THE TREE THAT HELD UP THE FOREST: SHIHUAHUACO (*Dipteryx* spp.) AND THE CHINESE TIMBER TRADE

by

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A dissertation submitted to the Graduate Faculty in Biology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2010

This manuscript has been read and accepted for the Graduate Faculty in Biology in satisfaction of the dissertation requirement for the degree of Doctor of Philsophy.

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ABSTRACT

Extending over an area of more than 5 million km^2, the forests of Amazonia are a repository of 25% of terrestrial biodiversity and play a vital role in regulating regional and global ecological systems. In addition to the direct damages caused by logging, timber extraction entails important collateral impacts on forests, including facilitating access for conversion of land to agriculture and pastureland. Over 650,000 km^2 (>12%) of the Amazon forest area is located in Peru. Unlike Brazil, where timber exports have declined in recent years, Peru's volume of annual timber exports increased 180% between 2004 and 2008. Mexico and the United States were long Peru's largest importers of timber. By 2006, however, China's imports had surpassed those of the US.

Although only a relatively small percentage of China's total timber imports originate in Peru, since 2000, there has been an exponential increase in the wood trade between the two countries. Using a multi-disciplinary approach combining forest ecology, economic botany, and political economy this research identifies the species which represents 80% of China's imports from Peru, i.e. shihuahuaco (*Dipteryx* spp.), and then follows the supply chains of that species along rectilinear transects in the Amazonian forest and back through the highly non-linear Peruvian industrial milling centers and export market.

Forest ecology methods are employed to assess the effects of logging on the regeneration of shihuahuaco, and the potential for local people to mitigate those effects and accelerate the reestablishment of shihuahuaco stands. Analysis of the Peruvian export market, broken down by species, illustrates the rapid increase of exports of shihuahuaco following intentional promotion by conservation-oriented programs and the emergence of the Chinese market. Finally, a dynamic commodity network analysis uncovers the connections between Chinese shihuahuaco traders located within the Amazon forest region and shows how these connections are evolving in unexpected ways in response to efforts to regulate the global timber trade.

Key findings include:

1.) In areas logged for shihuahuaco, regeneration will be greatly reduced by the removal of seed trees; however, since post-logging conditions and treatments by local residents favor the recruitment of saplings, there is an opportunity for recovery of the resource.
2.) In response to extraction of shihuahuaco, a number of smallholder farmers living within and around logging zones manage residuals, transplant residual seedlings into their agricultural fields, and collect seeds to germinate in nurseries.
3.) Exports of shihuahuaco to China have increased more than three-fold over the past 5 years, and now represent over 50% of Peru's timber exports.

4.) While Chinese shihuahuaco exporters, like the majority of Peruvian timber exporters, continue to be supplied by the informal market, new vertically integrated supply chains owned by Chinese processing companies have obtained international certification. This certification enables them to increase their global market share, but the ecological and social impacts in Amazonia are unknown.

To Tony Tate

for sticking around

ACKNOWLEDGMENTS

This project could not have been conceived and executed without the guidance of Christine Padoch, my doctoral adviser, and Miguel Pinedo-Vasquez; their invitation to study with them led to my following them deep into the Peruvian Amazonian forest. There, my research life was facilitated by their many friends, associates, and family members, including Medardo Miranda, the Pinedo-Romero family, the Cardenas family, Jim Rodriguez, and many others. In Peru, I am also extremely grateful to Monica Romo, whose prior research and current insights were invaluable; Victor Miranda, Amilcar Isuiza, and innumerable timber company personnel who hosted me in logging camps and on visits to sawmills.

Charles M. Peters and Robin Sears were constant sources of expertise on forestry methods as well as role-model field researchers. Other New York Botanical Garden colleagues included Valerie Imbruce, Angela Steward, Andrew S. Roberts and Selena Ahmad, all of whom provided many great insights and extremely helpful readings and critiques. Dwight Kincaid and Joseph Rachlin, also committee members, were invariably supportive throughout the development of research planning and execution. Hannah Stevens generously provided her mapping expertise, as well as edits.

Thanks are due to the following institutions and companies: The National Science Foundation, who provided me with funds through a Doctoral Dissertation Research Improvement grant to my adviser (C. Padoch, PI, Grant 0727187); INRENA, Pucallpa and Lima, Peru; ADEX, Peru; Universidad Nacional La Molina (UNALM), Peru; the Center for International Forestry Research (CIFOR), Peru and Bogor; Reforest, SA, Peru; NCS American Forestal, Peru; and INIA, Pucallpa; and, finally, but far from least, the New York Botanical Garden and Lehman College and The Graduate Center at City University of New York.

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INTRODUCTION

INTRODUCTION

1. Background

At a time when concern about the impacts of the excessive consumption of Western-type consumer countries is reaching a critical level, a new economic giant with many mouths to feed and unsatisfied development aspirations is putting new pressures on global resources ranging from Brazilian soy to Zambian copper. Combined with the growing affluence of China's own population, the migration of nearly entire productive industries from North America and Europe to Asia has resulted in an insatiable demand for raw materials and the extension of new supply chains beyond Asia into Africa and South America.

As the role of forests in mitigating the effects of climate change and, as always, fulfilling the subsistence needs of many hundreds of millions of people, is more-than-ever on the global agenda, it is critical to develop an understanding of the nature of China's transnational timber trade. The research presented here in a set of complementary articles focuses on a rapidly developing segment of that trade stretching between China and the Peruvian Amazon, using a multidisciplinary approach to understand the complex interactions between global commerce, national and international forestry policy, local logging and forestry practices and the potential impacts of these on the regeneration ecology of *shihuahuaco* (*Dipteryx* spp.), an ecologically and economically important timber resource.

Extending over an area of more than 5 million km^2, the forests of Amazonia are a repository of 25% of terrestrial biodiversity and play a vital role in regulating regional and global ecological systems (Dirzo and Raven 2003; Malhi et al. 2008; Oliveira et al. 2007). In addition to the direct damages caused by logging, timber extraction entails important collateral impacts on forests, including facilitating access for conversion of land to agriculture and pastureland (Mattos and Uhl 2004; Nepstad 2004; Asner et al. 2005). Over 650,000 km^2 (>12%) of the Amazon forest area is located in Peru (Oliveira et al. 2007). Unlike Brazil, where timber exports have declined in recent years, Peru's volume of annual timber exports increased 180% between 2004 and 2008 (ITTO 2008). Mexico and the United States were long Peru's largest importers of timber. By 2006, however, China's imports had surpassed those of the US (Figure 1), and in the first quarter of 2009, as the global financial crisis took hold, North American timber imports from Peru declined by more than 60%, while Chinese imports continued to increase (Andina 2009), making China Peru's largest timber importer. In 2009, the second, third, and fourth largest exporters of Peruvian timber are Chinese-owned companies (Peru.com 2009).

China's emergence in the 2000s as the world's largest importer of timber and exporter of finished wood products has been attributed to both domestic structural factors and global market trends (White et al. 2006; Sun et al. 2005; Sun et al. 2004). Domestic factors include the logging ban of 1998 and the reduction of import tariffs in 1999. Meanwhile, the Asian Financial Crisis of 1997 and 1998 left a vacuum in the global timber trade as important Asian importers such as Japan, Malaysia, Korea, and Taiwan faced a severe capital shortfall. Cash-rich

China inherited many of their dislocated supply chains worldwide (Kahrl et al. 2005; Zhu et al. 2004). In keeping with the outsourcing of labor by North American and European industry to China, capital (including technology, design, and management) from these regions' wood products manufacturing industries has migrated to coastal China (UN/ECE 2005). The intervening period (1997 – 2007) saw a global housing boom, which was particularly strong in China and the United States, China's largest foreign market for finished wood products. With the current global financial crisis, China's ability to secure future resources has been greatly increased, and for the first time, overseas timber industries are a target for investment from Chinese governmental sources such as the China Development Bank (CDB 2009).

Long before the emergence of China in global natural resource markets, Chinese traders had dominated timber markets in Southeast Asia, to the point where it was difficult for European and American interests to penetrate them, even during the colonial era. In the Philippines, Chinese traders for centuries had exported saltwater-resistant species for ships and wharves and red lauan (Philippine mahogany) for cabinetry to China and beyond: the Chinese were familiar with many tropical timbers (Tucker 2000: 365). In the 20th century, other East Asian countries were the largest producers and consumers of tropical timber. Japanese, Taiwanese, and South Korean companies sourced timber in the Philippines in the 1950s, in Indonesia and Sabah in the 1960s, and more recently in Sarawak, Papua New Guinea, and the Solomon Islands. In the case of Japan, large Japanese generalist corporations (such as Mitsubishi) acted as intermediaries between the logging companies, many of them diaspora Chinese companies, and the Japanese market.

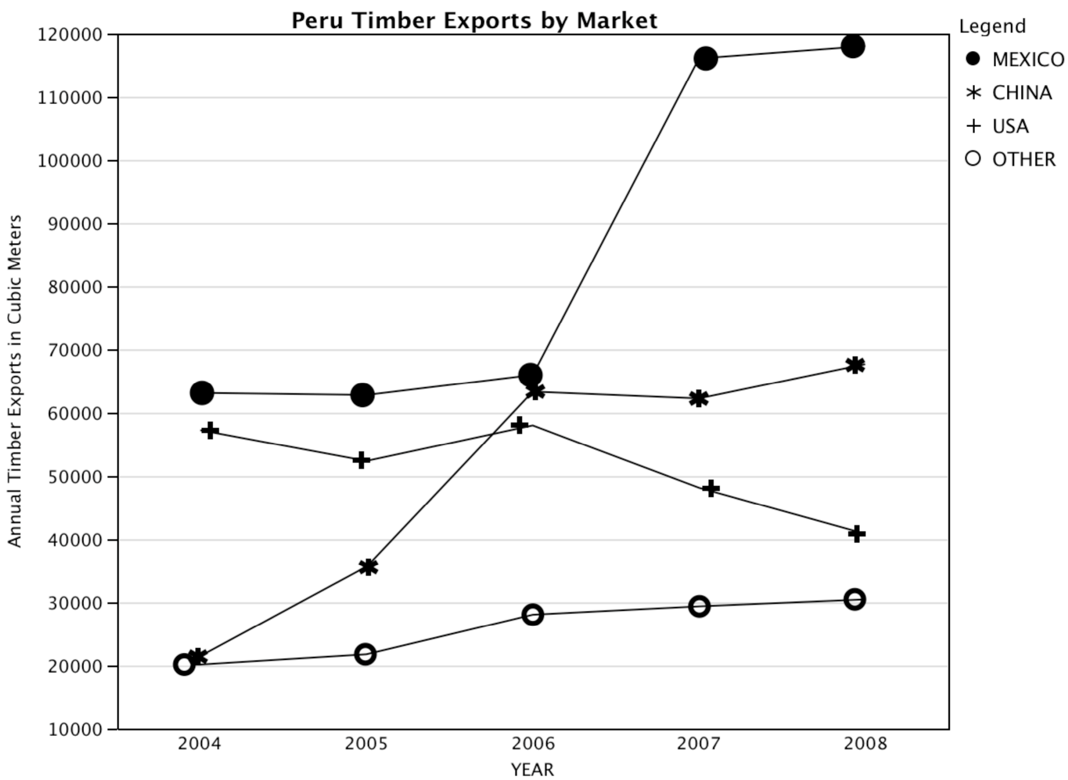

Figure 1. Exports of timber from Peru to China increased more than threefold from 2004 to 2006. Prior to the current global economic crisis, there was a short-lived boom in exports of *Virola* spp. to Mexico (Chapter 4).

Concerns about the actual and potential detrimental impacts – both ecological and social– of Mainland China's growing demand for and practices of obtaining timber have appeared in the literature pertaining to the international timber trade (Mayer et al. 2005; Sun et al. 2004; EIA 2005). Smouts (2003:122) for example states, referring to Chinese timber companies: "Everywhere these companies have overlogged the forest, harvested excessive quantities of timber, used devastating cutting methods, scorned the local people, and disregarded every rule of sustainable forest management." Once harvested and exported to China, the origin of timber may be obscured. A 2006 article in a Hong Kong newspaper about China's involvement in the illegal exploitation and importation of Burmese timber illustrates how timbers' origins may be obscured in the Chinese production process, terming the phenomenon "timber laundering":

> **"Once the timber has been `substantially transformed' - for instance in the production of wooden furniture from logs or processed timber – its designated country of origin becomes the country where the timber was processed, not where it was logged"… Thus the country of origin rules are a way to launder illegal wood"**(England 2006).

Of note, however, is the rapidity with which China and a growing number of Mainland Chinese timber importers have responded to global criticism: in 2006, China banned imports of timber from Burma (Global Witness 2006); in 2007, China signed a memorandum of understanding with the United States committing to address the shared problem of the illegal timber trade (USDOS 2009); in late 2009, a search of the Forest Stewardship Council's database revealed that over 1,000 China-based timber processing and logging companies had obtained international chain-of-custody certification, which is supposed to ensure the traceability of timber.

Prior to the research presented here, the history of China's timber sourcing in Peru had not been studied. Although only a relatively small percentage of

China's total timber imports originate in Peru, since 2000, there has been an exponential increase in the wood trade between the two countries (Figure 2). Using a multi-disciplinary approach combining forest ecology, economic botany, and political economy – a combination which might best be termed "timber ecology" – this research identifies (preliminary observations, Chapter 1) the species which represents 80% of China's imports from Peru, i.e. shihuahuaco (*Dipteryx* spp.), and then follows the supply chains of that species along rectilinear transects in the Amazonian forest and back through the highly non-linear Peruvian industrial milling centers and export market.

Forest ecology methods are employed to assess the effects of logging on the regeneration of shihuahuaco (Chapter 2), and the potential for local people to mitigate those effects and accelerate the reestablishment of shihuahuaco stands (Chapter 3). Analysis of the Peruvian export market, broken down by species, illustrates the rapid increase of exports of shihuahuaco following intentional promotion by conservation-oriented programs and the emergence of the Chinese market (Chapter 4). Finally, a dynamic commodity network analysis uncovers the connections between Chinese shihuahuaco traders located within the Amazon forest region and shows how these connections are evolving in unexpected ways in response to efforts to regulate the global timber trade (Chapter 5).

2. Understanding the regeneration ecology of shihuahuaco: A real-life approach

Once shihuahuaco was identified as the primary timber export from Peru to the growing Chinese market (and eventually the primary timber export overall), research efforts were directed towards understanding the implications of extraction on the regeneration and recruitment of shihuahuaco species under natural conditions. Unlike many ecological forest studies (e.g. Denslow 1987; Clark and Clark 1992; Clark and Clark 2001; Romo et al. 2004), where "natural" conditions signify by definition a supposed absence of human activity, the studies here define as natural the state in which shihuahuaco exists prior to and after logging, even with continuous intervention of people in the surrounding environment. Similarly, in contrast to other post-logging studies conducted in Amazonia (See Appendix I) (see e.g. Gullison and Hardner 1993; Fredericksen and Pariona 2002; Jackson et al. 2002; Van Rheenan et al. 2004; Grogan and Galvão 2006) where study plots are located in managed forest concessions -- i.e., supposedly located in areas where land conversion is prevented -- these studies occurred in areas of shifting *de facto* land tenure, regardless of the boundaries of the production forests in and around which they were carried out (See Chapter 3).

The post-logging environment in Amazonia is one of human frontier colonization, many studies of which have focused on the social organization associated with various forms of land use and forest management (see e.g Hecht and Cockburn 1989; Mattos and Uhl 1994; Perz and Walker, 2002; Smith et al. 2003). Rather than focusing on social organization, Chapters 2 and 3 of this study are restricted to the effects of the overall environment of both logging and trade as well as land tenure policy and resulting land use on the regeneration and recruitment of shihuahuaco.

With this research orientation, the following hypotheses are addressed:

1) Logging and its associated land use changes interrupts the natural regeneration of shihuahuaco in logged areas.

2) Management of shihuahuaco residuals and replanting by resident smallholders increases the frequency of medium size-classes.

The combined implication of these hypotheses, which the obtained data supported, is that while the current boom in shihuahuaco will result in a drastic reduction of new seedlings, a simultaneous mitigating effect of smallholder management creates a window for recovery of shihuahuaco populations through enhanced recruitment. However, that opportunity is time- and space-limited; without immediate management after logging and if total land conversion eventually takes place, the window is closed and the future of the resource is far from certain.

3. The Chinese shihuahuaco market: Bilateral trade and the Tropical Timber Trade Regime

The Peru-China timber trade of course does not operate in a vacuum. Firstly, many commodity chains in the global trade network pass through China and end up in the West and other points on the geopolitical compass (White et al. 2005). Secondly, the dynamic of bilateral trade between Peru and the United States, as defined by a new free trade agreement, has greatly altered the way the Peruvian government has structured its management of the timber industry.

Finally, the activities of global non-governmental or inter-governmental institutions, or the "tropical timber trade regime" (TTTR) (Gale 1998) have had substantial impacts on both Peruvian forestry and the behavior of Chinese corporations. These same factors of influence are now beginning to change the way the central Chinese government sees its role in international forestry. To address these complex interplays, a political economic narrative approach to commodity chains analysis (See Appendix II), using extensive data from interviews with many categories of actors in the shihuahuaco trade, addresses the following (third) hypothesis in Chapter 5:

> *3) The Chinese trade in shihuahuaco timber within the Pucallpa region is based on the structure of local supply chains established by local Peruvian actors rather than on the Forest Law.*

The rationale behind this third hypothesis, based on preliminary observations made before the research began, was that as individual agents arriving in the Amazonian timber market, Chinese traders interact with local agents in a customary structure that is an artifact of the Peruvian forest industry as it was prior to new legislation passed in 2000. This hypothesis is grounded in the debate on the primary dominance of agency vs. structure in determining the changing organization of human activity. This hypothesis is based also on prior research (Smith et al. 2006; WB 2006) showing that the new Forest Law of 2000 had not been legitimized through practice, in the sense that a new structure is only an idea (i.e. it is "signified" as per Giddens 1984) until it is realized by agents.

The fact that following the customary structure as opposed to the Forest Law is technically illegal is peripheral to the narrative.

Hypothesis 3 was initially strongly supported, as discussed in Chapter 1. However, as the research was being carried out, the structures of the Chinese trade developed in the environment of new trade deals and increased proximity of the TTTR to Peruvian and Chinese timber and forestry industries. A sudden shift occurred when a newly signified structure of vertically integrated (See Appendix III) supply chains based in China appeared. This new structure replicated the Peruvian forest law and the norms of an international certification body, thereby reducing support for hypothesis 3.

4. Research significance

It is hoped that this research will provide a few new insights into the complexities of the interactions of timber markets in a globalized political and economic space, and also of the importance of understanding the often unknown dynamics between people and forests at the local level. While the phenomenon of China's expansion into distant resource markets is alarming to many, and the logging of Amazonia often seems unrelenting and almost certain to destroy the forest, there are several things to bear in mind while reading the following chapters. First, the Peru-China timber trade, as one manifestation of China, developed largely as a result of the independent activities of many Chinese and non-Chinese actors acting in their own self-interest. At the same time, China as a nation is making efforts to adhere to the canon of international forestry norms; it could even surpass many other nations in its ability to control itself and mitigate its own impacts.

Secondly, while logging comes with a great deal of destruction, as many have noted before the Amazon rainforest has been through a number of resource booms and cycles of human transformation (Hecht and Cockburn 1989; Pinedo-Vasquez et al. 2001). Many landscapes are as much an artifact of past human exploitation and management as they are of "natural" phenomena. Now, as valuable species are removed, they also attract the attention of local people who for many reasons, ranging from economic to (even despite persistent poverty) aesthetic (see Appendix IV), conserve them both in remnant forests and in thriving stands.

Thirdly, these observations are supportive of a need for collaborative approaches to dealing with the problems of global forest loss and degradation. Unilateral criticism or marginalization of people who take economic opportunity of forest resources has not slowed deforestation, and may in fact accelerate it as people realize they may have limited time to take their profits. Relatively modest resources might greatly enhance the ability of local smallholders to participate profitably in sustainable forestry. Improved infrastructures and planning together with positive engagement with loggers of all categories might help to bring them into a process of rational resource exploitation.

Finally, these tentative statements are written optimistically, since forest loss proceeds apace despite others having proposed them before.

CHAPTER 1

THE CHINESE TIMBER TRADE AND THE LOGGING OF PERUVIAN AMAZONIA

Revised from:

Putzel, L., Padoch, C., & Pinedo-Vasquez, M. 2008. The Chinese timber trade and the logging of Peruvian Amazonia. Conservation Biology, **22**: 1659-1661.

CHAPTER 1

The Chinese timber trade and the logging of Peruvian Amazonia

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China has replaced Japan as the world's largest importer of tropical timber and Italy as the largest exporter of processed wood products (ITTO 2005; Liu & Diamond 2005; White et al. 2006; Wang et al. 2007). Now, a debate has ignited regarding China's responsibility for illegal logging of forests around the world (Laurance 2008; Wang et al. 2008) and reports in the popular press have proliferated that directly implicate Chinese logging companies, notably in Asia and Africa. For example, in January 2008, Sierra Leone banned timber exports due to alleged forest destruction by Chinese companies (BBC 2008) and, more recently, the Kachin News Group reported that Chinese loggers were exploiting Burmese children in the process of removing timber belonging to local people in northern Shan state (KNG 2008). Little has been reported on the scale or nature of Chinese timber procurement activities in Latin America, although some categorical and misleading statements have been made. A 2007 Conservation International study on conservation in Amazonia states "there is no appreciable trade between the Pacific coast of South America and China" (Killeen 2007). Conversely, the year before, a director of the Council on Foreign Relations, a policy think tank, testified before a U.S. congressional commission that "Chinese logging companies" were present throughout the Amazon and had been fined for "poor logging practices" (Economy 2006). Both statements are erroneous. Exports of Amazonian timber from Peru's Pacific coast to China are booming. In the region of Pucallpa, the major center of logging in Peruvian Amazonia, however, there is no evidence of logging by Chinese companies[1].

