperation among closer kin and places some distance between families with less affinity. There was a fourth area northeast of the settlement where Brazil nut tree access was not well organized and families did not have specific claims in the forest. The sketch map showed that Palma Real families agreed on the general distribution of areas where individuals worked and had detailed information about these sites including named trails, *centros* and other reference points. The map also noted numerous zones where divisions between family holdings were disputed.

The geo-referenced sketch map also illustrated that a significant portion of the forest used by Palma Real families actually extended outside of their polygon. Most of the area in question had not been contested before INRA began working. The far southeastern boundary had been defined by a stream that provided a natural division between the community and a neighboring *barraca* (see Fig. 2). However, INRA technicians recorded only two markers to the north of the stream, and once back at their office, they drew a straight line between the two points. This effectively excluded community land between the line and the meandering stream to the south leaving portions of seven *castañales* outside of the titled polygon. At the southwest corner, INRA placed but did not include one property marker, and as a result, the *castañales* of four other families were left in the polygon of the neighboring community of San Roque. Together, these excluded areas increase the total area of the community's land by almost 3,000 ha. After mapping the community met with INRA to discuss the problem. INRA assured them that their polygon would be adjusted, and San Roque would be compensated with additional forest land elsewhere[6].

In the end, the community mapped approximately 11,000 ha of forest, measured a total of 21,156 individual trail segments, and tagged 8,366 Brazil nut trees distributed across 38 distinct *castañales* (Fig. 4). The number of trees mapped was substantially different from the estimates given initially by families. Before starting this fieldwork, individuals were asked to estimate the size of

[6] Legally Palma Real should receive 16,000 ha (500 ha for each of the 32 families). INRA has identified lands to compensate the community but unfortunately the selected area does not cover the traditionally used forests that remain outside of their polygon so further negotiation will be necessary.

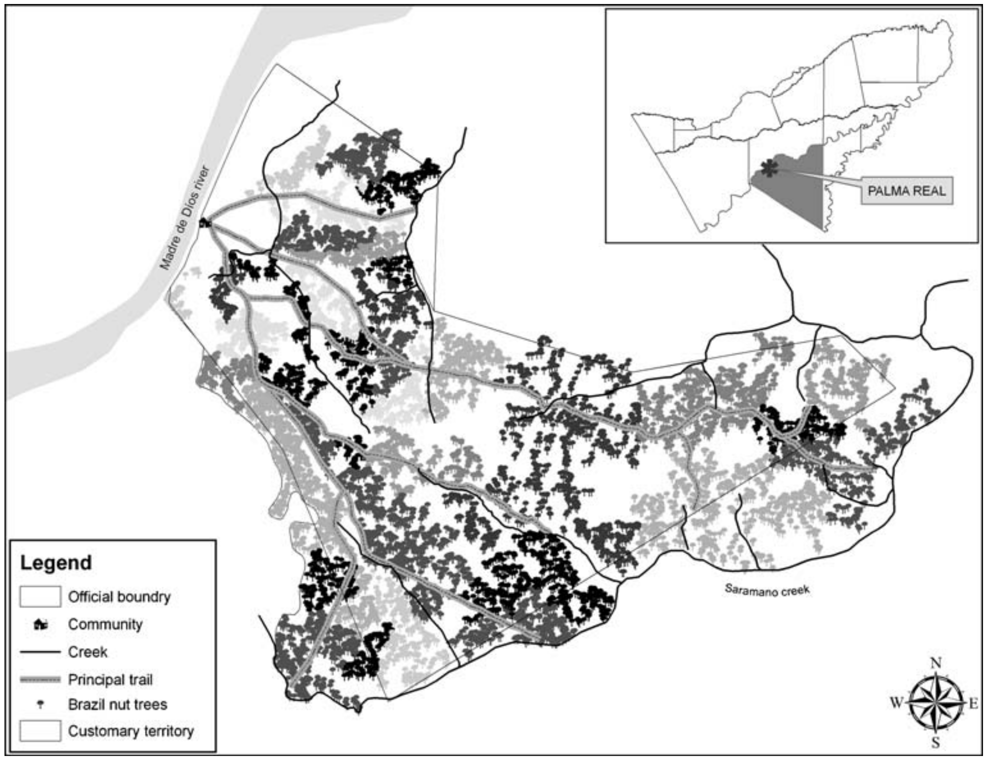


Fig. 4 Palma Real Brazil nut map (each color represents a separate *castañal*)

their family's Brazil nut tree holdings. Their estimates ranged from 40 to 200 trees. Once the work was completed, we learned that the average family holding was 298 trees, although there was wide variation. The largest holding consisted of 706 trees while the smallest was only 62 trees. Variation between initial estimates and the actual number of trees suggests that some families provided deliberately low estimates to avoid provoking jealousy in others, not surprising given the tension caused by resource conflicts in the community.

