Who Manages Home Garden Agrobiodiversity? Patterns of Species Distribution, Planting Material Flow and Knowledge Transmission along the Corrientes River of the Peruvian Amazon

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements of the degree of

Masters of Arts
(Geography)

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Montreal, Quebec

June 2005

Your file Votre référence
ISBN: 978-0-494-22614-8
Our file Notre référence
ISBN: 978-0-494-22614-8

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Abstract

Agrobiodiversity constitutes an essential resource for traditional rural populations. Home gardens are "hotspots" of agrobiodiversity and important loci of *in situ* conservation efforts. This study seeks to understand the factors affecting gardeners' choices and to assess the accessibility of planting material in rural communities of the Peruvian Amazon. Household surveys and garden inventories conducted in 15 villages of the Corrientes river (n = 300), and case studies in three of these villages (n = 89), allowed to describe the local and regional patterns of garden agrobiodiversity and the structure of planting material exchange networks. Analyses reveal a strong link between species diversity and both household cultural and socioeconomic characteristics, and village ethnicity and size. Planting material flows primarily through matrilineal bonds, from advice-givers to advice-seekers, from old to young and from rich to poor. Farmers with exceptional species diversity, propensity to give and/or expertise are identified and their role in the conservation of cultivated plants is assessed. Expertise is not found to be as closely related to high species diversity as expected, but knowledge and planting stock dissemination go hand-in-hand.

Résumé

L'agrobiodiversité constitue une ressource essentielle pour les populations rurales traditionnelles. Les jardins sont de riches foyers d'agrobiodiversité et d'importants centres de conservation *in situ.* Cette étude vise à comprendre les facteurs qui affectent le choix des horticulteurs et à évaluer l'accès au matériel de propagation des plantes dans les communautés rurales de l'Amazonie péruvienne. Des enquêtes dans les foyers et des inventaires de jardin menés dans 15 villages de la rivière Corrientes (n = 300) et des données recueillies lors d'études de cas dans trois de ces villages (n = 89) permettent de décrire la distribution de l'agrobiodiversité dans les jardins à l'échelle régionale ainsi que la structure des réseaux d'approvisionnement. Les analyses révèlent un lien entre la diversité interspécifique et, d'une part, les caractéristiques culturelles et socioéconomiques des foyers et, d'autre part, la taille et l'ethnicité du village. Le matériel phytogénétique est échangé principalement à travers les liens de parenté, via la ligne utérine, et circule des experts aux novices, des plus âgés aux plus jeunes et des plus nantis aux plus démunis. Des fermiers, caractérisés par leurs jardins, leur propension à diffuser du matériel phytogénétique et/ou leur expertise exceptionnels, sont identifiés et leur rôle dans la conservation *in situ* des plantes cultivées est évalué. L'expertise n'est pas aussi étroitement liée à la haute diversité qu'on aurait pu le croire mais la transmission des savoirs et la diffusion du matériel de propagation vont de pair.

Acknowledgments

This study was supported with the financial assistance of the Fonds pour la Formation de Chercheurs et l'Aide a la Recherche (FCAR) and the Social Sciences and Humanities Research Council (SSHRC). Field work was undertaken thanks to funds provided by SSHRC through the McGill Internal Grants and the generous financial support of Dr. Oliver T. Coomes. I wish to acknowledge the Latin American Specialty Group of the American Association of Geographers (AAG), the McGill Alma Mater Student Travel Grant, and Dr. Oliver T. Coomes for enabling me to present some of the findings of this research at the 2005 Annual Meeting of the AAG.

I wish to sincerely thank all the residents of the Corrientes river, who welcomed me under their roofs with warmth and trust and answered my long questionnaires unabashed, with unrelenting patience. To the young bathers who introduced me to the secrets of the red dolphin, to my 10-year old Achuar teachers, to the young men so keen to dance with the *gringa*, to you and your gifts of plantain, to you who fed me monkey, to all those who laughed with or at me, to all those whose daily life I shared, I owe infinite thanks. Every sentence of this thesis is imbued with memories of you; from Iquitos to Paris, to Montreal, your lively spirits accompanied me in every phase of the research.

My gratitude extends to Reynerio Macahuachi, my boat driver and cheerful companion on the river, a story teller without equal, a man of deep kindness and contagious laughter. I am also much indebted to the managers, field staff and medical team of Pluspetrol for their logistic support, and the nurses of Villa Trompeteros for their hospitality and their assistance with the boat.

Many thanks to Dr. Carlos Manrique, Padre Louis Castonguay, Victor Villalobos and the researchers of the Instituto de Investigaciones de la Amazonía Peruana, especially Kember Mejía, for their generous logistic and technical support, their company and for sharing their ideas.

In Canada and France, I am grateful to my family and friends who gave me unabating support and much needed distraction. I wish to thank my committee members Oliver T. Coomes and George Wenzel, as well as fellow students Christian Abizaid, Stéphanie Brisson, and Marie-Annick Moreau for our many discussions and for their insights into fieldwork and analysis, and particularly Maya Manzi, for the cheerfulness she shared with me from beginning to end. This work would not have been possible without the constant help and insights of my supervisor Oliver T. Coomes. Oliver, I wish to thank you particularly for your generous trust, for your untiring encouragements, but above all for your deep humanity and your attentive and considerate ear. Your eyes are incisive and insightful, but your vision is profoundly caring and compassionate.

A toi, Sébastien Dennetière, je dois les petits et les grands bonheurs, ceux des retours fêtés, des chutes amorties, des chemins solitaires peuplés de tes sourires et égayés de tes mots.

Finalmente, a ti, Jaime Salazar, medio-brujo de la selva, te quiero agradecer de alma entera, porque, con un canto mágico supiste dar vida a mis números, mis conceptos, mis elucubraciones, y con una mirada me enseñaste la magia humana que reside bajo cada techo de crisnejas.

Chapter 1. Introduction

The conservation *in situ* of crop genetic resources is a major focus of agricultural conservation strategies in Latin America (Brush 1995; Tapia 2000). Agrobiodiversity, as an asset in the process of livelihood formation among the rural poor, is a key element of food security, income generation and agricultural production stability (Allard 1999; Hardon-Baars 2000; Thrupp 2000). Yet this essential resource may not be equally accessible to all and equally maintained by all (Coomes & Ban 2004). While it is now a recognized fact that farmers play dynamic roles in the conservation of traditional crop species and landraces in their fields and gardens, these roles remain ill-defined. Little is known as to who actually conserves agrobiodiversity in traditional communities, how cultivated plant portfolios are formed, how germplasm diffuses locally and regionally, how social and cultural structures foster or impede the flow of planting material, and how knowledge and agrobiodiversity interplay to create rich agricultural systems. An essential first step in improving projects aimed at conserving germplasm on-farm resides in the identification of important local actors and in understanding the factors that affect their choice. A better appreciation of the social structures in which agrobiodiversity is dynamically conserved is crucial to trace a more thorough and complex picture of *in situ* conservation and its local dynamics.

Agrobiodiversity studies conducted among tropical rural people reveal that conservation, as a behaviour, is highly heterogeneous in nature across households (Ban & Coomes 2005; Coomes & Ban 2004; Lamont *et al.* 1997; Padoch & de Jong 1999; Watson 2000). While it is often assumed that the typical farmer is actively involved in maintaining diversity, only a small number of individuals may play a dynamic role, where dynamism refers to the farmers' ability to experiment and to acquire and transmit planting stock and knowledge. An investigation into the set of economic, social and cultural factors that affect the degree to which a household maintains and exchanges germplasm, and an assessment of the link between agrobiodiversity, exchange behaviour and expertise will help understand the local dynamics of traditional agriculture. A more nuanced understanding of these fundamental relationships promises to improve the success of *in situ* conservation strategies. The findings of this study will shed light on these questions and ensure that, by directing efforts toward the right farmers and by knowing who these farmers are, decisions will be made that are tailored to local needs and that will improve the livelihood options of Amazonian Peru's rural poor.

1.1. Literature review

The concern for loss of germplasm diversity has given rise to calls for an integrated *in situ* approach to agrobiodiversity conservation and the development of targeted initiatives, especially in the tropics and neo-tropics (Bellon *et al.* 1997; Brush 1989; Jarvis *et al.* 2000; Wood & Lenné 1997). In this context, home gardens are of particular importance as they are widely recognized as the land-use type *par excellence* fostering farmers' inventiveness, and as historical sites of domestication (Gómez-Pompa 1996; Johnson 1972; Smith 1999; Smith *et al.* 1995).

1.1.1. Agrobiodiversity distribution

A number of studies have sought to explain inter- and intra-village differences in agrobiodiversity. At a regional level, economic and environmental conditions as well as ethnicity are the most common explanatory factors. Aguirre (cited in Smale & Bellon 1999), in his PhD thesis on maize in Mexico, found that households in more isolated areas tend to maintain more varietal diversity than those in market-integrated areas. Lamont *et al.* (1999), in a comparative study between three villages in northeastern Peru, did not find a correlation between distance to urban market and agrobiodiversity, but did conclude that large influx of tourists changed the composition of home gardens and resulted in an overall reduction of diversity. Agrobiodiversity in swidden fallows of two Brazilian Amazonian floodplain villages was found to be higher than that reported in fields located in colonization projects and in areas belonging to cattle ranchers (Pinedo-Vasquez *et al.* 2000). These findings suggest that the integration of the community to larger economic systems may have overall negative impacts on local agrobiodiversity. In fact, there are suggestions to focus more *in situ* conservation initiatives on isolated communities (Tapia 2000). In terms of environmental factors, in the region of Iquitos, of three villages studied, that with most diverse microenvironments had most overall crop diversity (Lerch 1999). Salick *et al.* (1997) suggest that the exceptional manioc diversity found among the Amuesha is partially a result of the unusual diversity of environmental conditions of the region. Environmental heterogeneity and higher agrodiversity allow for greater agrobiodiversity. Ethnicity may also have explanatory power. The Karen and Hmong ethnic minorities in northern Thailand maintain more rice infraspecific diversity than the Thai majority (Bellon *et al.* 1997). Pinton (2002) finds that Amerindians in the Brazilian Amazon maintain more manioc varietal diversity than *seringueiros*. Lamont *et al.* (1999), however, finds no correlation between village ethnic composition and overall agrobiodiversity.

Studies of agrobiodiversity at the micro-scale point to the uneven distribution of crop genetic diversity within traditional communities (Bellon *et al.* 1997; Catalán & Pérez 2000; Coomes & Ban 2004; Lerch 1999; Peroni & Hanazaki 2002; Pinedo-Vasquez *et al.* 2000; Thurston *et al.* 1999; Watson 2000). Within a village, different farmers may hold different crop inventories. Often, the number of cultivars grown by individual households is much lower than the total number of cultivars in the village (Bellon *et al.* 1997), which implies that crop portfolio differs greatly from one household to the next. The large standard deviations reported in quantitative analyses of agrobiodiversity intra-village distribution are illustrative of these differences (Lerch 1999; Peroni & Hanazaki 2002). The distribution, in fact, is often positively skewed as some households diverge considerably from the average with large crop inventories (Lerch 1999; Salick *et al.* 1997).

Choice about crop portfolio is conditioned by a number of factors. Village- and household-level attributes interplay to create conditions more or less favorable to agrobiodiversity conservation. A complex set of environmental, economic, social and cultural factors affect farmers' decision-making processes about what crops to conserve. In turn, agrobiodiversity, as a household asset, shapes the household's economic, social and cultural characteristics by affecting wealth, social status and knowledge. Empirical evidence reveals a perceptible link between agrobiodiversity and economic household characteristics, especially wealth (Bellon & Brush 1994; Coomes & Ban 2004; Hardon-Baars 2000; Lerch 1999; Peroni & Hanazaki 2002; Subedi *et al.* 2001; Wright & Turner 1999), access to different microenvironments (Catalán & Pérez 2000; Coomes & Ban 2004; Peroni & Hanazaki 2002; Smale & Bellon 1999), social attributes, in particular involvement in social networks and status (Catalán & Pérez 2000; Coomes & Ban 2004; Lamont *et al.* 1999; Lerch 1999; Subedi *et al.* 2001; Watson 2000), age (Boster 1984; Lamont *et al.* 1999; Quiroz 1999; Salick *et al.* 1997; Works 1990), gender (Bellon *et al.*1997; Berg 1993; Boster 1984; Lerch 1999; Quiroz 1999; Salick *et al.* 1997; Thurston *et al.* 1999), and knowledge (Bellon *et al.* 1997; Boster 1984; Peroni & Hanazaki 2002; Subedi *et al.* 2001).

1.1.2. Planting material flow

The critical resources of agricultural societies are generally listed as the classic "trinity" of land, labour and capital. Crop genetic material is too often overlooked, as if germplasm was a given factor of production, easily obtained and equally accessible to all. Yet planting material may be difficult to procure, as noted by Watson (2000), and may flow through distorted networks, as is suggested by Coomes & Ban's (2004) study in a community of northeastern Peru. Understanding how farmers procure planting material – seeds, cuttings, suckers, etc –, what obstacles stand in the way of uninhibited access to the resource and how plants flow within and between communities is starting to arouse interest in traditional networks of planting material exchanges. Few studies as yet have focused specifically on these questions, but concern for the issue of accessibility and exchange is growing.

Traditional farmers' curiosity for non-local species and varieties, and efforts to acquire germplasm outside community boundaries have been documented in Mexico, in the Andes and in the Peruvian Amazon by a number of authors (Ban & Coomes 2005; Descola 1986; Hernández Xolocotzi 1985, Louette *et al.* 1997; Perales *et al.* 2005; Zimmerer 2003). WinklerPrins (2002) notes flow of seeds between kinfolk from rural to urban gardens in Brazil, and Watson (2000) describes geographically extensive exchange networks of plantain pseudostems and manioc cuttings on a tributary of the Tigre river. Interethnic exchanges of planting material have been reported between the Shuar and the Achuar (Descola 1986) and between Quichuas and Huaoranis of Ecuador (Caillon 2000). Sourcing patterns and local and regional exchange activity are affected by socioeconomic factors such as household age (Coomes & Ban 2004) and access to land (Louette *et al.* 1997). Intracommunity exchanges are also structured by cultural and social elements, but exchanges concurrently create social structure by forging social relations (Murrieta & WinklerPrins 2003). Planting material has been found to flow through kinship pathways (Caillon 2000; Coomes & Ban 2004; Pinton 2002). Gender plays different roles in different regions, with women occupying nodal positions in studies in the Amazon (Ban & Coomes 2005; Pinton 2002), men occupying nodal positions in Subedi's (2001) study on rice in Southeast Asia, and plant acquisition roles being gender- and geographical scale-specific in Andean communities (Zimmerer 2003). Planting material diffusion and knowledge transmission are thought to be closely linked (Perales *et al.* 2005; Subedi *et al.* 2001). Ethnographic work with Aguaruna communities in the Peruvian Amazon similarly describes exchanges of planting material as being shaped by kinship, gender and knowledge (Brown 1986)

1.1.3. Managers of agrobiodiversity

Some proponents of *in situ* conservation in the past have avoided questions of within-community heterogeneity by proposing frameworks that target communities as a whole with little consideration for unequal distribution of human, social and cultural capital (e.g. Jarvis *et al.* 2000; Montecinos & Altieri 1992; Pinton 2002; Smale & Bellon 1999; Tapia 2000; Thrupp 2000). However, since agrobiodiversity is unevenly distributed and all farmers will not contribute equally to the maintenance and creation of diversity, those whose contribution is likely to be greatest must be identified (Smale & Bellon 1999). Field work has begun to target specific "farmer innovators" as potential extension agents (Critchley 2000; Pinedo-Vasquez & Pinedo-Panduro 1998). Nevertheless, few studies have been undertaken to systematically examine those managers of diversity. The literature invariably refers to dynamic agroecosystems in general terms, praising the vitality of the system, its ability to renew itself and farmers' drive to experiment and innovate (e.g. Brookfield 2001; Chamber *et al.* 1989; Johnson 1972; Quiroz 1999; Smith *et al.* 1995; Wood & Lenné 1997). Wright & Turner (1999) warn of the danger of generalizing about farmers and their role in conservation. They argue that those who experiment and innovate, though they are in the limelight, only represent a minority within traditional communities. In a programme to promote the cultivation of forest *camu-camu* shrubs (*Myrciaria dubia*), Pinedo-Vasquez & Pinedo-

Panduro (1998) found that only a small proportion of farmers – the local "experts" – were willing to experiment. Even in a study that demonstrated that 90% of farmers are "avid experimenters", results were qualified with the statement that "perhaps some were more active than others" (cited in Quiroz 1999).