Exports of Amazonian hardwood to China already represent a substantial portion of Peru's market. Figures from the International Tropical Timber Organization show Peru exported 199,000 m^3 of sawn wood in 2006 (ITTO 2006). We collected the names of 95 companies exporting timber from Peru and examined digital customs declarations (SUNAT 2008) for all of their shipments in 2006. These declarations show that at least 56,425 m^3 of sawn wood was shipped to China, 63% of which (or 35,559 m^3) was separated by species. Of this quantity, 95% belonged to three ecologically important, but not endangered, rainforest hardwoods: *Dipteryx* spp., *Miroxylon balsamum*, and *Manilkara bidentata*. For comparison, mahogany (*Swietenia macrophylla*) and tropical cedar (*Cedrela odorata*), both listed as endangered and often mentioned in the context of illegal logging, remain high-volume exports to the United States. Without minimizing the potential impact of China's huge timber demand, it is significant to note that China imports negligible quantities of these two protected species.

Since China restricted domestic logging and lowered import tariffs to conserve its own forests (Wang et al. 2007), many new supply chains have been established to deliver timber from remote tropical forests to China. We collected

[1] This statement is now outdated: by 2009, wood transformation companies based in mainland China had established logging capacity (and international certification) (see Chapter 5).

information on these supply chains originating in Pucallpa, the largest center of logging and milling in Peruvian Amazonia, through 63 interviews in Spanish and Mandarin with individuals associated with the timber trade. We found that, although there are Mainland Chinese and other ethnic Chinese people, including Chinese Peruvians, involved in the timber trade, no Chinese companies or their subsidiaries are extracting trees from forests in the area. Rather, what distinguishes Chinese market actors is the diversity of their connections to different types of Peruvian sellers, including multiservice timber companies extracting and processing logs and exporting finished lumber directly to Chinese ports; contractors specialized in logging alone; sawmills specialized in processing logs; export companies trading already-processed sawn wood; and smallholder farmers and itinerant loggers selling rough chainsaw-milled lumber by the boatload on the banks of the Ucayali River and its tributaries.

Chinese traders have moved far up the timber supply chain in Peru and have begun to preprocess some of the sawn wood they send across the Pacific. Nevertheless, in order to assess the ecological impact of logging for the Chinese market beyond the gross effect of high demand, it is necessary to direct attention toward the specific practices of various categories of Peruvian—rather than Chinese—actors. The closest thing to a Chinese logging company in Pucallpa is a Peruvian multiservice timber company run by an ethnic Chinese family, with a subsidiary finishing plant and distributor in eastern China. The company, however, employs a Peruvian extractive team that works in accordance with local practices as it negotiates for logging rights and delivers logs to the mill. There are several smaller trading houses run by owners and key staff members from mainland China, some of whom have lived in Peru for decades—long before the current timber export boom. These trading houses purchase timber on the local market and ship it to clients, partner companies, or even subsidiaries in southern and eastern China. Only one buyer with a permanent presence in Pucallpa is reportedly the subsidiary of a Chinese timber conglomerate; this company, however, has no extractive activities in Peru.

Due to China's demand for timber, Chinese buyers have a large influence on the market and are perceived by some sellers to control timber prices, a perspective supported by a decrease in prices in Peru around Chinese New Year, when demand drops. The resource moves locally through both legal and nonlegal (or informal) channels and in various stages of processing from forest to market, which increases the elasticity of supply and causes some larger Peruvian timber companies to seek less price sensitive markets in, for example, North America and Europe. Notably, several (non-Chinese) companies have obtained Forest Stewardship Council (FSC) certification for timber they sell to these markets at higher prices while they continue to ship uncertified timber to China.

Chinese buyers located in Pucallpa and Lima support a segment of independent woodsmen, smallholders, and small sawmills (collectively known as *microempresarios*) that have organized to lobby the government to legalize their trade in what they term *predimensioned* timber. This term refers primarily to *Dipteryx*, which is too heavy to float on rivers and must therefore be chainsaw milled at the extraction site before transport because smaller traders cannot afford the equipment needed to lift and transport entire logs. At least one company with ethnic Chinese ownership has provided microempresarios with specialized equipment imported from Asia to cut the extremely hard *Dipteryx* wood into floorboards. When asked about issues of illegal logging's impact on forest conservation, one Chinese timber buyer praised the use of selective logging as practiced in Peru, whereas another talked of the importance of low-waste production efficiency, but the most prevalent theme was the importance of the subsistence needs of microempresarios. We do not know whether this people-need-to-eat argument for trade in the informal sector arises from a heightened social conscience or from a pragmatic rationale to continue trading in unregulated timber; nonetheless, it contrasts with perceptions that Asian timber companies invariably abuse local people and the environment (see e.g., Smouts 2003).

Although the importance of the Chinese market can be easily assessed by monitoring exports, the nature of Chinese actors in terms of ecological and social impact cannot be simply described. As noted by Mawdsley (2008), the identities of Chinese actors and companies are not nationally discrete. For this reason and because all timber shipped from Peru is documented as "legal" by the Peruvian government, whether in fact it was legally harvested or not, we argue that China's responsibility and capacity as a nation to selectively reject illegally logged Peruvian timber is limited. Meanwhile, until and unless Chinese loggers enter the area or China-based companies begin extractive activities, the specific ecological impacts of logging need to be addressed by assessing the practices of diverse Peruvian, rather than Chinese, actors. Finally, observation of the business relationships of various Chinese buyers and companies with diverse Amazonian actors reveals the surprising existence of an alternative, informal economy in which some benefits from the global timber trade flow to economically marginalized groups, a fact that should not be overlooked by those interested in reforming the sector.

CHAPTER 2

POST-LOGGING REGENERATION AND RECRUITMENT OF SHIHUAHUACO (*DIPTERYX* SPP.) IN PERUVIAN AMAZONIA: IMPLICATIONS FOR MANAGEMENT

Revised from:

Putzel, L., C. M. Peters & M. Romo. 2009. Post-logging regeneration and recruitment of shihuahuaco (*Dipteryx* spp.) in Peruvian Amazonia: Implications for management. In preparation.

CHAPTER 2

Post-logging regeneration and recruitment of shihuahuaco (*Dipteryx* spp.) in Peruvian Amazonia: Implications for management

Louis Putzel, Charles M. Peters, and Mónica Romo

Abstract

Over the past decade, shihuahuaco timber – comprising several species of *Dipteryx* (Fabaceae) traded internationally as "cumarú" or "Brazilian teak" – has become one of the most highly-demanded types of hardwood from Peruvian Amazonia. *Dipteryx* is an ecologically important canopy-emergent genus with widespread distribution in neotropical forests. To assess the response of *Dipteryx* to logging, we conducted pre- and post-logging size-class distribution studies in three logging areas in the Regions of Ucayali and Loreto, Peru. A significant change was observed in pre- and post-logging size-class distributions, which indicated that although removal of seed trees by logging severely reduces regeneration, initial post-logging conditions enhance recruitment of residual seedlings. These conditions are formed by a combination of the presence of logging gaps and the activities of farmers migrating into logged lands. Through protection and liberation of shihuahuaco seedlings in regenerating post-logged forest as well as within and around agricultural fields, local residents and timber companies might favor recovery of the resource; however, as logged land is increasingly converted to agriculture and pastureland, the reestablishment of mature seed trees is not assured.

1. Introduction

Logging pressure on traditional high-valued Amazonian hardwoods such as big-leaf mahogany (*Swietenia macrophylla*) and tropical cedar (*Cedrela odorata*) has threatened supplies as well as the potential of these species, without preferential management, to regenerate over much of their natural range (Navarro et al. 2003; Snook et al. 2003 Grogan et al. 2005; Grogan and Barreto 2005; Muellner et al. 2009). Over the past decade, in part due to the increased scarcity and legal protection of these species, growing global demand for tropical hardwoods has resulted in a diversification of internationally-traded Amazonian timber species (Table 1) and spurred the expansion of logging into new areas (Schulze et al. 2008a, b). One recently studied example of this phenomenon is *îpe* (*Tabebuia* spp.), an Amazonian hardwood that has been endangered by an extractive boom, especially in Brazil but also Peru and other countries (Schulze et al. 2008b).

Similarly, several species of *Dipteryx* collectively known in Peru as shihuahuaco and internationally traded as "cumarú" or "Brazilian teak" have for the past several years been the target of an extractive boom. Like îpe, shihuahuaco is valued for its high wood density and resistance to rot, making it ideal for outdoor applications such as decking and patio furniture, for which it is used in North America and Europe. However, due to the growing dominance of Chinese timber companies and exporters in Peru, the majority of extracted Peruvian shihuahuaco is shipped to China to provide raw material to that country's huge domestic and global flooring market (Putzel et al. 2008). In 2008, shihuahuaco represented nearly half of Peru's timber exports; of that approximately 80% was shipped to China (Putzel, in preparation).

Table 1. List of major non-coniferous sawnwood species exported from Brazil, Guyana and Peru in 1996 and 2006 as per data tables from ITTO annual reviews.

year	1996 (total 13 species or genera)	2006 (total 23 species or genera)
species	*Araucaria augustifolia*	*Aspidospema* spp.
	Bagassa guianensis	*Balfourodendron riedelianum*
	Carapa guianensis	*Carapa guianensis*
	Cedrela spp.	*Cedrela* spp.
	Dinizia excelsa	*Chlorocardium rodiei*
	Goupia glabra	*Dipteryx* spp.
	Hymenaea courbaril	*Goupia glabra*
	Mora excelsa	*Hymenaea courbaril*
	Ocotea spp.	*Hymenolobium* spp.
	Peltogyne pubescens	*Juglans* spp.
	Swietenia macrophylla	*Manilkara bidentata*
	Tabebuia spp.	*Mora excelsa*
	Virola spp.	*Myroxylon* spp.
		Nectandra spp.
	Others (537,000 m^3)	*Ocotea* spp.
		Paratecoma spp.
		Parinari campestris
		Peltogyne spp.
		Peltophorum spp.
		Senna spp.
		Swietenia macrophylla
		Tabebuia spp.
		Virola spp.
		Others (1,392,000 m^3)

Source: ITTO (2008)

While in terms of their particular value for outdoor uses îpe and shihuahuaco might be considered as alternatives to teak (*Tectona grandis*), their supply has not been supplemented, as has that of teak, by extensive plantation production. Rather, the future of these species thus far depends on their natural regeneration potential in post-logged forests, although plantation production of *Dipteryx* spp., along with other hardwood forest trees, is a current area of experimental research (Montagnini 2001; Romo 2005). Schulze et al.'s (2008b) study of the population-level and broader impacts of îpe logging in Brazil found that recovery of populations without protection is unlikely and that the targeted logging of îpe is a likely catalyst for forest colonization and conversion to agriculture. The purpose of this study is to quantify regeneration and recruitment of shihuahuaco in natural conditions and in selectively logged forest in Peruvian Amazonia.

Over the past 15 years, shihuahuaco has gone from virtual anonymity to boom time species. However, the population-level response of shihuahuaco to logging activities is not yet well understood. Given the rapid increase in shihuahuaco exports from Peru, we conducted a field study of the regeneration and recruitment response of shihuahuaco populations in three logging areas centered around Pucallpa, Peru's largest timber milling center. Our results are discussed in the context of previous studies of *Dipteryx* ecology and logging impacts on commercial tree regeneration. This discussion provides the basis for broader reflections on commercial timber management and species-level conservation strategies.

2. Shihuahuaco species description

2.1 Ecological characteristics

Dipteryx spp. trees are widespread neotropical canopy-emergents of up to 150 cm dbh (diameter at breast height) and 35 to 60 m in height (Terborgh and Wright 1994; Reynel et al. 2003). Their large mass is supported by broad buttresses, making them ecologically important both for the structural integrity they add to the forest while standing (Clark and Clark 2001) and also for the large gaps they leave when they fall, facilitating successional forest growth (Romo 2004c). Research on *Dipteryx panamensis*, a close relative of shihuahuaco, suggests that, at least in natural forest conditions, species of this genus are extremely slow growing, with an estimated median age of 72 years for understory juveniles measured at 4 cm dbh (Clark and Clark 2001; Romo 2004a). Maximum adult ages of 330 years (*D. panamensis*) and 1000-1200 years (*D. odorata*) have been estimated (Clark and Clark 1992, Chambers et al. 1998, Romo 2004a).

Their plentiful, large (3-4 cm) seeds, which mature in the dry season, provide food for many species, including bats and other herbivourous mammals such as agoutis, peccaries, deer, and tapir (Terbourgh and Wright 1994; Romo 2004b;). In addition, shihuahuaco trees are important nesting sites for several species of parrots and macaws, communities of which may use individual trees for decades or centuries, leading Brightsmith (2005) to refer to shihuahuaco as a "keystone tree." Frugivorous bats that feed on the fleshy mesocarp of shihuahuaco fruit disperse the seeds in deposits located away from parent trees. Bat seed deposits are evident, often appearing under palm leaves upon which bats rest while feeding and near the edges of open forest pathways that facilitate their movement through the forest (Romo 2004b, 2004c).

With its large seeds and shade-tolerant seedlings, shihuahuaco species regenerate in both late-successional and mature forest and a variety of habitats, from floodplain to upland forests. While shade tolerant at seedling and sapling phases, they require light to be recruited to larger size-classes. Medium size classes (poles, juveniles) have been found to exist in very low densities in natural unlogged conditions compared to other size classes (Romo et al. 2004c).

2.2 Species identification

A revision of herbarium specimens at the New York and Missouri Botanical Gardens and the herbarium of the forestry department of the Universidad Nacional Agraria La Molina in Lima reveals that only two species of *Dipteryx* are prevalent in the study area: *D. micrantha* and *D. alata.* These correspond roughly to two types commonly recognized by local woodsmen—*shihuahuaco rojo* and *shihuahuaco amarillo*, respectively—differentiated according to the color of the bark, size of the leaves, and color of the wood. Some woodsmen also recognize a type known as *shihuahuaco negro*, however this may be a variety of *D. micrantha*. A third species, *D. odorata*, which occurs over a large area of Amazonia and has been identified in both northern and southern Peruvian Amazonia, does not appear to be present in the study region, despite the common use of the name in local commercial forest inventories and export documents.

In the course of this study local identifications were not consistent, and a method of field seedling identification has not yet been developed. At smaller size classes (seedlings, saplings, and poles) leaf size appears to correlate more to height, diameter and light availability, while the distinctive differences in bark and wood color are not yet apparent. Further systematic work on *Dipteryx* is called for, because the genus has not been revised since Ducke's 1940 revision (Ducke 1940). For these reasons, this study is a genus-level study of Peruvian *Dipteryx* bearing the common name shihuahuaco.

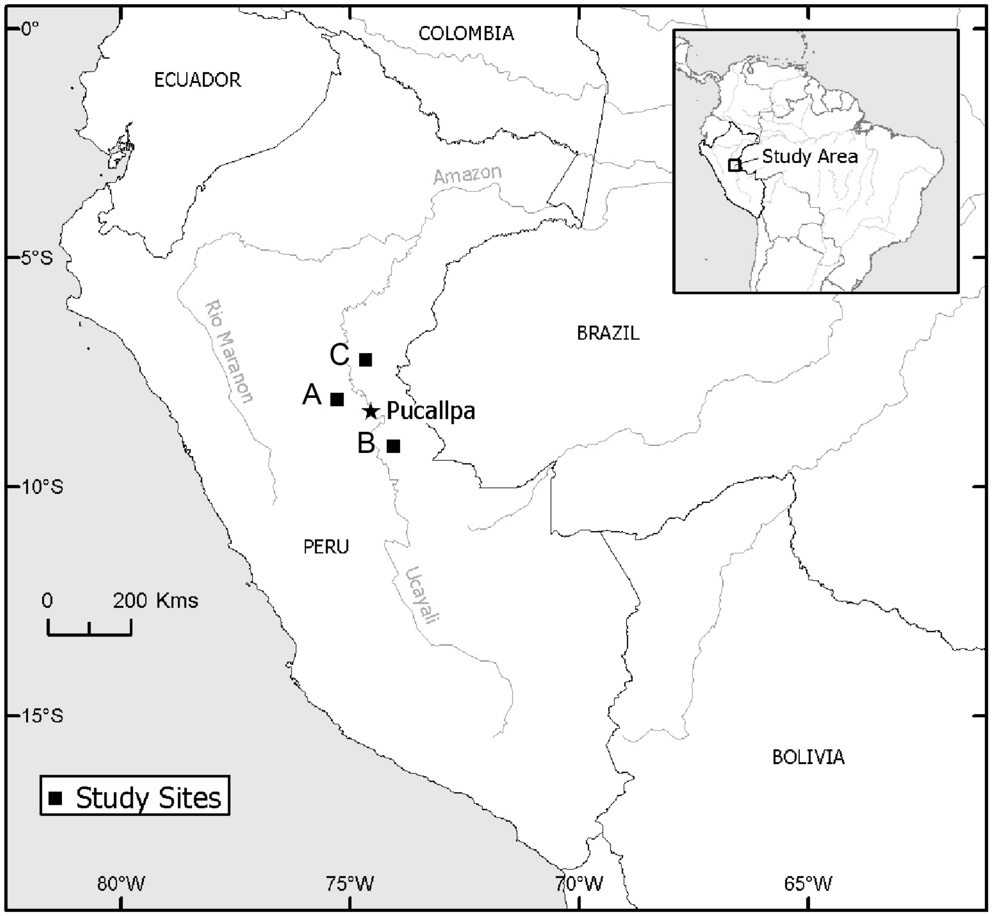
3. Methods

3.1 Study sites

Three active logging zones (Figure 1.) were identified through meetings with logging company personnel based in the mill-town of Pucallpa. The first, Zone A, is centered around a 40,000 ha. timber concession accessible from Km. 60 of the Federico Basadre Highway, which links Pucallpa to Peru's road network. Now being logged by the company that owns the concession, a number of other extractive companies have also held contracts to log the concession and private lands in surrounding communities. Zone B is a production forest and surrounding private landholdings accessible via the Ucayali River in the municipality of Iparia, located approximately 100km south of Pucallpa. There, a Pucallpa-based logging company is active. Zone C is a grouping of private landholdings located near the town of Contamana on the Ucayali River approximately 125km north-northwest of Pucallpa, now also being logged by a different Pucallpa-based timber company. Interviews with logging company personnel and local woodsmen indicated that all zones were selectively logged for mahogany, cedar, and in the case of Zone C, tornillo (*Cedrelinga catenaeformis*) during the 1980s. These forests were not previously logged for shihuahuaco.

Each of these zones is located on the edge of hilly or mountainous formations, and is in the process of being converted, to varying degrees, to a mixed agricultural and fragmented forest landscape. Prior to the reoccurrence of logging activities starting 0 to 4 years prior to this study, none of the zones had been logged since the initial logging of the 1980s, either due to insufficient demand to warrant the cost of logging residual species or due to abandonment caused by social unrest. For convenience, despite the previous logging history of the areas (for mahogany, cedar or tornillo), forest logged prior to the current period (i.e. in this decade) will be termed “unlogged” (for shihuahuaco).

Zones A and B, which contained both unlogged and logged forest, were suitable for pre- and post-logging studies, while logging in Zone C began in 2008. Post-logging study sites in Zone A were logged between 2 and 4 years prior to the study, while post-logging study sites in zone B were logged between 1 and 2 years prior to the study. In all zones, timber companies logging the concession and private parcels are in competition with local residents for the shihuahuaco resource, which in addition to being logged by industrial operations is artisanally extracted and sold in “predimensioned” forest-chainsawed blocks called *cuartones* to sawmills in Pucallpa or Contamana, where it is sized for parquet flooring. In Zone A, local residents also cut entire trees for charcoal which is bought by truckers and delivered to the market in Lima, from where some of it is reportedly exported to Japan.



Map: Hannah Stevens

Figure 1. Map of study areas centered around Pucallpa, Peru: Zones A, B, and C.

3.2 Sampling and measurements

Regeneration studies were carried out in unlogged areas of Zones A, B, and C, and in logged areas of Zones A and B. Inventories were conducted using a systematic sampling method (see e.g. Schreuder et al. 1993) with 10m x 20m plots arranged in parallel rectilinear transects for total inventory areas of 14.96 ha of unlogged and 14.04 ha logged forest. Seedlings less than 50cm in height were subsampled in 2m-wide transects central to the above-mentioned 10m-wide transects (Table 2). The location of smaller size-classes in relation to adult seed trees and water courses was noted in order to test the potential importance of seed dispersal patterns to post-logging regeneration and recruitment.

In a secondary study, in Zone A, nine permanent 10 m x 20 m plots were delimited to study seedling growth and survivorship from year 1 to year 2. Three plots containing seedlings aged one year or more ("1+ year seedlings") were located in undisturbed forest, three plots containing 1+ year seedlings were located in disturbed forest, and three plots containing seedlings younger than one year ("0 year seedlings") were located in logging skidtrails.

Table 2. Study site sampling areas, location, and logging history.

zone	**province, region** (logging history)	**total sample area (ha)**	**seedling sub-sample area (ha)**	**logging history**[a]
A. Km 60	Coronel Portillo, Ucayali			
unlogged		*6.96*	*0.728*	1980s
logged		*9.82*	*1.964*	1980s, 2-4 years prior
B. Iparia	Coronol Portillo, Ucayali			
unlogged		*4.5*	*0.9*	1980s
logged		*3.5*	*0.7*	1980s, 1-2 years prior
C. Contamana	Ucayali, Loreto			
unlogged		*4*	*0.8*	1980s
TOTAL		29	5.1288	
Total unlogged		14.96	2.328	
Total logged		14.04	2.8008	

Note: **a.** all areas were logged in 1980s for mahogany and cedar (not shihuahuaco).

Shihuahuaco individuals were assigned to six size classes: seedlings (<50 cm in height), saplings 1 (≥50 cm in height and <1cm diameter), saplings 2 (≥1cm diameter and <4 cm diameter), poles (≥4 cm in diameter and <10 cm in diameter), juveniles (≥10 cm and <40 cm in diameter) and adults (≥40 cm in diameter.) All measurements of diameter were at breast height (dbh) for all individuals > 150 cm in height; diameters of individuals < 150 cm in height were taken at the base of the stem. Seedlings were divided into two categories: 0 year seedlings (<1 year since germination) and 1+ year seedlings (more than 1 year since germination). In Zone A, inventories were conducted during the germination season, and results reporting numbers of 0 year seedlings are reported separately from all other results, which exclude 0 year seedlings.