There was great variation in the shape and size of *castañales* as well as variation in the density of trees present in each *castañal* (Fig. 5). Initially, we expected that the variation in size indicated underlying problems with the equity of resource access in the community. However, the variation appears to be due to the fragmentation of larger *castañales* as they are passed on to younger generations. The small *castañales* were usually those ceded to children as they married and started their own families. Although households with small *castañales* were frustrated, the problem had an underlying local logic that people accepted. Ten of the *castañales* mapped were newly formed from previously unclaimed trees in the unorganized northeastern corner of the community's polygon to provide additional resources for families with few trees. Nonetheless, the continued decrease in *castañal* size through inheritance could cause significant problems in the future.

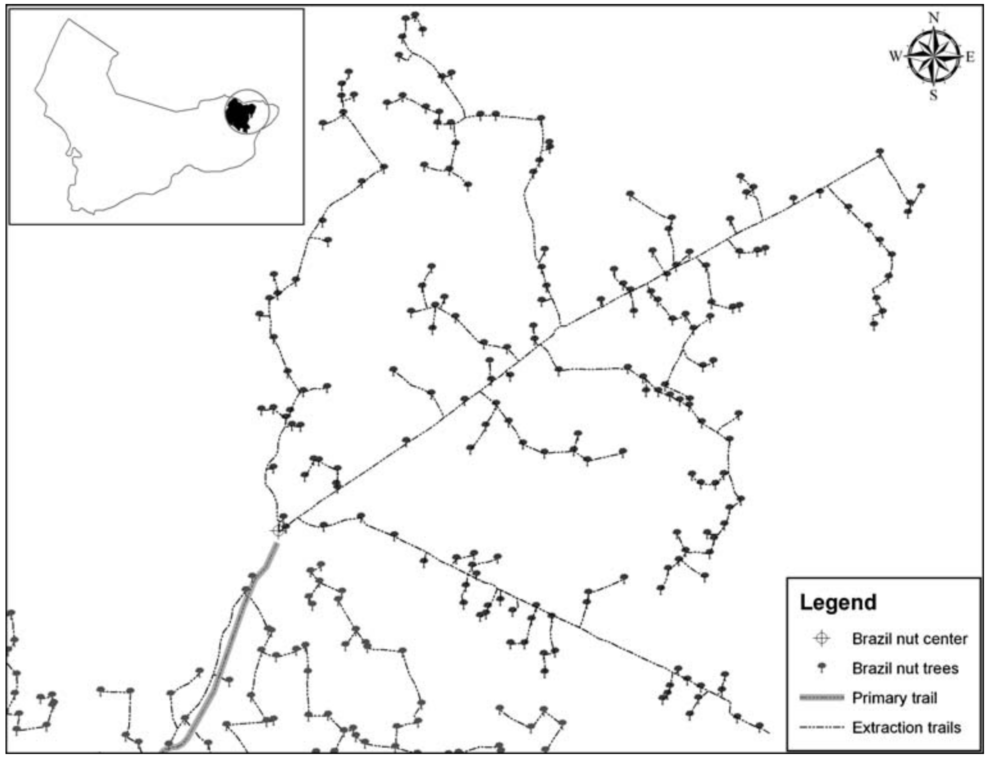
Discussion

This project demonstrated that the methods of geo-referenced sketch mapping followed by "direct connection" mapping of *castañal*es were useful and comprehensible to the Palma Real residents. The approach gave community members the skills and general understanding to carry out data gathering, and in the field they quickly mastered the techniques, and organized and implemented data collection fieldwork with minimal backstopping.

While the mapping methods limited dependence on outside technicians for gathering information, they did not entirely eliminate the need for technical assistance. In particular, external assistance was necessary to process the data generated by "direct connection" to produce maps. For the foreseeable future it is unlikely that communities will be able to process data to make *castañal* maps on their own, although such support could feasibly be provided by UFMs or regional NGOs promoting community forest management. Nonetheless, the maps will be based on information gathered by the community and will represent local perceptions that residents will understand. Community members will know what the maps represent, where the information came from and agree on its accuracy.

Palma Real residents reacted positively to these methods because they responded to a locally perceived demand. The willingness of individuals to invest time and labor without compensation is a strong indicator that they valued the

Fig. 5 Configuration of an individual *castañal* (shading indicates different *castañal* claim)



information produced and believed that the methods were appropriate. Because people understood the methods and the maps they generated, they were motivated to spend time in the forest collecting information. For these reasons, we expect that the maps and associated information will continue to be used for decision support into the future.

