Property Rights for Biodiversity Conservation and Development: Extractive Reserves in the Brazilian Amazon

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ABSTRACT

Many of the world's most valuable biodiverse areas are successfully managed by indigenous communities, often under peculiar property rights structures. In many cases, these communities are economically disadvantaged, even by local standards. But can particular local property rights regimes which are ecologically successful also allow communities to compete productively in market economies? The extractive reserves of the Brazilian Amazon offer an opportunity for investigating the connections between property rights, conservation and development in the context of tropical forests. This article aims to analyse whether the existing property rights in these reserves — an idiosyncratic mixture of public, collective and private property rights — can support the explicit development aim of a competitive, yet sustainable, exploitation of the area's natural resources. The analysis identifies three promising development paths open to extractive reserves, but points to a fundamental contradiction between the static structure of the property rights system and the dynamic nature of two of these paths. The current design of internal property rights fails to take into account the broader economic context in which reserves must generate a viable revenue stream. If extractive reserves are expected to develop without reliance on external aid, then changes to the property rights structure both inside and outside the extractive reserves have to be explicitly considered.

INTRODUCTION

Indigenous communities manage many of the world's most valuable biodiverse areas, under often peculiar property rights structures.[1] Starting with Hardin's (1968) seminal paper, these structures have been the subject of an economic literature that analyses the relationship between the design of

1. It is important to distinguish between the 'property rights structure' (or 'regime') and the property rights themselves. The 'structure' or 'regime' defines in what tangible or intangible goods property can be held by whom, and how it can be enforced. The rights, on the other hand, derive from the rules enshrined in the regimes. For example, the law of ownership defines that an individual can own a car and is thus a 'regime'. The ownership of a car is the property right that derives from that regime. Our article is concerned with the regimes.

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these property rights and the quality of a community's management of its natural resources. This literature has been mainly concerned with the assessment of different community-based arrangements in promoting efficient management of natural resources. These theoretical and empirical studies generally emphasize the property rights internal to the community area and examine whether private property, public ownership or communal property constitute the optimal resource management system (Baland and Platteau, 1996; Bardhan, 1993; Ostrom, 1990; Seabright, 1993). Their insights have been mixed. One conclusion is that we cannot rule out situations in which no individual property rights regime provides a viable solution on its own. In these settings, so-called 'co-managed systems' that combine features of private, communal and public property rights are seen as a natural response (Baland and Platteau, 1996).

While the property rights literature has mainly focused on optimal resource management within specific areas, other strands of development economics and policy-oriented research have been concerned with broader development issues (for an introduction, see Bardhan and Udry, 1999; Sadoulet and de Janvry, 1995). For the latter, questions regarding poverty alleviation, technological progress and the capability to compete in market economies pose challenges that go beyond the local areas in which traditional communities live and include the wider economy.[2]

The interface between the bodies of research on property rights and on development becomes important when traditional communities managing complex natural resources interact with the outside world by trading their natural products. The need to remain competitive in a market economy where heterogeneous players operate with different production systems creates an inexorable link between internal property rights inside and outside the reserve and wider development processes. Traditional communities must be able not only to manage their resources optimally but also to improve their production systems and technologies, offering products at competitive prices and deriving competitive advantages.

This raises a natural question: to what extent do particular local and external property rights regimes that are ecologically successful allow communities to compete productively in market economies? Research on the nature of the firm — the most common competitor of extractive reserves on output markets — has highlighted the crucial link between internal and external property rights in tangible and intangible (knowledge) goods, the internal organization of production activities, and economic viability of the enterprise (for a survey, see Milgrom and Roberts, 1992). These linkages are much less well understood in the case of extractive reserves, but are just as important for their survival. Like the conventional firm, extractive reserves

2. See also Aghion and Bolton (1997); Angelsen (1999); Foster and Rosenzweig (1995); Keller (1996); Lipton and Ravallion (1995); Rodriguez-Clare (1996).

trading products on markets need to be able to innovate, diversify and strategically position their products in order to survive. Does the structure of property rights allow the reserves to organize themselves in such a way that they can develop viable revenue streams whilst fulfilling their broader conservation remit?

Recently there have been a number of international initiatives aiming to enhance the efficiency of rural communities in exploiting their natural resources. A typical solution is the devolution of forests where the rights and responsibilities to use and manage resources are assigned to local people (Fischer, 1998; Ribot, 2002). However, the success of forest devolution initiatives in terms of resource exploitation and the livelihoods of local communities is contested (Shackleton and Campbell, 2001). Firstly, in many cases the actual rights assigned to local communities have been severely constrained and the state regulates resource exploitation differently in comparison with private farms (Shackleton et al., 2002). Secondly, forest devolution seems to have a limited impact where local communities have poor access to capital, skills or markets (Engel and Palmer, 2004).

The extractive reserves of the Brazilian Amazon offer one of the most interesting cases for investigating the interface between property rights, conservation and development in the context of tropical forests. In these reserves, the combination of public property, community management and private resource use of designated forest areas is expected to generate competitive and, at the same time, sustainable extraction of non-wood forest products (NWFP). It is therefore not only the internal property rights assigned to the reserve that are important, but also the broad set of property rights upon which the wider economy is structured.

In their first ten years of existence, extractive reserves attracted attention and funding from a number of institutions and have been considered by some as an important component of the regional development strategy (Allegretti, 1990, 1994; Menezes, 1994). Nevertheless, the economic reality of these reserves provides ground for serious doubts about their capacity to fulfil their economic development objectives.[3] Only a very limited number of products have been commercially exploited so far, and incomes have remained stagnant for the majority of the population. The threat posed by cultivated substitutes is eminent and the extraction of NWFP still depends on external support.