In the case of large-buttressed adults, diameter was estimated by the consensus of three observers. Height of individuals <5 m was taken using a tape measure and of individuals >5m and <8m using a pole. If the crown of taller individuals was visible through the understory, heights were taken using a clinometer from the greatest distance from which the crown was visible up to 30m from the tree, or otherwise by best estimate. For saplings >1cm in diameter and for poles, we estimated the number of times the apical meristem had been broken by counting the number of evident breakage scars, characterized by a knobby protrusion, on each stem.

4. Results

4.1 Size class distributions and differential growth rates of individuals in unlogged vs. logged forest

The observed average density of adults of all species of shihuahuaco in 33 ha of transects was 1.15 trees per ha (n=38). This figure includes, in logged zones, stumps of felled trees (n=19). Of trees (standing and felled) where an identification was possible (n=26), roughly 42% were identified as *shihuahuaco amarillo* (n=11), and 54% as *shihuahuaco rojo* (n=14), with one individual identified as *shihuahuaco negro.* In logged zones, 18 trees had been felled, one was left standing, and one had fallen naturally.

A comparison (Table 3) of size classes between all unlogged and post-logged sites revealed a difference in regeneration and recruitment patterns. The unlogged distribution is an inverse-J shaped or negative exponential distribution typical of many tropical forest trees, with high ratios of seedlings to saplings, saplings to poles, poles to juveniles and a low ratio of juveniles to all other size classes. The post-logged distribution shows a decrease in the proportion of seedlings to saplings, and an increased proportion of poles and juveniles. While the lower number of seedlings is explained by the removal of adult trees the increase in saplings and especially poles and juveniles indicates higher rates of recruitment in post-logged areas.

In comparison of size class distributions between zones, the distinction between pre- and post-logging configurations is maintained, with some interesting inter-site variations. Most evident is the overall lower count of individuals in unlogged Zone A compared to Zones B and C, however, all configurations are consistent with an inverse-J curve. In post-logging sites, the shape of the distribution tends towards larger size classes (saplings and poles) in Zone A, where more time had elapsed since logging, than in Zone B, which had significantly more seedlings and a more even distribution between seedlings and saplings (Figure 2).

Table 3. Per-hectare occurrence of shihuahuaco individuals by size class in Zones A, B and C, presented by logging history. Table excludes new seedlings, which were only counted in Zone A, and plots in which seedlings were not counted, also in Zone A, unlogged since 1980s. In logged zones, "adult" refers mostly to felled trees, shown here in parentheses to relate to logged residuals of other size classes.

unlogged since 1980s	seedlings	Saplings 1	saplings 2	poles	juveniles	adults
A	9.6	0.8	0.8	0.0	0.3	1.4
B	33.5	5.8	4.5	0.4	0.0	0.9
C	21.3	2.8	3.3	0.0	0.3	1.5
mean	22.3	3.3	3.0	0.2	0.2	1.2
recently logged						
A logged prior 2-4 yrs	2.5	5.1	17.2	1.5	0.4	(1.8)
B logged prior 1-2 yrs	7.1	17.7	6.9	0.3	0.9	(0.6)
mean	3.8	8.4	14.5	1.2	0.5	(1.5)

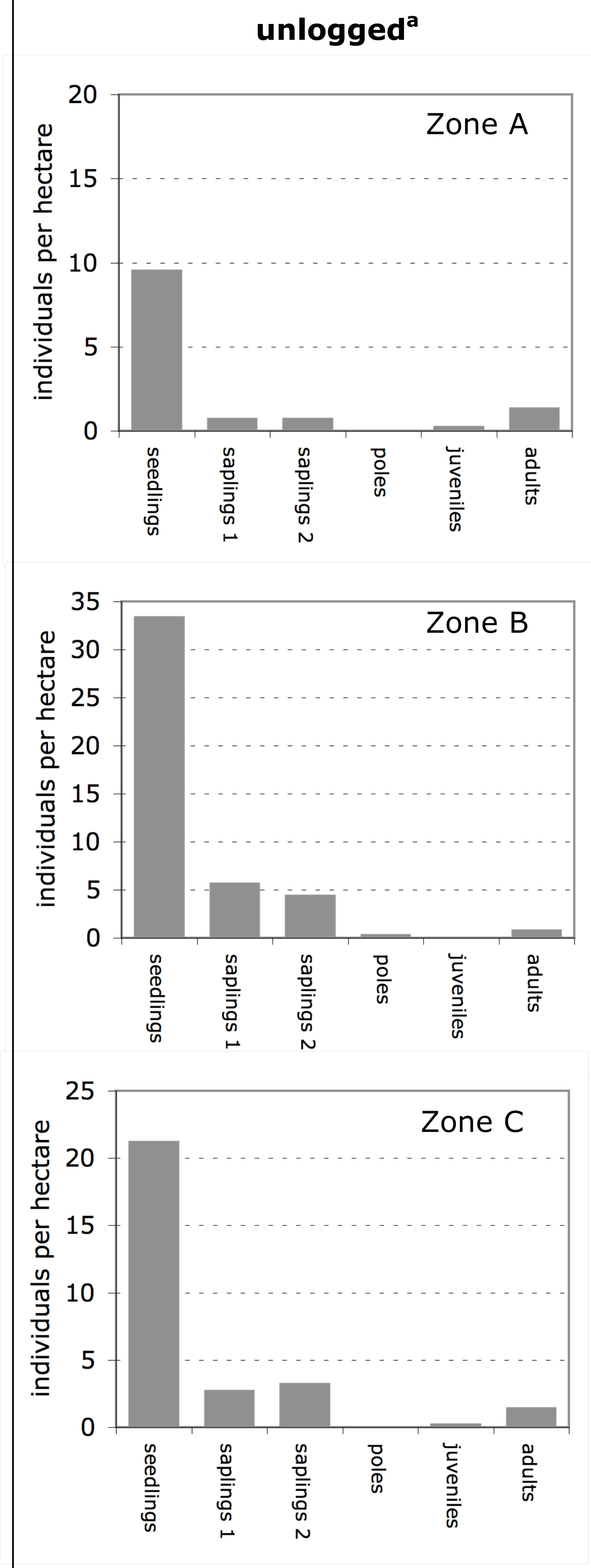
In a one-way ANOVA, mean height of combined seedlings and saplings was significantly higher ($p<0.0001$) in post-logged zones (195.9 cm, $n=315$) than in unlogged zones (101.3 cm, $n=130$).

Among zones, there was no significant difference in unlogged height of these size classes. In logged sites, however, mean height varied significantly from 227.7 cm in Zone A ($n=224$) to 117.6 cm in Zone B ($n=91$) ($p<0.0001$). This difference corresponds to the already mentioned tendency of the distribution of individuals in Zone A towards larger size classes as residual seedlings are recruited.

Height of seedlings in all sites (logged and unlogged) was significantly associated with their location in relation to treefall gaps. In particular, the mean height of seedlings located in proximity to gaps ($n=34$) (i.e. in the understory within 5 meters of gap edges) was 17% taller ($p<0.0001$) than seedlings located under closed or partially open canopy or in full gaps. In post-logged sites, 35% of inventoried seedlings were located near gap edges, compared to only 3% in unlogged sites, which reflects the comparative abundance of gaps in recently logged forest.

Of all seedlings, saplings and poles observed, 17% were located within 5 m of a stream or streambed, while only 8% of plots were crossed by streams. 18% were located in the crown shadow or in the case of logged areas, the former crown shadow of a shihuahuaco adult, representing only 3% of plots surveyed.

In logged areas, a subset of saplings >1 cm diameter and poles showed evidence of having been broken an average of 2.33 times, compared to 1.2 times in the case of unlogged areas ($p=0.0026$). In a nested ANOVA to ascertain whether this effect was related to a greater diameter size in post-logged areas, we found that the estimated number of times individuals were broken did not significantly relate to diameter. This suggests that, while logging (and potentially post-logging disturbances) results in a higher frequency of stem breakage, breakage does not necessarily result in greater mortality once individuals have reached a certain size.



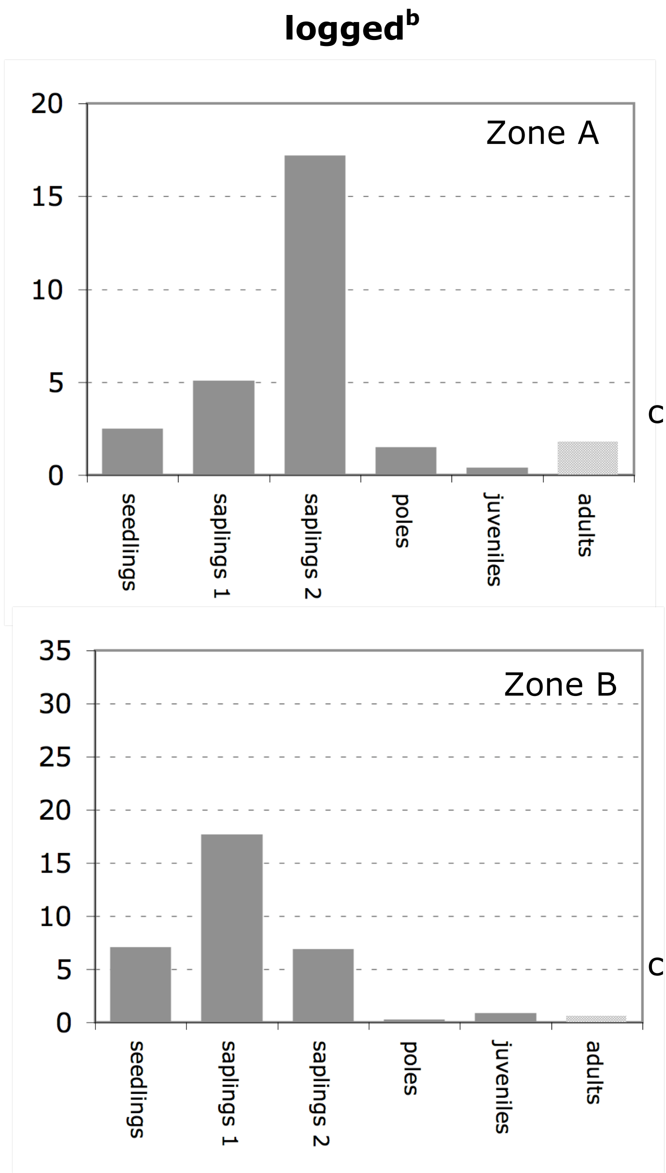


Figure 2. Shihuahuaco size-class distributions observed in unlogged and logged sites in three study zones in Ucayali and Loreto regions.

a. Forest termed "unlogged" was selectively highgraded for mahogany and cedar in 1980s. Shihuahuaco was left standing at that time.
b. Forest termed "logged" was logged for multiple species, including shihuahuaco, 2-4 years prior to study (Zone A) and 1-2 years prior to study (Zone B).
c. Adult category in logged sites reflects pre-logging density as ascertained by stump identification; shown for comparative purposes.

4.2 Permanent plot data – Growth and mortality of seedlings in understory, gap edge, and disturbed soil conditions

In permanent plots visited in two consecutive years, growth of seedlings varied substantially depending on conditions created by logging (Table 4). In low light understory conditions where the canopy had not been disturbed by logging, established seedling height (n=36) did not increase significantly between 2007 and 2008. In higher light conditions near newly created gap edges, on the other hand, established seedlings (n=130) grew a significant average of 6.5 cm, an increase of 16% over the one year period.

In plots containing new seedlings that germinated in 2007 in skidtrails where the soil had been substantially disturbed, seedling height increased a 21.28 cm, or 102% over the one year period.

Seedling mortality from year to year was not significant, though some reflection on the potential relationship of the numbers to observed conditions may yield several hypothetical explanations. Plots located in the understory showed no apparent change from one year to the next. Undergrowth in these plots was minimal, and the seedlings were located in low-undergrowth conditions overtopped by the canopy many meters above. It is therefore likely that the 36% mortality rate of these seedlings (n= 36) can be explained by a gradual failure of individuals due to insufficient light. In the gap edge conditions, on the other hand, two factors might explain the slightly higher mortality (42%, n=130). The first was the fact that a large tree branch had fallen onto one of the plots, destroying many seedlings. Another likely factor is that in the enhanced light conditions of the gap edge, competition among seedlings and with weedy plants was high. Finally, in the plots containing new seedlings growing on disturbed soil (n=56, mortality=23%), as compared to gap edges, the establishment of competitors was temporarily limited by the removal of the top soil layer, allowing seedlings to germinate and grow quickly with little competition. By the end of the first year, competing pioneer species were well on the way to interfering with the new seedlings, which, over the next year are expected to increase the mortality rate of this group.

Table 4. Permanent Plots - Growth and Survival in undisturbed (<5% canopy open) vs. disturbed (5-10% canopy open) Forest

		Understory 1+ yr Seedlings	Gap Edge 1+ yr Seedlings	Disturbed Soil New Seedlings
height (cm)	2007	36.63	39.7	20.7
	2008	36.95	46.2	41.98
Change (cm)		0.32	6.5	21.28
Change (%)		0.8%	16%	102%
P value		0.849	<.0006*	<.0001*
number	2007	36	130	56
	2008	23	75	43
Mortality		36%	42%	23%

5. Discussion

The configurations of shihuahuaco size-class distributions obtained from our inventories in unlogged forest in Zones A, B, and C are similar to results of previous research conducted in unlogged forest in Madre de Dios (Romo 2004c).

We identified a clear difference in shihuahuaco regeneration and recruitment patterns between areas that were recently logged and areas which had been relatively undisturbed for the past 20 years, and which had never been logged for shihuahuaco. As might be expected due to the removal of mature seed-producing trees, seedling abundance was lower in post-logged areas, and furthermore in comparison of sites logged 1-2 years prior and 2-4 years prior, appeared to follow a declining trajectory over time. However, a concurrent phenomenon of enhanced recruitment to sapling and pole size classes was apparent, and also associated to time since logging. Based on our data, the density of saplings (1-4cm diameter) in logged conditions might increase as much as 20 times compared to that in unlogged conditions. This has important management implications, because saplings over 1 cm in diameter have a high likelihood of survival.

Shihuahuaco regeneration is especially concentrated in two particular microenvironments associated either with streams, which have been associated with the movements and feeding behaviors of bat species that feed on shihuahuaco fruit and have more light, or where seeds accumulate under the crowns of adult trees. In, Cocha Cashu and other forest in Manu, the densities of seedlings, saplings and adults were also higher close to forest margins of lakes, rivers and streams than in other sites of the mature forest (Romo 2004c).

Our data support the hypothesis that shihuahuaco seedlings perform best in the understory near gap edges, as proposed by Romo (2004a), and these conditions are more common in recently logged areas. Unlike previous studies in Cocha Cashu, however, which found few seeds located under mature trees, in our study sites we counted a disproportionate number of seedlings under parent trees, and casually observed the frequent presence of seeds under adults during the fruiting season. This may be explained by a relative lack of seed predators due to hunting in logging zones. Given these factors, it is logical to expect enhanced survivorship and growth of residual seedlings located near the edges of a gap created by the felling of a conspecific adult, where such seedlings might not survive in the crown shadow of a standing tree.

As noted throughout logging areas in Amazonia, logging activities are followed by settlement by smallholders who make use of logging roads and gaps to engage in agricultural activities (see, e.g. Asner et al. 2005, 2006). We observed this phenomenon in all our logging zones, including those surrounding unlogged forest, and human activity in logged areas was apparent. For example, a number of gaps encountered in logged areas had been used to make charcoal or to salvage viable wood from large branches and stumps left by loggers. There was evidence as well of the slashing of undergrowth throughout the forest, indicating the regular presence of people. Additionally, local farmers recognize and are likely to spare shihuahuaco seedlings during their movements and small scale clearing activities (i.e. those that fall short of field and pasture creation through burning.) The creation of more gaps through logging as well as the nature of initial human activities in logged areas may well enhance the conditions for recruitment of shihuahuaco from residual seedlings to higher size-classes.

Although the Peruvian Forest Law requires that timber management plans, a precursor to obtaining permits to cut and transport timber, identify a percentage of seed trees to be spared in order to facilitate natural regeneration, in the case of shihuahuaco it is unlikely that any accessible mature tree will survive logging and the post-logging activities of local people. We observed that, during logging, even trees that are found to be completely hollow, and thereby useless for timber, are cut because they are extremely useful as culverts to channel the water of streams under logging roads, which are continuously extended during logging operations. Besides the extraction of logs by logging companies, there is an informal market for chainsawed *cuartones*, which are small enough (ca. 1 m x 20 cm x 20 cm) to hand carry out of the forest. Additionally, because shihuahuaco provides the highest quality charcoal in the market, during and following logging booms, a secondary shihuahuaco charcoal boom results in the cutting of even sub-marketable timber trees (Pers. Obs.).

Although the reforestation of logged concession areas by timber companies is legislated in the Forest Law, reforestation is rarely undertaken. For economic reasons and through lack of enforcement, the fate of logged areas is left to a combination of natural regeneration and to the beneficial or detrimental activities of local residents who come to occupy and use the landscape. In Zone A we observed that local farmers, both within and around the concession area we studied, were actively collecting seeds and replanting shihuahuaco along with several other useful species, in addition to protecting juvenile size-class individuals they encountered in the remnant forest patches around their fields. While some of these farmers had received seedlings from extension programs promoting reforestation of timber trees, others had acted independently and without outside assistance.

While the initial use of logged forest land results in a landscape of remnant forest patches, small agricultural swiddens, and some pasture, there is a progressive trend towards conversion of the landscape for large-scale pastures and plantation-style productive systems. Therefore, although the occupation of post-logged land by small farmers initially may create conditions favorable to the recruitment of shihuahuaco residuals, the long-term maintenance of these conditions is quite uncertain, unless some form of incentive for "family forestry" (see e.g. Nepstad et al. 2004) results in long-term management of productive forestry landscapes by smallholders.

6. Conclusion – Management implications

Our results show that that while logging of shihuahuaco is likely to reduce or eliminate seed production and future regeneration, the initial post-logging environmental conditions, both natural and anthropogenic, may in fact enhance the potential for recruitment of residuals.

In terms of management, there are several potential remediation strategies worth the consideration of logging companies and policy makers, beyond the legislated maintenance of seed trees and replanting of logged zones. On a biological level, we observed a higher-than-average concentration of juvenile size-class individuals in the vicinity of streams, both quebradas (where bats deposit seeds) and caños, where seeds fallen from fruiting adults are trapped, as well as around the based of mature individuals. During and in the several years after logging activities, protection of these areas combined with occasional management of competitors might greatly enhance the recruitment potential of shihuahuaco residuals. Additionally, considering the low mortality of individuals over 1 cm diameter is very low, it is worth protecting individuals over that size or reforesting only with such individuals.

On a social level, we observed the common Amazonian phenomenon of land occupation and use by small farmers in post-logged zones, and noted a tendency of some to protect residuals and even engage in small scale replanting efforts, with or without outside encouragement. While further research on land tenure rights, economic tradeoffs vis-à-vis planting slow growing timbers in agricultural systems, and processes of long-term landscape transformation are needed, the recognition and encouragement of such extant activities, both by timber companies and government, might favor the establishment of a future stock of shihuahuaco, as well as other valuable hardwood species.

CHAPTER 3

PUTTING BACK THE TREES: SMALLHOLDER SILVICULTURAL ENRICHMENT OF POST-LOGGED CONCESSION FOREST IN PERUVIAN AMAZONIA

CHAPTER 3

Putting back the trees: Smallholder silvicultural enrichment of post-logged concession forest in Peruvian Amazonia

1. Introduction

Tropical forests play key roles in the regulation of global and local ecological systems and contain economic resources that directly support the livelihoods of millions of people (Peluso 2005; Scherr et al. 2004), but processes of deforestation, degradation and impoverishment of biological resources continue to alter forest cover and species composition (Oliveira 2007; Schulze et al. 2008). Despite growing global awareness, demand for forest products and resources produced on cleared forestland has impeded efforts to reverse losses primarily associated with logging and burning (Nepstad et al. 1999; Asner et al. 2005; Asner et al. 2006; Malhi et al. 2008). On the other hand, substantial areas that were once deforested have seen some form of reforestation, either through natural regeneration of unused lands or through human-managed regeneration or planting activities (Perz & Walker 2002). There are numerous examples of local forest transition phenomena, resulting in reversion of deforested land to forest, which governments and the international community might encourage for carbon sequestration and other environmental reasons (Rudel et al. 2005). In addition, Barbier et al. (2009) discuss the possibility of a "forest tenure" transition that favors forest conservation and management because of increased landholding stability.

This paper presents a case of tree-planting and management of natural regeneration of shihuahuaco (*Dipteryx* spp., a slow-growing neotropical timber genus) by recent migrants to a Peruvian Amazonian logging frontier and provides support for policies that recognize the potential contribution of smallholders, including recent in-migrants, to forest management and post-logging remediation efforts. These efforts are especially important given an observed lack of such activities on the part of the logging companies and concessionaires technically responsible for managing the forests they exploit.

1.1 Logging, migration and deforestation

In tropical countries with endemic poverty, the links between logging, migration, and land conversion have been identified in numerous studies (Kaimowitz et al. 1999; ITTO 2006; Merry et al. 2006), and it is well known that people follow loggers into forests and convert land into agricultural fields and pastures (Haggith et al. 2003; Lima et al. 2006; Pan et al. 2007). Historically in Amazonia the phenomenon has been structurally determined, as in the state of Rondônia, Brazil, where national frontier policy encouraged migration and settlement from the south; there, for decades, farmers eked out a tenuous existence to the detriment of forest cover (Browder 1994). Some have called this process "invasive forest mobility" or IFM (Myers 1980; Repetto and Gillis 1988; Walker et al. 2002; Asner et al. 2006), a term which would seem to place people – in this case poor migrant farmers – squarely in the category of threats to nature that need to be controlled or removed. IFM can be readily tracked from afar through examination of satellite images showing the progressive clearing of land along logging roads (Asner et al. 2006; Souza 2006). While it is indisputable that migrant settlement in forests often results in some degree of deforestation as population increases and/or soil fertility declines (see, e.g. Thiele 1993; Smith 2003; White et al. 2005), the interactions between logging and smallholders and their relative effects on land cover are more complex than satellite imagery alone can illustrate.

