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Amazon Forestry Tranformed: Integrating Knowledge for Smallholder Timber Managemet in Eastern Brazil

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Abstract Recent discussions of local knowledge emphasize its dynamic nature invoking local peoples' ability to effectively integrate traditional or local with science-based or "modern" knowledges. The smallholder timber industry of the Amazon's estuarine floodplain provides an outstanding example of local patterns of resource management and economic activities transformed from within by smallholder farmers who participated in the industrial timber boom of the 1970s and 1980s. These farmers of eastern Amazonia have developed a vertically integrated local industry based on expertise reflecting profound locally developed knowledge of specific forests and management of ecological processes, individual observation and experimentation, as well as concepts and practices derived from temporary employment by large-scale industrial timber firms. At each stage of the smallholder forestry process—from managing natural regeneration to running small sawmills and marketing lumber—local managers apply an innovative set of practices reflecting their diverse experiences. This combination of technical, market, and ecological knowledge results in forests, timber markets, and economic patterns that do not correspond to many of the widely-held generalizations concerning either local or industrial tropical timber exploitation. This article uses data from 7 years of research in the Amazon floodplain.

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Introduction

Many recent discussions of local knowledge in natural resource management emphasize its dynamic nature and its "hybridity," invoking local peoples' ability to effectively integrate traditional or local knowledge with science-based or other "modern" knowledges (Agrawal 2005, Alexiades 1999, Antweiler, 2004, Gupta 1998, Padoch and de Jong 1995). The emphasis in much of the discussion has been on conflicts and accommodations between the knowledge, or practices, of local or rural peoples and those introduced to communities by agents of state- and NGO-sanctioned development initiatives. Relatively less discussion has focused on how local knowledge and patterns of agriculture and natural resource management emerge from encounters between local knowledge or localized practice with markets, wage labor and other contemporary rural realities.

In reality, sources of knowledge and technology are many and diverse. Local sources of knowledge related to agriculture and natural resource management include farmer-to-farmer learning, often from neighbors and relatives or other members of cooperative farm groups, and on-farm experimentation and innovation. Exogenous sources include not only the oft-discussed agricultural extension programs (Benad and Lupanga 1991; Gupta 1998), but also immigrants who bring it from their places of origin (Rudel 1993), migrants passing through an area (Guillaud 1991, Hanyani-Mlambo and Hebinck 1996), and off-farm wage labor (Tiffen *et al.* 1994).

Off-farm wage labor is rarely acknowledged as a source of new knowledge in agricultural development research. This omission is surprising given that wage labor is so common among farmers. Political and economic realities increasingly lead people to leave their fields in search of economic opportunities, either permanently or temporarily, and off-farm work has recently been an area of intense interest among economists, geographers, and other scholars (Barrett, Reardon and Webb 2001, Booth 2002, Bryceson 1996, 1999, MacDonald 1996, Meert *et al.* 2005, Rudel, Perez-Lugo and Zichal 2000). Furthermore, many, if not most farmers at some time in their lives secure seasonal labor in the industrial agriculture or forestry sectors. Indeed, rural agriculture has historically absorbed much of the off-farm labor in industrial sectors that was laid off during economic downturns (Zhang *et al.* 2001).

Until recently, wage labor was generally perceived to be bad for the farm, bad for the family and bad for the rural community. Some economists and development practitioners are now emphasizing the crucial income support that off-farm labor income provides rural families, although processes of "de-agrarianization" and "de-peasantization" that may result from this worldwide phenomenon do cause concern (Bryceson 1996, 1999, de Haan 1999). Off-farm employment does claim labor that might have been available for household production and may lead to the disintegration of the household and of the rural community. While eventual loss of knowledge and custom may result, this loss is often only temporary. While immigrant workers, particularly transnational immigrants, often do not return to their households or communities, resulting in the displacement of populations (Moberg 1996), seasonal or boom-time migrant workers are more likely to return home in the off-season or when the industry goes bust (Zhang *et al.* 2001).