Building on previous research on the spatial economics of extractive reserves (Goeschl and Igliori, 2004), this article investigates the relationship between the property rights regime in and around extractive reserves, tropical ecosystem conservation, and the development perspectives of indigenous communities living there. In this, we aim to contribute to a better

3. There is much on this, but see for instance, Almeida (1994); Assies (1997); Brown and Rosendo (2000); Goeschl and Igliori (2004); Homma (1992); Southgate (1998).

understanding of the intersection between resource management, property rights and development. We first explore three possible development pathways that the extractive reserves production system could pursue. We then confront these pathways with the property rights in place both within and outside the reserves in order to assess the capacity of these property rights to support each of the development pathways.

Our main result is a negative one: the current system of property rights properly supports only one of three principal development pathways, namely the extraction of established NWFP. We argue that this development pathway has very limited capacity to serve as a growth engine for the communities living in extractive reserves. On the other hand, the current property rights structure generates no, or very limited, rents for the inputs required to access the other two pathways — diversification into newly discovered NWFP and supply of biological inputs into the intensive production of NWFP.

While the economic activities in extractive reserves are not limited exclusively to extraction of NWFP, the importance of NWFP for local incomes makes it likely that our findings are characteristic of a wider fundamental tension between the static structure of the internal property rights system and the dynamic nature of the two more promising development paths. The current model of extractive reserves, based on the design of internal property rights, fails to take into account the broader economic context in which the reserves must generate a viable revenue stream. We therefore conclude that the current set of institutions does not support the development objectives inherent in the extractive reserves model.

This problematic conclusion has implications for policy making and provides material for further research. On the one hand, our analysis suggests that policies aiming to enable indigenous communities to develop viably should go beyond the design of internal property rights and address the issues regarding the ways these communities interact economically with the outside world. On the other, the results also indicate that there is a clear need for further research exploring in greater detail the link between internal property right systems and broader development strategies, rather than merely the optimal management of a given resource. For the time being, uncertainty remains whether extractive reserves will in fact be able to fulfil their development objectives in economic terms even if in an ideal set of property rights is found and instituted.

The remainder of the article is structured in four sections. The following section provides information on the historical background and current situation of extractive reserves. We then characterize NWFP production and explore the long-run perspectives of extractive reserves through alternative development pathways. This is followed by an analysis of property rights internal and external to extractive reserves. The final section discusses to what extent these property rights are conducive to alternative development pathways, summarizes the results and presents our conclusion.

HISTORICAL BACKGROUND AND CURRENT STATUS

Following the discovery of vulcanization in 1839 and the increased demand in the industrializing countries, rubber tapping gained importance in the Brazilian Amazon from 1850. Early rubber exploitation was organized in a system called *aviamento* in which intermediary agents (*Seringalistas*) recruited workers to carry out the extraction of latex in exchange for basic goods supplied to the rubber tappers at inflated prices.[4] There was no monetary circulation and tappers were frequently in debt given that rubber production was not sufficient to pay for the advanced goods (a system known as 'debt peonage'). *Seringalistas* would then send the rubber to large trade houses in the cities of Belém and Manaus.

Between 1900 and 1913, the rubber economy in Brazil increased dramatically due to the emergence of the automobile industry (the so-called rubber boom). However, the boom came to an abrupt end because of the competition posed by the newly established plantations in British and Dutch colonies in Asia. The decline of the rubber economy in the Brazilian Amazon motivated the expansion of other activities in the region such as agriculture, extraction of other goods and the commercial exploitation of Brazil nuts. World War II brought a temporary revival for rubber, but since then the traditional rubber economy has struggled to survive. The collapse of native rubber production was avoided through various schemes of governmental price support, but these schemes were abandoned in 1989 and prices have dropped dramatically since then.[5]

With the decline of the traditional rubber economy based on *aviamento*, an alternative form of small-scale production organization has developed, with autonomous rubber tappers selling their products directly to the market. Under the 'autonomous' system, the rubber tapper households produce a mix of subsistence and market goods in individual or collective land plots called *colocações*. Nowadays, both systems are present in the Amazon, but the traditional *aviamento* tends to be located in areas relatively distant from commercial centres (Allegretti, 1990).

In the 1960s and 1970s the military governments in Brazil introduced a series of development projects in the Amazon region. These projects were aimed at the occupation of a vast frontier and were based on colonization settlements associated with massive road building, provision of infrastructure facilities and other economic incentives. As a result the region experienced a dramatic process of economic growth and deforestation, with a significant impact on traditional activities (see Andersen et al., 2002).

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4. See Allegretti (1994) and Brown and Rosendo (2000) for a discussion of this traditional system.
5. For detailed accounts of the history of rubber in Brazil, see Dean (1987) and Weinstein (1993).

The increase of cleared areas for agriculture and pastureland forced traditional communities to move to urban areas. However, the clear-cutting of forests faced resistance from what became the Rubber Tappers Movement. This series of conflicts evolved through the 1970s and 1980s as the Rubber Tappers Movement increased in importance, gaining international recognition with the dissemination work by one of its leaders, Francisco Mendes (Allegretti, 2002). One of the main outcomes of the Rubber Tappers Movement was the creation of the National Council of Rubber Tappers around the proposal of the extractive reserves. In 1989 the legal framework for creating the extractive reserves was developed. Although the reserves were originally thought of as a proposal for agrarian reform adapted to the needs of populations living from the extraction of forest products, in reality they were conceived as conservation units. Nevertheless, they were presented as a strategic element in a new model for Amazon development combining economic competitiveness with environmental sustainability.[6]

According to the law that created the reserves (Decree 98,897/90), the extractive reserves are considered as territorial spaces of particular ecological and social importance for the country. In order to concede the right to access the flow of NWFP generated on public land, the federal government must approve a use plan elaborated by the communities. The creation of extractive reserves aims to promote the joint objective of forest conservation and economic development in the designated areas by granting the use right of its multiple resources for already settled communities, in a sustainable way. Three aspects of the extractive reserve model are expected to contribute to this joint objective: income generated through the resource exploitation allows the populations to remain in the forests and prevents alternative uses that rely on land conversion; the explicit public ownership of land resolves property rights uncertainty over the areas involved and thus encourages the conservative use of its resources; and the limitation of economic activities to non-wood forest products contributes to ecosystem maintenance and hence to the conservation objective. In addition, according to Allegretti (1990: 263), by creating a setting for research, the 'extractive reserves could represent dynamic laboratories for investigating both traditional and innovative forms of human interaction with the Amazonian environment'.