In Amazonia, most logging that is not conducted for the explicit purpose of clearing land is selective logging, concentrated on the extraction of valuable and usually low-density species currently demanded by the market (Browder 1987; Kaimowitz et al. 1999; Pinedo-Vasquez et al. 2001; Asner et al. 2005; Asner et al. 2006; Souza 2006). In this decade, the composition of marketable species from Peruvian Amazonia has changed greatly, both due to the emergence of new markets – most notably the Chinese market for hardwood flooring – and to single-species protection measures especially targeting mahogany (*Swietenia macrophylla*) and tropical cedar (*Cedrela* spp.) (Putzel et al. 2008). Peru's national legislative environment has also changed substantially, resulting in a new zoning of timber concessions, protected areas, and indigenous reserves (Smith et al. 2006; Galarza & La Serna 2005; Oliveira et al. 2007). With these changes, logging companies are entering new areas and returning to areas logged previously in search of currently profitable timber species, such as *Dipteryx* spp., *Manilkara bidentata, Miroxylon balsamum*, and others. In the process, new roads must be built, and old ones improved.

In their 2007 article on how Peru's new system of logging concessions and protected areas "protects the Amazon," Oliveira et al. found that "sanctioned forest extraction activities may be an effective deterrent against clear-cutting." However, in recognizing that most deforestation occurred in proximity to urban centers and along roads, they do not provide clarity on how concession logging, which requires opening new roads, will prevent clear-cutting associated with the so-called IFM phenomenon. While we agree with their statement that "forest disturbances in the Peruvian Amazon are not simply a precursor to deforestation," their use of a cumulative 13.8%

deforestation rate 5 years after initial disturbance to illustrate this point is somewhat confusing, unless they expect post-disturbance deforestation to slow down and eventually reverse: their supporting data would seem to suggest an exponentially increasing deforestation curve.

In Peruvian Amazonia, logging is a precursor to migration, and migration is a precursor to land cover change. However, this paper supports previous findings that post-migration land cover change is not simply deforestation, especially in the context of smallholder land management: it is many other things, including farming, reforestation and management of natural regeneration to enrich future timber stocks.

1.2 Land tenure security and forest transition

In contrast to ideas about "invasive forest mobility," which associates the migration of people into forested areas with deforestation, the hypothesis of land tenure security (LTS) proposes that with secure land rights, farmers will better manage and conserve resources, including forests (Mueller 1997; Walker et al. 2002). Barbier et al. (2009) refer to a global forest tenure transition from government to community and private ownership which will likely improve forest conservation and management and, their analysis suggests, contribute to shifting the curve of deforestation to a curve of reforestation along lines proposed by Mather (1992), Grainger (1995), Rudel (e.g. 1998, 2005), and others. While Walker et al. (2002) found that LTS did not necessarily prevent deforestation by smallholders in Pará, Brazil, it likely reduced the participation in logging and increased the conservation of hardwoods in smallholdings (Walker et al. 2002). Another analysis in the same area found that duration of tenure positively affected growth of secondary forest cover (Perz & Walker 2002). In a comparative study of reforestation by smallholders in Brazil and Panama, Simmons et al. (2002) found that land tenure security increased by 15.4 times the probability of tree planting activities in both countries.

In Peru, even as the new forest laws were created and implemented in this decade to encourage conservation and sustainable management of natural forests, a major initiative to formalize the land ownership of informal landholders that began under the administration of Fujimori in 1996 (Cockburn 2004) was extended from urban to rural areas. By February 2007, over 22,000 parcels had been formally titled in the Amazonian region of Ucayali, accompanied by governmental investment "shocks" designed to improve infrastructures (COFOPRI 2007). The lack of harmonization between the forestry and land titling policies results in a legal gray area where migrants can be granted titles to land even within the boundaries of a forest concession. In addition, a logging concession can be granted despite the presence of local inhabitants with claims to the land, a phenomenon also observed in Amazonian countries other than Peru (see, e.g. Contreras Hermillosa and Vargas 2002; FPP 2004; ITTO 2006). In illustration of the fundamental disconnect between forestry zoning and land titling, it is interesting to note that the governmental bodies responsible for administering the two systems do not even use the same computer programs: natural resources are mapped with GIS software, while titled land parcels are stored in CAD software.

1.3 Smallholder forest management and reforestation

Studies of timber production activities by Peruvian smallholders have focused on the production of fast-growing timber species, such as bolaina (*Guazuma crinita*) and capirona (*Calycophyllum spruceanum*) in fallows, and recognized the validity of local people's resource management practices (Padoch & Pinedo-Vasquez 1996; Sears 2003; Sears & Pinedo-Vasquez 2004). Given the immediate value of these timbers in the domestic market as well as their potential ecosystem services, it seems logical that stakeholders will be receptive to the promotion of systems that produce them.

In addition, the planting or management of slow-growing hardwood timbers for the use of future generations is also a well-documented phenomenon (see, e.g. Peluso 1992). Simmons et al. (2002) found that, in Brazil, farmers planted a number of slow growing timber trees such as mahogany, cedar, and ipê (*Tabebuia* spp.), often within mixed plantations of cacao and/or coffee, without expecting to harvest those timbers in their lifetimes.

In the literature on smallholder-forest interactions, as pointed out by Summers et al. (2004), most discussions of sustainable smallholder forestry focuses on "traditional" populations, while "non-traditional" populations, such as non-indigenous residents of forest regions as well as recent migrants, are generally associated with studies of deforestation and land-use change. In fact, not only do "non-traditional" people employ local knowledge of silviculture, it has also been shown that they hybridize and adapt local and "science-based" knowledges from many sources, including extension agents and sources of market information (see, e.g. Sears et al. 2007).

Nonetheless, in forestland recently settled largely by migrants from other regions of Peru – i.e. non-traditional residents – it may be counterintuitive to expect the long-term perspective accompanying the planting of slow-growing timbers, and it would certainly be careless, considering rural poverty levels, to encourage residents to devote their time and space to activities that might not benefit them in their lifetime. However, in areas located in and around logging areas near Pucallpa, in the Region of Ucayali, Peru, smallholders are planting, within their very diverse agricultural and agroforestry fields, trees of *Dipteryx*, a slow-growing neotropical genus (Romo 2005; Clark & Clark 2001).

2. Methods

2.1 Study area

Irazola District, Province of Padre Abad in the Region of Ucayali, covers an area of 2,006.98 km^2 and is located between the urban centers of Pucallpa and Aguaytía, which are connected to each other by the Federico Basadre Highway. In recent years, according to provincial documents, the population of the province multiplied, mainly due to a boom in coca production which attracted migrants from the central Sierra, which is located on the Amazonian side of the Andes and is culturally similar to the Amazon region. The District now comprises ca. 57 population centers including the district capital of San Alejandro; in 2005 the district population was 16,192. Overall, the rural population of Padre Abad Province increased from 5,679 in 1981 to 19,793 in 1993 and 23,868 in 2007. The majority of Irazola district lies within the boundaries of the 4074 km^2 Alexander von Humboldt national forest, which is a designated permanent production forest as well as the site of a number of logging concessions. Around and within these concessions, there are a number of permanently settled population centers. In recognition of the establishment of population centers within the boundaries of the national forest, the National Ministry of Agriculture excluded 13,450 ha from the national forest in 1999. However, since then continued migration has continued both within the national forest and into the forest concessions.

2.2 Research methods

In 2007 several communities of smallholders were identified in Irazola District, Province of Padre Abad, Region of Ucayali, within the historic and actual boundaries of a timber concession. At that time, it was noted that some families were actively managing residual trees of the genus *Dipteryx* as well as transplanting seedlings of the same genus in their agricultural fields. Data were collected on the growth rates of these trees in the fields of two farmers (Farm A and Farm B), the first measuring 2 ha, the second 1 ha, over three years in September 2007, September 2008, and October 2009. The trees had been transplanted as seedlings one year prior to the study, and the original size of the seedlings was not known.

In 2009, in-depth semi-structured interviews were conducted with 30 families in three communities. Due to the challenges inherent to sampling involving farmers distributed over large areas, frequently absent or following a daytime schedule of working in their remote fields, individuals were selected for interview using the principle of first opportunity, as described by Walker et al. (2002).

Data collected included information on the settlement and logging histories of the communities, reported landholdings and associated land uses, and the nature and extent of local involvement and interest in replanting initiatives. In particular, interviews focused on community members' management and replanting of *Dipteryx*, a slow-growing hardwood tree. In addition, several interviews were conducted with the owner of the timber concession contract. The results of these interviews are presented here, with additional background information derived from provincial documentation. Additionally, we present the results of three years of growth data collection on *Dipteryx* trees planted by in the fields of Farm A and Farm B.

3. Results

3.1 Description of communities and land tenure

Communities A, B, and C are located on the fringes of a 15,000 ha timber concession that was established in the 1980s but was subsequently abandoned for more than a decade due to civil unrest. The concession contract was renewed in 2005 under the new forestry legislation and relations between the communities, the company that owns the contract, and subcontracting logging companies vary a great deal. Community A and B are joined by a road built with funds from a US government "alternative development" program aimed at eliminating coca production in the area. While technically not intended for the passage of heavy vehicles, logging trucks use the road and pay a toll to the communities. In Community B, which lies closer to the current logging zones, land tenure disagreements with the concessionaire and loggers result in frequent confrontation. Communities A and C, which lie further from current logging areas have fewer difficulties in their interactions with extractors.

The logging history of the three communities as well as the concession is complex. Since the early 1990s, the area has been selectively logged repeatedly by a multitude of extractive companies and individual loggers, both with and without permits. The first species to be removed included mahogany (*Swietenia macrophylla)*, tropical cedar (*Cedrela* spp.) and ishpingo (*Amburana cearensis*); in this decade, the most demanded species have included azucarhuayo (*Hymenaea courbaril*), aguanomasha (*Machaerium inundatum*), quinilla (*Manilkara bidentata*), estoraque (*Miroxylon balsamum*), and shihuahuaco (*Dipteryx* spp.). Recently, demand for *Dipteryx* timber has resulted in a race for the resource between local residents and extractors. While companies may pay residents between $10 and $35 per tree on contested land (whether or not it is legally located within the concession) families with sufficient available human resources can earn more by cutting trees themselves and selling the timber in chainsawed blocks at around $0.30 per board foot ($127 per m^3). Alternatively, since *Dipteryx* charcoal is among the best in the market, they often salvage branches left by loggers or cut standing trees to produce charcoal, which sold at up to $15.00 per cubic meter in 2008.

Land tenure in all three communities has been relatively fluid because the majority of residents obtained the land through informal settlement followed by a process of formalization. The first step in obtaining title is to obtain a document from the regional government called a *constancia de poseción*, which recognizes a family's possession, location and area of a parcel of land without attesting to their right to own it. However, constancias are valid as proof of occupancy and are accepted as the basis for titling by the national organization COFOPRI, thus they constitute a type of formal tenure. Most families interviewed claimed formal ownership of a portion of their land while claiming informal rights to additional lands. Especially in Community B, the concession owner contests the rights of residents to occupy lands well within the bounds of the concession and has made efforts to restrict their activities and expansion. Overall, in the three communities families claimed formal ownership of an average 21.9 ha and informal tenure of an average additional 30.8 ha (p=0.0407). Thus, the average area of combined formal and informal landholdings is around 53 ha per family.

The average length of residence among respondents was 8.5 years, though in Communities A and B the earliest residents arrived up to 20 years ago, and in each place one family interviewed claimed to be among the first occupants of the community. Community A, the oldest of the three communities, was officially founded in 1996, while Community C, the newest community was founded in 2002. Although the migration history of individual families is very diverse, the majority of people in the area come from either Huanuco or San Martin, on the Amazonian or eastern side of the Andes.

There is some variation in land uses among the communities. All families report a certain amount of land for mixed agricultural production (including maize, plantain, cassava, dryland rice, etc.). In Communities A and B extension programs have promoted the production of oil palm and agroforestry including cacao. Residents speak of receiving palm and cacao seedlings in quantities of "hectares," i.e. enough seedlings to cover one hectare. However, while oil palm is planted in monoculture, cacao is planted in mixed agricultural systems which sometimes include both fast- and slow-growing timber trees. Cattle pastures are common, but are not the primary means of subsistence in the area. On average, families report holding an average of 4.6 ha in mixed agriculture, including subsistence production (*chacra*) and plantations of cacao and oil palm; 3.74 ha of pasture (*pasto*); 8.88 ha of secondary fallow (*purma*); and 20.32 ha of standing forest (*monte alto*). The reported amount of standing forest held by each family correlates positively to the size of their informal land holdings.

3.2 Post-logging tree planting and management of natural regeneration

In interviews, 76% of respondents were aware of *Dipteryx* residual seedlings or saplings growing in the forested parts of their landholdings. While 72% claimed to be active in management of other species, such as cedar (*Cedrela odorata*), ishpingo (*Amburana cearensis*), capirona (*Calycophyllum spruceanum*), and bolaina (*Guazuma crinita*) fewer (56%) were actively managing *Dipteryx.* In addition to management, which primarily involves liberation of seedlings or saplings through clearing and thinning, 52% of respondents reported that they planted timber trees, by transplanting seedlings found in the forest, delivered by extension agents, or by raising them in small nurseries. Answering an open ended question as to the rationale for replanting trees, roughly one third (n=11) of respondents mentioned environmental protection as a primary concern, including maintaining atmospheric quality (e.g. "purifying the air"), protecting the water supply, and providing habitat for animals. A number of respondents (n=7) cited benefit to future generations and especially to their own grandchildren as the primary reason to plant valuable timber trees. Several respondents who plant or manage trees for their own economic benefit primarily concentrate on faster-growing species. Overall, the probability of residents engaging in tree planting appeared to be strongly correlated with the length of time they had lived in the area.

While it appeared that a number of respondents were self-motivated in managing or replanting timber species, it was obvious that external influences had been important in the area. Although the concessionaire was accused of neglecting reforestation, one respondent who had worked for 2 years as a woodsman volunteered that the concessionaire had hired local residents to create a nursery for timber trees for the purposes of enriching the concession. When the concessionaire allegedly failed to pay for the work, the trees were sold to an alternative development project and they were distributed to local farmers. In 2006, a project delivered tree seedlings and fertilizer to farmers in Community A as part of a project to relieve pressure on the natural forest, to "stabilize" farmers, and to promote environmental education. The project was supposed to provide credit to participants, but it closed down shortly after reaching our study area. Problems associated with the project included the failure of some farmers to plant the seedlings they were given, and the loss of planted trees to escaped fires from neighbors' fields during a drought in 2005. We present below growth data from one field where seedlings from this project were planted. Finally, an association of Agriculture and Forest Producers of Monte Alegre (ACPAFMA), started in 2005 by a local politician, has attracted 330 members in 21 communities in the district, including Communities A, B and C. The association is seeking funding for mixed cacao and timber agroforestry projects.

Although the degree of general environmental concern expressed by respondents was high and many considered planting timber worthwhile for the purpose of providing resources for future generations, many also complained about lack of support from external sources of funding. While the combination of cacao and timber seems to be successful, such land use will have to compete with expanding smallholder oil palm plantations which is heavily subsidized by alternative development projects. At the entrance to the area from the Federico Basadre Highway there is an oil extraction plant, whereas the closest processing facility for cacao is located in Tingo Maria, Department of Huanuco, more that 200 km from the area. Nonetheless, planters of cacao prefer it because it requires less labor, and appear willing to experiment with timber production in a mixed system.

3.3 Performance of Dipteryx *spp. juveniles in agricultural fields*

The average growth rate of individuals in the field of Farm A and B between 2007 and 2008 was 49% and 75% in terms of height and diameter, respectively. From 2008 to 2009, the average growth rate slowed to 31% and 24%, respectively. No significant difference was identified between the two farms (Table 1); however, inspection of the data shows an apparent slowing of diameter growth in Farm B, where the trees were planted on well-drained slopes, vs. Farm A, where the trees were planted on a flat area surrounded by streams (Figure 1).

Table 1. Growth of *Dipteryx* spp. juveniles in fields of Farm A and Farm B.

year	n	mean diameter (cm) ± SD	mean height (cm) ± SD
farm A			
2007	30	2.79 ± 1.16	353 ± 120
2008	30	5.20 ± 1.75	549 ± 167
2009	30	6.93 ± 2.14	711 ± 179
farm B			
2007	47	3.35 ± 1.65	371 ± 160
2008	45	5.66 ± 2.09	538 ± 220
2009	44	6.73 ± 2.75	709 ± 260

Overall, growth in height was 178 cm from year 1 to year 2 (from 364.13 ± SD145.07cm to 542.8 ± SD199.09cm) and from year 2 to year 3, 167 cm (542.8 ± SD199.09 to 710.22 ± SD229.02). Growth in diameter from year 1 to year 2 was 2.35 cm (from 3.14 ± SD1.5cm to 5.48 ± SD1.96cm) and from year 2 to year 3, 1.33 cm (from 5.48 ± SD1.96cm to 6.81 ± SD2.5cm). A two-way analysis of variance shows significant growth from year-to-year, with no significant difference between farms (table 2.)

Table 2. Two-way ANOVA showing change in height and diameter is significantly related to age, and not to the location of study sites.

two-way analysis of variance – Height (cm)					
	SS	*df*	*MS*	*F*	*P-value*
Model	4524054	3	1508018	40.0393	<.0001
Error	8361289	222	37663		
Total	12885343	225			
Effect tests					
Farm	186.1	1		0.0049	.944
Year	5423842	2		60.0561	<.0001*
R^2 = 0.35					
two-way analysis of variance – Diameter (cm)					
	SS	*df*	*MS*	*F*	*P-value*
Model	528.39	3	176.130	43.0628	<.0001
Error	907.9974	222	4.09		
Total	1436.39	225			
Effect tests					
Farm	4.25	1		1.0397	.3090
Year	525.31	2		64.2179	<.0001*
R^2 = 0.37					

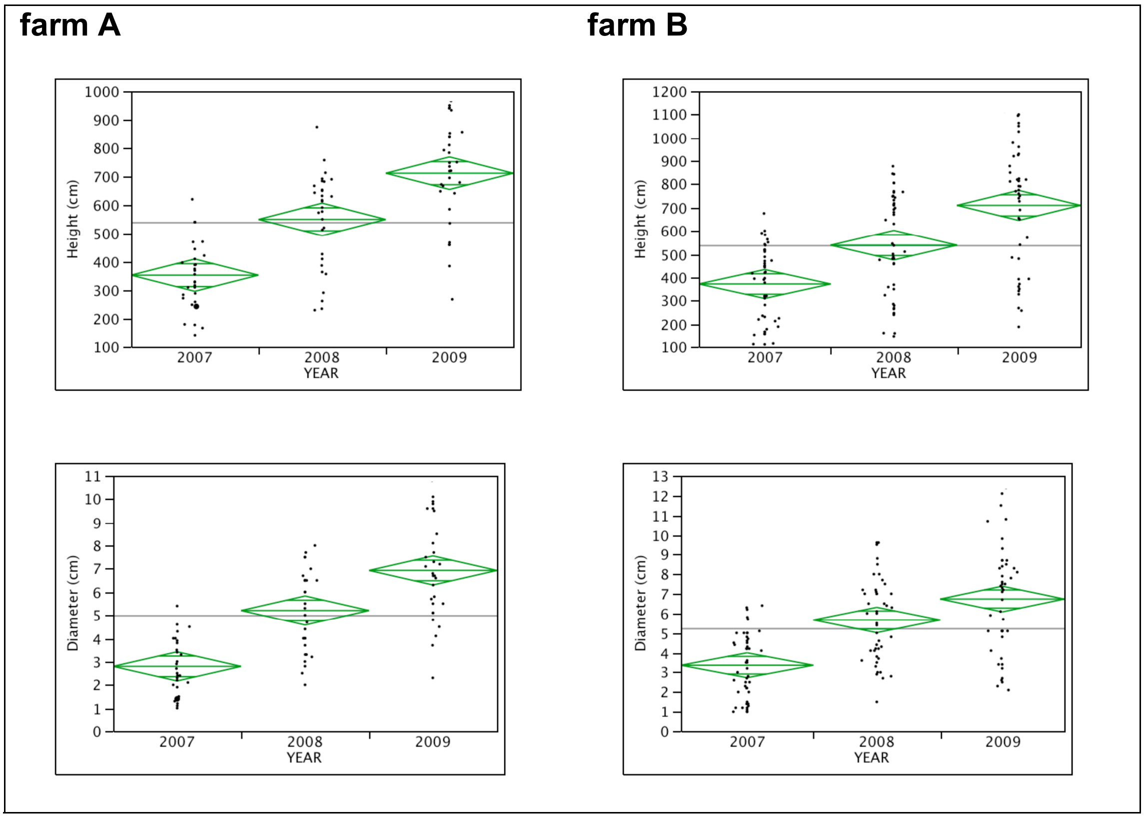


Figure 1. Growth of *Dipteryx* spp. juveniles in height and diameter on farms A and farm B.

4. Discussion

In forest concession areas of the Von Humboldt national forest in Irazola district, as elsewhere in Peru, there are overlapping areas of forest concession and farming communities. Migration has occurred both during periods of active logging, when concession contracts have been in effect, and during in-between periods when concession contracts have lapsed. The earliest current residents of the area only arrived at the end of the 1980s, when logging companies were active in the area and logging roads had been cut, and it can therefore be assumed that logging facilitated access to the area. As selectively logged land has been occupied by migrants, the area of the permanent production forest has been officially reduced, and with the national drive to formalize land ownership families have been granted titles both within the limits of the national forest and an active timber concession.