One of the positive aspects of wage labor that is not readily acknowledged in the literature is that through employment in plantations, forests, ranches and mills, farmers are exposed to new places, new social settings, and new production systems that may stimulate innovation at home. Padoch and de Jong (1990) described the acquisition of knowledge by migrant forest-product collectors in Peru. Off-farm labor can also provide much-needed cash income to establish a new business (Moberg 1996), as well as new skills, ideas and germplasm for on-farm improvement. This effect has been shown among farmers in Guatemala who began to produce non-traditional vegetables after several members of the community worked in agricultural commerce in the nearby city and learned the skills of trade and the value of the crops (Goldin 1996). We shall show here a case where rural residents made great gains in household income, market networks, and forest management by "hybridizing" their local knowledge with that gained during work experience in a large-scale timber industry.

Knowledge Transfer

Most research on change in local farmers' knowledge deals with how farmers respond to technologies or improved crop varieties that are introduced by outside entities such as agricultural extension agents (e.g., Forte-Gardner, Young and Dillman 2004, Ross 2001, Wilken 1989). Some researchers strongly criticize the introduction of "scientific" innovations by development agents. While some have focused on the role of knowledge and the relations of power that are affected by the introduction of development projects (e.g., Agrawal 1999, Escobar 1995), many others have examined the adverse environmental and cultural changes resulting from the transfer of inappropriate technologies (see, for example, contributions in Scoones and Thompson, 1994).

Arguments challenging the appropriateness of knowledge and technology introduced by development agents mount when loss of so-called traditional farming practices and agrobiodiversity is perceived to result from these introductions. Recently, it has been recognized that "scientific" knowledge and technologies are most appropriate when they build upon or enhance local practices (e.g., Bentley *et al.* 2004, DeWalt 1994, Sillitoe and Barr 2004, Walker *et al.* 1999) rather than attempt to replace them, a notion that has frequently characterized the approach of development agents (Richards 1993).

Farmers are adept, yet selective about adopting foreign technologies presented through extension projects, and some farmers are more capable than others of adapting to new market or environmental conditions (Padoch and de Jong 1992). This is a critical skill to develop since crops, technologies or practices that are incompatible with local climatic, soil, social, or economic conditions are bound to fail in the long run and may in fact result in the degradation of local conditions (Ali 2004, Pinchón 1996, Ridgely and Brush 1992). Market forces that stimulate the production of improved crop varieties are often blamed for the loss of traditional practices and local crop varieties that have been developed by local farmers over generations, as well as for resulting environmental degradation (Harms 1991, Tillmann 1991).

Positive Transformation of Knowledge

With some prominent exceptions (Siebers 2003, Tiffen, Mortimore and Gichuki 1994), the literature on traditional or indigenous knowledge tends to minimize the positive transformation of local production systems by knowledge obtained outside the community. This perspective ignores an important dynamic in the evolution of farming practices and natural resource use: the integration of knowledge and

technology acquired through labor outside the community by small farmers with their own local or endogenous knowledge.

We present a case wherein local farmers have themselves integrated exogenous technology and knowledge, gained while working for the large-scale timber industry, with their own local knowledge of the environment and their silvicultural practices in a classic case of hybridity, to develop a successful local industry. This case is unusual not only because the means by which knowledge is acquired—wage labor—is rarely discussed in the literature on traditional or indigenous knowledge systems, but also because the source of the knowledge is the timber industry, which is traditionally viewed as one of the most notorious "bad guys" of Amazonian resource use.

This case study resulted from our field research on the changing production systems, forest management and sawmill operations of smallholder farmers in the estuarine floodplains of Amapá since 1992.[1] The communities lie near the north bank of the mouth of the Amazon River in the state of Amapá, near to the capital city of Macapá. The communities of the region have a varied history of settlement and resource use. Most of the region's rural residents and most of the households we studied, however, have lived in Amapá or neighboring areas of the state of Pará for several generations and have participated in several booms and busts in forest products over the last half-century.

In the original field study about rural resource management, in 1991, we initially interviewed members of 140 of the 185 families residing in the region concerning their production, extraction and resource management activities. For 7 years after that we followed in detail the forest and agricultural resource production and use of a smaller sample of 12 households, all of which either ran, during that time period, a small sawmill or harvested and sold timber to one. This case study is based largely on information gathered during the time period between 1991 and 1998, but includes some updated information to the present.