In 1992, the Brazilian Institute of the Environment and Renewable Resources (IBAMA) created the National Centre for the Sustainable Development of Traditional Populations (CNPT) with a mandate to establish and assist in maintaining extractive reserves. In 1995, these reserves encompassed around 21,600 km^2. The number of federal reserves has been continuously increasing and in 2000 there were twelve across the Amazon

6. For a discussion on the creation of the extractive reserves, see Allegretti (1990, 2002).

states. Table 1 presents figures from some of the main current extractive reserves. Due to the economic importance of rubber extraction for local populations,[7] the concept of the extractive reserve was structured in most cases around the autonomous extraction of native rubber. Table 2 shows the composition of economic activities in 1993 for four reserves in the state of Acre: on average, about 30 per cent of income was derived from different extractive activities, complemented by agriculture, ranching, hunting and fishing.

Among extractive activities, latex extraction from rubber trees (*Hevea brasiliensis*) is dominant. A typical family produces an average of 900 kg of rubber annually (Brown and Rosendo, 2000). The income derived from rubber sales fluctuates over the year. In the wet season, rubber harvests decline considerably, since the rubber trees tend to be concentrated on floodplains. Although rubber is the most economically significant product, Brazil nuts (*Bortholletia excelsa*) and oils (such as the oil extracted from the palm tree, *Copaifera* spp.) constitute locally important sources of revenue. There is evidence that a more developed farming economy has been growing in some of the reserves (Peralta and Mather, 2000), which might represent an alternative source of income for the populations living there but at the same time conflicts with the conservation objectives assigned to reserves.

More recently, there have been attempts to enhance the income of families living in the reserves by a number of initiatives towards product diversification, technical innovation and business management. The development of marketing networks, extraction and marketing of new products, and local processing of extractive products are some of the initiatives promoted with the assistance of NGOs, governments and international agencies. However, most of these are still in very early stages and it is difficult to anticipate their economic impact (Brown and Rosendo, 2000).

The most promising opportunities seem to be associated with combinations of agriculture and extraction, the so-called agro-extractivism (Hall, 1997). In particular, a project called 'High Productivity Islands' developed in the Chico Mendes reserve is providing higher returns to the families involved; some studies have concluded that at least in the short run the project is likely to be economically feasible (Reydon and Maciel, 2002). 'High Productivity Islands' consist of small plantations in previously cleared areas within the reserve. Another interesting initiative, related to technological innovations, is cotton cloth covered by latex, known as 'ecological leather' (*couro vegetal*). 'Ecological leather' is manufactured in the Alto Juruá reserve and is traded both domestically and internationally as a substitute for durable natural or synthetic fibers (Andrade, 2003).

7. This is underlined by census data that estimate that 68,000 families were involved in rubber tapping in 1980 (Allegretti, 1990).

Table 1. Extractive Reserves in the Amazon

Name and Federal Unit	Area (ha)	Population	Main Resources
Alto Jurua (AC)	506,186	4,170	Rubber
Chico Mendes (AC)	970,570	6,028	Nuts/Copaíba/Rubber
Alto Tarauacá (AC)	151,199	–	–
Rio Cajari (AP)	481,650	3,283	Nuts/Copaíba Oil/ Rubber/Açaí Fruit
Rio Ouro Preto (RO)	204,583	431	Nuts/Copaíba Oil/Rubber
Lago do Cunia (RO)	52,065	400	Fishery
Extremo Norte do Tocantins (TO)	9,280	800	Babaçú Fruit/Fishery
Mata Grande (MA)	10,450	500	Babaçú Fruit/Fishery
Quilombo do Frexal (MA)	9,542	900	Babaçú Fruit/Fishery
Ciriaco (MA)	7,050	1,150	Babaçú Fruit
Tapajos Arapiuns (PA)	647,610	4,000	Rubber/Fishery/Oil and Resin
Medio Jurua (AM)	253,226	700	Rubber/Fishery
Total	**3,303,411**	**12,164**	

Notes: Copaíba is a tree producing oil used for pharmaceutical purposes; its wood is also used for furniture and construction. Babaçú is a palm; its nuts are used to produce cooking oil as well as for charcoal and animal feed. Açaí is a palm tree of which both the fruit and the 'palm heart' are used.
Source: web site of Brazilian Institute of the Environment and Renewable Resources: www.ibama.gov.br/resex/amazonia.htm (accessed December 2005).

Table 2. Composition of Family Income Sources in Extractive Reserves, 1993 (percentages)

Income Source	Extractive Reserve				
	Chico Mendes	Alto Jurua	Rio Ouro Preto	Rio Cajari	Average
Agriculture	47,12	36,08	26,43	43,06	43,06
Cattle/small animals	8,92	10,80	13,69	14,92	12,08
Hunting and fishery	5,78	32,52	8,92	9,66	14,22
Sub total	61,82	79,40	49,04	87,22	69,36
Extractive products					
Rubber	29,56	20,60	50,96	0,76	25,57
Nuts	8,62	–	–	3,63	3,06
Palm heart – fruits	–	–	–	8,29	2,07
Sub-total	38,18	20,60	50,96	12,68	30,70
Total	**100**	**100**	**100**	**100**	**100**

Source: ECOTEC – PPG7, extracted from www.ibama.gov.br/resex/textos/h12.htm (accessed December 2005).