Information on the "curators" of agrobiodiversity in traditional communities remains largely anecdotal. What data exist suggest that expert farmers occupy special niches in their community, either through professional specialization (Padoch & de Jong 1991) or through religious and/or social status (Lerch 1999; Salick *et al.* 1997). Such unusual farmers seem to stand at the center of exchange networks that can extend beyond their community (Ban & Coomes 2005; Lerch 1999; Subedi *et al.* 2001; Watson 2000). Elsewhere, exceptional diversity is mentioned in passing (Bellon *et al.* 1997; Boster 1983; Peroni & Hanazaki 2002; Tapia 2000) and strong correlation with knowledge is sometimes suggested (Bellon *et al.* 1997; Tapia 2000).

1.2. Study area

The research was conducted in riverine communities along a 150 km reach of the Corrientes river of the Peruvian Amazon. The reach of concern for this project lies in the District of Trompeteros in the Province and Department of Loreto, in the lowland tropical forest of northeastern Peru; it lies 200 km directly west of the city of Iquitos, at a distance of three days by public riverboat. The small district town of Villa Trompeteros, located 100 km upriver from the mouth of the Corrientes, is accessible by riverboat as well as by air, through private flights from Pluspetrol, the main oil company operating in the region.

1.2.1. Biophysical environment

The Corrientes river flows from the highlands of Ecuador into the Tigre river, itself a tributary of the Marañón river. The Lower Corrientes drains through the eastern extension of the Pastaza alluvial fan, which is composed of volcanic sediments originating from the Ecuadorian Andes. The upland comprises of deeply weathered and highly acidic Tertiary alluvium (Räsänen *et al.* 1992), likely Ultisols (*tierra colorada*), with low cation exchange, high aluminium toxicity and low levels of organic matter (UNAP & Pluspetrol 1997). Dark soils (*tierra negra*) composed of volcaniclastic debris

(Räsänen *et al.* 1992) are found in some areas of *terra firme*. The Corrientes river is a clear water river with pH varying from 5.5 to 6.5 (UNAP & Pluspetrol 1997). The region is classified as lowland moist forest and receives between 1729 and 3852 mm of rain annually (UNAP & Pluspetrol 1997).

The Corrientes river, jointly with the upper Pastaza and upper Tigre, is the source of 65% of Peru's oil (La Torre 1998) all of which is extracted by the Argentinean-owned oil company Pluspetrol. The regional headquarters of the company are located in the vicinity of an active exploitation site (Percy Rozas), across the river from Villa Trompeteros. Three other petroleum wells are in operation in the study area, upriver from Villa Trompeteros.

1.2.2. Local inhabitants and livelihood

The main native population of the upper Corrientes are the Achuar, members of the Jivaro ethno-linguistic group who also occupy the neighbouring Pastaza and Huasaga rivers on both sides of the Ecuador border. Despite the Dominican mission of Canelos founded on the Upper Pastaza in the late 18th century (Crépeau 1989), the Achuar had relatively little contact with *mestizos* and people of Iberian descent until the military garrisoned the border with Ecuador in the 1940s (Seymour-Smith 1985). In the 1942 Ecuador-Peru war, there were population exchanges between the Ecuadorian Quichuas and Achuar and the Peruvian Achuar. The various extractive booms of the 20th century generated waves of population movement between neighbouring rivers and beyond; many Quichuas of the Tigre river, for example, intermarried with the Achuar of the Corrientes. There was also an influx of Urarinas from the Chambira river in the middle of the 20th century and the consequent foundation of Urarina villages in the lower Corrientes. The more recent boom of oil exploration that begun in the 1970s attracted workers from neighbouring rivers, from the city of Iquitos and sometimes from as far as the Department of San Martín. As a result of all these population movements, ethnicity *per se* is not clear-cut, neither at the household nor at the village level. As noted by Crépeau (1989), ethnic identity is a "dynamic phenomenon" and, for the Achuar, it is a flexible, contextual notion (Seymour-Smith 1985). Nevertheless, as collective entities, individual villages identify with one of three ethnic denominations – Achuar, Urarina and *campesino* – and most of the villages are officially recognized as belonging to one of these groups.

The population of the Corrientes river in Peru is distributed among 32 riverine villages that have official recognition from the district authorities and a few other small recent settlements that have not yet gained administrative status. Fourteen of the 32 villages lie within the study area: San Juan de Trompeteros comunidad campesina, San Juan de Trompeteros comunidad nativa, Santa Elena, Nuevo Porvenir, San José de Porvenir, Nuevo Paraíso, Boca del Copal, Nuevo Peruanito, Nuevo Pucacuro, Dos de Mayo, Nuevo San Ramón, San José de Nueva Esperanza, Santa Rosa, and Valencia.[1] The 150 km reach visited comprises of an additional three communities, Nueva Vida, a recently founded Achuar village that has no official recognition although its existence is acknowledged *de facto* by the district authorities, and two small Urarina settlements currently being established, consisting of barely a few households. Authorities in Villa Trompeteros show no particular awareness of the existence of the two latter communities.

All but the two most recently formed villages, Nueva Vida and Paraíso, have primary schools. Preschool education is not as common, with only 53% of villages being endowed with preschool facilities. There are no secondary schools in the villages visited, but some children are sent to attend the schools in Villa Trompeteros or in the district town of Intuto on the neighbouring Tigre river.

The local population relies primarily on swidden-fallow agriculture in upland polycultural fields to meet its subsistence needs, complemented by other extractive activities such as hunting, fishing and gathering of forest edible products, medicinal plants and construction material. Additionally, some of the villagers near petroleum extraction stations receive wage as they are temporarily employed by the oil company.

1.3. Thesis structure

The thesis is organized into five chapters:

- Chapter 2 describes regional patterns of home garden agrobiodiversity among the Achuar and the Urarina of the Corrientes river, and analyzes the factors affecting

[1] For economy, these villages will henceforth be referred to as: San Juan campesino, San Juan nativo, Santa Elena, Porvenir, San José de Porvenir, Paraíso, Copal, Peruanito, Pucacuro, Dos de Mayo, San Ramón, San José de Nueva Esperanza, Santa Rosa and Valencia.

the size and composition of garden species portfolio at the village and at the household levels.

- Chapter 3 examines and compares regional sourcing patterns of gardeners in three Achuar villages of the study area. The social, economic and cultural elements that structure planting material exchanges in these villages are investigated through a social network analysis approach.
- Chapter 4 assesses the role of key actors on the Corrientes river in local and regional diffusion of germplasm and dissemination of knowledge. The links between expertise, crop conservation, and centrality in germplasm exchange networks are examined.
- Chapter 5 summarizes the main findings of the study and concludes by discussing their implications for *in situ* conservation of agrobiodiversity and by suggesting future research avenues.

Chapter 2. Distribution of Agrobiodiversity on the Corrientes River

2.1. Introduction

Home gardens in the tropics are centers of agrobiodiversity. Discourse about *in situ* conservation increasingly focuses on home gardens as the sites *par excellence* to foster conservation of agrobiodiversity – conserving crop species and varieties in the garden not only preserves a vital resource for humankind but also fortifies an important asset for rural households (Catalán & Pérez 2000; Fernandes & Nair 1986; Hiraoka 1985; Rajasekaran 1999; Thrupp 2000). Recent realization that diversity can be highly unevenly distributed has aroused growing interest in describing and understanding the local and regional geographical patterns of garden crop diversity (Bellon *et al.* 1997; Catalán & Pérez 2000; Coomes & Ban 2004; Lerch 1999; Peroni & Hanazaki 2002; Pinedo-Vasquez *et al.* 2000; Thurston *et al.* 1999; Watson 2000), especially as programs that seek to evaluate or to strengthen the potential for *in situ* conservation by communities must take account of local inequalities. Studies in the Amazon generally examine one to a few isolated communities and focus either on the comparison of these communities in terms of agrobiodiversity or on the distribution of crop species intravillage (e.g., Coomes & Ban 2004; Lamont *et al.* 1999; Lerch 1997; Lerch 1999; Padoch & de Jong 1991). This chapter seeks to integrate both approaches, first by combining the regional meso-scale and the micro-scale analysis at the village level, and second by looking at households and their individual horticultural choices while appraising larger geographical phenomena that have an exogenous impact on households. This approach allows us to examine the local and regional factors that affect the distribution of agrobiodiversity. Few studies as yet have considered distribution of crop diversity among indigenous peoples of the Peruvian Amazon, concentrating rather on rural peasant communities within one or two days' travel of Iquitos, probably because of language barriers and the complication of long fluvial trips. Those that have looked at agrobiodiversity among indigenous peoples have confined their study to one single group and have not embarked on a comparison between ethnic groups, with the notable exception of Lamont, Eschbaugh, and Greenberg (1999) and Caillon's (2000) studies (on the Ecuador side of the border). This chapter will examine the role played by ethnicity in shaping garden species portfolios with field work undertaken both in Achuar and Urarina communities of the Corrientes river of northeastern Peru.

The purpose of this chapter is to describe regional patterns of home garden agrobiodiversity on the Corrientes river and analyze the factors affecting the number of species held in a garden at the village level and at the household level. Demographic, socioeconomic and ethnic characteristics of households and villages, and regional and geographical features such as the presence of the oil company Pluspetrol and distance variables are examined, with particular emphasis on cultural factors through the comparison of Achuar and Urarina gardens. The study also investigates how and why the species composition of gardens changes geographically on the study river.

2.2. Study area

Fieldwork was conducted in 15 riverine communities of the Corrientes river of the Peruvian Amazon: San Juan campesino, San Juan nativo, Santa Elena, Porvenir, San José de Porvenir, Paraíso, Copal, Nueva Vida, Peruanito, Pucacuro, Dos de Mayo, San Ramón, San José de Nueva Esperanza, Santa Rosa, and Valencia (see map in Figure 2-1). Three of these, Porvenir, San José de Porvenir and Paraíso, are Urarina communities; the others are predominantly composed of Achuar and *mestizo* families (Table 2-1).

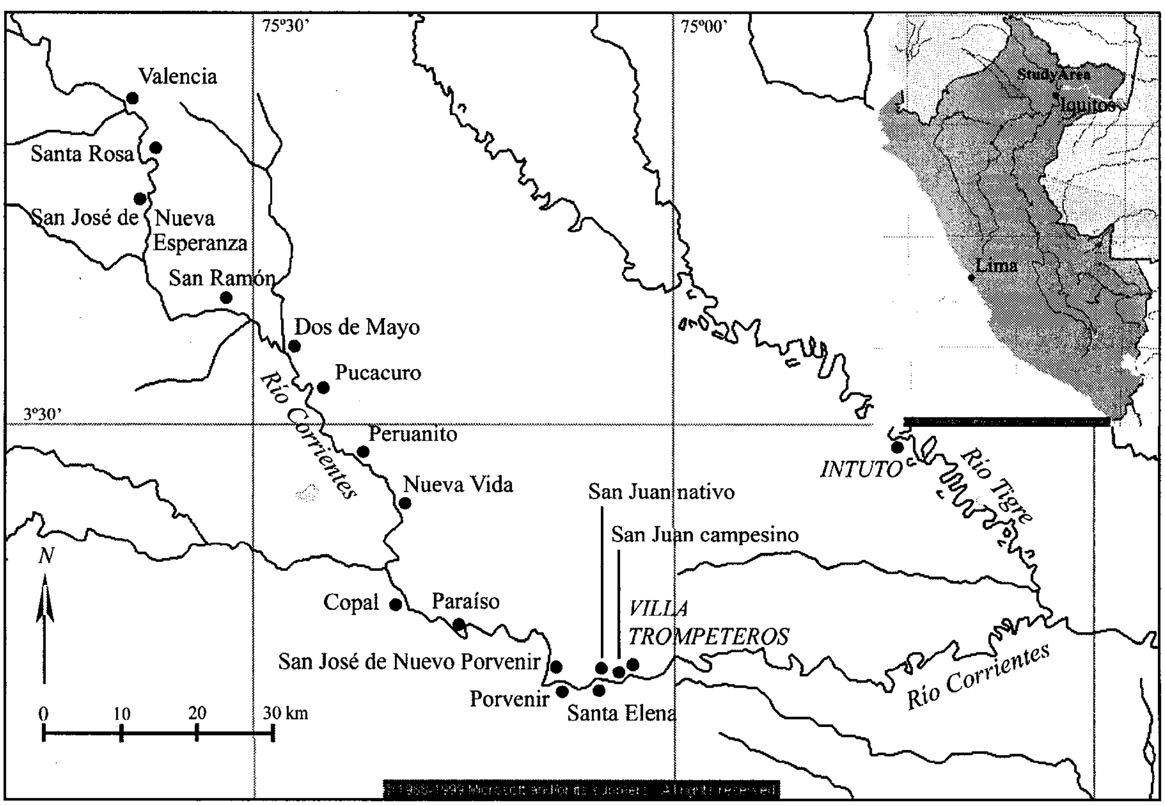
The Corrientes river, jointly with the upper Pastaza and upper Tigre, is the source of 65% of Peru's oil (La Torre 1998), extracted by the oil company Pluspetrol. The regional headquarters of the company are located in Percy Rozas, an active well site across the river from Villa Trompeteros. Three other petroleum wells are in operation in the study area, upriver from Villa Trompeteros. Oil is transported to the coast by pipelines that pass through most of the villages' territory. Some villagers have reported oil leakages. Employees of the company must periodically visit the communities for pipeline maintenance. Pluspetrol thus has some degree of interaction with all the villages in the study area. Influence of the oil company, however, is particularly strong in five of the 15 villages, which are in the direct radius of company bases: San Juan campesino and nativo and Santa Elena (Percy Rozas station), Pucacuro (Pavayacu station inland from the village) and San José de Nueva Esperanza (Nueva Esperanza station a little downriver of

Table 2-1 : Characteristics of study villages in Corrientes river, Peru.

VILLAGE	Ethnic group	No. houses	No. inhabitants	Year of establishment[a]	Distance from Villa Trompeteros (min.)[b]
San Juan campesino	Achuar/ *mestizo*	36	209	1971	2
San Juan nativo	Achuar	23	126	1970	5
Santa Elena	Achuar	33	175	1977	5
Porvenir	Urarina	25	113	1986	40
San José de Porvenir	Urarina	20	101	1998	55
Paraíso	Urarina	12	73	2000	130
Copal	Achuar	21	106	1977	170
Nueva Vida	Achuar	5	23	1999	240
Peruanito	Achuar	17	96	1996	280
Pucacuro	Achuar/ *mestizo*	68	305	1990	330
Dos de Mayo	Achuar	8	35	1990	370
San Ramón	Achuar	6	45	1988	400
San José de Nueva Esperanza	Achuar	30	133	1985	480
Santa Rosa	Achuar	17	79	1996	510
Valencia	Achuar	25	141	1982	540

a. Year of establishment of the village in its current location.
b. Time measured by 25hp motorized rowboat going upriver.