The gradual occupation of post-logged land in Irazola – because it occurs gradually, without planning, and follows logging roads – could be termed an invasive phenomenon. In the absence of such land acquisition and transformation, gaps created through logging would be closed by a suite of locally adapted gap-colonizing species and the forest cover would remain largely intact. In terms of species composition, however, the residual forest would likely be impoverished, especially from an economic perspective: without management, selective logging results in a shortage of key economic species and a severely reduced potential for recovery due to the removal of seed trees. To date, there is little evidence that timber concessionaires and logging companies are involved in efforts to replant timber species or manage natural regeneration of logged areas. While the arrival of migrants results in transformation of the landscape from forest to a mosaic of different land uses, the presence of people may increase the potential for replacement of valuable timber species, as has been observed in other locations by Peluso (1992), Padoch & Pinedo-Vasquez (1996), Simmons et al. (2002), Sears et al. (2007) and others.

This study focused on *Dipteryx* spp. Although we did not quantify the planting of *Dipteryx* vs. other timber species, we found that it was a species of particular interest to farmers in the area. Our measurements of the growth of *Dipteryx* spp. trees in two mixed agroforestry fields were comparable to the fastest growth rates of the species *Dipteryx micrantha* previously observed in "pure plantations" (Romo 2005), suggesting that this treatment of the species is likely to result in a future standing stock of these particularly valuable trees. Romo (2005) found that seedlings reached a height of almost 5 meters and a diameter of about 5 cm after two years of growth. In the second year of our study, i.e. ca. two years after planting, the juveniles we measured in Farms A and Farm B (n=75) reached an average diameter of 5.48 cm ± 1.96 and height of 542.8 ± 199.08cm. We were not able to measure the initial size of these individuals, since they had been planted in the year previous to the beginning of our study.

In this study we found that not only were the majority of landholders managing the natural regeneration of timber trees, but were also planting seedlings on their lands. We argue that these activities indicate not only a wish to obtain future economic benefit from timber, but an intention to maintain areas with tree cover, or to allow timber trees to recover areas currently being used for other purposes. Such activities are common among smallholder farmers that occupy tropical forest regions, and therefore should not come as a surprise. However, there are several points suggested by this study that are important to highlight. These are:

1. *Recent migrants engage in post-logging reforestation.* Through management of natural regeneration and replanting of timber species removed through logging operations, recent migrants in the study region promote the enrichment of residual forest as well as current fallows and mixed agricultural fields with hardwood timbers now valuable in the market.

2. *Smallholder management contributes to conservation of local genetic diversity.* By managing residual saplings and collecting seeds from trees of species

currently being cut in timber concession land and production forest, smallholders conserve genetic diversity which might otherwise be permanently lost.

3. *Reforestation practices are influenced by extension projects.* Although the success of extension projects promoting integration of timber production in agroforestry is mixed, the majority of people interviewed in our study were aware of these projects. The production of cacao and coffee interspersed with timber trees, which has been promoted in the area, is a form of cultivation that is known to work in other locations (Simmons et al. 2002), and represents an alternative to monocultural plantations such as oil palm, which is also being heavily promoted in the area. The hybridization of knowledge highlighted by Sears et al. (2007) is also apparent: while some farmers receive materials and follow the guidelines of extension projects, others improvise by collecting seeds and planting trees in their mixed agricultural fields from seedlings produced in their own nurseries.

4. Finally, it is to be noted that *land tenure security in the study area is being greatly increased by the process of land title formalization* under COFOPRI. The fact that migrants are getting title to their land in the area may increase their interest in long-term inter-generational management of timber trees. However, the long-term stability of communities depends on economic viability. In other studies, it has been found that the first occupants of newly opened forest areas are not necessarily present for the long term, and that titling may result in land sales (Walker et al. 2002). It has also been suggested that communal management, in the context of state-community partnerships, would be more effective than private ownership (Alcorn 1996). Nonetheless,

while land titled under COFOPRI is private, residents of Irazola communities showed an eagerness to join communal efforts such as ACPAFMA to obtain a combination of plantation materials such as cacao plants and timber seedlings.

5. Conclusion

Although the Peruvian forest law requires that timber concessionaires submit a plan for post-logging reforestation, in reality there is currently no evidence that concession holders or timber companies maintain a workforce that would be capable of such work. While recognizing that migration of people to post-logged forest land results in the conversion of the landscape into a mosaic of different land cover types, and that the extent of forest cover under smallholder management likely does not return to its original extent while it is used (Rudel 2005), it is important to recognize that management and planting by smallholders, including recent migrants, contributes to the conservation of timber tree genetic diversity and to the enrichment of forests for future generations. The activities of extension agents to provide seedlings leave an impression, not only among those smallholders that accept and plant the seedlings, but also in the minds of people who have not yet participated, supporting previous findings that smallholders are receptive to receiving knowledge and materials from many sources.

Our findings show that smallholders, even if they are relatively new to an area, have the impulse to engage in reforestation of valuable trees, and that their observation of the removal of valuable resources and contact with extension programs may increase that impulse. This finding, while we consider it relatively commonplace, suggests that there is a window in the deforestation process in which irreplaceable future genetic stock, represented by the seeds and seedlings of felled adult trees, might be conserved and the future availability of timber for which there is currently an insatiable demand might be secured. However, this study does not suggest that devoting large areas of land to the growing of slow-growing trees will satisfy the current livelihood needs of smallholders in tropical rainforests. Rather, we conclude that those interested in the remediation of post-logging impacts, especially in Peruvian Amazonia, consider the propensity of local people to participate in such efforts with or without outside assistance, and take steps to protect the economically fragile conditions in which such a propensity is expressed by rewarding activities already undertaken.

CHAPTER 4

THE *DIPTERYX* TIMBER BOOM: FROM LESSER-KNOWN SPECIES TO LEADING EXPORT

CHAPTER 4

The *Dipteryx* timber boom: From lesser-known species to leading export

Abstract

Beginning in the 1990s, international and Peruvian organizations involved in timber management, trade and conservation began a concerted effort to promote the marketing of lesser-known or "non-traditional" timber species from Peruvian Amazonia. A number of these species found a ready market in China, with its burgeoning demand and long experience in processing diverse tropical timbers from southern Asian forests. Using trade data from Peruvian customs, we analyze the exports of 170 companies and find that the species composition of exports to China is largely composed of several formerly obscure hardwood species and is distinct from patterns of export to other markets. In light of the difficulties the government of Peru has had in managing its timber stocks, we question the efficacy of promoting lesser-known species from Peruvian Amazonia in fulfilling conservation or sustainable forest management priorities.

1. Background

The promotion of lesser-known species of timber, or LKS, also sometimes referred to as "non-traditional" species, has a long history in international forestry. In the 1950s, LKS were promoted by the Organization of European Economic Cooperation (OEEC) as a means to reduce exploitation costs and achieve a higher per area output from colonial forest holdings. A brochure produced for this purpose (OEEC 1953) proposed Amazonian ipê (*Tabebuia* spp.) as an excellent choice for docks, bridges, and locks, shipbuilding, wagon building, furniture, and parquet flooring. Now, nearly 60 years later, with ipê cladding boardwalks from Coney Island to Brighton across the Atlantic and apartment floors in Beijing, researchers ask "how rare is too rare to harvest?" and propose that the ipê market not only threatens the species itself, but also catalyzes deforestation in general (Schulze et al. 2008a; Schulze et al. 2008b). Proponents of LKS marketing have highlighted several potential benefits of the approach, including: reducing pressure on high-demand "traditional" species such as big-leafed mahogany and tropical cedar (Vlosky and Aguirre 2001); increasing income from forestry in the context of community management (Forster et al. 2003); and increasing logging revenues per area in order to slow expansion into new areas (Toledo 1997).

Much attention has been paid to the mechanisms whereby the market accepts LKS in lieu of traditional species. Freezailah (1984) suggested that LKS would enter the market with increased prices and decreased availability of traditional species. This perspective was called into question by Vincent et al. (1990), who modeled substitution of LKS logs for traditional logs in the Japanese market and showed that price was unlikely to affect the choice of industrial producers. Bethel (1984) attributed the reluctance of markets to accept LKS to the difficulties of establishing productive systems of wood transformation capable of dealing with a wide range of woods of different qualities and technical properties. Nonetheless, the concept held on, and became a focus of intervention in the timber industry in some places.

By the late 20th century in Peru a number of organizations involved in economic development, tropical forest conservation and regulation of the timber industry, took up the promotion of LKS as a solution to a number of loosely related problems. Lists of species were drawn up, were tested for their particular mechanical properties, and glossy booklets featuring photos of their rich grains were distributed to potential buyers along with physical samples. Forest inventories were done showing the relative abundance of a number of "new" species (WWF 2003). Reasons for promoting LKS included increasing the yield from logged areas by 400%, reducing unitary costs of extraction, and reducing areas cut to satisfy industrial demand. Further benefits included the creation of funds to cover the costs of forest management, the establishment of silvicultural systems incorporating lesser-known species of proven economic value, and the stabilization of migratory agriculturalists (Toledo 1997).

In 1990, the International Tropical Timber Organization (ITTO) undertook a three-year project (PD37/88) entitled "Industrial Use of New Forest Species in Peru," in collaboration with the Peruvian natural resource authority (INRENA) and the national forest chamber, to test 40 new species, instruct timber companies in their processing, and to develop markets for them. 50 species were selected based on a minimum stand density of 0.7 m^3ha^{-1}, proven industrial value, and timber company interest (Toledo 1997). A decade later, the Worldwide Fund for Nature (WWF) with support from the United States Agency for International Development (USAID) continued along the lines established by the ITTO, in a project entitled "Promoting Lesser Known Species Harvesting, Industrialization and Marketing to Support Sustainable Forest Management in the Peruvian Amazon." This project produced a number of workshops, manuals and technical reports, including regional inventories of volumes of lesser-known species available for harvest, processing techniques, and market analyses (WWF 2003). WWF rationalized their foray into logging as follows:

> **The widespread extraction of big-leafed mahogany and a few other key species by an informal forest sector motivated by the promise of short term, unsustainable economic gains has created a major threat to the forests of the Peruvian Amazon. With the removal of these trees of high value and no incentive to manage the remaining area, the forest lacks economic value and becomes nothing more than a nuisance to resource-poor farmers. This lack of incentive for sustainable forest management together with the infrastructure laid in place by the removal of mahogany frequently results in the clearance of large tracts of forest. The remaining forests contain a large variety of timber species that are not well known in national and international markets, but, after preliminary studies and analysis, have proven to hold considerable economic potential. Finding markets to justify the harvesting of these lesser known species to increase the profitability per hectare of forests is a key step towards ensuring viability of the forest sector and will in turn safeguard the sustainability of timber and other environmental products and services (WWF 2002).**

While the ITTO, WWF, and Peru's national forestry and trade bodies were working to find new markets for lesser-known species, a new market found Peru. With market prices depressed by the Asian financial crisis and having entered a national plan to protect its own forests (Liu & Diamond 2005; Wang et al. 2007; Laurance 2008), China in the late 1990s suddenly became the world's largest consumer of logs and semi-processed timber, and new supply chains quickly stretched from there, beyond Asian producing countries, to Africa and South America. By early 2009, Chinese demand accounted for over 50% of the value of Peru's timber exports. As has previously been noted elsewhere (Putzel et al. 2008), Chinese demand for traditional species, such as mahogany and tropical cedar, has been minimal. Rather, the Chinese market has favored less expensive and more plentiful woods, many of which were promoted as lesser-known species in the 1990s. In this paper, we are interested in examining whether Chinese demand for LKS replaces demand for traditional species from other markets such as the US and Mexico. Through examination of trade data, we conclude that this is not the case and that therefore the goals of the promotion of LKS in Peru were not achieved.

2. Methods

We examined over 12,300 customs declarations from 170 timber exporting companies located in Peru, collecting data on the destination, quantity in m^3 and kg, the FOB US$ value of shipments and the species of timber exported from Peru over 5 years from 2004 to 2008. In addition, we examined data from ADEX (the Association of Exporters from Peru) and reports by PROMPEX, the Peruvian Export Promotion Agency. Customs declarations generally contain information on species included in shipments, however, in some 15% of cases individual shipments contained several species that were not individually quantified. In such cases, we divided the total quantities by the number of species in the shipment to obtain an estimate by species. In addition, shipments to the United States sometimes are not expressed in m^3 but rather in units. In such cases, we calculated volume using an average weight per volume obtained from the remaining data, correcting for both air and kiln-dried weights per volume, for which data was also available in the customs forms.

3. Results

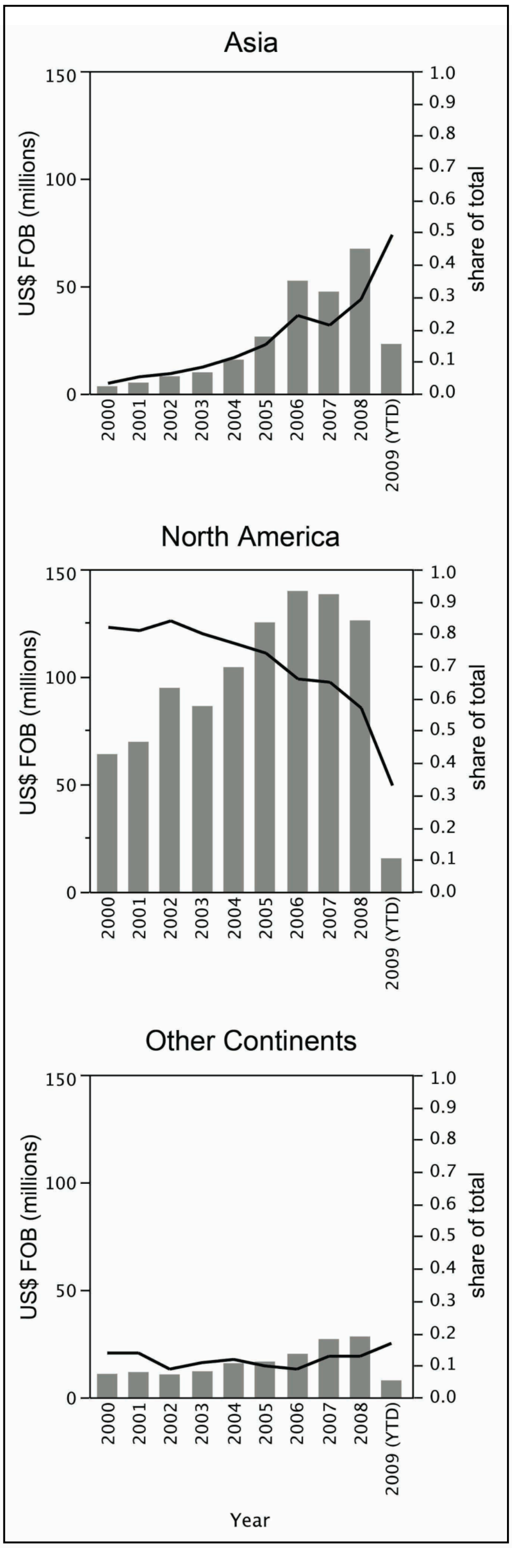


Figure 1. Value of timber exports from Peru to Asia, North America, and other continents from 2000 to 2009 (March year-to-date).

ADEX trade figures show that the value of annual timber exports from Peru increased 185% to US$ 222.8 million between 2000 and 2008, largely due to demand from Mexico, the US, and China. However, while the dollar value of exports to North America peaked in 2006, Asian market demand has continued to increase until the present and in the first five months of 2009 represented over 50% of Peru's total timber exports by value (Figure 1). In a further breakdown of this data, in 2008, ca. 42% of export value comprised plywood destined largely for the North American markets. Secondary processed products (e.g. furniture) and veneers accounted for 15%. Another 43% of total value was made up by sawn hardwood timbers.

It is in this latter category that the growing importance of the Chinese market is apparent. ADEX data shows that 70% of sawn hardwoods were sent to Asia in this decade. In terms of volumes derived from customs declarations between 2004 and 2008, the Chinese market represented 98% of Asian demand for Peruvian timber. With a tripling in volume of shipments of hardwood timbers, the Chinese market moved to 2nd place (after Mexico) in 2008 compared to 2004 (Table 1) and of the 170 companies for which customs data was collected, 101 (59%) shipped timber to China between 2004 and 2008.

Table 1. Data acquired from the customs forms of 170 companies shows that, by 2008, China was Peru's second largest timber export market by volume.

ranking of markets for Peruvian timber	**total volume in m3 shipped per year (170 companies)**						
	2004	**2005**	**2006**	**2007**	**2008**	**2008 rank**	**2004 rank**
MEXICO	63101	62773	65929	116077	118036	1	1
CHINA	21480	35628	63299	62255	67639	2	3
USA	57261	52388	58001	48149	40844	3	2
DOMINICAN REPUBLIC	5099	3164	5422	5618	9563	4	4
ITALY	615	1570	6599	2502	2723	5	12
CANADA	614	698	389	1306	2457	6	13
NEW ZEALAND	1132	1849	808	1535	2115	7	7
VENEZUELA	382	.	.	2435	1345	8	17
SWEDEN	275	1032	484	1572	1287	9	22
BRAZIL	.	2471	6208	757	1195	10	42
UK	660	523	109	91	991	12	10
GUATEMALA	702	659	861	955	866	13	8
SPAIN	3209	1751	559	3419	618	17	5
COLOMBIA	687	.	6	1039	44	36	9
TAIWAN	1349	2544	968	122	39	37	6
OTHER	5422	5503	5622	8000	7216		
TOTAL	**161987**	**172555**	**215265**	**255833**	**256978**		

In terms of species demanded, the Chinese market (including Taiwan) and the North American market (including Caribbean countries) present very different profiles. From the data, we can discern two separate booms in this decade. One boom was associated with the North American market, particularly Mexico and the United States, consisting in exports of plywood and lumber made largely from the low density *Virola* spp., which is listed as

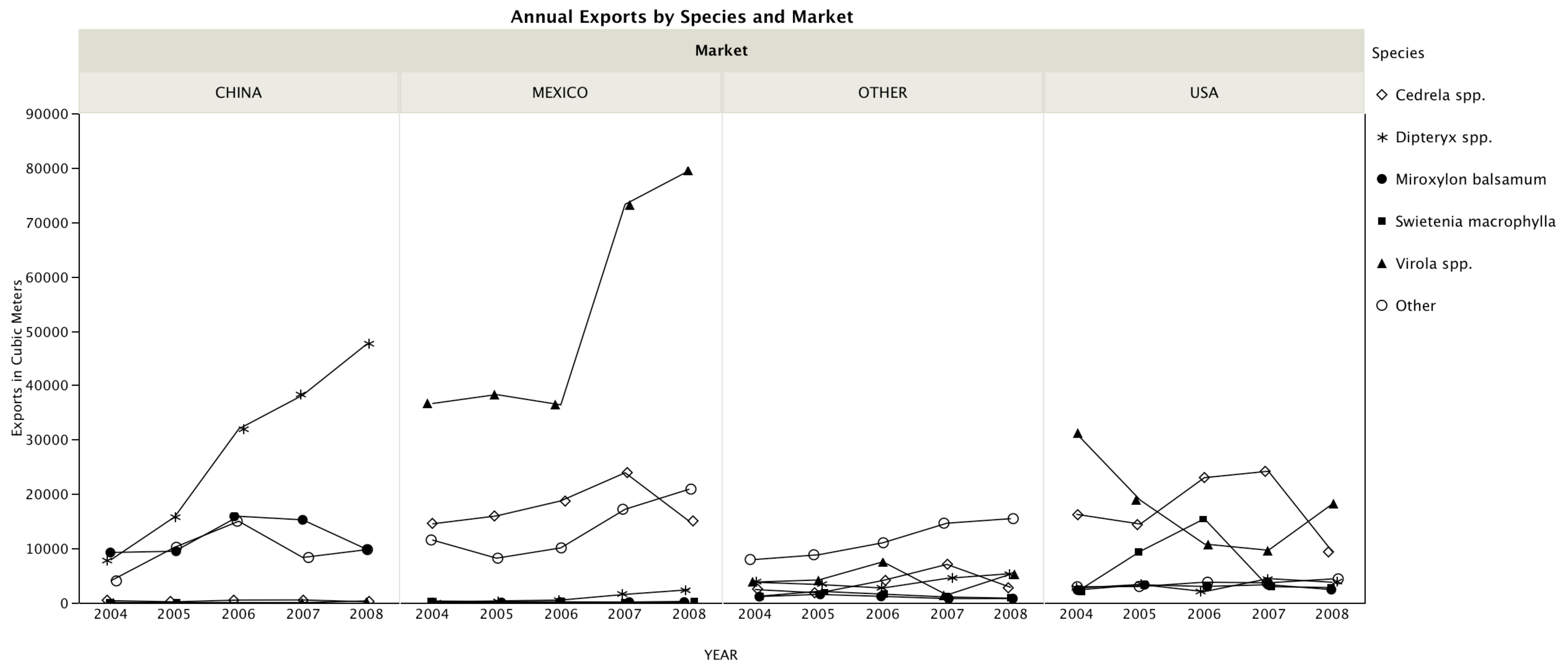


Figure 2. Between 2004 and 2008, exports of *Dipteryx* spp. to China increased steadily while exports of *Swietenia macrophylla* and *Cedrela* spp. to other markets declined sharply from 2006 or 2007 while exports of timber identified as *Virola* spp. to Mexico increased drastically in 2007 and 2008, prior to the global economic crisis. The decline of exports of *Miroxylon balsamum* to China may indicate growing scarcity of the species.

endangered in several countries along with continued, though now declining, exports of tropical cedar (*Cedrela odorata*) and mahogany (*Swietenia macrophylla*), both now endangered and controlled (Figure 2). These three species are all "traditional" species. The other boom was a rise in exports, mainly to China, of extremely dense woods, in particular *Dipteryx* spp., *Miroxylon balsamum*, and *Manikara bidentata*.

In terms of revenues, *Dipteryx* was the greatest contributor to the bottom line of the170 export companies between 2004 and 2008, representing 14% of revenues and 17% of volume (Table 2). By contrast, *Virola,* which represented 35% of exports by volume, brought in only 6% of revenues.