Despite these initiatives to enhance household income, if extractive reserves are to offer an answer to the development–conservation trade-off, it is crucial that the extraction of NWFP generates above-subsistence levels of revenue over prolonged time periods. This development objective was explicit in the creation of the reserves, and their size is ultimately determined by the extent of extractive activities. For the remainder of this article, we will therefore concentrate the analysis on the economics of NWFP extraction, even though it is clear that in reality the mix of economic activities can be more complex and diverse.

NWFP PRODUCTION AND DEVELOPMENT PATHWAYS

Capital Stock and Cost Dynamics

In this section we characterize the main features of the reserves' NWFP production system. To capture the peculiarities of NWFP production, we earlier developed an explicit dynamic model of spatial competition between an extractive reserve and a plantation (Goeschl and Igliori, 2004). Here we discuss the model's main features and results.

The production of NWFP involves the harvesting of products generated by trees or shrubs. This makes clear that in an abstract sense, the production process relies on an underlying stock of biological capital. This capital stock differs from the standard physical capital used in conventional production systems. As a result of biological processes, the depreciation of a plantation's capital stock is directly linked to its size and composition. Take the rubber tree as an example. Prior to the development of rubber plantations in Brazil, incidence of leaf blight was limited due to genetic variability in natural tree populations from which rubber was extracted. Early rubber plantations using intensive methods were devastated by the impact of leaf blight epidemics that made Brazilian rubber permanently uncompetitive on world markets, while southeast Asian plantations were unaffected by the disease (see Kloppenburg, 1988). In all, there are about ninety species of fungi known to attack *Hevea* (rubber) trees, two species of bacteria, and various nematode and insect pests (Duke, 1983). These pathogens seriously impact on the costs of intensive production development since they require continuous investment into the protection of the biological capital base, most significantly through breeding (Gonçalves, 2002; IRRDB, 1998; Rubber Board, 2002). On the other hand, intensive production in plantations benefits in a static sense from lower harvesting costs and in a dynamic sense from productivity gains in complementary inputs (physical capital, human capital) driven by technological progress and knowledge (FAO, 1995).

The general dynamics of an industry dependent on a biological resource stock imply that production costs of a NWFP producing enterprise will vary over time depending on the productivity of its capital stock. The productivity of the biological capital stock will be negatively affected by increases in the size of production, but can be augmented through simultaneous investments in biological resources. A conventional enterprise will be able to optimally choose price and output as well as the path of its production technology.

In contrast to plantations, extractive reserves combine a severe restriction with regard to the choice of production technology with an abundance of biological capital. With respect to NWFP production, extractive reserves are peculiar because the government rather than the community is the owner of the biological capital stock. It grants the community free use of that stock subject to the stock not being depreciated. Implicit in this use condition is also a restriction of the production technology that limits the marginal productivity of physical capital (Browder, 1992). These restrictions together with the intrinsic difficulties in operating within the forest, low capital intensity, little access to capital and the persistence of traditional methods, suggest that the depreciation of the biological capital stock in NWFP production in reserves is negligible. Conversely, the rate of cost reduction given an existing physical capital stock will be extremely low in reserves because labour-intensive production involves little physical capital. With this configuration, the cost dynamics are not relevant to the inter-temporal management of an extractive reserve. What will matter for the profitability of NWFP production, however, is that unit costs will be at a level commensurate with the constrained production conditions in the reserve.

While constrained in the choice of technology, the abundance of biological capital means that extractive reserves have direct and inexpensive access to a critical input in the NWFP production process. This stock potentially allows a diversification of NWFP production into the various extractive activities (rubber, nuts, fruits, oils, fibres) thus reducing the reliance on each individual product. It also opens up the interesting prospect of extractive reserve potentially benefiting from the demand for biological inputs from other NWFP producing enterprises subject to cost dynamics. This demand could be met in accordance with the use restrictions as long as the reserve can supply these inputs at a price lower than the cost of bioprospecting to the enterprises.

To summarize, the peculiar production conditions in the extractive reserves present both a set of constraints for each NWFP production process, by virtue of not being able to choose the first-best technology, and a set of opportunities through the free access to an abundant biological capital stock that allows both diversification of output and sale of biological inputs. In terms of biodiversity conservation, these production conditions have clear benefits as they secure land use rights for activities that do not rely on land conversion. Economically, these conditions represent a significant improvement in terms of social equity compared to the traditional *aviamento* system of rubber 'barons' and quasi-indentured labour. However, it is less clear whether this constrained production system offers viable pathways to development through sustainable income flows for their populations.

Markets for Existing NWFP

NWFP enterprises generate revenue through sale of their products on markets where they interact with other producers of NWFP. Following Goeschl and Igliori (2004) we focus on two unusual features of this market for NWFP. The first is the spatial structure of enterprise location in the NWFP sector. Due to the considerable distance involved in the domestic market and resultant transportation costs, space is an important determinant of the profitability of operations. At the same time, production depends on particular local characteristics that are not present everywhere, thus limiting the choice of production sites. The second feature is the heterogeneity of enterprises competing on the market. Extractive reserves are expected to generate revenue on output markets where they will be competing with other producers that are operating using different technological choices and resource bases.