The study was conducted in this region because forestry had recently acquired a new local importance following several changes in agricultural production and prices that had devastating effects on cash crops as a source of income in much of Amazonia, including Amapá. With the development of transportation and communications between Amazonia and the industrial south since the 1980s, the Amazon region has become more integrated into national market networks. This has allowed for the transport to Amazon towns of high volumes of industrialized agricultural products, such as maize, beans and rice, produced inexpensively in the industrial south. Amazonian smallholder farmers have since found commercial crop production less economically rewarding because they cannot compete with the high volume, uniform quality and low prices of those crops that had provided significant household income in the past. As an adaptive measure, Amapá smallholders increased their production of and dependence on bananas, which are not imported extensively from the south, as a source of household cash income. In the 1980 and 1990s, however, an epidemic of Moko disease (*Ralstonia solanacearum*), a bacterial-caused wilt disease, almost eliminated field crop production of bananas in the region (Coelho Netto *et al.* 2004). The sharp decline in banana production and low prices for conventional cash crops left smallholder farmers with few sources of stable household income. A local response to these changes has been an increasing management emphasis on forest-based products, including timber and fruits. Thus, timber production has become increasingly important to smallholder households. They have been able to shift from agricultural crops to forest crops because of the flexibility of their production systems and the integral part that forests play in their life and livelihoods.

Three characteristics of smallholder farming identified in this and other studies provide the foundation for our case study. First, farmers adopt or "borrow" ideas, technologies or practices from a diversity of sources both within and outside of the community. This feature is a cornerstone of their ability to adapt to the changing market environment and other factors. Second, the acquisition and incorporation of the new knowledge or innovations tends to be opportunistic, and farmers have a strong "improvisational capacity" (Richards 1993). Third, and as a result of these first two, knowledge and farm practices are in a constantly evolving state as farmers carry out their "tradition of change," as described for Peru by Pinedo-Vasquez *et al.* (2002). Farmers' constant adaptation to changing economic, political, biophysical, and social conditions has allowed rural residents to subsist in Amazonia for generations. This aspect of periodic change in economic activities in Amazonia and in other regions has to date been largely ignored by researchers. Finally, this case is situated in a time and place, the estuarine Amazon in the 1980s and 1990s, that was characterized by an economic oscillation associated with a boom-bust cycle in timber.

Timber Boom, Timber Bust

Recurrent economic booms and busts, often based on extraction of forest and river products, have punctuated

[1] The research methods and detailed results from that field research are presented in Pinedo-Vasquez *et al.* (2001), in *Human Ecology* 29:2 (219–239).

the history of Amazonia. While the rubber boom of the late nineteenth and early twentieth centuries is by far the most prominent of these, it was both preceded and succeeded by a large number of other important booms and busts of native natural resources, including those for rosewood (*Aniba rosaeodora*), *timbó* or barbasco (*Lonchocarpus* sp.), and *leche caspi* (*Couma macrocarpa*). More recently there has been a basin-wide boom for high-value timber such as mahogany (*Swietenia macrophylla*), tropical cedar (*Cedrela odorata*) and *virola* (*Virola surinamensis*), to name a few.

These swings in the economic fortunes of Amazonian societies are generally believed to have yielded but momentary benefits for a select group of people, while damaging, if not destroying, many rural communities and their resource management practices and leading to a serious erosion of resource management knowledge (Hecht and Cockburn 1989, Weinstein 1983). Padoch and de Jong (1990) for instance recount the long history of disruption of one Amazon floodplain community by the series of economic booms and busts that enveloped the Iquitos region of Peru in the mid-twentieth century. Similarly, Smith (1995) discusses the devastating effects of the collapse of jute production in the floodplains of Brazilian Amazonia on both rural and urban inhabitants in the last several decades.