Figure 2-1 : Map of study area, Corrientes river, Peru.



the village).[2] These five villages have undergone changes in their livelihood activities: many of their inhabitants rely on the company for employment (less so in San José), for income from the sell of plantain and manioc, and as a provider of services, such as electricity and medical assistance. The degree of influence of and reliance on the company is variable in the other villages, ranging from periodical visits from the medical and human resources teams to daily transport up and down river, to temporary employment opportunities. The five villages mentioned above enjoy electricity, some 24 hours a day, others in the evening only, as do two other villages of the area, Copal and Peruanito. Daily river transport is offered by a subcontractor of Pluspetrol for all the villages downriver of San José de Nueva Esperanza. San José, Santa Rosa and Valencia are served on a much less regular basis by company boats. However, contact between these villages and communities up- and downriver is maintained through travel by motorized dugout canoe or motorized rowboat. Members of different communities meet regularly through soccer competitions organized between neighbouring villages, village celebrations or communal labour that brings kinfolk together.

The 15 villages in the study area, though similar in livelihood activities, are highly variable in size, composition and market integration. All are located on the upland and most agricultural activity revolves around the traditional swidden-fallow cycle of upland fields. Villagers also rely on fishing and hunting to meet their subsistence needs, but their fishing activities are being reduced upon recommendation from a Lima-based NGO, *Racimos de Ungurahui*, because of the suspected presence of heavy metals in the water and fish.[3]

The villages range in population from 23 (Nueva Vida) to 305 (Pucacuro) inhabitants, and have between five and 68 households. The mean number of inhabitants and households per village across the study area is 117 and 23, respectively. The total area studied comprises of 346 households with a population of approximately 1760 inhabitants.

[2] Another oil well, between Peruanito and Pucacuro, is more isolated and therefore not considered in the analyses.

[3] The only published study, conducted in part by Pluspetrol itself (UNAP & Pluspetrol 1997), reveals such presence only within permissible limits but warns against the threats posed by oilspills.

Market integration varies along the river but does not follow a geographical gradient by distance because of the presence of oil company bases at different points on the river and their demand for local produce. Villagers who are within short travel distance of Villa Trompeteros by foot or by dugout canoe (San Juan campesino and nativo and Santa Elena, and less so Porvenir and San José de Porvenir) can sell their produce at the local market or to the *lancheros* who travel weekly between Iquitos and the district town. Subcontractors of Pluspetrol buy manioc, plantain and other local produce at the Percy Rozas, Pavayacu and Nueva Esperanza stations. In addition, villages between San José de Nueva Esperanza and Porvenir receive bi-monthly visits from a *regatón*, a merchant bargeman who buys local produce to sell in Iquitos. The same trader sometimes reaches Santa Rosa and Valencia; his schedule, however, is unpredictable. Another *regatón* runs the zone upriver of San José, but his visits are irregular and not dependable.

2.3. Methodology

2.3.1. Data collection

During fieldwork, 15 villages were visited along a reach of approximately 150 km of the Corrientes, upriver of the district town of Villa Trompeteros. These communities represent all villages established more than a year prior to the beginning of the research project.[4] Of the 15 villages, three are officially designated as Urarina, 11 are considered, either by official or self designation, as Achuar, and one is a *mestizo* community (*comunidad campesina*). The ethnic composition of the villages, however, differs even within a single denomination, and some of the Achuar villages around Villa Trompeteros and the Pavayacu station are closer in ethnic make-up to the aforementioned peasant community, which itself comprises a large number of Achuar families. Given the looseness and elasticity of the terms *Achuar* and *mestizo*, all villages in the sample will be categorized in one of two groups: Achuar (12 villages; includes the *mestizo* community) and Urarina (three villages).

[4] Two small Urarina settlements were omitted from the sample because they were not yet fully established when the study was undertaken. The inchoate state of their peridomestic agriculture made them of very limited interest in terms of agrobiodiversity distribution.

The data collection period for this section of the research project lasted one month, between July and August 2003. It consisted of a visit to each of the 15 villages during which all home gardens were inventoried in the presence of the garden tender, or, when the tender was unavailable, of another member of the household. The home garden is defined as the peridomestic area that household members consider as belonging to their house and where useful plants grow and are tended. This can include a *patio* - the area in front of the house where ornamentals are grown - a *huerto* - the garden *per se* most often located behind or beside the house - a *puerto* - an extension of the household land that gives on to the river, where family members go to bathe and where canoes are launched - and the forest edge, where forest plants are sometimes transplanted and tended. The informant was asked to identify all plants deemed useful in the peridomestic area belonging to his/her house. The plant names recorded were either domesticates, semi-domesticates or wild plants used and/or managed by the garden tender, regardless of whether the plant was planted, grew on its own, or was preserved from clearing at the time of garden formation. A brief questionnaire was administered to all households visited, with questions relating to household demography, land assets, garden history, and garden tender profile (see Appendix 3). The garden inventories and questionnaires were approximately 30 minutes in duration and were applied on a voluntary basis. All households were visited with the exception of the few who refused access to their land and those where the family was absent for the entire duration of the researcher's stay in a village. Teachers with temporary appointments were omitted from the sample. Once teachers' houses are removed, between 88% and 100% of a village's households were visited, capturing overall 300 households; that is 94% of gardens in the study area (excluding the two newly forming Urarina settlements).

The author speaking Spanish fluently, questionnaires and interviews in Achuar villages were conducted in Spanish, since the majority of informants either mastered the language or were native Spanish speakers. In the most remote villages, Spanish was less commonly spoken among the women, but men communicated in Spanish with ease and were able to translate for their wives. In the Urarina communities, however, most women only spoke Urarina. For visits to their gardens and factual questionnaires, the investigator was accompanied by the male head of household or by a young villager fluent in both languages who served as interpreter.

Participant observation yielded little qualitative information in Urarina villages because of language and cultural barriers. In the two remotest Urarina villages, women turned their back to me when I approached their house and avoided eye contact; it was only with great patience, greetings in Urarina and the intercession of the husband or a younger member of the household, that the woman accepted to turn towards me, answer my questions and show me her garden. Time was a constraining factor as week-long stays in the smaller villages were not possible. Long sojourns may have otherwise allowed breaking some of the cultural barriers and gaining valuable insights.

Communication was easier in Achuar villages, but a small number of households denied access to their garden or welcomed me at gunpoint. Much of the mistrust expressed in such behaviour can be explained by the fear of the *pelacara* (literally: face peeler), a myth from the Andes which tells of white supernatural beings who roam the forest and enter houses at night to kill people, peel their skin off and collect their body fat. The story was told time and time again, with a number of variations on the theme of the white murderer: helicopters dropping *pelacaras* into the forest, NASA rockets fuelled by indigenous peoples' body fat collected at night by blood-thursty *pelacaras*. I was sometimes asked to confirm that I was not a *pelacara*; a hint of suspicion and disbelief invariably tainted the sigh of relief that followed my answer. Nevertheless, on the whole, the Corrientes dwellers welcomed my boat driver and I warmly and joyfully and were proud to show their plants and talk about them.

2.3.2. Data analysis

Two indices of diversity were used to compare agrobiodiversity between villages. β diversity, an index of between-garden diversity, was measured using Whittaker's index. It is computed according to the following formula:[5]

$$\beta_i = \frac{S_i}{\alpha_i} - 1$$

[5] Formula adapted from Whittaker (1972).

where S_i = total number of home garden species in village i and α_i = mean number of species in each home garden of village i. A coefficient of 0, occurring when each garden holds all of the village's species, indicates perfect similarity between gardens. As the coefficient increases so does heterogeneity between gardens.

Whittaker's index is very sensitive to sample size and can only be used with circumspection when comparing villages of different sizes. To circumvent the problem, only the 12 largest villages were compared using this index and random samples of 11 gardens (the number of gardens inventoried in the smallest of the 12 villages) were drawn from each village. Comparisons between villages were made on the basis of total and mean species in the 11-case random samples. With a sample size of 11 gardens, Whittaker's index can range from 0 – perfect species overlap between gardens – to 10 – perfect dissimilarity between gardens.

Similarity was also measured with Jaccard's binary similarity index. This index measures the number of species shared between two sites – in this case two villages – expressed as a proportion of the total number of different species present in both sites. It is calculated in the following way:[6]

$$\text{Jaccard} = \frac{S_{i \cap j}}{S_i + S_j - S_{i \cap j}}$$

where $S_{i \cap j}$ = number of species shared between villages i and j, S_i = total number of species in village i, and S_j = total number of species in village j.

This coefficient can range from 0, indicating no species overlap between two villages, to 1, indicating two villages with identical species portfolios. A similarity matrix assembling Jaccard coefficients was used to cluster villages in groups of similar species composition using the software SPSS 11.5 for Windows.

2.4. Results

2.4.1. Village agrobiodiversity

The study villages all lie within relatively short distances of one another and are, for the most part, interlinked by tight networks of planting material exchange (see

[6] Formula adapted from Coffey (2002).

Chapter 3), yet they differ considerably from one another in terms of crop species diversity (Table 2-2). The total species endowments of the small villages San Ramón and Dos de Mayo, for instance, sharply contrast with that of a large village such as Pucacuro. The mean number of species per garden likewise varies greatly from one village to the other, with a low of 14 species in the Urarina village Porvenir and a high of 39 in the small community of Nueva Vida.

A look at the specific composition of gardens reveals major differences among villages. Some species are unique to one village or to a single garden; some villages have a high number of these distinctive species; some species are common in limited sections of the river, and almost absent from other areas. Yet the composition of gardens by use category remains fairly constant across the sample (Figure 2-2). The main categories are medicinal species - which include hallucinogenic, magic and ritual plants - fruit species, and non-fruit food species. They constitute 17%, 44% and 23% of the typical garden respectively. The other categories, though important as a whole, each only comprise of a few species. In order of relative importance, these categories are: seasoning (5%), handicraft species[7] (4%), construction species[8] (2%), ornamentals (2%), extractive species[9] (2%), dye and varnish (1%), species of undetermined use (0.3%), environmental species[10] (0.2%), and firewood (0.1%). In spite of the great variability among villages in the exact species composition of each use category, the relative size of categories remains remarkably constant, obliterating cultural specificity and unequal access to planting material. Paraíso, the only exception, departs slightly from the norm with a prevailing "other species" category and a reduced number of fruit species.

What explains the heterogeneity in the species richness and species composition of garden portfolios between villages? To explore this question, multiple regression analysis was performed on the data, setting each in turn total, mean and modal village species diversity as the dependent variable. Only two independent variables were retained in the final model: ethnicity and size of village, represented by the number of

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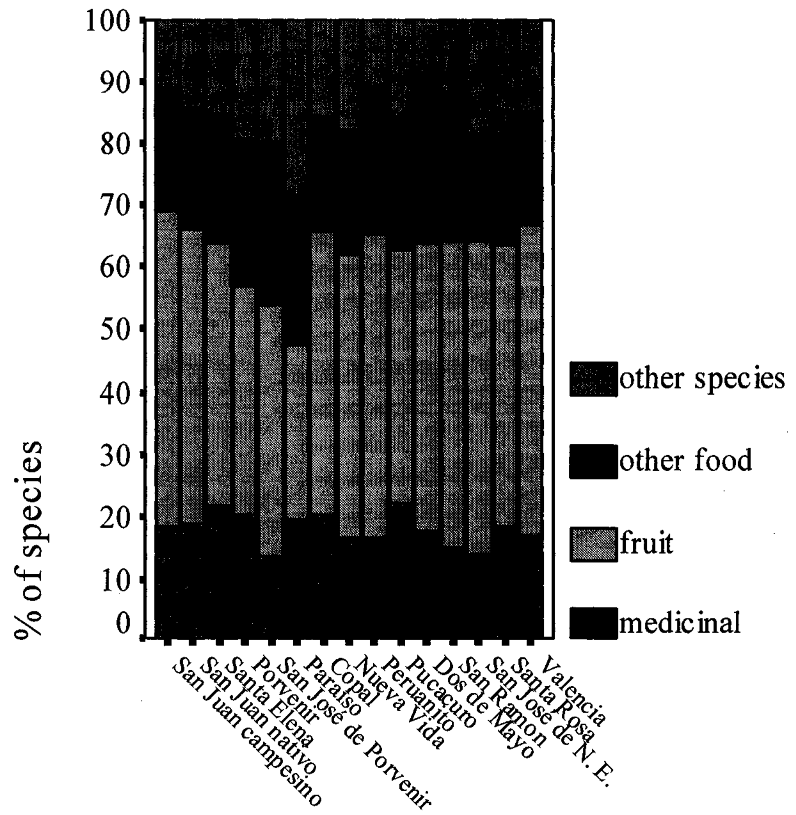
[7] Species used for the making of small objects, kitchen utensils and handicraft, including fiber.
[8] Species used for house building, roofing, and construction of large objects such as rafts and canoes.
[9] Species used for the preparation of fish poison or for the making of weapons.
[10] Species used as domestic or wild animal forage, natural fertilizer or natural hedges.

Table 2-2 : Agrobiodiversity in home gardens of study villages, Corrientes river, Peru.

VILLAGE	Total no. of species	Mean no. of species per garden	Std. deviation	Range	No. gardens inventoried	% of total no. gardens
San Juan campesino	114	21.4	11.9	9-75	35	97%
San Juan nativo	108	24.2	10.0	14-58	22	100%
Santa Elena	141	30.5	14.8	11-78	30	97%
Porvenir	83	13.7	9.8	3-49	22	96%
San José de Porvenir	84	20.9	9.3	2-38	18	100%
Paraiso	83	19.1	15.7	9-64	11	100%
Copal	108	26.1	11.3	9-57	19	91%
Nueva Vida	85	39.4	5.3	34-48	5	100%
Peruanito	88	20.8	14.7	8-66	15	94%
Pucacuro	161	29.8	11.9	5-72	54	88%
Dos de Mayo	48	18.0	3.2	12-21	6	100%
San Ramón	45	23.0	7.8	14-32	4	100%
San José de Nueva Esperanza	136	28.9	14.6	4-70	24	93%
Santa Rosa	122	38.8	11.7	19-62	14	93%
Valencia	146	29.7	14.7	6-65	21	91%

Figure 2-2 : Relative number of species per use category in mean home garden, Corrientes river, Peru.



inhabited houses. Multiple regression analysis of total species yields significant results for the size variable only. Number of houses is positively related to the total number of species in each village. Modal diversity is explained in terms of ethnicity. The model, however, yields no statistically significant result for mean diversity. These results are presented in Table 2-3. An important geographical variable, the proximity of oil company bases, was put aside in the multiple regression model because of its high positive correlation with village size. A simple regression against total diversity reveals the significance of this variable, but it is difficult to tell the effects of size from those of external influence of the company as these two variables are endogenously related. The dummy for proximity of oil company bases, however, is not significantly related to either modal or mean diversity. The main variables affecting agrobiodiversity at the village level will each be examined in turn.

2.4.1.1. Village size

According to the model, large villages tend to be more species diverse than smaller ones; each house contributes an additional 1.6 species to total village diversity. This relationship between village size and agrobiodiversity reflects the degree of social and cultural diversity of the area. Each garden is at least slightly different from adjacent plots, bespeaking the uniqueness of the family that cultivates it. Different households contribute different plants to the agrobiological landscape of the village. Large villages are more likely than smaller ones to be home to families from diverse backgrounds, who in turn make choices in the garden that reflect their specificity. Indeed, the largest villages of the sample, in particular Pucacuro and San Juan campesino, harbour many families from other rivers or other regions who came to the Corrientes river attracted by the employment lure of the oil company. Tía Rosalia, for example, returned to San José de Nueva Esperanza after a sojourn of several years on the Marañón river with her husband and brought back several plants that now grow in other gardens of the community. Village size and proximity of the oil company base are indeed highly correlated (see Section 2.4.1.3), but size is decidedly the most powerful explanatory variable. When controlling for the presence of a Pluspetrol base in or near a village, the

Table 2-3 : Regression models of total, mean and modal number of home garden species per village, Corrientes river, Peru.