The combination of spatial considerations and producer heterogeneity is not only analytically interesting, it is also empirically relevant: extractive reserves and potential plantations are usually localized in different parts of the country (in rubber production most of the plantations are in the south-east of the country). Wunder (1999) shows that NWFP production outside extractive reserves is very concentrated, with just eighteen municipalities accounting for 25 per cent of the total extraction values.[8] These production belts are mostly characterized by proximity to market areas and by previous intervention or degradation in current sites of extraction. These environments are now dominated by the commercial species, sometimes up to the point of forming 'quasi-plantations', as a consequence of natural re-growth combined with management practices to deliberately eliminate competitive vegetation (ibid.).

Goeschl and Igliori (2004) show that, given the constrained production conditions, the development of the market share for extractive reserves, even under the most favourable assumptions, is likely to lead to a declining revenue stream. This is because the unconstrained producer is able to reduce costs through investment. This investment is justified because it allows the producer to capture a higher market share from the reserve in the spatially differentiated market. If eventually the cost difference reaches a threshold the low cost firm takes over the whole market. This implies that there is only a limited time period within which production of a NWFP will generate significant revenues for the reserve. This limitation is exacerbated by the fact that the more revenue potential the product has, the greater are the incentives for the unconstrained producer to reduce costs quickly, and consequently the shorter the time period of profitable operation for the reserve.[9]

This rather pessimistic view regarding the revenue prospects in established markets for NWFP is supported by various empirical observations. Homma

8. These municipalities form the so-called 'açaí belt' (state of Pará) and 'babaçú belt' (mainly state of Maranhão).

9. Apart from the threat of domestication in plantations, revenues from NWFP produced in reserves are limited by the availability of substitutes. The substitution of natural products by synthetic ones can be triggered either by a shortage of supply or by technological advance.

(1992), analysing the historical development of extractive activities in the Amazon, characterizes the dynamics of NWFP as an economic cycle composed of four phases: expansion, stabilization, decline of the extraction, and cultivated plantations. The expansion phase is characterized by the existence of large reserves of the resource and by the monopolistic position of the extraction region in the product market. Stabilization occurs when the market tends to equilibrium close to the maximum capacity of extraction, while decline starts with the reduction of the resource base and the increase in the extraction costs. The domestication phase begins during the stabilization phase as long as technological and substitution constraints are not high enough and the demand remains reasonably stable. This theory of a revenue cycle is also supported by more recent empirical evidence for current NWFP produced in extractive reserves, most strikingly in the case of rubber over the last ten years. Although rubber is still their main product, its production has been constantly declining since the extractive reserves were created. At the beginning of the 1990s, rubber production in Brazil amounted to almost 25,000 tons a year; by the end of the decade it was less than 6,000 tons, a decline of more than 75 per cent (IBAMA, 2001). Furthermore, rubber plantations are increasing in other regions of Brazil, particularly in the state of Sao Paulo. Similar developments have been observed for other NWFP.[10]

Both the industrial analysis and the empirical evidence suggest that over a longer time horizon, extractive reserves are able to compete with plantations in the NFWP markets only under very restrictive conditions: (1) technology-induced cost savings in the NWFP industry are limited; (2) biological inputs are sufficiently expensive; and (3) there is spatial differentiation (Goeschl and Igliori, 2004).

Markets for New NWFP

While the probability that extractive reserves can generate a long-run revenue stream in existing NWFP markets is limited, the empirical evidence points to temporary monopolies for extractive reserves in early stages of the market. Particularly in rubber,[11] but also more recently in various nuts, fruits and oils, it has been observed that the initial phases of the NWFP market generate significant profits (Homma, 1992). There are various

10. One might argue that the case of Brazil nuts constitutes an exception, as there are currently no plantations cultivating this product. However, recent studies suggest that the viability of the extraction of Brazil nuts is problematic even without the competition of plantations (Assies, 1997; Escobal and Aldana, 2003). There is no guarantee that plantations would not be formed as production conditions improve.
11. It is sufficient here to mention the rubber boom in the late nineteenth and early twentieth centuries.

factors underlying these transitory periods of abnormal profits: competitors face fixed costs of market entry; initial production costs for competitors may be higher while cost reduction will not occur immediately; and the demand for products may be partly endogenous and hence initially clustered around the reserve where it enjoys a location advantage over competitors even when its unit costs are higher.

This potential for a temporary monopoly in a specific NWFP market raises the possibility of a development pathway for extractive reserves that builds on the abundant biological capital available therein. If reserves are in a position to generate a sequence of novel NWFP, they are rewarded for this activity with a sequence of temporary monopolies in the markets for these new products. Whether this strategy is economically feasible depends on the returns to product search activities carried out in the reserve. Two factors need to be considered: the cost of a product search carried out in the expectation of discovering a new NWFP with market potential; and the pool of potential products over which this search can be conducted. These factors will determine the returns to the search activity.

Markets for Biological Inputs

Besides pursuing a strategy of product discovery, the inexpensive access to a biological capital opens up a third strategy for extractive reserves. This is to supply the biological inputs that its plantation competitors will be demanding in order to control the cost function dynamics. Productivity in plantations is under constant pressure from diseases, pathogens and high-yield fatigue requiring more resources to be spent on replenishing the biological capital stock of production as the scale of operation increases (IRRDB, 1998; Rubber Board, 2002).

In Brazil and South Asia, originally resistant rubber clones used in plantations have lost resistance over time due to mutation in pathogens that survive in the epidemiologically favourable environment of plantations (Gonçalves, 2002). In fact, disease evolution represents a key limiting factor to increasing productivity and requires continuous R&D expenditure (IRRDB, 1998).[12] Several studies have shown the relevance of pest evolution in terms of yield losses in plantations (Radziah et al., 1996; Tan, 1990; Tan and John, 1985; Tan et al., 1992). For instance, looking at the development of originally disease-resistant clones planted in Malaysia, Tan and John (1985) find that after fifteen years, the average clone loses 31 per cent

12. According to IRRDB (1998), 'There has been limited success in breeding trees which are resistant to specific diseases and other conditions. Where such success has apparently been attained there is mounting evidence that in many cases present breeding techniques merely provide a *transient protection* as the pests or diseases adapt to overcome the resistance'.

of its attainable yield on account of becoming increasingly susceptibly to the two most important diseases alone.