Table 2. Revenues and volumes of exports by species of 170 companies for 5 years from 2004 to 2008, and the percentages they represent.

species	Revenue (US$)	revenue %	m^3	volume %	value/M3 (US$)
Dipteryx spp.	181637468	14%	182020	17%	998
Manilkara bidentata	41135441	8%	36858	3%	1116
Cedrela spp.	158812597	8%	195072	18%	814
Virola spp.	162641543	6%	375103	35%	434
Miroxylon balsamum	109420835	6%	79658	8%	1374
Calycophyllum spruceanum	8465663	6%	17915	2%	473
Swietenia macrophylla	60779754	4%	40087	4%	1516
Aspidosperma macrocarpon	8679667	4%	11558	1%	751
Brosimum alicastrum	3942229	4%	6609	1%	596
Amburana cearensis	4128355	4%	5971	1%	691
Cariniana domesticada	5990033	4%	8943	1%	670
Cedrelinga catenaeformis	7365923	3%	12932	1%	570
Ceiba pentandra	13092296	3%	28630	3%	457
Simarouba amara	4960513	3%	17134	2%	290
Tabebuia spp.	7764087	2%	4048	0%	1918
Hymenaea courbaril	23650862	2%	11355	1%	2083
Ormosia coccinea	720219	2%	1156	0%	623
Sterculia spp.	1884167	2%	3869	0%	487
Terminalia amazonia	1335269	2%	2398	0%	557
Copaifera spp.	994961	1%	1819	0%	547
Calophyllum brasiliense	266743	1%	582	0%	458
Apuleia leiocarpa	533513	1%	881	0%	606
Hura crepitans	251454	1%	1025	0%	245
Machaerium inundatum	200562	1%	127	0%	1585
OTHER	10219645	8%	16846	2%	607

4. Discussion

The Chinese market's preference for *Dipteryx* spp. and *Miroxylon balsamum* as well as a suite of other species exported in lower volumes cannot be discussed in terms of market substitution: when the new market appeared, these were the species that were being promoted for export, and Chinese buyers began immediately to purchase them. However, if the intention of the various programs to promote the marketing of LKS was to increase revenues through the sale of new species in the market, the performance of *Dipteryx* and *Miroxylon balsamum* might be viewed as a success. These species were listed as LKS in the early 1990s ITTO project, and were listed on WWF inventories of trees available for extraction in the 2000s. Favored by the Chinese market these woods belong to a category known in Chinese as *yinmu* or, in Spanish, *madera dura,* and are differentiated, due to their unusually high density, from other woods classified internationally as hardwoods but often used for plywood or veneer, such as *Virola* spp.

It is unlikely, however, that the proponents of the LKS programs anticipated such focused market pressure on only a couple of species; rather, in proposing an additional 40 species to the market, their intention was obviously to spread the extraction pressure across a wide range of species, thereby achieving their goal of intensified extraction over smaller areas. Additionally, the decrease in exports of *Miroxylon balsamum* starting in 2006 (Figure 2) suggests that the resource has already been overexploited.

Meanwhile, the market pressure from the United States and Mexico on mahogany and tropical cedar did not apparently drop as a result of the Chinese market's increasing imports of LKS. A more likely explanation for their decline was the imposition of market controls, including export quotas, when mahogany was listed on CITES Appendix II in 2003 and tropical cedar was listed on Appendix III in 2007. If substitution has occurred for lost export revenues from these species, then it is likely the traditional species *Virola* that is making up the shortfall. In fact, *Virola* is listed by some wood companies as a good substitute for both mahogany and cedar, being similar in density and color.

However, the interpretation that *Virola* is substituting for mahogany and cedar in the Mexico market may be to some extent misleading. In a key informant interview in 2007 with an official from ADEX, it was learned that the listing of species on customs declarations to Mexico (and *only* to Mexico) is not reliable. Because Mexico has long limited the number of species it will import from Peru and other South American countries, Peruvian exporters have long falsified the species designation on customs forms. In fact, what is listed as *Virola* on exports from Peru to Mexico may in fact consist of other species, or several other species.

In terms of the benefits the promotion of LKS was intended to provide the results are mixed. On the positive side, *Dipteryx* appears to be fulfilling the goals of added economic benefit from logging by contributing additional revenues to Peru. Bethel's (1984) concerns about the difficulties to industry of processing a set of new species were apparently unfounded, or else were overcome by the extensive efforts of the ITTO, WWF, USAID, and Peruvian institutions to develop and disseminate the appropriate technologies.

However, it is far from apparent that the *Dipteryx* (and other LKS) market has resulted in a slowing of expansion of logging activities into remote areas. On the contrary, as orders come in for the newly popular LKS, loggers have prospected for new areas rich in those species (personal observation). Similarly, there is no evidence that LKS programs have resulted in a reduction of land conversion for agriculture: new logging ventures focusing on LKS and increased migration into the Amazonian region has resulted in an increased rate of land conversion. Meanwhile, due to lack of follow up by the initiators of the LKS promotion projects, assessment of impacts such as the intensification of logging and resulting increased damage of concern to Freezailah (1984) have not been carried out.

5. Conclusion

The promotion of LKS for reasons identified by the WWF and others – i.e. to reduce pressure on key economic species, to slow agricultural expansion and increase the viability of the forest sector – have long been controversial. In 1997, several prominent forest scholars argued "[l]arger markets for secondary species may only increase the number of trees that are harvested unsustainably" (Reid et al. 1997). Freezailah (1984) also warned that "The nature and extent of the damage needs critical evaluation, so that indications of the increased damage resulting from the inclusion of the LKS in logging operations can be determined". He particularly advocated the promotion of LKS only on forestlands that were slated for conversion to agriculture, timber plantations, or otherwise lost, in order to avoid wasting valuable resources. He did not suggest promoting LKS as a mechanism to protect standing forest. In fact, as Schulze et al. have suggested, logging of "secondary" species (which may, like ipê, become "primary" in the marketplace) can open up new areas of forest for conversion to agriculture as surely as mahogany and tropical cedar. Indeed, the assumption that increasing the per-hectare profitability of forests through the introduction of new species to the market will result in more sustainable forestry might only be true if demand for the "traditional" overexploited species is replaced by demand for the new species. Similarly, for the assumption—that the increased intensity of logging per area facilitated by the promotion of new species will slow the expansion of logging and subsequent agricultural colonization—to hold true, there needs to be a replacement in the market. Otherwise, increased demand for new products could have the inverse effect of drawing loggers (and, subsequently, farmers) into areas where newly popular species are abundant. Finally to return to one of the original foundations of the LKS promotion scheme initiated by the ITTO, remediation of logged forest through silvicultural systems incorporating lesser-known species assumes that those species are suitable (economically and ecologically) for reforestation projects, and also that such projects will be supported. Such is not known to be the case in Peru.

In conclusion, as Vlosky and Aguirre (2001) point out, in areas where regulation of logging activities is deficient, promotion of LKS is not recommended. This is because illegal extraction and trade can prevent the requisite substitution of threatened species with LKS and limited expansion of logging areas. Despite efforts by the government of Peru, illegal logging in Amazonia remains rampant, and the illegal extraction and export of controlled species (mahogany, tropical cedar) continues. The likely scenario in Peru is an overexploitation of the species identified as most demanded by the Chinese market, without achieving the goal of protecting previously overexploited species. Since logging in Amazonia is followed by land conversion, as noted by many authors, the promotion and now rapid cutting of the several LKS identified here is therefore likely to result in more land conversion in areas where those species are abundant.

CHAPTER 5

GLOBAL FORESTRY POLITICS REVERSES DIRECTIONS OF OWNERSHIP IN PERU-CHINA TIMBER COMMODITY CHAINS

Revised from:

Putzel, L., 2009. Global forestry politics reverses directions of ownership in Peru-China timber commodity chains. Proceedings of the XIIIth World Forestry Congress, Buenos Aires, Argentina. October 18 – 23, 2009.

CHAPTER 5

Global forestry politics reverses directions of ownership in Peru-China timber commodity chains

Abstract

In the context of globalized trade, the impact of international markets for timber on tropical forests is a major concern. With shifts in global commodity chains increasingly relocating production systems to China, the potential impact of that country's timber transformation industry on Amazonian forests is great. Meanwhile, a major factor affecting trade is the globalization of forest policy through intervention by international institutions and bilateral trade arrangements. Peru, which encompasses over 12% of the total area of Amazonia, is susceptible to both the economic pressures of the forest trade and the political influence of institutions with a mission to regulate that trade and protect forests. Field observations support previous findings that resulting reforms do not adequately govern the logging industry and raise questions about the equitable distribution of its benefits. Using data collected from timber industry actors in Peru, this study describes the structure of Chinese timber supply chains in the Amazonian region and finds that control is shifting towards China as corporations adapt to new trade norms, in particular timber certification.

1. Background

The global impact of China's growing timber imports, amplified by legislation curtailing domestic logging and subsequent tariff reductions in the late 1990s (Liu and Diamond 2005; Wang et al. 2007; Zhang & Gan 2007; Laurance 2008), has, not surprisingly, become the subject of substantial interest and debate. In part, differences in views on this topic are due to misconceptions about the activities of different national, ethnic, corporate, and individual entities. In addition, the existence of national and international forest governance systems may not prevent Chinese timber traders from working within informal local timber provisioning structures that do not comply with these systems (Putzel et al. 2008). "China" as a unitary entity as well as "Chinese loggers" as a group have been criticized for their role in illegal logging (see, e.g. Economy 2006; Laurance 2008) though sometimes these criticisms are biased or ill-informed (Mawdsley 2008; Putzel et al. 2008).

On the other hand, a growing number of studies attempt to provide the requisite detail to understand the interactions of companies, ethnic trade networks, regulatory structures, and extractive systems that together form the China timber trade. White et al.'s pioneering study (2006), for example, emphasizes that the responsibility for ecological and social concerns associated with China's demand for timber is shared among many parties—from private actors to global institutions and from producer nations to end consumers in Europe and the United States. Notwithstanding, the report states that the China/global forest product industry must improve its practices or risk "losing its license." Sun et al. (2008) provides a commodity chains analysis with case studies from Russia and Mozambique to elucidate the structure and benefit flows associated with Chinese timber acquisition, providing the basis for a set of detailed recommendations towards meeting international standards of accountability and sustainability. There is evidence that China and a number of Chinese companies are responding to these demands: for example, in December 2007, China and the US concluded a memorandum of understanding committing to address the problem of the illegal timber trade (USDOS 2009). A growing number of Chinese timber and timber processing companies including major hardwood flooring manufacturers, are obtaining forest management and chain-of-custody certifications from Forest Stewardship Council (FSC)-approved certifiers, some with endorsement from conservation programs such as the WWF's Global Forests and Trade Network (see, e.g. FSC 2007; WWF 2008).

Until recently, the timber supply chains linking Peruvian forests to the Chinese market were Peru-based and producer-driven (see, e.g. Gereffi et al. 2001 for an explanation of producer- vs. buyer-drivien commodity chains). Numerous actors with access to the resource, operating in isolation from the main instruments of international oversight, sought opportunities to market timber in China and managed sourcing and exporting from bases near the transnational shipping center on the Pacific coast or from Amazonian sawmill towns. However, as China and its larger corporations endeavor to comply with the requirements of global institutions and national laws vis-à-vis the timber trade, there is evidence that the rules of the game may now be changing. The most apparent change is the appearance of new buyer-driven supply chains owned by large multinationals headquartered in China, thereby shifting the directionality of ownership and control from Peru to China. With this shift comes an implicit redistribution of responsibility for the ecological, economic and social impacts of the timber trade away from a wide range of decentralized actors in Peru towards a smaller number of larger actors in China as well as global institutions that validate their activities. In this paper, I will describe the prevalent and changing structures within Chinese supply chains for Peruvian timber, and discuss how those structures relate to both the Peruvian forestry system and international norms.

1.1 Logging in Peru: External influences on legislation, enforcement, and oversight - Peru's timber exports occur in the context of a changing landscape of national legislation and enforcement as well as the global mechanisms of international intervention and oversight which can be collectively called the tropical timber trade regime (TTTR) (Gale 1998). In 2000, Peru passed a new forestry law (Law no. 27308) based on conservation and sustainable management principles, and favoring larger timber companies (Smith et al. 2006; Granoff 2008). Since its implementation in 2002, up to 88% of logging in Peruvian Amazonia has been conducted under illegal, or "informal" conditions (WB 2006). This failure is in part due to the reluctance or inability of loggers and logging companies to conform to the new national rules (Smith et al. 2006). In its restructuring of Peru's forest industry, the new law may have introduced a higher degree of inequity into the industry, engendering resistance among some stakeholder groups, particularly small companies and landholders (Granoff 2008).

TTTR institutions such as conservation NGOs played a role in formulating the new forest law, and in executing key elements of its implementation such as the awarding of concessions to timber companies. WWF-Peru, with funding from the United States Agency for International Development (USAID), participated actively in designing and activating the legislation (White et al. 2005; Granoff 2008; WWF 2009). The new concession system has been the basis for the awarding of forest management and chain-of-custody certification to a number of logging companies, which enables them to sell timber to the most restrictive and lucrative markets; the goal is to have 2 million ha of concession forest under certification by 2011 (WB Bank 2006).

During negotiations towards a new US-Peru free trade agreement (FTA), a lawsuit against a large exporter of mahogany from Peru to the US (Hebert 2006) elucidated problems associated with the application of the new forest law. A subsequent amendment to the FTA contains an eight-page addendum (Annex 18.3.4) on Forest Sector Governance, requiring that Peru increase the power of its mechanisms to enforce its forest law failing which US customs will reject questionable shipments of Peruvian timber (PUSFTA 2006). In response, Peru passed legislative Decree No. 1085 which increases the authority of the timber industry oversight body OSINFOR (*Organismo Supervisor de los Recursos Forestales Maderables*), and modified the penal code (effective January 1, 2009) to increase the penalties for infractions to up to six years prison (Ortiz 2008). These changes removed the final impediment to implementation of the US-Peru FTA, which was finally implemented in February 2009, and facilitate Peru's compliance to market restrictions – embodied in an amendment of the US Lacey Act (USDA 2009) and Europe's voluntary FLEGT licensing scheme (EC 2008) – on illegally logged timber.

The combined influence of global institutional involvement and conditions attached to bilateral trade on Peruvian forestry legislation and implementation is important. Not only have these forces contributed to changes in where and how Peruvian logging can legally be carried out, but also who is legally able to log. Together with the higher standards of FSC-certification, which is increasingly imperative, the market may be further divided into groups who can log profitably, and those who cannot.

1.2 Triangular relationships: China, Peru, and the TTTR - China's large and growing market for commodities and resources represents both opportunities and threats to developing economies such as Peru. Increasingly, China's role in the global market centers on processing imported raw materials, which has been termed "verticalized trade." This has increased from 5.7% of 1981 to 48% total trade in 2003 (Kaplinsky and Messner 2008). To developing countries, increased demand for natural resources can improve their overall terms of trade: Chinese demand increases primary commodity prices, while verticalized Chinese production, mostly dominated by foreign companies such as large multinational retailers, decreases prices of manufactured imports (Jenkins et al. 2008). The opportunities associated with China's demand for developing country resources is paired, however, with the threats of competition in export markets for labor-intensive manufactured goods as well as competition for global foreign direct investment. Thus, countries (such as Mexico) whose economies are dependent on manufactured goods exports to third markets are likely to lose out, while countries (such as Peru) whose exports are dominated by natural resources may see a net economic benefit (Jenkins et al. 2008).

The policy of China towards the internal affairs of other countries has traditionally been one of non-intervention; according to Jeffrey Sachs "China gives fewer lectures and more practical help" (Polgreen 2006). However, this may be changing as China seeks to secure strategic resources to fuel its growing export-oriented production system and domestic market (Radke 2007; Pehnelt 2007).

Like the US, in 2009 China also established an FTA with Peru (PCFTA 2009). The agreement, which has yet to come into force, contains a commitment to increase sustainability in Peru's forest sector. In particular, Article 162 of the FTA promises bilateral cooperation in the forestry sector, training and studies for sustainable forest management, improvement of rehabilitation and sustainable management of forests, studies on the sustainable use of timber, and technological development for the transformation and processing of forest products, among other things. In contrast to the US-Peru FTA, which came into effect in February 2009, the China-Peru FTA does not require changes to the Peruvian forest law, proof of compliance thereof, or mechanisms of enforcement such as rejection by customs of shipments deemed to violate said mechanisms. No mention is made of controlling illegally extracted timber, nor is any commitment made to favor timber certified by third parties.

Within China, however, certification is increasingly seen as a means to protect the timber processing industry's position within the global market (Wang et al. 2007). It is recognized that foreign legislation such as the Lacey Act favors certification by third parties; the most prevalent certification program in China is the Forest Stewardship Council (FSC) (CIBC 2009), which has not only certified timber plantations within China, but also companies that transform imported timber. To date, FSC has issued over 1000 certificates to Chinese companies including a number of flooring manufacturers that process tropical hardwood species. Particular timbers listed on Chinese company chain-of-custody certificates include Amazonian species such as *Dipteryx* spp., *Tabebuia* spp., *Hymenaea* spp., and *Terminalia amazonia*.[2] This listing facilitates their re-export, following processing, to increasingly

[2] Information acquired through searching FSC's online database (www.fsc-info.org) by country and by species

restrictive and lucrative North American and European markets (Guéneau and Tozzi 2008). Operating in complement to FSC certification, the WWF-China organizes the Global Forest Trade Network - China, which promises to facilitate transnational business connections for Chinese timber companies that include certified timber in their product lines, while improving their "corporate image" (WWF 2009b).

In sum, the bilateral trade of timber between Peru and China is subject to fewer binding restrictions than that between Peru and the US or Europe. It is unclear exactly how the China-Peru FTA will affect timber acquisition by China or sustainable forest management within Peru. However, TTTR leverage on markets and market actors might be expected to have an impact on the structure of trade between the two countries, as companies seek to conform to the new realities of the global marketplace.

2. Research Approach

Commodity Chains Analysis - Processes of timber extraction, processing, and exporting were observed between 2006 and 2009 by following movements of *Dipteryx* spp. timber from two timber concessions and 4 smallholder communities in the regions of Ucayali and Loreto in Peruvian Amazonia to Pucallpa, the main center of primary processing located in the province of Coronel Portillo, Ucayali and the point from which timber is transported by road to the trans-Pacific port in Callao, Lima. *Dipteryx* was selected as the focal species of this study because it is the species subject to the highest demand from China. A detailed analysis of trade data, which will be presented elsewhere, shows that *Dipteryx* represents ca. 70% of timber exports from Peru to China and that ca. 80% of *Dipteryx* exports between

2004 and 2008 were China-bound.

Through semi-structured interviews with 92 informants, actors in the *Dipteryx* trade were categorized according to their roles in the Chinese trade and to their position within the structure of the Peruvian timber industry. Interviews focused on identifying buyer-seller relationships among actors and between them and third parties, on corporate hierarchies, and on distribution systems. Based on the data acquired about these relationships, general models of commodity chains relevant to 22 Chinese companies operating in Peru were developed.

3. Results

3.1 Categorization of actors - The following table describes the types of companies and individual actors that play key roles in the *Dipteryx* market, and the number of such actors represented in interviews conducted during the study.

Category	Number	Role
Multiservice timber company	17	Plays multiple roles in the industry, from extraction to exporting and distribution. May have concession contract.
Concessionaire	9	Owns forest concession contract and produces management plans and logging operation plans.
Sawmill	23	Mills timber for own company or for third parties
Extractor	16	Extracts timber using heavy equipment. May be subcontracted by other parties, or work independently.
China exporter	24	Sells and ships timber to China
Small Entrepreneurs	30	Including small "artisanal" producers, transporters and millers of *Dipteryx* on the informal market

3.2 General market conditions - The observed *Dipteryx* supply chains from Peruvian Amazonia to China range from highly vertically integrated to horizontally dispersed. In a vertically integrated supply chain, a large multiservice timber company may log its own concession, transport logs using a barge to its own mill, transform the logs into parquet flooring, dry the parquet in kilns, prepare the timber for shipping, and ship the timber to its own distributor in an overseas market.

In horizontally-dispersed supply chains, companies purchase wood from extractors or small entrepreneurs. These range from large professional extractors to smallholder farmers who fell trees and cut them into blocks using chainsaws, then transport the blocks by hand to the nearest riverbank or road. They may sell the timber to a remote buyer or pay a small cargo boat or truck to transport it to Pucallpa where they are sold to a mill. At the mill, the chainsawed blocks are transformed into boards. The boards are purchased by exporters, who may kiln-dry them or export them undried to a factory in China. They may be purchased with or without legal documentation.

The ability of any particular agent to fulfill any number of the described stages from extraction to distribution of the wood in the final market depends on economic and organizational capacity; virtually any configuration can be found in the marketplace. At any given step in the process the wood may change hands, moving from a relatively horizontally organized group of actors to a company that also owns its own vertically organized supply chain(s), or vice versa. In vertically integrated systems, companies sometimes follow the processes specified in the forest law and, if they are certified, the criteria established by the FSC; other times, as is generally necessary in the horizontal systems, they purchase paperwork from concessionaires to "legalize" their timber.

These documents, attesting to the legal origin, extraction, and transport of timber, become increasingly necessary at each stage in the process, and absolutely obligatory by the time timber leaves Pucallpa by road on its way to Lima. The price of the documents, which may be purchased from concessionaires and bear the seal of the natural resource authority, varies according to the volume of timber to be laundered and the availability of "volume" for sale by concessionaires, among other factors. In May, 2009, documentation for a truckload of *Dipteryx* timber (24 m^3) bound for Lima could be purchased for ca. US$450.