The boom in extraction of valuable hardwood timbers that continues in some areas of Amazonia has also had disruptive effects on many Amazonian environments (Nepstad *et al.* 1999), as well as on the social networks of households, villages, towns and cities throughout the region, over the past several decades. In the estuarine region of the state of Amapá we have heard many personal narratives of community dissolution, urban migration and family disruption as a consequence of the timber boom and bust cycle. The results are not all bad, though, as we report here. A positive outcome of the timber boom emerged after the collapse of the large-scale timber business in Amapá. It turns out that residents gained valuable knowledge during employment in the industrial timber sector. Out of the integration of that exogenous knowledge with their local knowledge, coupled with the adaptation of industrial technologies to local conditions and a smaller scale, a new type of timber industry emerged and continues to thrive today. This integration of knowledges and technologies provided numerous rural families with the conditions for the establishment of alternative small-scale household-based timber processing businesses, which in turn permitted some rural residents to resituate themselves in the timber industry of the region.

Historical records indicate that substantial stocks of commercial timber species were identified in the estuarine floodplain forests of Amapá by the early twentieth century, eventually leading to flourishing timber industries in Amazonia (McGrath 1955). These timber industries were a major source of off-farm employment for rural residents of the estuarine floodplain of the states of Amapá and Pará (Barros and Uhl 1995). During the several decades that the industrial timber boom lasted, local residents, many of whom grew up working in the timber industry, benefited from its many different aspects, ranging from extracting timber from their own land or the forest around them, to service jobs supported by the presence of the industry in the region, and operating wood processing machinery in the large sawmills.

Industry people had no illusions about the sustainability of the timber boom in this region. Because the large-scale industry was interested in only a handful of tree species at any given time, and because the industry was able to migrate from one region of Amazonia to another to seek the most economically advantageous conditions, the stocks of valuable hardwoods in this region were largely exhausted by the early 1970s, and all mills closed down or moved to other regions by the early 1980s (Barros and Uhl 1995, Pinedo-Vasquez *et al.* 2001). Many of the local residents were hard-hit by the rapid economic decline in the region. At the same time, workers and families began to adapt their income strategies to old and new economic opportunities, as they have done for generations. One of those strategies is timber management and is described in the next section.

Timber Production in the Várzea of Amapá

The management of a plethora of products in a complex and dynamic portfolio of fields, forests and fallows has been described for rural communities up and down the Amazon. Small farmers of the Amapá estuary—like other rural Amazonians—typically employ a complex and dynamic set of production technologies to make a living (Anderson 1992, Hiraoka 1992, Padoch and De Jong 1989). The many variations of these systems and their creators' successful response to market opportunities have also been discussed (Padoch and de Jong 1995, Sears and Pinedo-Vasquez 2004). The management systems we observed in estuarine communities of Amapá are examples of such systems, in this case with timber as a leading product at the moment.

Floodplain smallholders of the region have a long history of managing trees in their fields, fallows, house gardens and forests for household uses. Forestry is an integral part in their production systems and is carried out through a series of concurrent and complementary processes (Padoch and Pinedo-Vasquez 2006, Pinedo-Vasquez 1995, Sears and Pinedo-Vasquez 2004). The management techniques employed by the estuarine farmers of Amapá are

part of an elaborate system that builds on the natural dynamics of vegetation and stand development and utilizes the favorable aspects of each stage of land use. Simply described, on a typical swidden-fallow farm farmers maintain one or several active fields where a variety of annual crops are grown for an average of two years until production of those decline. At this point the farmer ceases intensive crop production, leaving the natural vegetation to regenerate in an effort to recuperate the soil fertility. The growth of timber and other useful woody species is encouraged during this transition from field to fallow, particularly during the final season of intensive cropping when farmers encourage or assist in the development of valuable tree seedlings that establish through natural regeneration or are planted. This is usually done by weeding around the seedlings or freeing them from vines.

Fallow management for timber production focuses on juveniles and on the removal of selected vines, shrubs and trees to create the gradients of light and humidity necessary for the natural regeneration of a diversity of timber species. Timber management in fields and house gardens also focuses on the protection of seed producer trees and seedlings. Selected seeds and seedlings from these trees are planted or transplanted into more hospitable environments. Seedlings are managed by weeding and are protected from insects, rodents and floods. The house garden is also an important component of the system serving as nursery and experimental plot where farmers test selected varieties and species of plants, including timber species.

This process of fallow enrichment allows farmers to increase the utility and option value of their landholdings while allowing for the necessary recuperation of soil fertility. When one annual crop field is allowed to fallow, they open another field, usually from an old fallow. A trend noted of late in the region, however, is a decrease in the area dedicated to annual crops and an increase in area of production forest (Brondízio *et al.* 1994, Brondizio 1999).