Currently, there is no functioning market for such biological inputs, but it is clear that the presence of such a market would create incentives for reserves to study the traits of various tree varieties with respect to yield, disease resistance, quality of output and so on (Goeschl and Swanson, 2003; Rausser and Small, 2000). A key variable is the price of biological capital. The plantation has a reservation price, which corresponds to the cost associated with setting up an enterprise to collect natural resources in the Amazon region. However, the plantation can alternatively pay the price charged by the reserve to supply biological resources. If the latter is lower than the former, there are incentives for the plantation to buy biological inputs from the reserve. It is not unreasonable to assume that this inequality will be fulfilled given the labour-intensive production methods in the reserves, which allow those involved in extractive activities to observe the traits of various tree varieties. It is plausible, therefore, that extractive reserves will be able to identify characteristics valuable to plantations at a lower cost than a search process not relying on this prior information.

From the reserve's point of view, the most attractive feature of the supply of biological inputs to competitors is that it establishes a negative link between the development of the reserve's share of the market for NWFP and the revenue generated by the sale of inputs into NWFP production. Goeschl and Igliori (2004) show that to the extent that reserves can supply these biological inputs, some mitigating compensation for the revenue loss on the NWFP market is available.

PROPERTY RIGHTS

Our analysis of the production possibilities in extractive reserves has identified three main development pathways: the continuing production of existing NWFP; the development of new NWFP; and the supplying of biological inputs to other producers. For development to take place and revenues to be generated, it is not sufficient that the activities associated with these pathways are possible in principle. What is required are regimes of property rights inside and outside the reserves that are designed in such a way as to enable reserves to organize themselves around the activities involved in each of these trajectories. Ideally, we would hope to find property rights arrangements that support each of the three pathways in an optimal fashion and to find these arrangements both inside the reserve and in the wider economy with which the reserve is interacting. This means a set of property rights that enables the continued production and sale of existing NWFP, the innovation and marketing of novel NWFP, and the production and sale of biological inputs from the reserve. It is therefore relevant to examine the current property rights within and outside the reserve, with respect to their contribution to these three main development pathways.

Property Rights within the Reserve

Extractive reserves have an innovative and idiosyncratic internal property rights regime. It has a tripartite structure and can be seen as a co-management system involving the government, the community, and individuals.

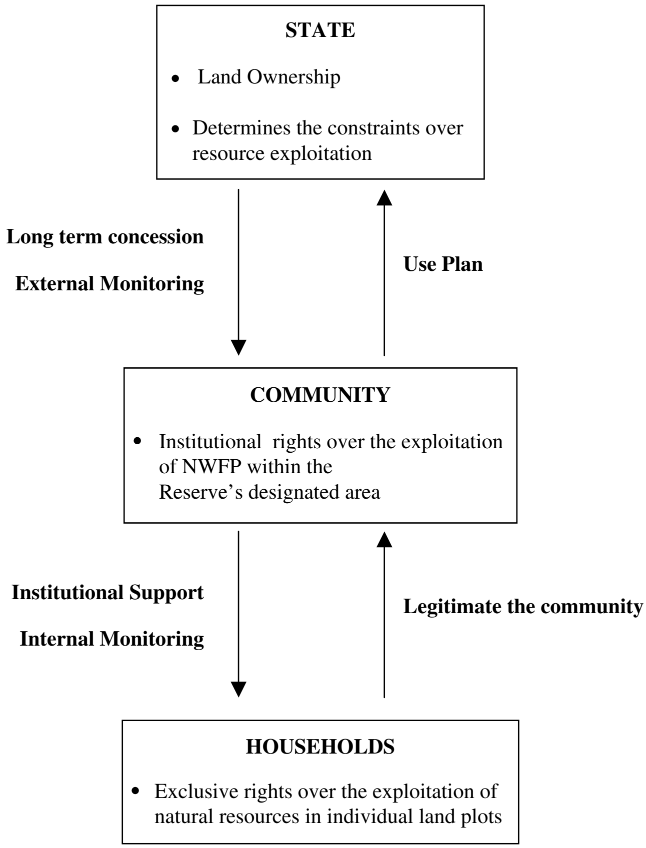
- The state owns the land and regulates the exploitation of the resources, giving the concessions to the communities and approving a use plan, and monitoring its compliance.
- Communities write the use plan, receive the long-term use concession of the natural resources, and are responsible for the full application and respect of the use-plan. Communities also negotiate with the government over the construction and management of health and education facilities in the reserves.
- The exploitation of the resources occurs on individual land plots (*colocações*). Each household organizes his/her extraction activities and cultivation of subsistence crops. Co-operation between households is more or less frequent depending on the particular case, but the results are privately appropriated.

The external property rights structure includes only NWFP. Households can sell and fully appropriate the value of their production of extractive products. They cannot sell the land or the exploitation rights. Figure 1 illustrates the property rights structure in a typical extractive reserve.

Rather than a top-down measure imposed by government agencies, extractive reserves were originally proposed by the rubber tappers themselves (see Allegretti, 2002). Potentially, this fact contributes to the compliance with respect to the constraints in resource exploitation prescribed by the use plan. Meaningful boundary definitions also contribute to avoiding conflicts, as they are determined in accordance with the already established exploitation methods and geographic coverage. The communal design of the reserve boundary provides access to natural resources such as rivers and lakes for all members of the community without the need for costly fencing. Communal facilities for storing and processing products can also be built without promoting disputes regarding land allocation.