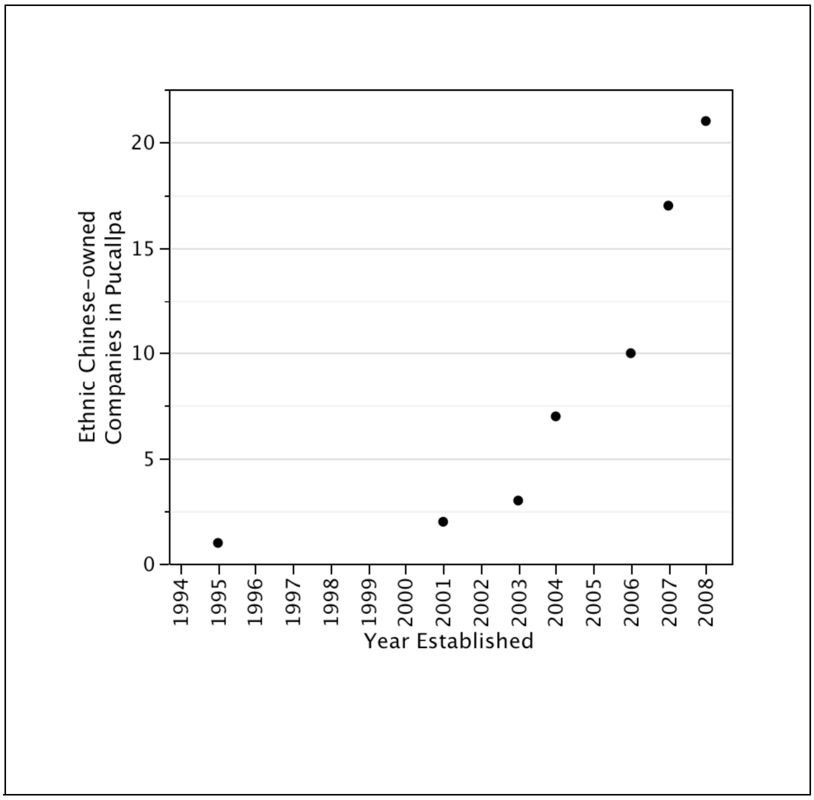


Figure 1. Number of Chinese companies established in Pucallpa, Peru from 1995 to 2008.

Since 1995, the number of ethnic-Chinese owned timber companies incorporated in Pucallpa has grown to 21 companies. This number does not include buyers that come from China to place orders (Figure 1).

3.3 Structure of Chinese timber supply chains – The structural characteristics of ethnic Chinese-owned *Dipteryx* exporters in Pucallpa can be described by three business models: labeled A, B, and C. The three models (illustrated in Figure 2.) are geared towards producing boards for China's flooring industry, and all are specialized in hardwoods such as *Dipteryx* spp. In all models, companies own distributorships in China and some in other locations such as in the United States. In A and B, the companies are headquartered in Pucallpa, whereas in C, a newly observed model, companies are headquartered in China and own subsidiaries in Peru. In most other aspects, the configurations of B and C resemble those of traditional Peruvian timber companies; in particular the illustration of Model B is roughly equivalent to Peruvian companies encountered, except the latter do not own distributorships in China.

Model A. Owners of model A companies are specialists in the export business, rather than forestry or logging experts, and come from a diversity of professional backgrounds. In model A, companies purchase timber on the market in Pucallpa, from either large traditional timber companies or on the more horizontal market of small producers. The timber they purchase may be logs, chainsawed blocks, or milled boards (either kiln-dried or undried). When purchasing unmilled timber, model A companies generally outsource milling, though a number of them are gradually acquiring the capital to do their own milling. In purchasing timber from microempresarios working in the informal market, model A companies increasingly prefer to purchase milled boards that come with full documentation to avoid sanctions by the natural resource authority. Most A companies either have or are now installing kilns to dry timber before packing it and shipping it to customers (often friends or family members) in China. Those without kilns often export "wet" timber.

Model B. Owners of model B companies are best described as industrialists. These companies have a vertically integrated extraction team and a barge for river transport. The extraction team logs areas by contract with numerous local communities and individual landowners. In order to make an extraction expedition cost-effective, these companies often work with groups of landholders to help them to formalize their land titles and support them during the process of obtaining the necessary logging permits, which are generally permits to remove timber for conversion to agriculture. After extraction, B companies transport their timber by barge and truck to their Pucallpa-based mill headquarters. It is processed fully using imported equipment and shipped ready-to-use to company-owned wholesale distribution centers in China and other countries. These centers are generally managed by friends and family. At least one Model B company has attempted to acquire timber concessions, and is likely to succeed in the short term.

Model C. Run by businessmen and financiers, model C is a multinational corporate model with headquarters based in China. It is the most recently established model, having appeared within the past two years. Model C companies have their own timber concession contracts obtained by transfer from Peruvian concessionaires. Like B, they employ extractive teams, and are developing sawmill operations. However, final milling is conducted in their China factories. An interesting phenomenon that emerged from this new configuration was the purchase of large blocks of *Dipteryx* from a certified third-party concession for direct export to China. In order to maintain a certified chain of custody prior to the establishment of a certified plant in Peru, the timber was exported in a less-processed state and a portion of value-added was lost to Peru.

In practice, there is substantial overlap among the three business models. In particular, B and C companies purchase timber from the horizontal market or from A companies when their own production is insufficient to fill standing orders. Several A companies purchase from B companies and even share office space within their mills, while C companies have purchased entire A companies to increase their supply options.

An emerging trend is for C companies to seek (and obtain) FSC forest management and chain-of-custody certification. In interviews with C company personnel, the primary reason cited to establish extractive activities was to develop certifiable chains of custody in order to maintain FSC certification. In addition to better access to more lucrative markets for certified timber, another reason to be FSC-certified mentioned was to increase a company's attractiveness towards investors in preparation for a public listing on the stock market.

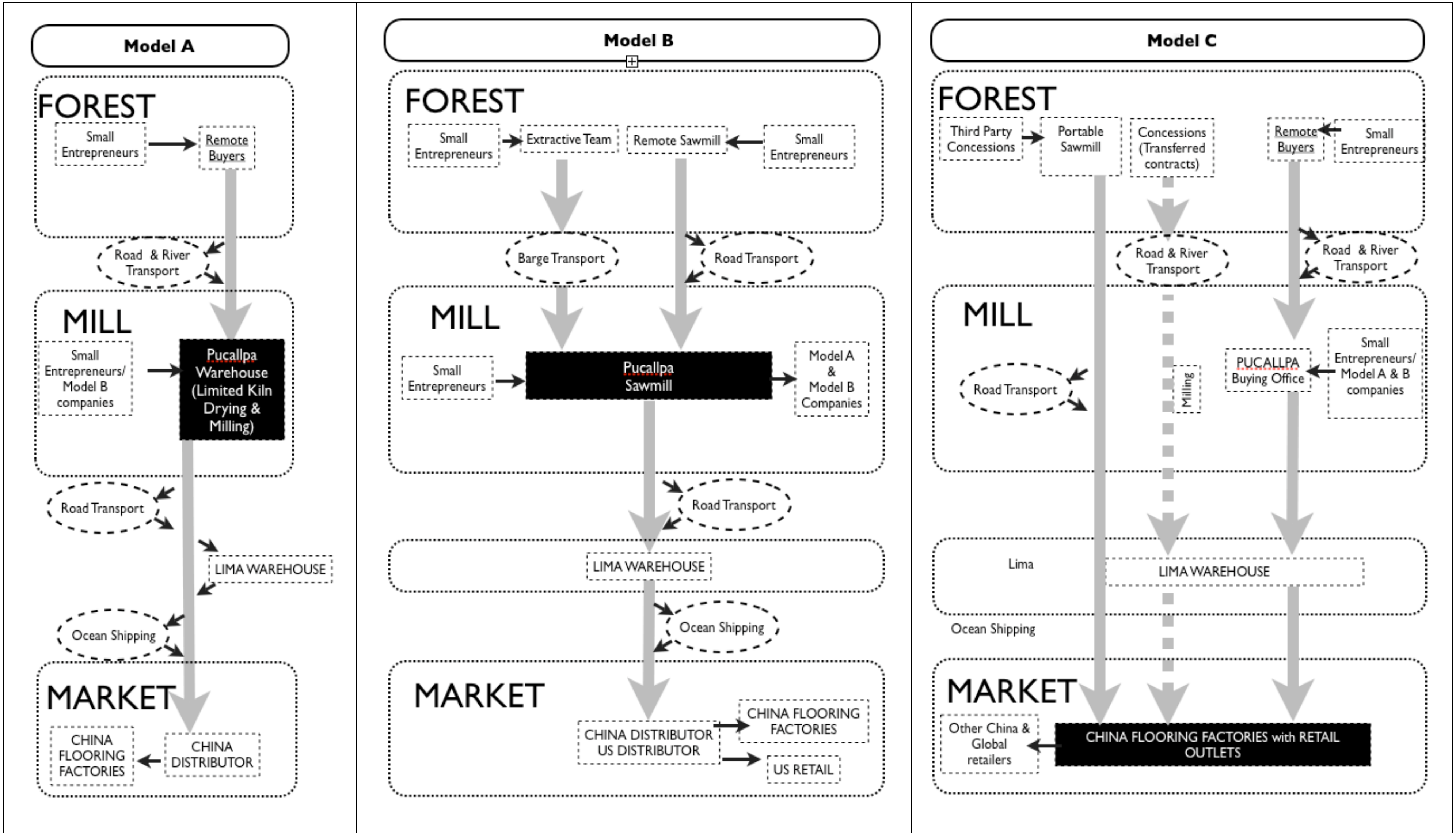


Figure 2. Illustration of the configuration of ethnic-Chinese exporters of *Dipteryx* timber operating in Pucallpa, Peru. Black boxes indicate the location of the headquarters of companies or conglomerates. Light gray arrows connecting boxes indicate the vertical processes owned by the main company and the direction of timber flows. Small black arrows represent the horizontal trading and movements of timber among different actors in the industry. Arrow with dotted line indicates a developing chain.

4. Discussion

Several generalizations can be drawn from the observation of the structure of Chinese timber commodity chains in Peruvian Amazonia. First, the wide range of practices observed among Chinese actors within the Peruvian market are not unique to them. Both the legal and informal methods of timber extraction and trade are widely used by Chinese and non-Chinese timber companies. Companies that have mostly verticalized their timber acquisition also deal in the horizontal market.

Second, the evolution of structural norms governing the timber industry appears to be affecting the different models in different ways. Model A companies, while dealing heavily within the informal horizontal market, distance themselves from risk by requiring their suppliers to acquire the necessary documentation prior to the delivery of timber. In effect, their strategy to adapt to new rules is to further horizontalize their operations and deal only in timber that is legal or that has been "legalized". These companies support a great number of small entrepreneurs.

Model C companies, meanwhile, are vertically integrating entire production chains, from logging in Peru to production of flooring in China, in order to demonstrate compliance not only to the Peruvian legal structure but to the institutions that provide international certification. This change represents some fundamental changes in the landscape of Peruvian logging. It could be described as a reverse in the polarity of commodity chains, from producer-driven and Peru-based to buyer-driven and China-based chains. The impacts of such a shift on local people within Peruvian Amazonia and on the Peruvian timber economy have not been studied, but could be assumed to decrease value added to timber in Peru and channel greater profits towards China. This is especially true in cases where certified timber is exported in less-processed forms in order to avoid damaging the timber's chain of custody by having it milled in a non-certified plant in Peru.

The polar shift is also changing the nature of Chinese companies: companies that were once dedicated to producing flooring from imported timber are now trying their hand at running logging operations in Peruvian Amazonia.

5. Conclusion

Compliance with Peru's forestry law remains inconsistent nearly 10 years after it was passed. Although it is too early to ascertain the effects of the more rigorous enforcement mechanisms designed to bring Peruvian forestry in line with the US-Peru FTA, the Lacey Act and FLEGT, the underlying configurations of the customary system have so far proven to be highly resilient. As new mechanisms of control are introduced, informal actors (with their many business connections to formal-appearing actors) develop new ways to avoid them.

As noted by Muthoo (2009), "There is a wide gap in the developing/tropical countries between the existing level of management across the supply chain and what is required for credible certification". The actual structure of Peruvian logging, as opposed to the structure designed by legislation, may be too flexible to ensure that the system of timber certification cannot be manipulated. If this is the case, then the dilemma facing the institutions that embody the TTTR is as follows: Is it acceptable in the name of promoting sustainability in the timber industry, once it is determined that the sustainability "brand" is not entirely reliable, to offer advantages – in the form of certification and access to markets for certified timber – to a subset of larger companies that have the capacity to produce some evidence of compliance to a set of imposed norms? If one of the fundamental problems of Peruvian forestry legislation is that it produced inequity, and that inequity is a reason for continued disregard of the law, then it seems important to ensure that third party certification systems do not exacerbate the problem by causing the marginalization of additional groups of actors.

Finally, in comparing the requirements of the US versus the Chinese FTAs, the former required modification to and greater enforcement of the Peruvian Forest Law, while the latter includes a more general promise of promoting sustainability in forestry and the forest trade. As a first step towards achieving that, the results of this study suggest that Chinese decision makers and researchers need to understand the current status of the Peruvian timber industry and not take for granted that the established structures imposed on the forestry system will guarantee the sustainability and economic fairness of their imports.

CONCLUSION

CONCLUSION

The tree that held up the forest: Shihuahuaco and the Chinese Timber Trade

1. Overview

The purpose of this research project, comprising an introductory overview and four complementary studies, was to understand the complex interactions between global trade, national and international forestry policy, local logging and forestry practices and the potential impacts of these on the regeneration ecology of *shihuahuaco* (*Dipteryx* spp.), an ecologically and economically important timber resource. The cross-disciplinary nature of the main research questions required the use of methods from ecological and social sciences and linked the study into several theoretical frameworks, and the results contain a number of important messages and lead to new questions for the fields of conservation, forest management, and forestry policy as well as resource rights. This final chapter of the compendium of studies that were conducted as part of this project is presented for the purpose of reviewing key findings, relating those findings to their theoretical contexts and, in conclusion, proposing a continuing research agenda based on what has been learned.

The key findings of the project, presented below in greater detail, are summarized as follows:

5.) In areas logged for shihuahuaco, regeneration will be greatly reduced by the removal of seed trees; however, since post-logging conditions and treatments by local residents favor the recruitment of saplings, there is an opportunity for recovery of the resource.

6.) In response to extraction of shihuahuaco, a number of smallholder farmers living within and around logging zones manage residuals, transplant residual seedlings into their agricultural fields, and collect seeds to germinate in nurseries.

7.) Exports of shihuahuaco to China have increased more than three-fold over the past 5 years, and now represent over 50% of Peru's timber exports.

8.) While Chinese shihuahuaco exporters, like the majority of Peruvian timber exporters, continue to be supplied by the informal market, new vertically integrated supply chains owned by Chinese processing companies have obtained international certification. This certification enables them to increase their global market share, but the ecological and social impacts in Amazonia are unknown.

2. Key findings

2.1 Regeneration ecology of Dipteryx *spp. in unlogged and logged forest*

The study of *Dipteryx* regeneration ecology (Chapter 2) used data gathered by quantifying the presence of individuals in transects located in three logging zones centered around the timber consolidation and processing center of Pucallpa, Peru, in the Region of Ucayali. All three logging zones had been selectively logged in the past, but the targeting of shihuahuaco was a recent phenomenon. In two of the logging zones, transects were located in two types of forest: forest that had yet been logged for shihuahuaco (termed in this study *unlogged forest*), and forest where shihuahuaco had been extracted in the prior 1-2 or 2-4 years (termed *logged forest*). In one of the logging zones, where extraction of shihuahuaco was only just starting, transects were located only in unlogged forest.

In unlogged forest, the inverse-J shape of the observed overall size-class distributions in all three zones supported findings previously reported by other researchers working in a protected area in the region of Madre de Dios in southern Peruvian Amazonia. This distribution, with an extremely low density of established juveniles (i.e. poles) suggests a low rate of replacement of adult trees over long time frames in natural forest conditions. One significant difference between this study and previous studies, however, was in the location of seedlings in relation to parent seed trees. Where previous studies found no seedlings in the immediate vicinity of seed trees, this study found a significant percentage of seedlings within the crown shadow of adult trees. One possible hypothesis to explain this difference is that, in current logging areas, with presumed higher numbers of people versus protected areas, the presence of seed predators such as large rodents may be reduced due to hunting. This hypothesis makes sense in light of a previous study which found predation by large rodents to be density dependent, and therefore especially acute directly under the crown shadow of seed trees where seeds accumulate. With lower populations of predators, it is logical that seeds under seed trees would germinate, thereby explaining the presence of seedlings. In order to confirm this hypothesis, a comparative study of the demographics and behavior of shihuahuaco seed predator populations in logging zones versus protected areas could be conducted.

In logged forest, the shape of the size-class distribution of shihuahuaco was greatly altered. Of course, the number of seed trees was reduced due to extraction, and while the relative number of seedlings to larger size-classes was greatly reduced, the recruitment of seedlings to saplings per area was significantly greater. The number of poles per area was also absolutely, though not significantly, in a statistical sense, greater. It was observed that the density of saplings in logged areas was higher within 5 meters of logging gap edges (but not within the gaps themselves). These data suggest that the liberation of seedlings by logging initially creates conditions that enhance the recruitment of seedlings which, in the absence of other factors (such as total landscape conversion) could favor the recovery of shihuahuaco populations in logged areas. In addition, in logged areas it was observed that certain human activities, such as intentional or unintentional liberation clearing, tended to maintain the conditions likely to favor the recruitment of shihuahuaco.

2.2 Smallholder response to removal of the shihuahuaco resource; Performance of shihuahuaco transplanted in smallholder fields

As previously described in a number of studies on logging in Amazonia, logging activities in this project's study zones are accompanied by the advance of smallholder farmers along roads made for timber extraction. Due to conflicting policies on land use arising from a lack of harmony between laws governing forestry and human settlement, there is a trend to formalize the tenure of migrants in Peru, including on forest lands.

In addition to claiming rights to land, migrants also acquire *de facto* rights to timber resources, even within designated logging concessions, as evidenced by per-tree payments by timber companies to smallholders. Because of the multiple values of the shihuahuaco resource as timber extracted as both logs (by timber companies) and chainsawed blocks (sold by individual families in the local market) as well as for charcoal, there is competition between companies and smallholders to extract and sell these different shihuahuaco products.

Although the forestry law requires post-logging reforestation by timber companies, such activities are rarely carried out. However, as in other parts of Amazonia, many smallholders in the study region actively manage forest patches both within and beyond their own land holdings, and also establish forest-tree nurseries and plant both fast- and slow-growing native timber species in their agricultural fields and swiddens. To document the remediation activities of smallholders in relation to the shihuahuaco resource (Chapter 3), a rapid appraisal was conducted in three communities in and around one of the logging zones of this research project. This appraisal indicated a general awareness of the environmental importance of maintaining forest cover and the future economic importance of tree planting. Informant's accounts indicated that the activities of extension agents, non-governmental organizations and local associations as well as international donors had contributed to this awareness. While the actual response to this awareness in terms of tree planting was not consistent, it is interesting to note that when practiced, tree planting was conducted in a manner that more resembled traditional management of diversified multi-use agricultural fields than conventional timber plantation methods.

In addition to the rapid appraisal, which consisted in semi-structured interviews with smallholders, measurement of shihuahuaco juveniles, first taken in two smallholder properties in 2007, was repeated in 2008 and 2009 to ascertain growth rates. The data, presented in this study, confirm the results of a previous study on the rapid growth of shihuahuaco in plantation conditions. However, where the previous study found that such rapid growth applied only to “pure” as opposed to “mixed” plantations, the current study’s results, based on data from plantations mixed in traditional agricultural fields incorporating numerous tree species, including other timber species as well as fruit trees, were comparable to the data from “pure” plantations in the prior study. This finding supports a hypothesis that performance of shihuahuaco individuals in plantations or agricultural fields depends more on the management given to individual trees (maintenance of liberated conditions) than it does on composition of the cohort of other tree species.

2.3 Chinese demand for Peruvian timber: The shihuahuaco boom in a decade of rapid growth

Using trade data from 170 timber exporters acquired from Peruvian customs, this study (Chapter 4) analyzes the changing configuration of Peru’s international timber trade in the 2000s. While exports to all of Asia represented less than 5% of Peru’s total timber exports, by 2008, China was Peru’s second largest international timber market after Mexico, and moved to first place after the beginning of the global financial crisis in 2009. Meanwhile, while China moved to the number one spot in the market, shihuahuaco, representing 80% of Chinese demand in 2009, moved quickly to the number one export species.

Chinese demand for shihuahuaco provides an interesting new case in the history of Amazonian resource booms, which in the past included the rubber and mahogany booms. As one of the species actively promoted as a "lesser-known species" by the forestry industry, with support from international agencies such as the International Tropical Timber Organization and the WWF, the case of shihuahuaco is an example of the perverse phenomena associated with the intervention of institutions in the marketplace for purposes of conservation and economic development.

2.4 The changing structure of the Peru-China timber supply network

Based on data from semi-structured interviews and field observations, Chapters 1 and 5 describe the changing structure of the Chinese timber supply network from the forest in Peruvian Amazonia to the export market. In contrast to previous perceptions of the Chinese timber market, it was found that prior to 2008, no Chinese companies were themselves extracting timber; rather, a diverse constellation of Peruvian actors, including individuals and companies provided timber to a growing number of mainland Chinese timber exporters based in Pucallpa. These actors ranged from large multi-service timber companies extracting logs from concessions to smallholder farmers selling chainsawn shihuahuaco blocks to roving buyers on the banks of remote tributaries of the Ucayali River. Only one (Peruvian) logging company was owned by an ethnic Chinese owner. Through this complex and constantly changing network, timber moved through both formal and informal channels towards the global, and increasingly Chinese, market.

However, between 2008 and 2009, a number of mainland China-based timber processing companies acquired logging concessions in Peruvian Amazonia and established the beginnings of their own extractive operations. While continuing to obtain timber through the existing network of suppliers, including both formal and informal channels, the new Chinese-owned supply chains were certified by international certification bodies prior to their activation. The purpose of the entrance of Chinese processing companies into the extractive industry was, in fact, to establish verifiable chains of custody in order to access markets in North America and Europe which, increasingly, require timber certification. The change represents a shift in ownership of entire timber supply chains from the Amazonian forest to the Chinese and global retail market. The ecological implications, for shihuahuaco species and for forests in general, and the local socio-economic impacts of this change in ownership are yet to be known.