	Total no. of species	Mean no. of species	Modal no. of species
	Coef. (Std. error)	Coef. (Std. error)	Coef. (Std. error)
(Constant)	68.898 (11.193)***	27.434 (3.349) ***	19.600 (2.988) ***
Ethnicity (1= Urarina; 0= other)	-16.808 (14.374)	-9.620 (4.300) **	-9.169 (3.837)**
No. of houses	1.644 (0.382)***	0.005 (0.114)	0.065 (0.102)
R^2	0.643	0.299	0.357
F	10.817	2.563	3.326
P(F)	0.002	0.118	0.071
df	12	12	12

*** $P(t) \leq 0.01$; ** $P(t) \leq 0.05$; * $P(t) \leq 0.10$.

partial correlation between number of houses and number of species per village remains high ($r = 0.616$, $p = 0.019$).

While the large villages are diversely populated, the small villages of the sample are composed of households with more ethnic and cultural similarities. Nueva Vida, Dos de Mayo and San Ramón, by far the three smallest communities, each consist of a single kin group (plus one in-migrated couple in Nueva Vida). Having similar background and being more bound by kin exchange networks, all members of the family are likelier to have similar garden compositions. A field observation illustrates this point: in Nueva Vida, the patriarch indicated a young shoot of the fruit tree *shimbillo* (*Inga sp.*) in his garden and explained that he had received the fruit from a travelling journalist and immediately shared the seeds with all his daughters, who make up, with husbands and children, the bulk of the village. I found indeed a similar shoot in one of the daughters' garden (the other daughters claimed to have planted the seed in their fields rather than the garden). *Mandarina* (*Citrus reticulata*), a fruit tree that is not encountered frequently in the sample (occurs in 14% of gardens), is likewise ubiquitous in Nueva Vida, occurring in all but one garden. The plant *rupiña* (undetermined sp.) is only grown in Copal, in 20% of gardens, all of which are owned by members of the Piñola kin group.

In contrast to total diversity, modal diversity is not significantly related to village size. Likewise, a simple regression of mean number of species per village against number of houses yields no statistically significant result. The finding that size positively affects total village diversity without having a sizeable effect on mean diversity raises the question of exchange barriers: is exchange of planting material between members of the same community impeded by more pronounced obstacles in larger villages? Whittaker's index, a measure of β diversity, is highly correlated with village size ($r = 0.713$, $p = 0.003$). Unfortunately, the measure is not independent of sample size; the correlation can therefore not provide conclusive answers. Using random samples of equal size ($n = 11$; see Section 2.3.2), we find no correlation for the 12 largest villages ($r = -0.045$, $p = 0.889$). Indeed, the resulting Whittaker's indices have a narrow range, varying from 1.97 to 3.35 (Table 2-4), compared to their possible range from 0 to 10. The β diversities across villages along the river suggest that there is an equivalent degree of fluidity in intravillage germplasm exchanges in all of the study villages, regardless of village size.

Table 2-4 : Whittaker's index for random samples (n = 11) of the 12 largest study villages, Corrientes river, Peru.

VILLAGE	β	VILLAGE	β
San Juan campesino	2.96	Copal	2.55
San Juan nativo	2.60	Peruanito	2.61
Santa Elena	2.48	Pucacuro	2.60
Porvenir	3.19	San José de Nueva Esperanza	2.54
San José de Porvenir	2.30	Santa Rosa	1.97
Paraiso	3.35	Valencia	3.18

2.4.1.2. Ethnicity

Ethnicity is not statistically significant as a determinant of total village diversity. However, it undeniably plays a critical role in explaining differences in species richness across villages. As a means to evaluate the influence of ethnic factors, modal diversity in each village is a better comparative measure of agrobiodiversity. In contrast to total diversity, it is significantly affected by ethnicity: Urarina villages have much lower modal diversity than Achuar villages. The total number of species in Porvenir, San José de Porvenir and Paraíso is in fact biased by the presence in each of Achuar households (between one and five households) whose species richness is by far superior to that of their Urarina neighbours. Indeed, once Achuar families living in Urarina villages are excluded from the sample, total species richness is reduced to 68 in Porvenir, 59 in San José de Porvenir, and 55 in Paraíso. Replacing the totals for these three villages in Table 2-3 above, the multiple regression yields highly significant results for both the village size and the ethnicity variables ($R^2 = 0.723$, $p < 0.001$). While the Urarina-restricted model returns a coefficient for the village size variable almost identical to that of the first model, it yields a significant difference of 39.4 species between Urarina and non-Urarina villages.

In reality, the contrast is stark even to the uniformed eye. Urarinas clearly focus much less attention to their home gardens than do their Achuar neighbours. While Achuar respondents often made use of the unplanned visit to the garden with the researcher to uproot weeds, pick ripe fruit or examine plants, such behaviour was rarely observed with the Urarina respondents. Care must be taken when interpreting these observations, however, because the Urarinas were, for the most part, much shier than the Achuar and often reluctant to spend much time with the researcher. This reservation, coupled with linguistic barriers, limited my ability to engage in conversation with Urarina garden tenders and to get a comprehensive understanding of their home agricultural practices.

Cultural factors are important in explaining not only total home garden diversity, but also the composition of that diversity. Jaccard similarity coefficients were measured for all pairs of villages to compare species composition. The similarity coefficients between the three Urarina villages are relatively high, indicating high similarity in species composition between the three (Table 2-5). They are significantly higher than the average Jaccard coefficient between villages ($t = 2.967$, $p = 0.080$).

There are, indeed, plant species that are cultivated almost exclusively by Urarinas and that serve purposes specific to their needs as a cultural group. Three such plants were identified in Urarina home gardens: *hanitadi* (*Phyllantus acuminatum*), a fish poison that is used in a mixture with *waka* (*Clibadium spp.*), *lidiane* (undetermined sp.), a red dye for fiber, and *maraca* (undetermined sp.), which serves as decoration for baby hammocks. None of these plants are utilized by the Achuar in the survey, whereas they are in daily use in Urarina communities. Furthermore, *waka*, a fish poison, and *trigo* (*Coix lacryma-jobi*), the grains of which the Urarinas use as beads in the fabrication of necklaces, are found more frequently in Urarina gardens than elsewhere. On the other hand, many species occur only occasionally in Urarina villages while they are prevalent in the other communities, among which are citric fruit, fruit trees such as *sacha mangua* (*Grias spp.*), *macambo* (*Theobroma bicolor*) and *uvilla* (*Pourouma cecropiifolia*), and medicinal plants such as *ajo sacha* (*Mansoa alliaceae*), *hierba luisa* (*Cymbopogon citratus*) and *mucura* (*Petiveria alliacea*). The Achuar, for their part, also cultivate culturally specific plants, *mamá nukurí* for example, an Amaranthaceae (uncertain family identification) which, according to Achuar beliefs, stimulates the growth of manioc, and *huayusa* (*Ilex guayusa*) used as a purgative in daily or weekly early morning cleansing ceremonies.

2.4.1.3. Proximity of oil company

As mentioned above, the proximity of oil company bases and village size are two endogenously related variables. They have a highly significant Pearson correlation coefficient of 0.702 ($p = 0.004$). The real or perceived employment opportunities offered by the oil company attract peasants and workers from the Corrientes river but also from neighbouring rivers, from Iquitos and sometimes from as far as the department of San Martín. Some villages exist as demographic "poles" essentially because of the economic activities of Pluspetrol. Pucacuro is a case in point: its population grew at a prodigious rate since the late 1990s when Pluspetrol took over from the state-owned company Petroperú. In the 1970s and 1980s, however, petroleum activities had the reverse effect in Valencia. The Occidental International Corporation and Petroperú had wells near the

Table 2-5 : Jaccard similarity coefficients for three Urarina villages, Corrientes river, Peru.

	Porvenir	San José de Porvenir	Paraíso
Porvenir	1.00	–	–
San José de Porvenir	0.62	1.00	–
Paraíso	0.55	0.52	1.00

current location of Valencia and the village, contrary to Pucacuro, changed locations twice to move away from the company bases and protect itself against what it viewed as the deleterious social influence of petroleum workers. Because of the recent signature of bilateral agreements between Pluspetrol and village chiefs, agreements in which the company commits to compensating local communities with medical and infrastructural support, villages generally accept the oil company or at least suffer its presence, with an eye to the material and practical benefits of hosting a rich multinational in their backyard.

The effects brought about by the oil company are manifold and go well beyond the obvious well-documented economic, health and ecological impacts of petroleum activity. The proximity of Pluspetrol bases indirectly affects the species richness and composition of the villages in the region. The five villages that are located within short distance of company stations stand out with their high diversity, as evidenced by the simple regression of the dummy variable for proximity of oil company base against village total species richness ($R^2 = 0.373$, $p = 0.016$), where the dummy variable has a positive coefficient of 42.8. When controlling for village size, the partial correlation between Pluspetrol proximity and total species diversity loses significance ($r = 0.147$; $p = 0.617$) because of the endogenous character of the two variables.[11]

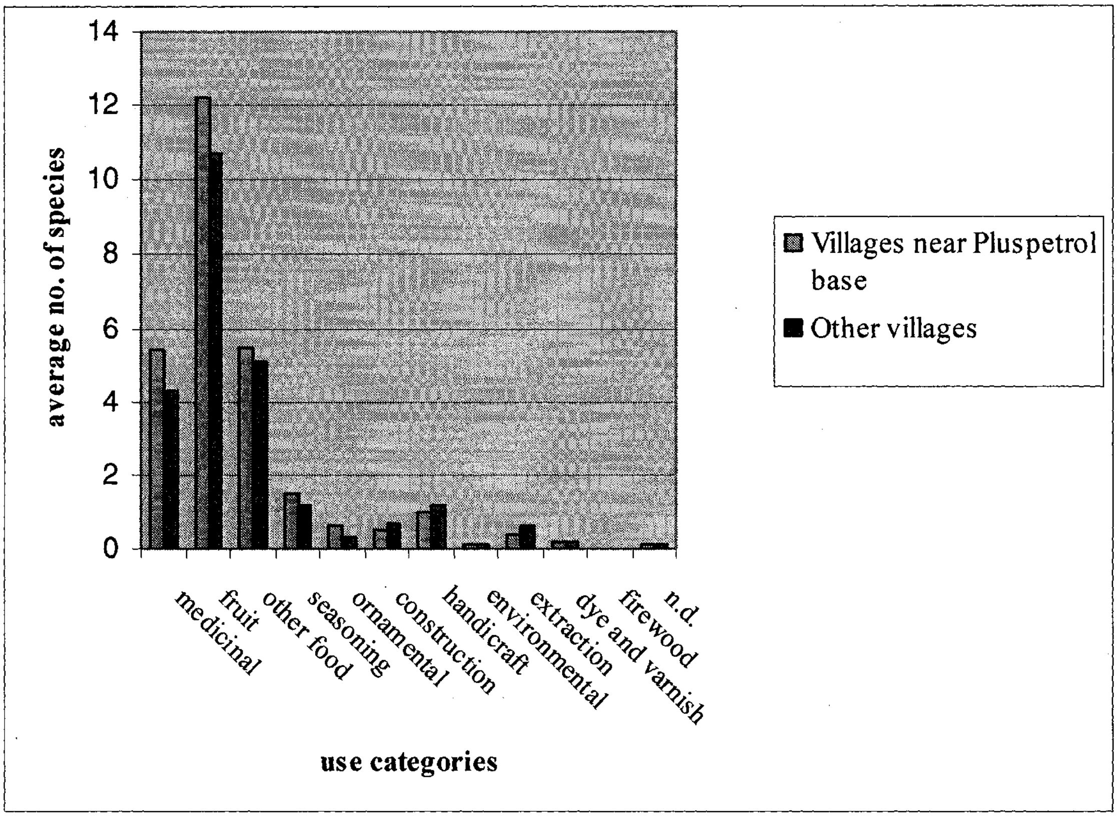
This striking difference between the villages remote from and those near oil wells can be viewed firstly as a result of social agglomeration. The oil company attracts workers from various regions and thus pools together a range of households from diverse backgrounds, who carry with them planting material and agricultural practices that contribute to the formation of a rich village species portfolio. Pluspetrol is also a powerful economic force and injects money in the communities near its stations by employing villagers and buying local produce. Purchasing planting material in the Trompeteros and Iquitos markets becomes a possible alternative to barter and gift for those who have become richer due to their dealings with the company. In addition, Pluspetrol has a direct effect on the species composition of some gardens by being a

[11] Interestingly however, the correlation becomes significant when Valencia is considered a near-Pluspetrol village, on account of the historical existence of a base in its proximity ($r = 0.495$; $p = 0.072$). Aggregating Valencia and the other near-Pluspetrol villages implies that the effects of the oil company are long-lasting: the origins of some of the phenomena observable today can be traced back to the 1980s when Petroperú extracted oil near the village. In this case, *historical* proximity to the oil company has a positive influence on total species portfolio. This implies that plants acquired some twenty years ago may still be circulating among gardens, although villagers' memory of plant origin does not generally go back so far.

source of planting material. Pluspetrol grounds are generally well-cared for and adorned with fruit trees and ornamentals. Villagers often take advantage of medical visits to the station or of meetings with Pluspetrol officials on company sites to pick fruit or collect cuttings of ornamentals – with or without permission – which they later plant in their garden. Employees of the company are well aware of the villagers' endeavour to put together large plant collections and are keen to offer them bags of fruits or branches of ornamentals. Workers bring home fruit that grow on the Pacific coast and their seeds are often collected for experimentation. Some families reported having planted grape and apple seeds obtained from the company; needless to say these attempts failed. The data in this study does not permit to trace the movement along the river of species originating from Pluspetrol because of the species' multiple potential sources. Cashew (*Anacardium occidentale*), for example, was often reported as having been acquired at company posts, but some bought it at the market, and the exchange networks through which the fruit seeds transit are so complex that determining the exact origin of all cashew trees in the sample is not possible with the existing data. Citrus fruit, likewise, can often be traced back to gifts from Pluspetrol employees. *Lima dulce* (Rutaceae, undetermined sp.), in particular, only occurs in the near-Pluspetrol villages. Ornamentals are more prominent in these villages as well, most likely because they are readily available on Pluspetrol flowerbeds and often given for free. In absolute and relative numbers, these villages have on average more ornamentals per garden than the other communities. *Buseta macho* (*Anthurium sp.*) is one such ornamental that is almost exclusively cultivated in the five villages in question.

Although the number of garden plant species in near-Pluspetrol villages is higher than elsewhere in the sample, the function of the gardens is constant: use categories remain roughly equivalent in both types of geographical location. Only minor differences occur, in the smaller, more marginal use categories – whereas ornamentals are more common in the five villages near company bases, most other non-food and non-medicinal use categories are less important in individual gardens (Figure 2-3). The differences are nevertheless slight. This subtle divergence may be the result of a substitution from home-produced to commercial goods in villages closer to company stations and reflects better access to manufactured goods and market products and perhaps the allure of a more urban

Figure 2-3 : Average number of species per home garden by use category, Corrientes river, Peru.



lifestyle for those who are in daily contact with workers from the city. It is noteworthy however that the health services offered by the oil company have not caused a reduction in the number of medicinal plant species grown in home gardens.

While Pluspetrol does affect the species composition of home gardens, home agriculture remains in essence the same whether or not the oil company is established in or near a village. The company's presence has no statistically significant effect on the mean number of species per garden ($R^2 = 0.018$, $p = 0.633$). The only appreciable impact of the company is on the total diversity of home garden plant species. Fruits and medicinal plants account for most of the difference in total diversity between the villages near and those distant from oil company bases (Table 2-6).