The majority of residents in the area also plant tropical cedar (*Cedrela* spp.) and other valuable hardwood timber trees on their land (Pinedo-Vasquez and Rabelo 2002). Pinedo-Vasquez et al. (2001) provide evidence that incorporating timber management into an existing swidden-fallow agricultural system enhances the value of labor and inputs while increasing revenue and option value.

Efficiency in management of seedlings, juveniles and adult trees in the mosaic of productive units on the farm—the fields, fallows, house gardens and forests—allows smallholders to maintain large stocks of valuable timber on their properties as well as non-timber forest products (NTFPs), including firewood, thatch, medicinals and fruit. Individuals of commercial size of the several dozen economically important timber species were found in all these land use types, but while forests contain the highest density (Pinedo-Vasquez *et al.* 2001), the majority of individuals of commercial size of the high-value timber species that were once featured during the timber boom are now found only in house gardens (Pinedo-Vasquez and Rabelo 2002). This pattern indicates the depletion of these resources,in fact their commercial extinction in forests and fallows. These valuable trees are protected in the house gardens as seed producers or kept as sources of emergency cash.

Integration of Knowledges

The 1960s and 1970s saw a number of industrial sawmills established in Amapá during the timber boom in the region. These mills drew a large workforce from the nearby towns and villages to engage in logging, milling and transport. The people of the region easily moved toward these new centers of economic activity as they had in the past, chasing employment into the forest to extract rubber, collect seeds, and plant and tend seedlings. What is remarkable is the breadth of knowledge these mobile and flexible residents have collected during each stage in their employment history. They accumulated knowledge about technologies and practices, information about business and politics, and productive skills that would serve them elsewhere.

In this case of the timber boom in Amapá, workers learned different skills during their participation in industrial activities (Table I). Some workers learned technical skills, such as the rudiments of wood processing, including how to run and maintain the machinery. Others learned managerial and marketing skills related to how sawmills and logging businesses were managed. On the technical side of forestry they learned to value, recognize and promote the characteristics of quality timber using pre- and post-harvest management techniques. Probably the most important thing that the returning farmers took with them was an appreciation of the economic value of the wood resources on their land and the potential gains to be realized by managing timber. The outcome was a generation of people with knowledge and skills in lumbering and milling. These people then put those skills to work at a smaller scale, in a hybrid system, effectively transforming the rural economy in the region.

Eventually, either for lack of commercial logs or mismanagement of operations, or both, the industrial mills in Amapá closed. The economic bust period in the region after the collapse of the industrial mills was characterized by a void in employment opportunities and a dramatic gap in lumber supply, even to the local market. The loggers, millers and associated workers who had become dependent on wages were compelled to find other sources of income.

Most of these workers moved to the cities of Santana and Macapá to seek urban employment, but some returned to their villages and farms. The returning farmers brought their observations of forestry practices, sawmill operations and marketing strategies back to their farms and forests. The conditions of the market and income void, coupled with the decline in profitability of agricultural crops mentioned above stimulated some of the former industry employees and their relatives to manage and process timber.

These innovative residents utilized the integration of the new knowledge learned from employment in the industry with their local knowledge (see Table I). For example, because most of these former employees had been farmers or came from farmer households, they already possessed an intimate knowledge of the forests, trees and productivity of the land. They possessed a wealth of local ecological knowledge about where and how trees grow and respond to different management activities. They combined knowledge they had gained from commercial logging for the company about pre-harvest management techniques and selection criteria for high-quality trees with their own experience of locally-appropriate management techniques to improve production on their landholdings. At the market level, all producers and millers in the region learned the commercial value of timber during the timber boom, which inspired some to manage their trees for production.

The breadth of their knowledge and skill allowed for the emergence of a network of producers, processors and consumers that formed a vertically integrated, small-scale timber industry in the region. As evidence, during the timber bust in the 1970s dozens of small sawmills sprang up in the region to fill the void left by the withdrawal of the large-scale operations. Some of these family-operated sawmills have fared better than others, and currently 14 of them are still operating at the mouths of the Mazagão and Ajudante rivers in the Brazilian state of Amapá. These are all owned and operated by former employees of the larger mills or their close relatives. Through relationships in the extended social network, the mill owners have been able to develop marketing networks. This allows them to process a wide diversity of tree species to provide a variety of products from high-quality "polished" boards to wood for school furniture to parquet flooring. These family mills serve both local and regional markets.