Conflict Mediation

A principal objective of this project was to generate information that could be used to manage resource conflicts between households in extractive communities. We believed the process would begin once maps were developed and disputed zones had been identified. Unexpectedly, the mediation process began in the field while data were being gathered. Because brigades consisted of property owners and their neighbors, discussions of conflict occurred as soon as the workers reached disputed areas or individual trees. Since the interested parties were present, as were witnesses, the individuals involved found it easier to negotiate agreements immediately. In most cases, disputes involved small numbers of Brazil nut trees at the fringe between neighboring *castañales*. Since the discussions focused on a finite set of disputed trees (rather than vague perceptions of injustice), it was easier for those involved to agree on how to divide the trees, then tag them accordingly.

Some of the perceived "theft" and insecure control over resources had to do with the blurring of property lines when the formal titled polygon was overlaid on the customary forest use system. For example, where INRA had left portions of some *castañales* in the neighboring community polygon, Palma Real families had to contend with San Roque residents who now had legal claim to the resources. Previously, the control of Brazil nut trees in these forests had not been disputed, but the new polygon changed the boundary. Residents were unsure whose rights were legitimate. Given the high prices that Brazil nuts commanded, each side tried to use the property rights framework, whether legal or customary, that supported their claim: San Roque residents claiming new legal rights while affected Palma Real residents asserted the legitimacy of their traditional forest claim. Once this area had been mapped, the problem could be visualized and it was more apparent to the participants that tension was caused by the overlapping systems for defining property rights. Regardless of the new "legal" rights held by San Roque, the affected families from Palma Real were unlikely to give up the resource base of their livelihoods without a struggle. At last report, the status quo has been maintained although affected Palma Real families were considering registering as San Roque residents.

Mapping will not eliminate conflict but it will provide a basis for initiating mediation and negotiation processes. The method worked well in Palma Real because the community's customary system was consolidated and generally viewed as legitimate by the residents. The fact that Palma Real is composed of a small number of extended families certainly contributed to the project's success. Other communities do not benefit from such strong social cohesion, even where kinship networks are extensive. Once the contested resources are documented and mapped, it is possible to discuss them in specific terms with factual information rather than as a hypothetical problem. It can also illustrate the nature of competing claims. Adapting a procedure based on the mapping methods described here as part of the titling process could avoid unnecessary conflicts when the State attempts to delineate and legalize customary land rights. Mapping patterns of traditional forest use will ensure that these practices are considered in the decision making process. Ultimately, greater effort to equate customary forest property rights with new land rights could give the land policy reform greater legitimacy.

Conclusions

Bolivia's Northern Amazon represents a clear example of the mixed results that can arise from tenure reform that is intended to benefit forest dependent communities. While the land titling process was modified in response to the forest livelihoods of households in the region, in practice the application of the titling process has not guaranteed that rural families have a more secure hold on their traditionally used forests. The reform has in fact generated conflicts where they had not existed before. Furthermore, by not addressing internal boundaries in the communal properties, issues related to resource access remain and are susceptible to conflict driven by changing conditions. The experiences with participatory resource mapping described here indicate that it is feasible to mediate forest resource conflicts by giving rural people the capacity to document their customary practices. The willingness of rural families to invest their labor in the mapping exercises without compensation is a strong indicator that the method is appropriate to address their needs and that they had confidence that the information generated would be useful to them.

The information gathered with these mapping methods illustrates the complex mosaic of individual and collective access systems with distinct rights and demands that have been used to manage Pando's forests for generations. Efforts to strengthen property rights through titling or to introduce new forest management practices need to begin with a full understanding of these customary systems. If not, they risk provoking unintended consequences that will debilitate these forest livelihood systems or generate conflict. Involving local people in the definition of their territory offers one strategy for avoiding haphazard decisions when titling communal lands and also for dealing with the resulting insecurity and conflict. There are several reasons why local people should carry out this important initial step:

- Only local people know where traditional boundaries are and how the customary systems work—it would be impossible to document such a tenure system without input from these local stakeholders;
- Collectively mapping as a group creates opportunities for comparing information with neighbors and is crucial for determining legitimacy and mediating conflict;
- Empowering local people to document their customary systems ensures that the results reflect their perspectives and those of their neighbors;
- Community level stakeholders have a vested interest in assuring that their systems are documented accurately. It is not difficult to motivate them to take responsibility for the activity. Conversely, it is unlikely that outside institutions will have the incentive or capacity to meet a large number of dispersed demands.

Mapping their traditional systems will not resolve all of the property rights issues facing communities in Bolivia's Northern Amazon. However, once documented, the resulting information provides a basis for addressing those areas contested by neighboring households and communities. Such a process can serve as a starting point for mediating property rights conflicts and developing forest management plans. Of course, there are many actors within communal territories, and local perceptions are multifaceted. However, by identifying and making these differences more explicit, the stakeholders involved can establish parameters for discussion and recognize key details for mediation. In the end agreements based on collective understanding will have greater local legitimacy. Although conditions vary from community to community, these types of participatory mapping techniques could help mediate property rights conflicts in other parts of the world, contribute to the strengthening of communities with forest based livelihoods and, in turn, support the maintenance of tropical forests.

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