2.4.1.4. Other geographical variables

Measures of distance[12] in the study area have little predictive power for the size of a village's species endowments. There is in fact no correlation between the relative geographical location of villages and total or mean number of species per village. Notwithstanding, the interspecific composition of villages' species portfolios reveals geographical trends that are not perceptible when only considering global species numbers. Indeed, cultivated species are not uniformly distributed along the Corrientes river and some follow a discernible geographical pattern that corresponds to socioeconomic and cultural features of villages.

A Jaccard similarity matrix was computed to compare the home garden species present in each village. At similarity coefficient 0.50, villages can be grouped into four clusters:

Cluster 1: San Juan campesino, San Juan nativo, Copal, Porvenir, San José de Porvenir, Peruanito, Nueva Vida, Paraiso;

Cluster 2: Santa Elena, San José de Nueva Esperanza, Pucacuro;

Cluster 3: Santa Rosa, Valencia;

Cluster 4: San Ramón, Dos de Mayo.

[12] Three measures of distance were computed: distance between villages, distance from Villa Trompeteros, and distance from nearest Pluspetrol base.

Table 2-6 : Average number of medicinal and fruit species in near-Pluspetrol and other villages, Corrientes river, Peru.

	Average # of medicinal and ritual plants per village	Average # of fruit species per village
Villages near Pluspetrol base	38	46
Other villages	25.1	33.1
t value	2.415**	3.855***

*** $P(t) \leq 0.01$; ** $P(t) \leq 0.05$.

These clusters reflect a certain structure in the geographical distribution of cultivated species along the river. Species similarity forms fairly uniform village clusters in terms of the following geographical variables: proximity of Pluspetrol base, market access and relative location on the river (Table 2-7). In fact, Jaccard clusters coincide more or less with geographical clusters. Cluster 1 includes all but one of the villages downstream of Pucacuro. Clusters 3 and 4 each correspond to two strongly tied neighbouring villages. Santa Rosa was founded in 1996 by villagers from Valencia and many of the founders still have family in Valencia; one of the wives of the Dos de Mayo chief is a member of the main kin group in San Ramón. Additionally, clusters 3 and 4 represent the four most remote non-Pluspetrol villages. Only cluster 2 is composed of villages distant from one another, all of which are nonetheless near oil company stations. The proximity of Pluspetrol bases and the good to intermediate access to market in clusters 2 and 1 respectively partly explain the garden similarity between members in each of the two clusters. Indeed, these villages have comparable access to planting stock. Near villages, Santa Rosa and Valencia in the case of cluster 3, Dos de Mayo and San Ramón in the case of cluster 4, may also share common sources of planting material because of their sheer propinquity. Their proximity to one another and their interconnection through kinship ties also fosters the circulation of planting material through informal exchange networks and contributes to the homogenization of agrobiodiversity within geographical clusters, as will be discussed in Chapter 3. The discussion of culturally specific plant species in Section 2.4.1.2 reveals the existence of another phenomenon explaining the overlap of Jaccard clusters with geographical clusters: like needs, preferences and knowledge between neighbouring communities results in like agrobiodiversity choices.

An examination of the occurrence of specific species across the sample underscores the relevance of geographical factors as explanatory variables of species distribution. The proximity of markets, where garden production can be sold, influences the choices of species tended. *Toronja* (*Citrus paradisii*), one of the most marketed garden species, is much more frequent in villages near markets, i.e. the near-Trompeteros group consisting of San Juan campesino, San Juan nativo and Santa Elena, and the central upriver village of Pucacuro. *Aji dulce* (*Capsicum spp.*), which also moves easily through markets, is most prevalent in these four villages. Tomatoes, similarly, are found in

Table 2-7 : Geographical descriptors of Jaccard clusters, Corrientes river, Peru.

Jaccard clusters	General geographical descriptor	Avg Jaccard coefficient (range)	Villages with proximity to Pluspetrol base	Market access[a]	Propinquity (Average distance separating closest villages in min.)	Average time from Trompeteros by 25 hp (min)
1	Downstream, near-market	0.55 (0.46 – 0.66)	some	good to intermediate	39.71	115.25
2	Pluspetrol	0.56 (0.54 – 0.58)	all	good to intermediate	237.50	271.67
3	Most remote; related families	0.52	none	Poor	30.00	525.00
4	Small and remote; related families	0.50	none	Poor	30.00	385.00

a. Good = within walking or short (< ten min.) paddling distance of Trompeteros market or direct within-village selling opportunities to Pluspetrol food supplying subcontractor.
Intermediate = Trompeteros market within a day's travel by motorized dugout canoe and/or regular visits by *regatón*.
Poor = Trompeteros market inaccessible within a day by motorized dugout canoe and/or irregular visits by *regatón*.

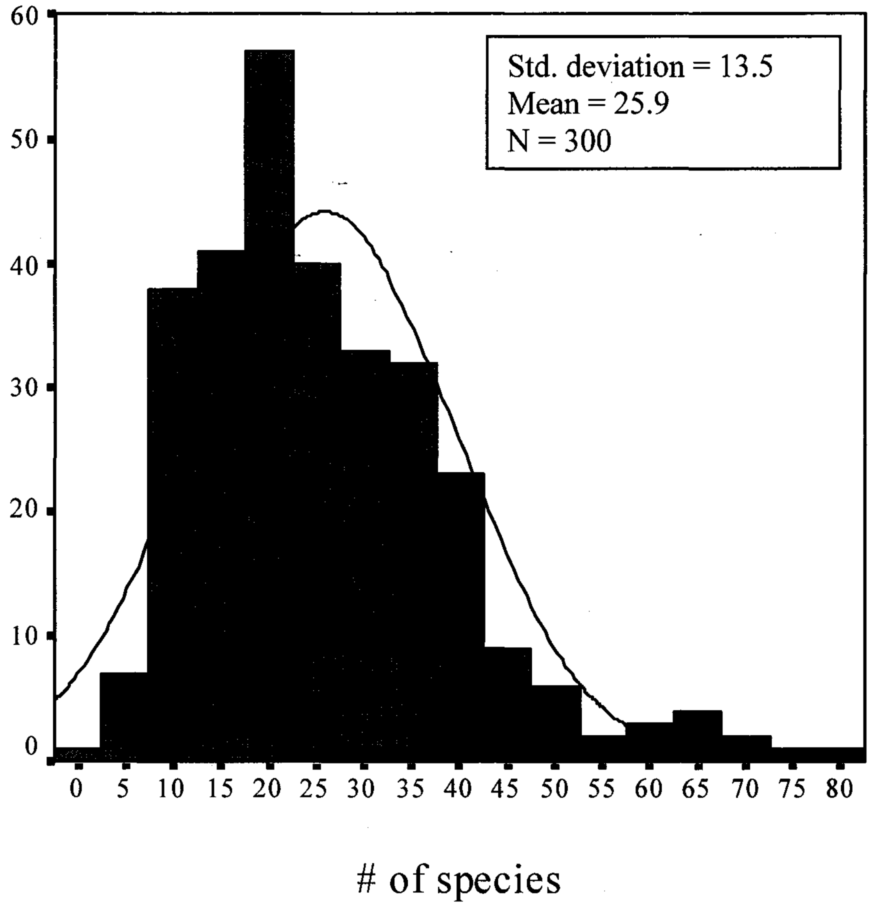
highest proportion in the near-Trompeteros group: seeds are readily accessible through the Trompeteros market, and the fruit are easily sold on the market stands. *Huingo* (*Crescentia cujete*), on the other hand, occurs least frequently in the most market-integrated villages, likely because the home-made gourd carved into *huingo* fruit has been replaced there by plastic containers while calabash, together with clay pottery, remains the preferred vessels in more remote villages. *Barbasco* (*Lonchocarpus nicou*), a fish poison, is only found in home gardens upriver of San José de Porvenir, probably because these villagers rely primarily on their own fishing activity since the distance to the Trompeteros market makes the latter an inaccessible source of fish, while those living near Trompeteros have the alternative of purchasing fish at the market. Many plant species are grown much more frequently and in some cases exclusively in the villages most remote from Trompeteros: *motelohuayo* (undetermined sp.), *metohuayo* (undetermined sp.), *huevo de sachavaca* (undetermined sp.), *chambira* (*Astrocaryum chambira*), *chimicua* (*Batocarpus amazonicus*), *chirisanango* (*Brunfelsia grandiflora*) and *pichana* (undetermined sp.), to name only a few. These are for the most part species that initially occur as volunteers and that are spared when the garden is cleared, or wild species that are intentionally brought from the forest to be planted in the garden. Their seeds or cuttings are later exchanged, but the origin of the plants can generally be traced back to the forest or to old fallows. Indeed, a simple regression of village distance from Trompeteros against the mean number of forest species[13] per garden is highly significant ($R^2 = 0.418$, $p = 0.009$). Each increment of 100 minutes in distance is associated with an increase of 1.1 in the mean number of forest species per garden.

2.4.2. Global agrobiodiversity

In the entire study area, an average garden contains 25.9 species. There is, however, great variability in species richness across the sample, with gardens being endowed with as little as two to as many as 78 species (Figure 2-4). A similar degree of

[13] For the purpose of this analysis, a forest species is defined as a species that was reported to have been brought from the forest by at least one of the 100 respondents that were questioned on the origin of their cultivated plants in a later phase of the research. It may underestimate the real number of forest species because some of the species in this larger sample of 300 households were not cultivated by any of the 100 respondents and are therefore not categorized in terms of their origin.

Figure 2-4 : Frequency distribution of species richness, Corrientes river, Peru.



heterogeneity in species diversity is observable at the village level: the standard deviations of the number of species per garden in all but the three smallest villages are of the same magnitude as in the pooled sample (see Table 2-2). Such an uneven distribution of species richness within village has already been noted by various authors (Coomes & Ban 2004; Lerch 1999; Padoch & de Jong 1991) and underscores the relevance of a garden-centered approach to the analysis of agrobiodiversity. While some differences in plant portfolio between villages can be explained in terms of village characteristics (size, ethnicity, geographical factors), the micro distribution of species richness on the Corrientes river strongly suggests that some factors at the household level affect the willingness and/or ability of households to diversify garden portfolios.

The fact that village size is the most important determinant of total cultivated species diversity at the village level further indicates that a good understanding of the patterns of agrobiodiversity relies on the evaluation of species distribution at the individual level. In fact, the discussion in Section 2.4.1 above brought to the fore the importance of social and cultural diversity in enhancing agrobiodiversity. If it is the particularity of individuals that bring about much of the rich home agricultural landscape of the Corrientes river, then which characteristics of individual households govern choice of crop portfolio?

Two tools of analysis were used to tease out the effect of household-level demographic and cultural factors on the species richness of gardens. First, multiple regression analysis was conducted on the data, with number of species per garden as the dependent variable. Independent variables were chosen based on theoretical considerations and on the previous work of Coomes & Ban (2004) and Coomes & Barham (1997). The model most appropriate for the data explains species richness in terms of eight independent variables: size of the garden, number of years that the caretaker has tended the garden, ethnicity of the household, number of cultivated fields belonging to the household, size of household (number of people currently living in the house), age, gender and education level of the garden tender. This model, presented in Table 2-8, accounts for 35.4% of variability in species richness between gardens. Five of the eight variables are statistically significant. Garden area, age and gender of tender, and number of fields are positively correlated with garden species richness. Ethnicity has a

Table 2-8 : Regression model of number of species per garden, Corrientes river, Peru.

	Coefficient (Standard Error)
(Constant)	14.363 (3.772)***
Size of garden (100 m^2)	0.137 (0.023)***
No. of years in charge of garden	0.130 (0.131)
Ethnicity (1= Urarina; 0= other)	-14.391 (2.074)***
No. of cultivated fields	1.756 (0.584)***
Age of tender	0.140 (0.058)**
Gender of tender (1= female; 0= male or both male and female)	4.204 (1.811)**
Household size	0.089 (0.266)
Education of tender	-0.333 (0.254)
R^2	0.354
F	19.393
P(F)	<0.001
df	283

*** $P(t) \leq 0.01$; ** $P(t) \leq 0.05$.

negative relationship with the dependent variable. The other variables – household size, number of years of caretaking, and education of caretaker – are not statistically significant. The significant variables of the model will each be explored in the following sections.

Second, a visual assessment of village maps allowed understanding the influence of geographical variables on the distribution of species diversity at a small spatial scale. Plotting diversity quartiles on village maps reveals the existence of a relationship between the location of a household within a village and species diversity at the household level.

2.4.2.1.Size of garden

The positive relationship between the area of the garden and the number of species cultivated is highly significant. When access to planting material is not impeded, size is the ultimate limiting factor in the formation of rich garden portfolios. During a second visit to Pucacuro, a month after the first, a change in the composition of a garden was brought to the attention of the gardener. A mature, productive *Psidium guayava* tree had disappeared. "I cut the *guayaba* to leave room for the *toronja*," the caretaker explained. Space constraints had forced her to renounce growing some plants otherwise useful. The model indicates that an increase of garden area by approximately 50% (730 m^2) is required to raise that garden's species diversity by one species.

As villages grow, the possibility to add to garden area becomes limited since an expansion of the land often encroaches on neighbouring gardens, fields or communal pathways. In a larger village such as Pucacuro, newly arriving families are allocated small plots of land on sites cramped against an abrupt river bank, where garden area is irrevocably fixed. Living in the remote periphery of the village is a solution to space constraint since the only limits to garden size in isolated sites are natural barriers and labour required to clear land and maintain it cleared. In fact, isolated households often have larger gardens: garden area is positively correlated with a dummy for isolated households ($r = 0.399$, $p < 0.001$).

Beyond the effect of increased space on the ability to grow a wide range of species, large gardens are more suitable for the diversification of species portfolios because they exhibit more microvariations in soil, moisture and other biophysical characteristics. In addition, some large gardens include marginal areas of secondary forest or forest edge where uncommon forest species are tended and harvested. In Santa Rosa, one man considered a small area of forest adjacent to his garden *per se* as part of his home garden because he had brought planting material of the medicinal plant *chirisanango* (*Brunfelsia grandiflora*) from the forest and transplanted it a few meters from the forest edge, thus appropriating, as it were, some of the forested area around his house.

2.4.2.2. Ethnicity

Urarina households have on average 14.39 fewer plant species than their non-Urarina counterparts. The role of ethnicity on agrobiodiversity in the Corrientes river has already been discussed in Section 2.4.1.2. It is worth, however, adding a note on garden composition across the sample. Notable here is the difference in relative size of use categories between Urarina and non-Urarina gardens. Medicinal plants and fruit species are proportionately less important in Urarina gardens, whereas non-fruit food species and other smaller use categories are larger (Figure 2-5). Particularly noteworthy is the relative importance, compared to non-Urarina gardens, of species used for extractive purposes (fish poison, weapons) and those used in the fabrication of small objects and handicraft (Figure 2-6), a clear indication that households have needs specific to their cultural group, needs which home gardens play key roles in meeting. In addition, while Urarina gardens are composed on average of 30% of non-fruit food species, only 22% of the portfolios of non-Urarina gardens are made up of such species. These numbers corroborate the observation that Urarina gardens are generally less complex and less a center of activity than those of Achuar and other ethnic groups. Non-fruit food species are among the easiest to cultivate, requiring little attention and little design. Seven of the 13 non-fruit food species found in Urarina gardens are plant species that often grow fortuitously through natural propagation or germination from planting material thrown away in the garden after consumption, and are staples of the area. Fruit species are proportionately less cultivated, but this might result from the young age of Urarina gardens, formed on average five years before the date of interview compared to eight years for the non-Urarina gardens.

Figure 2-5 : Species composition of home gardens by ethnic group, Corrientes river, Peru.