The local vertical integration of the industry depends on family ties, good neighbor relations and trustworthy transaction partners. A producer may sell logs to a neighbor for milling. The miller, in turn, sells only to someone she/he has known for a long time and trusts; it may or may not be a family member. This transporter then sells or delivers the lumber to another *conhecido*, or known person, in the city. Anywhere along the line of transactions the whole lot of wood, or even cash, could "disappear" if relationships are not nurtured.

Mill owners, who also manage timber, are not alone in profiting from this new industry. Many local farmers, some of whom also had worked in the forestry industry during the boom, supply an assortment of woods to the mills. Local farmers know the distribution and inventory of trees on their lands, the wood characteristics and uses of many species, and the growth conditions they require. In fact, producers in the region have adapted their flexible systems of resource management, as described above and by Pinedo-Vasquez and Rabelo (2002) and Sears and Pinedo-Vasquez (2004), to the local market opportunities of "post-timber-boom" Amazonia by increasingly integrating wood production into their existing production systems. Our results from a study of the household economy during 1996 and 1998, reported in Pinedo-Vasquez *et al.* (2001), indicates that producers sold a diversity of products, from pole timber for construction infrastructure to rough boards and larger pieces for furniture making. During that period each family profited on average US $6240 from the sale of sawlogs, pole timber and fuelwood from their land-

Table I Sources and Types of Knowledge in the Macapá Timber Sector Used by Local Farmers and Sawmill Operators

	Ecological	Technical	Market
Local knowledge	Species inventory and distribution	Tree and stand management techniques	Market networks
	Growth conditions required by tree species		Local timber needs; market niches
	Species response to management activities		Wood characteristics of tree species
Learned from industry		Pre-harvest management techniques to produce higher quality timber	Value of timber in the market
		Management and selection for high quality individual trees	Recognition of the economic value of timber management in production systems
		Operation and maintenance of small sawmill equipment	

holdings, utilizing trees from the set of 36 commercial species found in the forests, fields and house gardens in the sample. The vast majority of income came from sale of poles ($5685/y), many of which were cut during thinning operations in the fallows. Households sold on average 46 m^3 of commercial sawlogs per year, ranging from 28 to 65 m^3, for a $460 profit from sawlogs (Pinedo-Vasquez and Rabelo 2002, Pinedo-Vasquez *et al.* 2001).

A Diversity of Family-run Sawmills

Each participant in the new hybrid timber business has a different story of integrating knowledges and skills to help establish the local industry. Two cases are illustrative of the ingenuity and perseverance of those who participated in the boom-time timber industry and have used both the post-boom market void as well as some of the abandoned equipment to their own advantage and to that of other members of their community.

Since childhood, Pancho[2] worked alongside his father in the timber industry in the várzea in the Amazon river estuary. In 1977, Pancho lost his job when the timber industry was in decline. During the following 2 years he worked as a laborer for a mining company in the city of Santana, neighboring Macapá, and managed to save some money before being laid off. In 1979, he was able to purchase land near Macapá, as did many families that had been migrating locally for the past several decades, following employment and land opportunities. Pancho decided to establish a small sawmill on his land. He salvaged parts from the mills abandoned on the várzea by the large industry during the timber bust period and uses a motor from a fishing boat in his redesigned sawmill.

Pancho started business by milling the hardwood timber *pau mulato* (*Calycophyllum spruceanum*) along with 24 other fast-growing species. He supplemented his own supply of timber with logs purchased from neighbors. To ensure buyers for the lumber he produced early on, Pancho established a contract with a company that was building river piers and identified and sold to other specific markets. Eventually, he met marketers who sell wood in the city to poor people in shantytowns. He sold his rough boards and pole-sized roundwood to those marketers and through them met other wood dealers from the premier Amazonian city, Belém do Pará. Pancho, one of the pioneers who have been in business in the region for over 20 years, eventually came to sell a diversity of products in the regional market using the full spectrum of timber species locally available.