3. Theoretical significance of research findings

3.1 Forest ecology and management

As a set, the findings of the studies in Chapters 2 and 3 of this project place it in between two distinct bodies of literature related to forest ecology and management. The first of these is the discipline of forest ecology and concerns the population biology impacts of logging on single species or groups of species. The second is the hybrid thematic research area of smallholder forest management and frontier land-use change, on which much has been written by Amazonia scholars. In the former research area, a typical study would identify a logging concession where logging is conducted and measure the response of species after logging either in the absence of subsequent human activity or through a set of controlled experiments such as comparing the performance of seedlings in clearings, on skid trails, or in the understory. In contrast, the current study recognizes the presence of people in logged areas, which better reflects the reality in Peruvian Amazonia, and suggests that observed post-logging size-class distributions are the natural result of a local ecology which includes substantial human activity, including intentional and unintentional management of competition, hunting of potential seed predators, and the use of logging gaps for economic activities.

Tenure transition is an important factor now affecting forests in Peruvian Amazonia, as in many forest regions worldwide. In contrast to past periods of population expansion, which were based on centralized state programs to colonize new areas of Amazonia, the current tenure transition in Peru is occurring in the context of decentralization and is intended to stabilize populations and eliminate the "informal" sector by formalizing the ownership of land. At the same time, the legal separation between land and the resources it holds appears increasingly difficult for the state and companies holding contracts to maintain. This combination of factors – decentralization, tenure transition and forest resource acquisition by migrants – is a relatively new phenomenon in Peruvian Amazonia, and may result in a new relationship between smallholders and the forest. Where frontier colonization in Amazonia has long resulted in widespread clearing of land for pasture and crops, the titling of forest land in Peru without the requirement of clearing and with new possibilities of economic benefit from forest resources could result not only in deforestation or forest degradation, but conversely may result in a long term reconfiguration of the forest landscape including preserved residual areas, areas reforested with valuable timber species and stands of fast-growing species for the domestic market. As compared to *forest transition*, which has theoretically been considered a post-industrial phenomenon associated more with land abandonment than forest management, a trend of local *forest reconfigurations* in Peruvian Amazonia associated with tenure transition might represent an active incorporation, by titled smallholder farmers, of a combination of species conservation, management, enrichment and use.

3.2 Timber commodity chains analysis and the structure-agency binary

This project set out to employ the method of commodity chains analysis, using data collected through semi-structured interviews with a broad range of actors in the Peruvian shihuahuaco trade, to test the hypothesis that *"the Chinese trade within the Pucallpa region is based on the structure of local supply chains established by local Peruvian actors rather than on the Forest Law."* If supported, the hypothesis, based on a loosely-interpreted formulation of the agency-structure binary, would signify that Chinese exporters of shihuahuaco timber, acting independently from state control, would replicate local customary practices of timber acquisition.

In fact, as data collection started in early 2007, and through 2008, preliminary results from interviews conducted suggested that the hypothesis was robust, and that Chinese timber exporters, in terms of their connections to the various sources of timber supply in the formal and informal timber markets of the Pucallpa region, replicated the actor-driven structure. Except for one ethnic Chinese-owned Peruvian multiservice timber company, Chinese companies occupied a single level or "box" within the shihuahuaco commodity chain, i.e. that of the buyer/exporter. All other boxes located on the Peruvian end of the chain, including ownership of timber concessions, extraction of timber, transport, and to a large degree primary processing of timber, belonged to Peruvian actors, while the secondary processing and retail sales boxes belonged to clients in China.

Between 2008 and 2009, as described in Chapter 5 and the summary above, the hypothesis was weakened by the formation of new supply chains by China-located companies that included all the boxes of timber resource ownership (concessions), extraction, buying/exporting, primary processing, and secondary processing. While the number of companies establishing these new supply chains was small, in terms of volume they represented a major share of the Peruvian export market. In the course of interviews, it was revealed that the reason for the shift was based on corporate decisions to conform to structures replicating the Peruvian Forest Law and international timber certification standards.

In terms of the application of agency-structure theory to the study of China-Peru timber commodity chains, the approach was simplistic and ignored many of the nuances of the larger agent-structure debate. In particular, both the Forest Law as well as the aggregate customary practices represented pre-existing structures to which newly arriving Chinese actors might conform, and in the end, different actors conformed to either one or the other. The theory did, however, provide a useful way of examining resource acquisition behaviors of different actors.

The greater contribution of this work is likely in the area of commodity chains analysis. Previous studies have used the methodology to describe past changes in global trade structures and flows, or to present a snap-shot image of a current trade configuration involving multiple actors and markets. This project showed that by using commodity chains analysis over an extended period, the meaning of a change in the configurations of trade at the global level, and in the presence of external influences such as global institutional policy, can be revealed in real time, potentially allowing researchers to develop a predictive models for wider geographic applications.

3.3 Globalized markets and failures of neo-liberal regime-building

Two of the studies in this project, presented in Chapters 4 and 5, highlight cases in which the best intentions of global institutions resulted in failures (or potential failures) in the face of global market forces. Chapter 4 explains how, following two programs by international organizations and donors to promote the marketing of lesser-known species from Peruvian Amazonia, including shihuahuaco, a resource boom ensued when the Chinese timber processing industry emerged with its new set of preferences. Chapter 5 shows how, following a general failure in a forestry law designed and implemented, in part, by an international conservation non-governmental organization, Peruvian timber commodity chains are being captured, as explained above, by multinational timber processing corporations located in Mainland China for the purpose of following the sustainability criteria of international timber certification non-governmental organizations.

These are examples of failures related to the activities of global non-state institutions working to realize the creation of international conservation and forestry or timber trade regimes. The revelation of these failures does not negate the probable need for such regimes in the face of global forest loss, nor does this research project adequately explain why such failures occurred. It is quite possible, that despite numerous failures in the course of designing structures and policies that influence forestry and trade, that the activities of global institutions to protect and better manage forests will eventually result in a global increase in forest cover, and it is to be hoped that such an eventuality will be accompanied by adequate safeguards for the livelihoods of people who depend on forest resources. The reasons for these particular failures, meanwhile, may stem from an inadequate processing of information that may have prevented them.

4. Recommendations for future research and methodology development

4.1 Future research questions

The current research raised a number of questions that could not be answered within the scope of the project. These questions are presented here, with a short explanation.

A. What is the current standing volume of shihuahuaco timber in Peruvian Amazonia, and at what rate is that volume being extracted?

Shihuahuaco exports from Peru are increasing rapidly and many industry experts expect that the resource will be economically exhausted within a 5-year time frame. The single-species focus on the conservation of mahogany led to programs to promote lesser-known species, including shihuahuaco, which has now come under great pressure. Besides single-species conservation measures, how could shihuahuaco and other valuable timber resources be conserved for the future?

B. In Peruvian Amazonia, is post-logging remediation involving local residents more effective than reforestation by logging companies or government?

In selectively-logged forest, the planting of seedlings of many species, especially shade-tolerant forest species, in logging gaps is not effective. Local residents are known to plant seedlings within their agricultural fields, where they can be cared for, and to manage natural regeneration within residual forest stands. Encouragement and financial support of such activities could favor the reestablishment of valuable timber species while improving rural livelihoods and, potentially, reducing conflict between logging companies and local populations.

C. Is certification of timber processing companies in industrialized markets, such as China, causing the capture and vertical integration of timber supply chains in other developing countries?

While it has been found that Peruvian timber supply chains have been captured by Chinese multinational companies in order to satisfy the requirements of timber certification, it is not known whether this is a generalized phenomenon throughout tropical forest countries, nor is it known what the ecological and social implications of such a reconfiguration will be.

5. Methodological development

This project employed a range of methods from forestry and the social sciences. The following methods could be developed for future multidisciplinary research.

5.1 Species-centered transects for timber ecology studies

The current project used shihuahuaco as a conceptual transect for multiple studies around which to collect data about the potential effects of logging and the global timber trade on a key species and about the structure of the market in which that species is traded. This method could benefit from formalization and application using a number of key species simultaneously, thereby contributing to a broader understanding of the ecological and social impacts of the trade in different species between different markets and arriving at stronger generalizations about local and regional timber industries.

5.2 Dynamic commodity chains analysis

In the course of conducting a multi-year commodity chain analysis for this project, a reconfiguration was witnessed which highlighted the fact that the method of commodity chains analysis could be enhanced by observing changes over time.

APPENDICES

APPENDIX I

Impacts of logging on commercial timber regeneration

Impacts of selective logging of tropical forests include damage to residual stands (Gullison and Hardner 1993; Jackson et al. 2002), loss of canopy cover (Broadbent et al. 2006), liana infestations of logged gaps (Alvira et al. 2003), soil disturbance and scarcity of seed trees of commercial species (Fredericksen and Pariona 2002). In addition, it has been widely recognized that logging is a precursor to conversion of forest by farmers, generally using fire, due to increased access provided by logging roads and the partial clearing of forest (Uhl et al. 1991; Mattos and Uhl 1994; Nepstad et al. 2004; Asner et al. 2005).

Numerous studies have been conducted into the effects of logging on tree species regeneration. These include both community-level effects such as overall post-logging density and species richness (Magnusson et al. 1999; Park et al. 2005) as well as effects on regeneration and recruitment of one or more individual species. Van Rheenan et al. (2004) examined experimentally the germination, survival, and growth of five commercial timber species in different post-logging microenvironments (e.g. log landings vs. logging gaps) and found that all species performed better in log landings, which have both greater light availability than the understory or skidtrails and, at least initially, less competition than logging gaps. Performance among species was similar; however, since seeds were planted for the experiment, the study, though useful for management, was not designed to take into account the very different seed dispersal characteristics of the five species. This effect is mentioned by

Fredricksen and Pariona (2002), who emphasize that while soil disturbance (the primary difference between log landings and logging gaps) enhances the regeneration of commercial species, the presence of seed trees and the dispersal characteristics of particular species limit natural regeneration.

While soil disturbance favors regeneration of seedlings when seeds are present after logging, subsequent competition with pioneers, once they are established, reduces survival probabilities (Fredericksen and Pariona 2002; van Rheenan et al. 2004; Paul et al. 2004). Human intervention to liberate commercial seedlings and saplings by controlling competitors such as overtopping pioneers and lianas can increase the recruitment potential of hardwood timbers (Wadsworth and Zweede 2006), which in upland Amazonian forests are mostly late successional species or mature forest species.

In Peruvian Amazonia, logging of upland forests is generally conducted in the dry season, when access by heavy equipment is possible. This coincides with the fruiting season of shihuahuaco species; therefore, it is reasonsable to expect to observe enhanced growth and survivorship of seedlings that germinate in areas disturbed by logging.

APPENDIX II

Commodity chains analysis

An interesting view of the global timber trade, as it pertained to shipbuilding from the 16th to the 19th century, is provided by Eyüp Özveren (1994) in Commodity Chains and Global Capitalism. Prior to the 19th century, shipbuilding was the largest consumer of timber. In the late 16th century, the Dutch gained control of the Baltic timber trade, largely due to the technological superiority of the fluyt, the most economic cargo ship ever built, as well as to geographic proximity. Thus, Dutch shipyards, through innovation and control of resources, outstripped those in the increasingly deforested Mediterranean region. Dutch hegemony over Baltic timber limited the potential of the English, but only for a time: relocation of shipbuilding to the timber-rich North American colonies facilitated an explosion of transoceanic trade and the ascendance of England to leadership in the world economy. The regional centralization of Dutch shipbuilding, which facilitated its rise to dominance, was eventually its downfall as English production was decentralized.

This project combines a commodity chains analysis (CCA) of Chinese timber supply chains (see, e.g. Bryant & Goodman 2004; Gellert 2003; Kaplinsky 2000) and is conceptually grounded in an integrated agent-structure approach (Leach and Fairhead 2000; Giddens 1984) to elucidate the relationships between national forestry policies and the realities of timber extraction and trade from logging zones to centers of consolidation to export points. In addition, and central to this project, the CCA approach provides the information needed for the selection of sites for pre- and post-logging forest inventories, the results of which are then correlated to trends in timber procurement to assess impacts associated with particular actors or groups of actors.

Commodity chain analysis was developed to analyze global processes of production and trade that operate in transnational environments, often governed more by corporate behaviors than by the state. The state is generally part of the external environment that exerts various pressures, creates obstacles and opportunities through its implementation of laws and economic policies governing trade, resource extraction, and labor. However, corporate actors can shift various parts of their extractive, productive, and marketing operations across national boundaries, while maintaining others (Gereffi 2001; 1994). When, for example, Indonesia in 1985, stopped exporting logs to Japan and an "oligopoly" of timber firms began, instead, exporting plywood, the ultimate result was the capture by Indonesian firms of a valuable node in the Japanese plywood commodity chain (Gellert 2003). However, the structure of the Japanese market in the 1980s and 1990s, in contrast to the Chinese market, was characterized almost entirely by large generalist trading houses purchasing timber from third-party timber companies based in other countries. Mainland Chinese companies today have the tendency to move further up China's timber supply chains, vertically integrating processes ranging from exporting to forest extraction.

In the growing field of commodity chain analysis, the terms "box" or "node" refer to a set of processes including "the acquisition and/or organization of inputs (e.g. raw materials or semifinished products), labor power (and its provisioning), transportation, distribution (via markets or transfers) and consumption" (Gereffi et al. 1994). Each box in a given chain has its own owners (or set of owners) and a highly plastic social organization. Thus, a particular box in a pre-existing chain can be colonized by different actors either upstream or downstream, resulting in new configurations of social relationships and accrual of "value added" associated with the subject box by the new owners.

In the global timber trade, the people who have the best view of both the provenance (of raw material) and the destination (of finished products) are those in the middle of a given commodity chain. Thus, large producers have more awareness of boxes further upstream and further downstream than small producers (see, e.g. Hopkins and Wallerstein 1994). In the Indonesian example mentioned above, it was a consortium of Indonesian firms that acquired this larger perspective on the market, allowing them to acquire a box located in Japan, thereby moving "up" the commodity chain away from the periphery (i.e. the forest.) In this research study, movement has occurred in the opposite direction: from the center of Chinese production towards the periphery.
In the process of moving from center to periphery, the acquisition of boxes by transnational corporations is referred to as **"vertical integration,"** and the network is termed **"producer-driven"** (Gereffi 2001). However, the

interpretation of these terms is not always clear: in Peruvian Amazonia, **exports** of timber were driven by Peruvian *timber producers* and Chinese *timber buyers;* when the center of ownership started to shift to factories in China, **imports** of timber from Peru were then driven by Chinese *flooring producers*, who are *buyers* of Peruvian timber. I chose to describe these newly configured vertically-integrated chains as "buyer driven".

APPENDIX III

Chinese resource acquisition and the role of the Chinese diaspora

Locally-based diaspora communities are an important "channel of impact" in developing countries' export markets (Kaplinsky and Messner 2008). Diaspora communities, with their intricate economic and social ties to home and host country contribute to what Bouteiller (1995) called the Unidentified Flying Economic Object that is Greater China. Chinese diaspora communities form a "ring of bases" that developed over a thousand years from coastal China to ports around Southeast Asia (Redding 1995) and has over the past 150 years expanded to connect Greater China to economic centers worldwide. Peru's own ethnic Chinese community was formed by several waves of immigration, starting with laborers in the mid-19th century, followed by the establishment of groups of farmers, merchants and restaurant owners who migrated back and forth between the continents, and, most recently, a class of expatriate industrialists, importers of Chinese products, and exporters of Peruvian natural resources (Yamawaki 2002).

While China and Peru proceed to formalize state-to-state trade relations, established social relationships between Peru's diaspora community and mainland importers are exceedingly important. As described by Crawford (2001) such relationships, or *guanxi*, "are at the center of the region's economic gravity." Based on trust in transnational family and sub-ethnic relationships rather than on written contracts, the "bamboo network" facilitates cross border exchanges of goods, capital and information. Because they are direct personal contacts between family, friends and otherwise socially proximate individuals, and therefore opaque to outsiders, Crawford calls them “secretive.” Nathan and Tsai (1995) describe guanxi networks as “noded community-based groups” which form when an individual turns for cooperation to one or more people with shared ties of race, religion, region, etc. In their taxonomy of social group configurations, noded patterns are “tight, authoritative, and more secret” than open network patterns. Community-based patterns have stable membership because associations are more psychological and group-regarding; they are not risk averse and can circumvent repression.

The tendency of Chinese guanxi networks toward opacity, at least to outsiders, likely contributes to negative perceptions of diaspora logging companies by Western observers. Smouts (2003) remarked on the difficulty in understanding them: “Wherever these huge conglomerates establish their presence, a multitude of subsidiaries are formed, themselves divided into sub-subsidiaries, corresponding to as many vaguely bankrupt or bought out local companies, holding vague permits to extract timber from vaguely delimited concessions.” The IDRC (Glastra 1999), reporting on illegal logging in Brazil, notes that “Asian” logging companies are established in “virtual anonymity” after inconspicuous visits to test the commercial, administrative, and political climate. The configuration of these companies and subsidiaries is constantly shifting, making it difficult for local people and officials to know who is really operating in a given area and how much timber they are logging or purchasing, processing, and shipping.

It has been suggested that the perceived secrecy surrounding ethnic Chinese trade may be a result of insecurity, which has been identified as a common characteristic of diaspora groups operating as minorities in foreign social environments (Redding 1995). While lack of transparency may be of concern to advocates of an effective international tropical timber regime, it is important to recognize the dangers of descending into a xenophobic discourse that is all too familiar in Western accounts of the Chinese resource trade (Mawdsley 2008). In fact, through regular interaction with Chinese shihuahuaco traders in Peru over a period of three years, the author's subjective observation is that the secretive nature reported by other Western scholars is likely much influenced by the same scholars' linguistic handicaps rather than on a particular tendency on the part of the subjects. In formal interviews and informal conversations, Chinese traders for the most part seemed to enjoy discussing the details of their business, even when that business, as is typical of the entire Peruvian timber trade, was not entirely legitimate in a legal sense. It is through these interactions that it was possible to gain a basic understanding of the intricate workings of the China-Peru timber trade, and to observe the radical vertical integration thereof described in the final chapter of this compendium.

APPENDIX IV

Popular article published in New Scientist

An abridged version of the following article was published in New Scientist (1 November 2008) as "Mr. Medina plants a forest." It is an anecdotal (but entirely factual) account of how a Peruvian smallholder farmer is reforesting with shihuahuaco trees, in part for aesthetic reasons.

At the End of the Road, Hope Itself

Louis Putzel

In the Amazon rainforest of Peru, on a dusty, unpaved road through villages of palm-thatch houses, timber trucks thunder by in an endless procession, scattering the round river rocks brought in to fortify the road. China's middle-class housing boom is helping drive insatiable demand for a low-profile but ecologically indispensible tropical tree at the end of that road built by the US war on drugs.

A cement marker proudly recounts the road's brief history: built in 2004, this thoroughfare was part of a program funded by the United States as an incentive to local people to find economic alternatives to growing coca, the plant from which cocaine is produced. Four years later, the road is the sucking end of a global vacuum through which timber is whisked from the Peruvian rainforest to China, the world's No. 1 timber importer. Some of the wood will be polished into luxury parquet flooring for high-rise apartments in Shanghai and Beijing. More will be processed in Chinese factories and dispersed as patio furniture, decking or flooring to North America and Europe. Further along, down muddy tracks leading into the old-growth forest known as *monte alto,* local farmers have begun to take advantage of sunny openings in the forest canopy created by logging to grow a variety of subsistence food crops such as cassava, sweet potatoes, bananas and plantains. They also plant a few cash crops – among them coffee and cacao – to cover such essentials as school fees and medical bills.

I came to the region to trace the movements – from Amazonian forest to Chinese factory – of a species of timber wood known in Peru as *shihuahuaco* (*Dipteryx* spp.). On a New York park bench or the Bristol promenade it would be called *cumarú,* or Brazilian teak, though it is three times harder and a third the price of true Asian teak. It is known to ecologists as a "keystone" tree species because its large seeds are an indispensable food source to forest herbivores in the dry season and its hollow places are used by nesting parrots and macaws. It is so sturdy that local people run to the shelter of a big shihuahuaco tree when storms grow powerful enough to bring down lesser trees.

Starting from the hectic sawmill town of Pucallpa, a two-day journey into the forest via car, *motocaro* (motorcycle taxi) and donkey in the company of a jolly group of loggers brought us beyond the end of the road to a new community called *Esperanza*, or "Hope." There, in the middle of an abundant *chacra*, a biodiverse agroforestry farm typical of the area, was a temporary logging camp. The chacra belonged to an enterprising young family (I'll call them the Medinas) who, in addition to their productive farming efforts were providing refuge to any number of birds, primates, and wild piglets rescued from logging gaps. From there, in the company of my friends Victor, Amilcar, and Michel who know what's what in those parts, I walked for ten days through the soon-to-be-logged *monte alto*, counting shihuahuaco trees, saplings, and seedlings to understand the species' regeneration ecology. The adult trees were giants, up to 50 meters tall and 1.3 meters thick above their giant buttresses, which spread up to 5 meters around the main trunk. There were fewer than 1.5 trees per hectare left, and most of those were headed for the long voyage across the Pacific. Although we found about 250 seedlings and saplings, there were only two juvenile trees that had reached the canopy and could therefore expect to grow into adults.

As a student of the timber trade, I try not to be sentimental about trees. Nonetheless, sitting near the campfire on one of my last nights there and explaining my initial findings to Pedro, the logging company's chief woodsman, there must have been a heaviness in my tone that prompted him to reassure me. "Well," he said, "at least there are Medina's *arbolitos*."

"What little trees?" I asked.

"Tomorrow, let's have a look around this chacra," he replied.

The next morning, we walked just a bit up the hill, and Pedro stopped in front of a bushy and very healthy-looking shihuahuaco juvenile growing in full sun. "See?" he said. That day, we counted 47 thriving young trees in just two hectares, all planted by Medina within the previous two years. Around them grew diverse food and cash crops. On our return, when asked why he had planted shihuahuaco in his chacra, Medina replied, "I like them. They have beautiful leaves."

"And when do you expect to harvest them?" Like many hardwood species, they can take a good generation to mature, and I hoped he wasn't expecting to profit from them in a few years.

"Well," he pondered for a moment, "they're not for me. They're for my children."

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