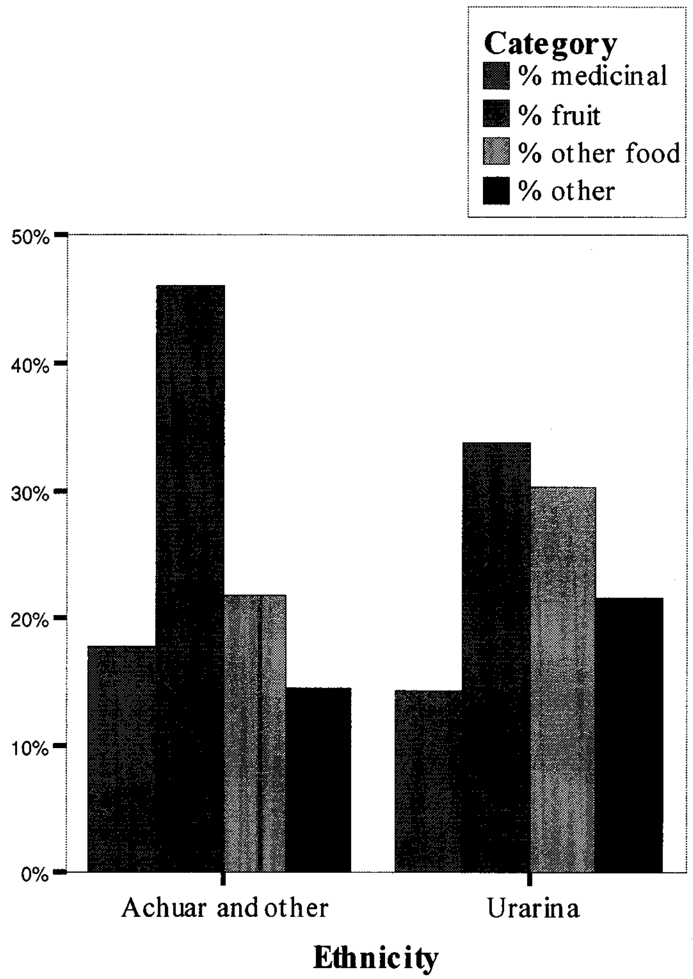
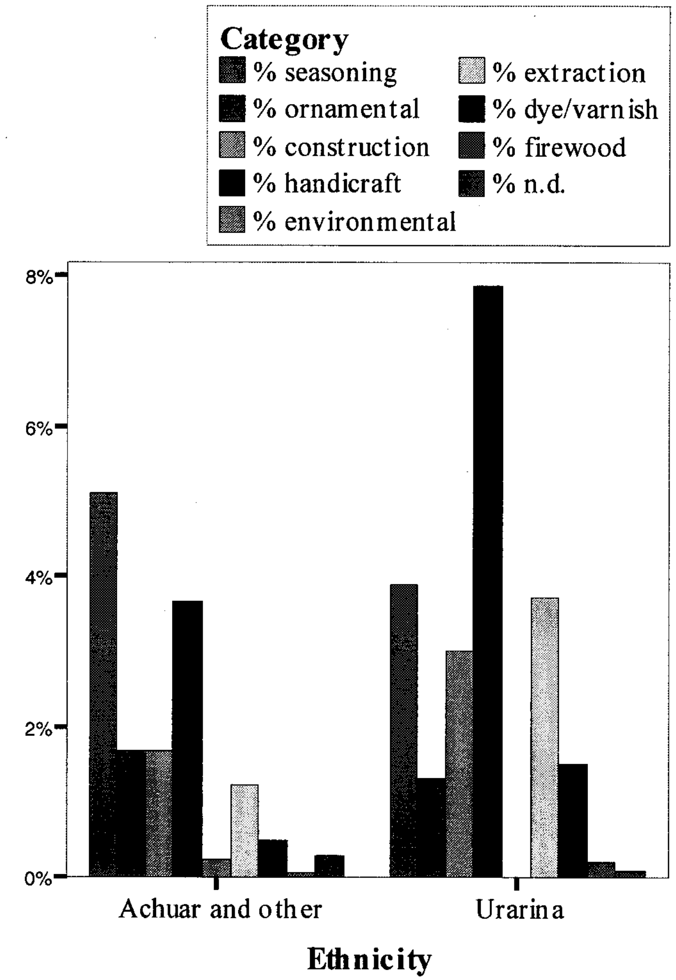


Figure 2-6 : Species composition of home gardens by ethnic group – non-food and non-medicinal categories, Corrientes river, Peru.



The small number of plants in Urarina gardens and the fact that easily grown staples constitute almost a third of the average Urarina species portfolio demonstrates the marginal role played by the home garden among Urarina people.

2.4.2.3. Land assets

Land ownership is significantly related to garden species diversity. Land-wealthier peasants are generally endowed with larger garden species collections than the land-poor. A unit increase in the number of cultivated fields relates to an increase in home garden species of 1.76. The numbers used for this analysis are unfortunately imprecise because the only data available describe land in numbers of plots rather than in area, but we would expect the number of fields and total land holding to be highly correlated. Most fields are upland swiddens; the lowland is only cultivated in rare instances on the Corrientes river. Soil fertility varies from village to village and from bank to bank, ranging from poorer *tierra colorada* to the more fertile *tierra negra.* Despite this variability and the rough nature of the measure, the variable can nevertheless be used as a proxy for land wealth, one of the most important assets of rural people in agricultural societies. Indeed, a more precise data set - area in hectares was collected in three villages, Pucacuro, Santa Rosa and Valencia, in a later phase of the research - indicates a low variability in size between fields. Of the 185 cultivated fields reported in the later study, only two are larger than two ha (2.25 ha and 4 ha) and over 80% range in size from 0.25 to one ha (std. deviation = 0.508). The correlation between number of fields and field holding in hectares in Pucacuro, Santa Rosa and Valencia combined is high ($r = 0.593$, $p < 0.001$). It is thus reasonable to compare number of fields across respondents in the present study, although the regression coefficients must be taken with caution. In some regards, looking at number of fields rather than cultivated area may be useful as such and may add information that is lost when field holdings are compared in terms of total area only. Because fields are not necessarily adjacent, number of plots gives some idea of the perimeter of forest edge and the number of different microenvironments accessible to the farmer. Also, the variability in numbers of fields imply that some farmers must walk regularly through fewer or more zones of secondary forest, which they may appropriate as zones of intensive use.

Initially, the relationship between land holdings and species diversity was deemed to be quadratic: an increase in the number of cultivated fields related to a diminishing marginal increase in species diversity, and eventually, for some of the land-richest households, an impoverishment in species diversity. This goes counter to theoretical considerations and reports of empirical studies. A deeper look at the data, however, proved useful in explaining the counterintuitive shape of the scatterplot of species against field holdings. Indeed, when the data is divided into two separate geographical sets, with the ten upriver villages in one set and the five downriver villages in the other, the relationship becomes clearly linear ($r = 0.336$, $p < 0.001$) in the former while no statistical relationship links fields and species diversity in the latter ($r = 0.054$, $p = 0.547$).

This phenomenon implies a difference in people's relationship to the land between upriver and downriver villages. The downriver villages are all within short distance of one another and of the Trompeteros market, separated from the nearest village by two to 35 min. in 25 hp motor boat. Traveling from the fifth to the sixth village requires 75 min., which makes the latter more than twice as far from Trompeteros as the former. The five downriver villages are thus more directly affected by the Trompeteros market, the activities of the district town and the Pluspetrol central base. This proximity to market, to the largest employers of the river and to the town, with its ever-changing social landscape, may transform the traditional bond between the farmer and his land. In some cases, fields may be dedicated primarily to cash crops, in which case the flow of seeds between fields and garden may be weaker. In other cases, wealth is exogenous to the field, with money coming from off-farm wage labour. Employment in the town or with the oil company disrupts the close link between wealth and land assets, and concomitantly that between wealth, prestige and garden diversity.

Another explanation of the lack of statistically significant results in near-Trompeteros villages may relate to the weaknesses of a variable defined in terms of numbers of plots, as outlined above. Because of the accessibility of market and the possibility to grow cash crops, the variability in field size across households may be considerably higher than in the upriver villages, thus limiting our ability to analyze the field variable.

2.4.2.4. Household demography

Age and gender of the garden caretaker are significant variables explaining the differences in agrobiodiversity between households. Gardens tended by women are more diverse by 4.20 species than gardens tended by men or by both men and women. Older caretakers are associated with more species-diverse gardens: an increase of ten years in age relates to an increase of 1.40 species in the garden.

Caretaking of the garden is traditionally a woman's responsibility in many Amazonian societies and especially among the Achuar (Descola 1986). Knowledge is somewhat segregated by gender and is transmitted along gender-specific lines (e.g. Brown 1986). Planting material similarly moves mostly in female dominated networks (see Chapter 3), thus limiting men's access to plants. Women tend to manage more plant species in their gardens than men because of their traditional role as garden caretakers but also because of their easier access to planting material and to knowledge pertaining to horticulture. Age also matters because species acquisition is a lifelong undertaking. When they leave the maternal house, young women often take along a few cuttings and seeds of the mother's plants and acquire other species through their travels and their moves on the river, thus accumulating species over time. The deepening of knowledge with time and experience may similarly give rise to more diverse garden portfolios in older households. In addition, with increasing age, households develop stronger social networks through which planting material can be exchanged, in such a way that they often become nodal points in their kin group (see Chapter 3).

The availability of inhouse labour is also an important determinant of garden species diversity but was not included in the global model because data on number of adults per household was only collected systematically in four of the villages. While the total number of people per household does not hold predictive power in the model, the number of adults (between the ages of 15 and 64 inclusively) per household in the reduced sample of 113 households is highly significant in a simple regression against number of species per garden ($R^2 = 0.163$; $p = 0.000$), with an additional adult resulting in as much as 4.61 extra species in the garden. Young adults in the house, especially young girls, generally help out in the garden, and pupils who are sent to secondary school in neighbouring or more remote villages sometimes bring planting material home during school holiday.

2.4.2.5. Spatial factors

Mapping diversity quartiles in each village reveals local intravillage geographical trends. Only 12 villages are considered because Nueva Vida, Dos de Mayo and San Ramón are too small for such microscale analysis. Discernible patterns emerge from eight of the remaining villages.

In Santa Elena and Porvenir, many households in the two highest diversity quartiles are located at the geographical extremes of the villages. In San José de Porvenir, most houses upriver from the village belong to the third and fourth diversity quartiles. In Valencia, households of high diversity are positioned in the periphery while low diversity gardens are concentrated in the village center. The latter phenomenon also occurs in San José de Nueva Esperanza. As was described in Section 2.4.2.1, isolated households generally have among the largest gardens. A simple regression of species richness against a dummy for isolated households yields highly significant results: $r = 0.289$; $p < 0.001$. Isolated gardens have on average 11.44 more species than peripheral and centrally located gardens. This is due in great part to size, as the correlation in Section 2.4.2.1 demonstrates, but also to isolation, which reduces the frequency of the neighbour's judgement and intervention.[14]

San Juan nativo, Copal and Pucacuro are all similar in that a certain degree of quartile clustering is observable. Households belonging to the higher quartiles are grouped together in one area of the village while those belonging to the lower quartiles cluster in another area. By way of illustration, the pathway bordering the cliff in Pucacuro regroups mainly low diversity gardens while the road leading inland to the Pluspetrol station, where houses are more spaced out, is occupied by high diversity households.

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[14] Of the two variables, size is the most powerful predictor: when controlling for isolation, garden size and species richness are significantly correlated ($r = 0.319$, $p < 0.001$). The partial correlation of isolation and species richness, controlling for size, is weaker ($r = 0.151$, $p = 0.009$).

2.4.2.6. Garden convergence

While the heterogeneity between gardens in terms of number of species and species composition is striking, the differences in composition by use category are more subtle. Individual gardens, of course, differ significantly from one another in terms of use composition, but the variability is mostly concentrated in the lowest diversity quartile (Figure 2-7). As gardens get more diverse, differences in the relative size of use categories lessen and their use composition converges (Figure 2-8).

Neither the ethnicity, household demography nor the socio-economic background of people and/or villages affects the functional make-up of the garden in any degree more than described in Section 2.4.2.2. Whereas the species portfolio of gardens is greatly influenced by geographical, demographic and cultural factors, the function of gardens remains more or less constant in the higher diversity quartile and is primarily affected, across all quartiles, by the size of the species portfolio. The function of home gardens is similar across the sample and the convergence observed suggests the existence of a paradigmatic functional structure of gardens. There is thus a desired garden make-up that species-poor gardens cannot always attain owing to their limited portfolio. Species-poor gardens with atypical use composition can thus be considered to be in a transitional stage; some bound to stay in perpetual transition because of obstacles to the acquisition of planting material, others gradually accumulating species to take on the ideal structure of garden at maturity. The choice of species made by the garden caretaker thus reflects both the immediate needs of the specific household and the obstacles to species accumulation. For example, some of the least diverse gardens belong to newly arrived households who use their garden merely as a source of staples for house consumption before their fields are ready for larger-scale production, at which time they begin to diversify their garden species portfolio.

2.5.Discussion and conclusions

The number of home garden crop species cultivated is highly variable at every scale observed. Differences in the composition of gardens by use categories, however, are almost insubstantial. Indeed, the results show that the functional composition of gardens

Figure 2-7 : Relative species composition by use in home gardens of lowest diversity quartile, Corrientes river, Peru.

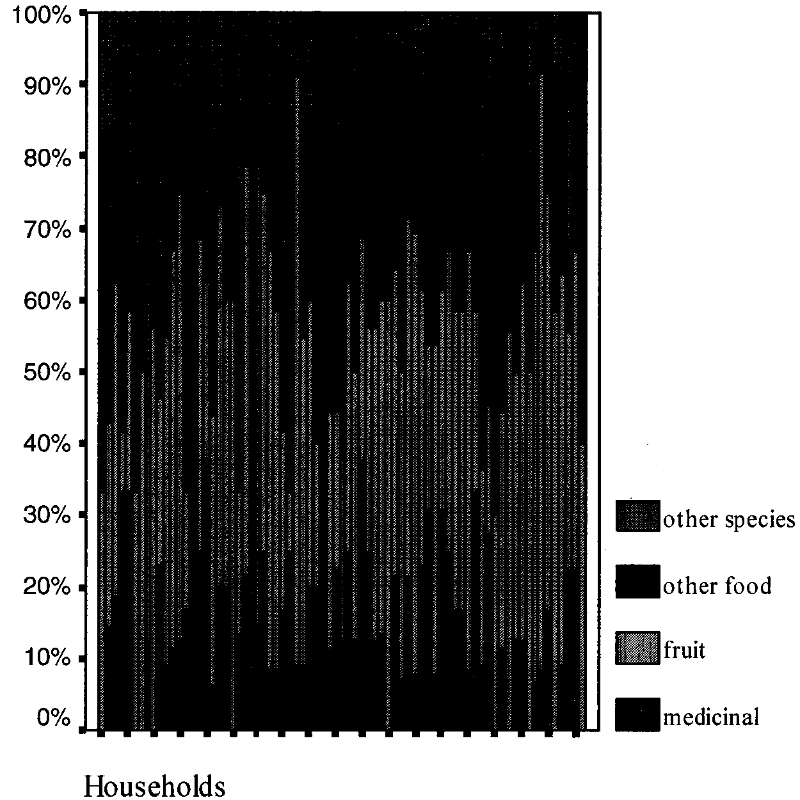
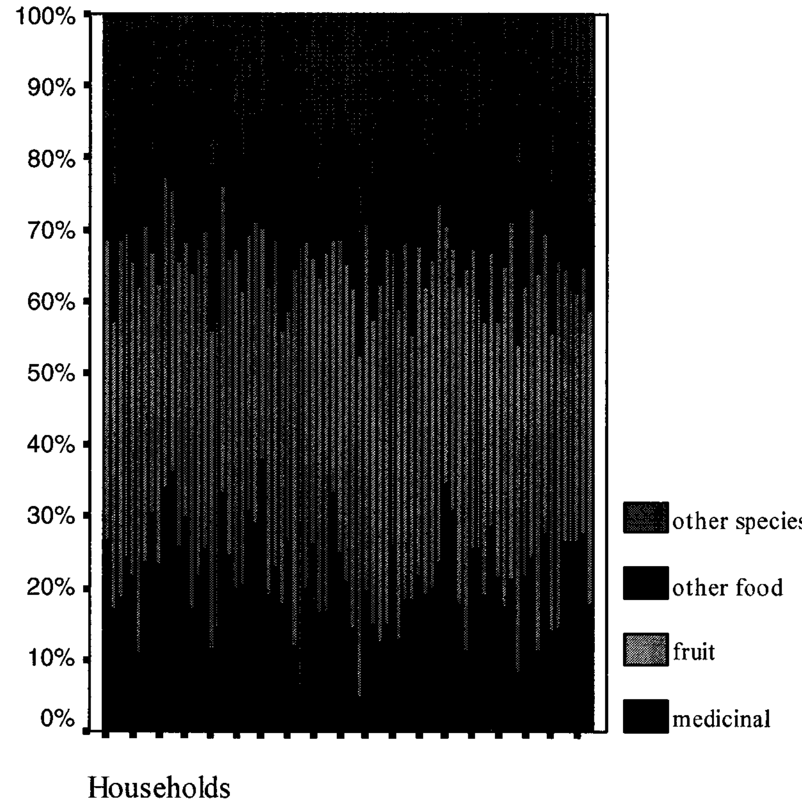