Pancho also embraced the government's efforts to control logging and ensure sustainable management of this valuable natural resource. In 2000, when the new federal forestry regulations required all timber operations to present an approved management plan, Pancho was one of the first to develop such a plan and begin a formal cutting cycle on his 100 ha of forest and fallow. He based his management plan on growth and yield data that he and others had collected over the years. His management plan integrates the production of fast-growing species and the conservation of valuable slow-growing hardwood species such as *jacareuba* (*Calophyllum brasiliense*). He explains that his major interest is in maintaining a gradient of gaps and mosaics that encourage the natural regeneration of both fast and slow growth timber species. Pancho continues to incorporate the production of agricultural crops such as bananas and sugarcane in his forestry operation. These are his preferred crops for managing natural regeneration in fields and gaps and for transplanting seedlings of slow-growing hardwoods.

In 2004, while Pancho was in the city, and the sawmill was temporarily closed down, thieves stole the motor and tools from the sawmill. Pancho decided to stop operation permanently and to devote his time to the extraction and sale of timber from his property to other mills and to marketing of *açaí* (*Euterpe oleracea*) fruit. Production and sale of this palm fruit has recently been enjoying a significant boom throughout the estuary (Brondizio, Safar and Siqueira 2002). This way Pancho still enjoys a good income from the management of his garden, fallows, and fields and has taken up residence in the nearby town of Mazagão Velho.

Maria José's husband worked in a sawmill at the mouth of the Mazagão river since childhood. In 1982 the timber company collapsed and he was laid off. By this time some small mills, such as Pancho's, were already operating, and the couple was able to sell wood to them from their own secondary forests. Eventually, Maria José discovered through relatives who regularly traveled to or lived part-time in the urban center that there was a need in the rapidly expanding municipality for lumber to build furniture for schools and other public institutions. She decided to establish her own sawmill to take advantage of this market niche. Her husband designed the mill and she built it. As many new operators did during this period, Maria José also salvaged mechanical parts from an abandoned sawmill on the várzea. The new mill was and continues to be powered by a diesel boat motor.

From the start Maria José specialized in processing sawlogs and producing high-quality boards that fetched a higher price in the market than the rough-hewn lumber provided by other mills. To achieve this quality she started with only quality sawlogs. Then she used a technique to

[2] Fictitious names are used here.

"polish" the boards that she invented using a planing mechanism she developed using carpentry tools and parts from an automobile chassis. For this, Maria José is known for the quality of boards she produces, not the volume. While she has managed timber on her restored pastures, having let go of her cattle when the mill began to take up too much of her time and energy, she also bought sawlogs from neighbors and provided advice on producing quality logs. Other members of her household have worked for Maria José for more than 15 years. In 2004 Maria José gave over control of the sawmill to her 25-year-old son, Benedito. The latter does not have the same personal contacts in the urban areas that his mother enjoyed. He thus prefers to process logs as a service to the producers in the region rather than selling the lumber in the urban market. As payment for his services he usually keeps 40% of the boards that he produces at the mill, while the producer receives 60%. In many cases, he then sells the boards back to the producer who in turn uses them or markets the boards her or himself.

The Timber Industry Transformed

Because of the hybrid nature of the emerging local timber industry, one in which both local and exogenous knowledge and technology are integrated, forestry in this post-boom phase differs from boom-phase forestry in a number of ways: in the scale of operations, in the number of timber species processed and sold; in the diversification of wood products to include sawlogs, poles and firewood; and in the management practices employed by producers.

First, the mills of smallholders are small, efficient and sustainable. The owners can maintain a living because they are working on the principle of sustainable forest production. Because they have purchased the land, and many expect to retire there, passing the operation on to their younger relatives, as in the case of Maria José, the mill owners have strong incentives to ensure that their timber providers are not practicing unsustainable extraction. They have embraced the rational aspects of the forest management law and share this knowledge with their timber providers. Also, the regional timber market is small, diversified and flexible compared to more rigid national and international timber markets.