As mentioned above, economic incentives in extractive reserves are ultimately assigned at the level of the individual who will benefit from his/her own production. Thus, the standard efficiency mechanism associated with private property is present in the property design of extractive reserves. Since members have no rights over the other members' production, consumption possibilities are connected with individual efforts and free-riding

Figure 1. Property Right Structure in a Typical Extractive Reserve



is avoided. On the other hand, households can benefit from collective initiatives to store, process, and market the products.

In order to assess the possibilities of a community to cope with the challenges of managing local natural resources based on collective action, Ostrom (1990) has elaborated seven 'design principles' that characterize robust institutions, present in several cases of common property resources (CPRs) which she studied.[13] Table 3 presents Ostrom's principles. Assessed

13. The term 'design principle' refers to 'an essential element or condition that helps to account for the success of these institutions in sustaining common property resources and gaining the compliance of generation after generation of appropriators of the rules in use' (Ostrom, 1990: 90).

Table 3. Design Principles Illustrated by Long-enduring CPR Institutions

1. Clearly defined boundaries. Individuals or households who have rights to withdraw resource units from CPR must be clearly defined, as must the boundaries of the CPR itself.
2. Congruence between appropriation and provision rules and local conditions. Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labour, material, and/or money.
3. Collective choice arrangements. Most individuals affected by the operational rules can participate in modifying the operational rules.
4. Monitoring. Monitors, who actively audit CPR conditions and appropriator behaviour, are accountable to appropriators or are the appropriators.
5. Graduated sanctions. Appropriators who violate operational rules are likely to be assessed with graduated sanctions (depending on the seriousness and context of the offence) by other appropriators, by officials accountable to these appropriators, or both.
6. Conflict-resolution mechanisms. Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.
7. Minimal recognition of rights to organize. The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.

Source: Ostrom (1990: 90).

against these criteria, extractive reserves have most of the necessary institutional characteristics to enhance the chances of a successful management of natural resource with an active role for the rural community:

1. boundaries and population with use rights are clearly defined;
2. although approved by the government, everyone involved in the community designs operational rules;
3. monitors are the appropriators themselves;
4. there is an association, which is a local forum for conflict resolution; for more serious or complex problems there is also the National Council of Rubber Tappers, which brings together the associations of all reserves. The government also provides an institution structure which represents the communities called the National Centre for the Sustainable Development of Traditional Populations (CNPT) based in the Ministry of the Environment;
5. governmental authorities do not challenge autonomous institutional building; on the contrary there are many initiatives sponsored by the government and NGOs focused on governance and institution building within the extractive reserves.

Overall, therefore, the structure of property rights within reserves creates incentives that are compatible with a conservative use of the biological capital base and provides incentives for the extraction of a defined set of NWFP in the extractive reserves. This structure ensures that contributions from members of the community to the specific extractive activities in the reserves will be rewarded in congruence with local production conditions.

While compatible with established NWFP production, the adequacy of this property rights structure for supporting alternative activities in the reserve is less clear-cut. This support is important given the alternative development pathways highlighted in the previous section. There is little evidence that the appropriation and provision rules reward the two critical inputs required to access the development pathways of diversification and biological input supply — search activity directed towards the discovery of new NWFP with revenue potential, which is the critical input required for diversification; and accumulation and disclosure of knowledge about production-relevant characteristics of the local biological capital stock, which is required to generate a functioning supply of biological inputs.

In the case of search activity, since individuals in the reserves cannot exclude others within the reserve from benefiting from potential discoveries, there are no well-defined incentives for putting individual effort into research and development activities. In addition, the property rights structure does not direct the human capital base shared by the community towards the aggregation of expertise necessary to carry out systematic research and product development. This can be potentially overcome if there is systematic co-operation between the communities and research institutions or NGOs, which in fact has been happening in some cases (Brown and Rosendo, 2000; Hall, 1997). While the economic effectiveness of such partnerships is still to be verified, a more direct approach would be to reward research and development activities within the reserves more explicitly.

In the case of knowledge about production-relevant characteristics of the local biological capital stock, there is currently no mechanism to reward the information an individual has with respect to the biological characteristics, productive properties and resistance to diseases that different varieties might possess. None of these inputs is therefore considered under the use plan or included in the quasi-contractual relationships between households and the wider community such as those that govern the benefit sharing over revenues from the marketing of NWFP.

Our finding that the internal property rights structure is deficient is not to suggest that it positively obstructs the development of novel NWFP or biological inputs. But it highlights that there is a lack of systematic support for such activities and that — at least at the margin, but probably more extensively, resources within the reserves will not be directed towards these activities.

Property Rights in the Wider Economy

In a context in which extractive reserves are expected to participate in a broad set of markets, external property rights (in the sense of rights over the reserve's outputs in the wider economy) are as relevant as their internal structure. One obvious example is in the area of existing NWFP: since the property rights over the output of the production system can be easily defined and are well-established both within and outside the reserve, resources and labour can be devoted to these activities in the certain expectation that revenues will be generated. This is because the existing NWFP products such as rubber and nuts have the classical characteristics of private goods: they are both excludable and rivalrous in consumption and protected by adequate legal titles. This rights structure over NWFP in the wider economy facilitates the definition of boundaries and helps ensure congruence between input provision and share of benefits from the output within the reserve. The production of existing NWFP is therefore adequately supported.

With respect to the discovery of new marketable NWFP and the supply of biological inputs, the property rights structure in the wider economy is much less supportive. The first problem is that the type of discoveries likely to occur in extractive reserves do not enjoy the same property protection as discoveries typical for a laboratory. The discoveries will for the most part consist of finding new uses for existing plants and material. To qualify for protection under intellectual property rights, the search procedure would have to involve the legal requirement of an 'innovative step' leading to the creation of an entirely novel product. Indigenous innovations have usually failed to meet this criterion on technical grounds and extractive reserves are therefore not protected from imitating companies through intellectual property rights in the intangible components of their discovery. For the tangible outputs, at least, the property rights in the new NWFP itself are again compatible with rewarding inputs since those products themselves have the classical features of private goods.