Figure 2-8 : Relative species composition by use in home gardens of highest diversity quartile, Corrientes river, Peru.



converges towards similar proportions of use categories across all gardens of the highest diversity quartile, with the three most important categories being, in order of importance, fruit species, non-fruit food species and medicinal plants. Concomitantly, all but one village have more or less equivalent functional composition of village species portfolio. In spite of small differences across households, species-rich gardens thus play similar functions for their owners across the sample, regardless of the ethnic background of the gardener, his/her social position within the community or his/her economic means. Ethnicity gives rise primarily to differences in the specific composition of gardens but does not significantly affect their functional composition. Differences are more substantial between less diverse gardens, an indication that gardens have not attained their full maturity, either because they are still in a transitional stage between incipient field and home garden[15] or because of various constraints to the accumulation of species – limited space, obstacles to acquisition of planting material, etc. These atypically structured gardens thus reflect, through the choice of species, the most immediate needs of the household.

While the functional composition of gardens is similar across the sample, species richness and species composition of individual gardens and villages are highly variable. The uneven spread of species diversity throughout the region and within villages can best be understood in terms of geographical, cultural, socioeconomic and demographic factors. On a regional geographical scale, diversity is held in greatest proportion by the largest villages. This finding is almost self-evident, as more households are expected to bring new plant species to the total village pool of species. The relationship here is of particular significance because the larger villages are those whose human composition is most socially diverse, consisting of households of various ethnic, geographical and social backgrounds who, through their idiosyncrasies, contribute new plants, but also new techniques, new focuses and new knowledge to their host communities. The relationship between village size and agrobiodiversity opens a door to microlevel analysis. Indeed, the fact that it is the marginal household that effectively increases a village's species

[15] Brown (1986), in his ethnography of the Aguaruna of the Alto Mayo, describes this transition from the "slash-and-burn garden" to the "kitchen garden": when a house is first built, the main source of root crops is the peridomestic area. When this field is no longer satisfactorily productive, new areas are cleared further from the house and the function of the original garden shifts from a source of staples to a source of medicinal, ritual and other non-food useful plants.

diversity points to the necessity of fully appreciating the household-level determinants of agrobiodiversity and tying them to larger geographical phenomena.

2.5.1. Intravillage spatial organization of agrobiodiversity

Garden size is the primary determinant of species diversity globally: space constraints are the main factor limiting the accumulation of species in the garden. Gardens are often fixed in size, with streams, fields, pathways or steep river banks impeding the enlargement of the cultivable area.

In the larger villages, there is a discernible structure in the spatial distribution of gardens. Some degree of high diversity and low diversity clustering is visible in all but one of the nine largest villages of the sample. High diversity gardens are generally found on the periphery of the village, where gardens are more spacious and where the relative isolation creates more auspicious conditions for plant breeding, i.e., decreased likelihood of theft, possibility to grow less socially acceptable species away from the inquisitive eye of the neighbour[16], freedom to choose the most suitable plot of land for the establishment of the house and garden, nature of garden edges, consisting mostly of forest rather than cleared pathways or soccer fields.[17] Indeed, all of the Achuar whose houses are located within Urarina territory live remote from the village center. Low diversity gardens cluster mostly closer to the village center, where space is constrained by soccer fields and communal pathways. Whether the causes of this quartile clustering are intrinsic or extrinsic is difficult to assess. Land in different clusters may have different characteristics, giving rise to more or fewer constraints on the cultivation of a profusion of species. Or, people of like characteristics who choose to live close to one another have like botanical preferences. Alternatively, as will be seen in Chapter 3, members of a single kin group may cluster together and the circulation of planting material may be

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[16] Several plants with magical or medicinal properties are tended secretly. Women are sometimes ashamed to admit they grow love charms such as *Pusanga* (undertermined sp.) and some species of *patiquina* (*Dieffenbachia sp*). *Parapara* (undertermined sp.) is grown against male sexual impotence. *Ayahuasca* (*Banisteriopsis caapi*) a plant closely identified with shamans, is grown more and more secretly as owners of the hallucinogenic are afraid of being labeled as shamans and accused of black witchery.
[17] Eccentric farmers who choose to settle away from the busy communal life of the village were reported by several researchers (Coomes 2003, Emperaire 2004) and were observed as well on the Corrientes river.

more fluid among close neighbours, especially those belonging to the same family, resulting in the convergence of gardens.

2.5.2. Indigenous agrobiodiversity

The analyses in this chapter reveal a strong link between the ethnic composition of villages and species richness. In fact, the Achuar, whether viewed as a single cultural entity or whether considered individually, hold significantly more diversity than their Urarina neighbours. The species composition of the Urarina gardens hints to the secondary role conferred on gardens in Urarina communities.

Whether the low diversity of Urarinas is due to cultural reasons or to difficult access to planting material is unclear. Despite the lack of formal data on exchanges among the Urarinas, field observations suggest that this group lives in social isolation on the Corrientes river. No informant in the 12 non-Urarina villages reported having taken part in any planting material exchange with an Urarina counterpart; yet many report exchanges with a more remote Murato village, with Quichuas from the Tigre river or from Ecuador and with other, distinct Achuar groups of the Pastaza river. The only reported Urarina-Achuar plant exchanges occurred between inhabitants of one single Urarina village. Urarinas could potentially procure seeds and tubers through exchange with their Achuar fellow villagers, but their garden portfolios do not testify to frequent exchanges. Due to their low population on the river, they may not have access to intraethnic exchange networks as developed as those of the Achuar, but the Urarina villages are located fairly closely to market where they could use more formal means to gather planting material. Moreover, they have the same physical access to wild forest species as do the Achuar. Cultural differences – knowledge of the surrounding forest, know-how, livelihood choices and priorities, and ritual practices - may be key to explaining the differences in species richness between Urarina and Achuar households. Indeed, cultural reasons are brought to the fore by the widespread breeding of culturally specific plants among the Urarina.

A similar situation of a low diversity group, the Huaorani, living in close quarters with high-diversity groups, the Quichuas, was described by Caillon (2000). In this case, cultural and historical reasons are at the root of the difference, but exchanges between

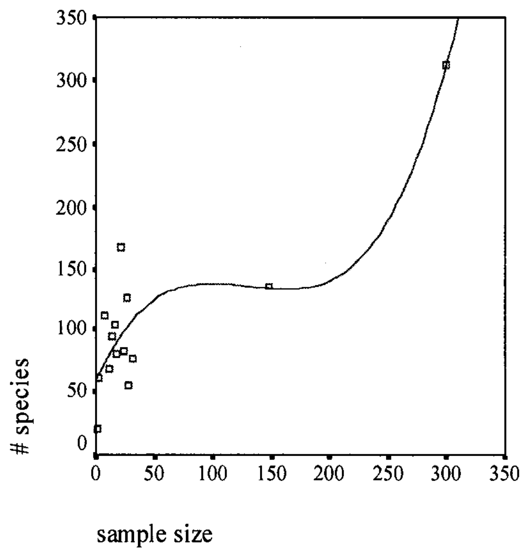
Huaoranis and Quichuas has somewhat equalized the species diversity of both groups (Caillon 2000). The populations in the present study have striking similarities with those reported by Caillon, but interethnic exchanges are still too infrequent to generate any visible homogenization of the distribution of species across villages. One would need to cast an ethnological eye on the region to fully appreciate the patterns of horticulture among the Urarinas and to understand the dynamics of exchange among Urarinas on the Corrientes river and between Urarinas and their Achuar neighbours. Fathoming the roots of regional inequalities necessitates an understanding of livelihood choices and options, of which home garden practices, cultivation priorities and access to plant propagation are important variables.

Comparison of the Corrientes river data with data available in the literature on Amazonian home garden agrobiodiversity highlights the agrobiological richness of the Achuar as a distinct ethnic group (Table 2-9). The total number of species cultivated by the 12 Achuar villages as well as the Achuar families living within Urarina communities, 297 species in total, is by far superior to any other reported number for a specific ethnic or *mestizo* group in the Amazon basin. However, the sample size in the present study (n=300) is much larger than those reported in the literature and may well account for some of the differences in species diversity among ethnic groups. Figure 2-9 illustrates the relationship between gamma diversity and sample size in the Amazonian literature. Each point on the graph represents the gamma diversity reported by a study in Table 2-9. All reports with known sample size are included with the exception of Boster's (1983) and Works's (1990) because they did not specify exact species numbers. As can be seen on the graph, there exists a positive relationship between gamma diversity and number of gardens surveyed, but it is not clear how strong this relationship is or whether it is best viewed as linear or cubic. A certain distortion may be created by the nature of the sample size in smaller samples. Indeed, the latter often include only a limited percentage of a village's households which are not chosen randomly but are selected by convenience and/or are subjectively deemed to be "representative". For a geographical comparative assessment of agrobiodiversity in the Upper Amazon region, these data skew the analysis by associating small sample sizes with higher than expected agrobiodiversity merely because of the sampling method.

Table 2-9 : Summary of literature on agrobiodiversity in gardens of the Amazon basin.

Source	Most diverse garden	Total # species (mean)	# gardens surveyed	# villages visited	Ethnicity
BRAZILIAN AMAZON					
Smith 1996		76	32		? (pby *caboclo – mestizo*)
Smith et al. 1995		80	18		id.
Guillaumet et al. 1990		61 (37.3)	3	3	id.
ECUADORIAN AMAZON					
Garí 2001		37		>2	Quichua, Shiwiar and Zaparo
PERUVIAN AMAZON					
Berlin 1977 (qted in Descola 1986)		80			Jivaro Aguaruna
Paredes et al. 2001		74		1	*Mestizo*
Oré Balbin et al. n.d.	50	94	14	3	*Ribereños* (Cocama?)
Caceres Concha et al. n.d.	34	68	11	2	*Ribereños* (Cocama?)
Padoch & de Jong 1991	74	168	21	1	*Ribereños*
Lamont et al. 1999		125 (30)	27	1	*Ribereños*
Lamont et al. 1999		104 (27)	16	1	Yaguas
Lamont et al. 1999		111 (39)	8	1	Yaguas
Boster 1983		>50	135	Many	Aguaruna and Huambisa
Coomes & Ban 2004; Lerch 1997	32	82 (16.3)	24	1	*Ribereños*
Works 1990	49	>120	50	1	*Mestizo*
Denevan & Treacy 1987		20	1	1	Bora
Lerch 1999	42	136 (8.03)	148	3	*Ribereños*
Oré Balbin & Llapapasca Samaniego 1996		55	28	1	*Ribereños*
Chaumeil 1979		59		Many	Yaguas
Perrault-Archambault, present study	78	308 (25.86)	300	15	Achuar, Urarinas and *mestizos*

Figure 2-9 : Species diversity as a function of sample size in agrobiodiversity studies in the Amazon basin.



Bearing in mind these considerations, a comparison nonetheless yields interesting insights. While it is unclear whether the high number of species observed among the Achuar is an idiosyncratic characteristic of this ethnic group or a mere correlate of the large sample in this study, the mean number of species in Achuar gardens (27.9) is undeniably high, only outmatched in the Peruvian Amazon by the Yaguas and the *ribereños* in Lamont's study (Lamont *et al.* 1999), while the species diversity of the Urarinas (14.3) is among the lowest reported. Even more convincing, Descola (1986), in his ethnography of the Ecuadorian Achuar, mentions that he found 62 cultigens which, he claims, are grown in almost all gardens (his use of the term "garden" is slightly different from ours, see Section 4.4.1). It is not clear whether this number is based on systematic field surveys, but the mere magnitude of the number quoted, even if overestimating true diversity, is a clear indication that the Achuar hold a particularly rich palette of plants.

The striking inequality in species richness between ethnic groups suggests that the factors explaining agrobiodiversity are not purely geographical, social or economic. Cultural factors – preferences, beliefs, know-how, lifestyle and the cultural capital embodied in knowledge – unquestionably matter as important determinants of species diversity.[18] What clearly stands out from the table is that some groups have much richer species endowments than others. The Yaguas from Lamont, Eschbaugh and Greenberg's (1999) study, in particular, are high diversity holders. The *ribereños* neighbouring the Yaguas are likewise well-stocked in species. These findings are consistent with the observations in the Corrientes river that ethnically mixed groups such as San Juan campesino and Pucacuro who rub shoulders with high-diversity ethnic communities have high aggregate diversity. Indeed, when considered as a single, distinct group, the Achuar are among the highest diversity holders. But diversity begets diversity: social and cultural diversity begets agrobiological diversity. The mix of cultural backgrounds in the Achuar villages of the Corrientes river may well contribute to the particularly high diversity observed in the sample. Whereas one species-rich group, the Achuar, dominates, there are many contributions from other less dominant groups – *mestizos*, Quichuas intermingled with the Achuar. In addition, the proximity of other cultural groups - the

[18] The importance of ethnolinguistic diversity in the formation of agrobiodiversity is noted as well in Perales, Benz and Brush (2005) in a comparison of maize varieties between two ethnic groups of Chiapas, Mexico.

Muratos on the Copalyacua, a small tributary of the Corrientes river, and the Quichuas on the Tigre river – facilitates the supplying of diverse species. Indeed, many respondents report procuring planting material of medicinal plants or fruit seeds from Muratos in Santa Isabel or Quichuas from the Tigre river.

2.5.3. Wealth and social capital

While ethnicity is doubtless a strong predictor of species diversity, agrobiodiversity is also linked to access to various forms of physical and social capital. Land assets show some degree of correlation with species diversity, with the latter increasing overall with land holdings. The strong link between wealth and agrobiodiversity has been noted by a number of authors (Bellon & Brush 1994; Coomes & Ban 2004; Hardon-Baars 2000; Lerch 1999; Peroni & Hanazaki 2002; Subedi *et al.* 2001; Wright & Turner 1999) but the exact cause and effect relationship is unclear. Three attributes of wealth may interplay in this relationship: social wealth, physical wealth and prestige. The development of extensive social and kin networks for the exchange of labour may be associated with land wealth, and may equally enhance the formation of rich gardens because social networks facilitate the procurement of planting stock. Physical wealth, a corollary of large field holdings, clearly fosters the acquisition of planting material through an increase of purchasing and bartering power. Prestige and wealth are also tightly connected. Garden agrobiodiversity is considered prestigious in many societies, the Achuar among them (Descola 1986), as confirmed during this study by poor Achuar villagers who were ashamed to show scantly vegetated gardens in the same way that an urban dweller is reluctant to show a visitor a poorly furnished house. Being "rich" without exhibiting a garden that attests to one's wealth may cast doubt on the legitimacy of one's prestige. To quote Sahlins in his sociology of the "primitive exchange": "[i]f friends make gifts, gifts make friends." (Sahlins 1972). In other words, rich gardens allow their owners to be generous and to enter a virtuous cycle of gift and counter gift and of expansion of social networks. The positive relationship between number of cultivated fields and species diversity also stems from the complementarity between fields and gardens. Gardens are sometimes used as nurseries for plants that will in due time be transplanted in the field. When seeds are first acquired, they are often initially planted close to the house – unless they are subject to theft or to social disapprobation - where they can be closely examined and monitored. Conversely, species that naturally occur in the field are sometimes brought to the garden for readier access.