Second, the number of species harvested, processed and sold is high. During the boom period loggers extracted sawlogs of only six valuable tree species. In the post-boom period smallholders harvest poles for sale as they thin their stands and sell logs, branches and debris from as many as 36 tree species. Smallholders increased the efficiency of timber management through the production of firewood, poles and other wood products. These characteristics of post-boom management and processing have greatly increased the value of any given tree as well as of the landholdings.

Finally, there are marked differences in forest and timber management practices between smallholder and large-scale industrial operators in Amazonia. Among the most important of these, and one that especially distinguishes some smallholder production systems from the simpler patterns more characteristic of industrial agriculture and forestry, is the practice of concurrent management, that is, the simultaneous and multi-purpose management for food and forest crop production (Padoch and Pinedo-Vasquez 2006, Pinedo-Vasquez *et al.* 2001). In this system, where multiple resources are managed in complex spaces, managers produce many types of products simultaneously and can shift their allocation of labor and resources among agriculture, wood products and NTFPs from year to year, depending on household needs and market changes.

Furthermore, farmers actively manage forests and trees to improve production while the extractive industry tends to use the standing resource with little or no pre- or post-harvest activity. Also, the practices of farmers are adapted to local contexts whereas industrial-scale forestry tends to employ the same practices under dramatically varying conditions. By maintaining a diversity of environments and species on their properties and using available resources in multiple ways, rather than converting their landholdings to a single use, as is the case with cattle ranchers and the timber plantations, smallholders not only reduce risks but also enhance their economic options.

One characteristic of post-boom forestry that has been key for its success is the diversification of timber markets, a phenomenon that dramatically increases the merchantable stock of timber in these forests and the speed at which it could be regenerated. More importantly, the diversification included fast-growing species, which are more abundant in secondary forests and reach commercial size much faster than hardwoods. The extension of management and processing of many species increases the value of a variety of forest stands managed by these farmers and provides more income to both the farmer and the sawmill owners. The market diversification in this region results not only from farmers' intimate knowledge of forest management but also from the sawmill owners' knowledge of commerce.

Conclusions

Many smallholder farmers and family-run sawmills in the Amazon estuary are enjoying economic success today because they have formed a new "hybrid" forest product industry and have fashioned a niche in a market left open after the great timber boom ended in the 1970s. They have transformed the local and regional timber market to include

many more locally-grown timber species than were found previously, and they have developed a vertically integrated timber industry in which millers are also producers and loggers and strong social networks are vital for effective transport and market transactions. The phenomenon started with a diversified resource management system in which many species are encouraged, taking advantage of the environmental gradients in the area, and incorporating the knowledge and technology gained during employment with boom-time large-scale timber operations. It has resulted in the establishment of small, family-operated sawmills that fill the void left in the region when the industry passed on to more profitable regions after effectively causing the commercial extinction of timber in this one.

These farmers and entrepreneurs have added value to an abundant and renewable local natural resource and by doing so have transformed both the local timber industry and their own economic situation in Amazonian society. The integration of local ecological knowledge and their expertise in management with information and technology gained during temporary employment with large-scale timber firms has enabled them to do this. The post-boom timber revival in Macapá is an example of a rural community's "transformative engagement with modernity" (Escobar 1995) whereby traditional practices have hybridized with outside technologies and knowledge resulting in the enrichment of a local industry and an adjustment of the social structure and economic situation of some farmers and forest managers in this region.

We would like to emphasize several important points that emerge from this case study. Amapá farmers are profiting from an industry that was thought to have gone "bust" after the large-scale operations depleted the most valuable timber species. They are enjoying economic and environmental benefits from the timber industry, a sector that is traditionally considered as harmful, exploitative and unsustainable. The success of these farmers attests to their ability to appropriate the remains of the boom-time timber operations into their own resource management strategies. By acquiring valuable outside knowledge from wage labor in the industrial timber boom, these riverine farmers have assumed a position in the local economy not traditionally available to smallholders. They used their existing knowledge of ecological processes and silvicultural activities, they salvaged equipment from the abandoned mills, and they incorporated industrial standards into their production. This combination of technical, market and ecological knowledge results in forests, timber markets and economic patterns that do not correspond to many of the widely-held generalizations concerning either local or industrial tropical timber exploitation.

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