The case of new NWFP contrasts with the case of biological inputs. Although the Convention of Biological Diversity has motivated systematic discussions about legislative proposals aiming to protect indigenous rights related to biological diversity, the property rights over biological inputs in their natural state are currently in the public domain (see Arcanjo, 2000; Dutfield, 2000). This means that no property rights in the local biological capital are assigned to the community living in the reserve. The obvious consequence is that the supply of biological inputs in a narrow sense cannot generate economic rents for the reserve under the current set of property rights.[14] In this, external property rights fail to provide any support for activities directed at identifying economically feasible biological inputs in reserves.

DISCUSSION AND CONCLUSIONS

Theoretical and empirical studies indicate that pure property rights arrangements (open access, common property, private property, public property)

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14. In this article we emphasize the possibility for the communities to benefit from supplying biological material to plantations aiming to control pests and diseases. However, one could imagine other applications for biological inputs such as those attached to medicinal, pharmaceutical or cosmetic products.

cannot generally guarantee efficient management of natural resources (Baland and Platteau, 1996; Seabright, 1993). Instead, they suggest that co-managed structures frequently offer alternatives for balancing the development–conservation trade-off.

Extractive reserves combine public, common and private property rights with the aim of providing incentives for achieving the joint objective of biodiversity conservation and economic development, for populations selling NWFP in a market economy without converting designated forested areas. The analysis presented in this article suggests that the current set of property rights in extractive reserves is primarily based around the continued extraction of established NWFP. Within this narrow domain, the property rights structure represents a very effective response to the competing objectives of conservation and income generation.

However, considering a wider choice of development pathways, the adequacy of the current property rights structure is less apparent. Rewarding contributions to an expansion of products that the community markets is conducive to a pathway directed towards diversification. Likewise, rewarding the supply of biological inputs and knowledge about the characteristics of these inputs contributes to a development process built around biological input supply. Incentives directed at pursuing these development pathways are lacking.

This finding is problematic when set into the development context: the current property rights structure encourages the reliance on only one of the three possible pathways. This limits the width of the revenue base on which economic development of the extractive reserve could be based. Over time, this limitation becomes even more problematic, as both analytical and empirical evidence suggest that revenues from existing NWFP production will be maintained only under very restricted conditions. The current property rights regime also contains features that in themselves undermine the development objective of the extractive reserves. For example, the fact that there are no functioning property rights for biological inputs, while at the same time, the government conserves biological capital on public land (notably extractive reserves), means that plantations benefit from an inexpensive supply of these essential inputs into NWFP production. This reduces plantations' expenses for inputs, enabling them to compete even more effectively with extractive reserves on the NWFP markets that are supposed to generate the revenues to develop reserves economically. In such cases, the conservation and development objectives are clearly in conflict and require adjustment.

These rather discouraging conclusions highlight the challenges ahead for extractive reserves. Firstly, in the light of the political difficulties inherent in establishing property rights over biological materials,[15] it is not clear

15. Witness, for example, the debates over the national implementation of the Convention on Biological Diversity in the Brazilian Congress.

whether property rights will be changed to enhance the chances of extractive reserves to survive in the long run. That change is not impossible is illustrated by that fact that Brazilian legislation has in the recent past addressed property rights deficiencies that share some of the same problems as those faced by extractive reserves. A 1997 law (Law 9,456/97) has brought Brazil in line with the common standard on intellectual property rights in plant varieties by creating plant breeders' rights. More recently a provisional act (Number 2, 189-16/2001) was approved regulating access to genetic resources and associated traditional knowledge. This act states that institutions must have authorization from the federal government before carrying out activities of bioprospection, scientific research or technological development. Moreover the act establishes that contracts must be signed between firms and traditional communities when the resources come from local areas such as extractive reserves. Even though the precise interpretation of this act is currently subject to debate (see Azevedo, 2005), it demonstrates that policy makers are responding to the challenges inherent in designing property rights for biological resources. If this response could be widened to embrace emerging policy concepts such as farmers' rights, there is potential for significant benefits to the regimes under which extractive reserves are operating.

Secondly, the limitations of a property rights structure narrowly focused on the management of the natural resources base of the community are quite evident, particularly when communities operating a constrained production system are expected to develop economically in market competition with unconstrained firms. For development to take place, the dynamic processes of product discovery and the creation of markets for biological inputs set in a broader context must be taken into account, a design process that has to go beyond the static context of mixed property rights assigned to extractive reserves. In other words, policy makers need to address the fundamental contradiction between the static nature of property rights in the reserve and the economic dynamics of competition in the markets in which the reserves are expected to operate.

The difficulties of long-run viability of NWFP extraction have been recognized by NGOs, governments, international agencies and the communities themselves. As mentioned above, solutions so far have focused on enhancing income opportunities by introducing other activities with higher value added for the communities, rather than examining the structural property rights features of the concept of extractive reserves. Whether such initiatives will only induce changes at the margins (mainly in the previously approved use plans) or whether they will, if successful, undermine the original concept of extractive reserves, remains to be seen. At the moment, these activities are still in their early stages and it is not clear whether they will provide long-run positive returns for the communities.

In principle, there is no reason why carefully designed local property systems cannot successfully address the joint objectives of conservation and development. Under the current property rights structures, however, this success is likely to elude communities operating in extractive reserves, because their design fails to take into account the relationship between the indigenous communities and the competitors beyond their internal remit. A modification of internal and external property rights will be a prerequisite for these communities to truly benefit from the unique asset base that they are managing.

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