Social and cultural capital is represented by important demographic factors at the household level: age and gender of the garden tender and inhouse labour. Older caretakers generally tend more species because they have accumulated species, experience, knowledge and social capital through time. The role of garden caretaking is traditionally attributed to women, especially in Achuar society. Women are in fact associated with greater agrobiodiversity, which reveals the attachment to tradition in matters of horticulture in societies where traditional lifestyle meets wage labour and urban markets. The significance of age and gender as determinants of species diversity points to the importance of understanding the role played by knowledge and social capital (in the form of social resource networks) in the formation of gardens and the conservation of agrobiodiversity. These issues will be taken up in Chapter 3 and Chapter 4. Inhouse labour is positively related to species diversity because adults participate in the chores of gardening and often contribute plant propagation material to the family's stock of species.

2.5.4. Knowledge and the geographical distribution of agrobiodiversity

Spatial variables that affect the number of species cultivated in villages and the distribution of species in the river are numerous. The proximity of oil company bases, through its social and economic impacts on the villages in its direct radius of influence, positively affects the total number of species grown in these villages but has no clear effect on mean diversity. Brush (1991) has noted similarly that the emergence of off-farm employment in the Peruvian Andes does not result in an impoverishment of agrobiodiversity. As a direct source of planting material and through its reshaping of communities, the oil company also brings about changes in the species collections of villages in the proximity of its sites of activity, as exemplified by the higher incidence of citric fruit trees and ornamentals in the vicinity of Pluspetrol stations.

Because a greater diversity of fruit and medicinal plants can be found in the villages near oil company bases, Pluspetrol may have a positive impact on health and nutrition on the villages closely tied to its economic activities. It is not clear, however, whether the periodical oil spills on the river, and soil and water contamination in general affect agriculture in the studied villages. In terms of conservation and knowledge of agrobiodiversity, on the other hand, the high number of species in Pluspetrol-influenced communities should be taken with much circumspection as it may not be a significant contribution to agrobiodiversity conservation because the new species adopted, especially ornamentals, are not associated with any knowledge specific to the plant – garden tenders often do not know their name, their use, and do not integrate them to local folklore and to the local body of knowledge. The plants are anonymous and soulless, used only to adorn the flowerbeds marking the entrance to a family's property.

Location along the river, especially as it reflects distance from the market town of Villa Trompeteros, also affects the species composition of village portfolios. Proximity to the district town results in the cultivation of more species with market value such as grapefruit and tomato while remoteness from Trompeteros is associated with the garden cultivation of more species needed for the home production of goods and products otherwise purchased in town and of more local forest species. These findings suggest that, as one moves upstream along the river and thus gets further from the market town of Villa Trompeteros, riverine people are more inclined to adopt the plant species that occur naturally in their environment, perhaps because they are more aware and more knowledgeable of their forest environment. Indeed, as one moves westward along the Corrientes river, away from the district town, villages tend to become more ethnically uniform, peopled primarily with long-established Achuar families who have developed knowledge of the local environment and experimented with the surrounding resources over countless generations. It is likely that many of these species, brought to the garden for easier access, are imperceptibly undergoing a slow process of domestication. Although this process is difficult, if not impossible, to observe directly over the short term, the human behaviour behind it, that is to say the agricultural practices, the development of expertise and the processes of selection and experimentation that induce physiological changes in the plant can be described and deserve closer study.

Chapter 3. Local and Regional Networks of Planting Material Exchange along the Corrientes River

3.1. Introduction

Access to crop biodiversity is essential for the rural poor in peasant communities, whose livelihood depends in great part on subsistence agriculture. Traditional agricultural societies rely heavily on informal seed flow systems to acquire the planting material necessary for the formation of diverse fields (e.g. Louette *et al.* 1997 for maize infraspecific diversity; Pinton 2002 for manioc infraspecific diversity; Subedi *et al.* 2001 for rice infraspecific diversity). In the Peruvian Amazon, inhabitants of remote rural areas have little opportunity to procure plants through formal means and must thus turn to their neighbours and family to get the much needed resource. Most agrobiodiversity studies in the Amazon look at the specific and infraspecific diversity found in rural communities (Padoch & de Jong 1991; Lamont *et al.* 1999), though few consider the sources of such diversity and how diversity diffuses through communities. In the last half decade, some attention has been turned to systems of informal seed provisioning in the Amazon (Caillon 2000; Lerch 1997; Lerch 1999; Coomes & Ban 2004; Watson 2000) and in the Andes (Zimmerer 2003), but much remains to be learned about the social and geographical organization of exchanges. Agrobiodiversity is not only a primary source of food and medicine; it is also, and importantly so, a dynamic social object (Brown 1986; Descola 1986, Murrieta & WinklerPrins 2003). Planting material transits from hand to garden and from garden to hand; the flow follows tacit rules and social practices, it is structured, sometimes impeded, by a number of socioeconomic factors.

The purpose of this chapter is to understand the multiple scales of crop movement on the Corrientes river of the Peruvian Amazon, by exploring regional patterns and the internal structure of exchange networks in three case study villages of the river. How does planting material flow regionally? What social, economic and cultural elements structure planting material exchanges within villages? Are there differentiated exchange roles? Who are the key agents of seed flow? The focus of the study is on home gardens rather than fields because of their easier accessibility and their importance as microlevel agrobiodiversity "hotspots" (Coomes & Ban 2004; Smith *et al.* 1995). The consequences of the establishment of an oil company station near one of the study villages on local exchange networks will be assessed through a comparative approach between the three villages.

3.2. Study Area

Fieldwork for this chapter was undertaken in three villages of the Corrientes river, a clear water river flowing from the Ecuadorian highlands into the Tigre river west of Iquitos in the Peruvian Amazon (for more detail, see Section 1.2). The three villages – Pucacuro, Santa Rosa and Valencia – are located upriver of the district town Villa Trompeteros, in a region of active oil extraction (for map of study area, see Figure 2-1). All three villages are located upland and are unaffected by seasonal flooding.

Valencia, located nine hours[19] upstream of Trompeteros, is one of the oldest villages on the Corrientes river. It was founded in 1942, following the Peru-Ecuador war, near an Ecuadorian military garrison downstream of the village's current location. According to local informants, it was relocated twice, because of the undesired impacts of oil extraction in the vicinity. Nuevo Valencia was officially founded at its current location in the early 1980s (probably 1982), and the state-owned oil company, Petroperú, moved its activities from Valencia to the downstream site of San José de Nueva Esperanza in 1985. Most of the nearby communities were founded by inhabitants of Valencia, yet the village, despite its historical role as a mother-community, remains relatively small, with a population of less than 150.

Santa Rosa is the village most recently founded by former Valencia residents (1996). It lies at a distance of 0.5 hour downstream of Valencia. Its population is still small, with approximately 80 residents distributed in 17 houses. Neither Valencia or Santa Rosa is supplied with electricity.

Pucacuro is located 5.5 hours upstream of Trompeteros. It was founded in the late 1960s or early 1970s by Achuar and *mestizos* downriver of its current location but was relocated upriver in 1990 because of persistent flooding. In 1974, Petroperú began commercial extraction near present-day Pucacuro, until 1996 when the concession was

[19] All distances are measured by 25 horse-power motorized rowboat going upriver.

ceded to the Argentinean company Pluspetrol. In the past decade, a dramatic population increase,[20] driven by the lure of employment with the oil company, has brought about changes in the social and ethnic landscape of the village, with an influx of families from nearby regions, primarily *mestizos* and Quichuas. In 2003, the population exceeded 300 inhabitants. Since 2002, Pluspetrol supplies the villagers with electricity in the evening.

The map presented in Seymour-Smith's (1988) ethnography of the population she calls "Shiwiar Jíbaro"[21] attests to the demographic and economic changes of the past decades: in a map of the upper reach of the Corrientes river, she identifies Valencia and Peruanito, a village downstream of Pucacuro with a present-day population of less than 100 inhabitants, but Pucacuro does not appear.

Daily river transport downstream is offered to Pucacuro residents by a subcontractor of Pluspetrol, and emergency flights to Iquitos are provided from Villa Trompeteros. Santa Rosa and Valencia are served on a much less regular basis by company boats. Subcontractors of Pluspetrol buy manioc, plantain and other agricultural produce from Pucacuro farmers. In addition, a *regatón* visits the village bi-monthly and buys local produce to sell in Iquitos. In contrast, the only commercial outlet for Valencia and Santa Rosa product is a *regatón* that visits the village on an irregular, less than monthly basis. During fieldwork in November, 2003, villagers in Santa Rosa claimed that the last *regatón* visit dated back three months.

Valencia and Santa Rosa are composed primarily of self-denominated Achuar families. Many of the "Achuar" heads of household in fact have Quichua ancestors, but they identify with the Achuar ethnic group and use the Achuar language to communicate within and between family units.

3.3. Methodology

3.3.1. Data collection

Data for this study were collected during August, September and November, 2003, in three villages of the Corrientes river, selected for their different sizes, their

[20] Over one third of Pucacuro's heads of households settled in the village after 1993.

[21] Seymour-Smith's "Shiwiar Jíbaro" correspond to the population I call here "Achuar". My choice of the term "Achuar" corresponds to the local population's self-denomination in Spanish ("Achual" is also used).

ethnic compositions and their different degrees of remoteness and integration to market. Authorization to conduct research was sought from the traditional village authority upon arrival to each community; permission was granted either immediately or through a village council. Village maps were drawn for each village and the population censused. All surveys, interviews and questionnaires were conducted on a voluntary basis, with the respondents' informed consent. In Valencia, where many gardeners understood Spanish but did not speak it (about 24%), a fully bilingual young Valencia woman accompanied the investigator in some household and garden visits. When she was unavailable, a bilingual, adult member of the household acted as interpreter. The latter solution to language barriers was adopted in Santa Rosa (20% of gardeners do not speak Spanish). During the three months, each home garden was visited in the company of its caretaker. The garden tender was asked to identify each species in the garden, to give the plant's vernacular name, its social and geographical source (where and from whom the plant was acquired), and the type of transaction undertaken (gift, barter, purchase) (see Appendix 4). Additionally, a comprehensive socioeconomic questionnaire was administered to one or both heads of household. The survey solicited information on such topics as household demography, household history, cultural background and economic livelihood (see Appendix 4). A second questionnaire relating to garden history, knowledge, expert networks and access to planting material was administered to all garden caretakers. The questionnaire asked informants to identify the people they considered most knowledgeable or most helpful in situations relating to agrobiodiversity management, identification or access. Examples of questions are: "Who would you ask for help if there was a pest outbreak in your garden or fields?", "Who could identify this plant (picture shown)?" or "Who has taught you most about garden tending?" (see Appendix 4). Expertise networks were constructed based on responses to these questions. The three data collection components varied in duration from one to two and a half hours in each household. Eighty-eight percent of the households were fully visited in Pucacuro, 91% in Valencia and 93% in Santa Rosa. Teachers' houses are omitted from the sample except for one teacher in Santa Rosa who is married with a woman born of the largest of the village's kin groups. The other gardens could not be entered because of denial to grant access or prolonged absence of the caretaker. The sample comprises 89 households.

3.3.2. Data analysis

The tools and methods of social network analysis (SNA) are central to the analyses in this chapter. SNA is an important analytical framework in sociology, which developed from the mathematics of graph theory and the structuralist and functionalist strands of anthropology in the 1960s and 1970s to explore the structure and patterns of social relations (Scott 2000). The overarching focus of SNA is the relations among actors rather than the categorization of actors according to inner attributes (Wellman & Berkowitz 1988).

SNA is applied here strictly to intra-village exchange networks, that is to say, exchanges where the actors involved resided in the village under study during the field season. Network data are stored in a collection of matrices: adjacency (actor-to-actor) matrices, representing relational data, and attribute matrices, representing attribute data, i.e., characteristics of actors. The latter correspond to the type of data storage generally used in standard statistical software such as SPSS. Three types of adjacency matrices are constructed: exchange, kinship and expertise matrices. Exchanges are stored in directed (non-symmetric) valued square matrices where a given cell X(i,j) contains a value representing the number of plants given by household i to household j. Kinship data is similarly described through a set of square adjacency matrices where X(i,j) = 1 if one of the heads of households i and j are tied through a specified kinship relation and X(i,j) = 0 otherwise. Expertise is represented through a square binary adjacency matrix, with X(i,j) = 1 if someone in household i is considered to be an expert by the informant in household j and X(i,j) = 0 otherwise. Attribute matrices contain household socioeconomic data, such as age or wealth category. A cell X(i,j) contains quantitative information on attribute j – say, land assets – for household i.

Four different centrality measures are calculated from the exchange matrices in order to compare actors and their roles in seed flow systems: indegree, outdegree, outreach centrality and size of ego network. They are computed with the help of the software Ucinet 6 for Windows (Borgatti *et al.* 2002).

- Indegree is measured as the number of plants received from other households in the network:

$$\text{Indegree}_j = \sum_{i=1}^{n} X(i,j); i \neq j$$

- Outdegree is the number of plants given to other households in the network:

$$\text{Outdegree}_i = \sum_{j=1}^{n} X(i,j); i \neq j$$

- Outreach centrality measures the proximity of an actor to all other actors in the network. The calculation of this measure is based on geodesic distance, i.e., the length of the shortest path separating two nodes in a network. Given a matrix of geodesic distances D, a reciprocal matrix R is constructed such that $R(i,j) = 1/D(i,j)$. Outreach centrality is computed in the following way (Borgatti 2005):

$$\text{Centrality}_i = 1 + \sum_{j=1}^{n} R(i,j); i \neq j$$

- Size of ego network represents the number of households that have given to or received from ego, i.e., the focal household.

Correlation and linear regression analyses on the centrality indices described above were computed with the software SPSS 11.5 for Windows. Statistical analysis of the matrix data was performed with the software Ucinet 6 for Windows. The two tests used in this chapter are multiple regression quadratic assignment procedures (QAP-regression) and ANOVA autocorrelation tests.

QAP-regression is a procedure that performs standard multiple regressions on matrix data. Regression analysis of corresponding cells in the dependent and independent matrices is performed. After this analysis, rows and columns are randomly permuted 2000 times. Regression analyses are performed 2000 times with the permuted data, and results are stored and compared with the original coefficients. The proportion of coefficients with absolute value as high as that observed in the first regression gives the significance level of the test (Borgatti *et al.* 2002).

The ANOVA autocorrelation test is analogous to an analysis of variance. A categorical variable – for example, age quartiles - is chosen to partition the adjacency matrix into two or more groups. The density of each of the matrix's sets is computed.[22] One set becomes the reference category and differences between the density values of each category are calculated. Subsequently, the rows of the partition vector are permuted 5000 times; densities and deviations are computed and stored each time. The significance level is given by the proportion of deviation values that are as extreme as those observed with the real partition vector (Borgatti *et al.* 2002).

All gardens for which species inventories are available were included in the analyses. The few gardens that could not be inventoried were excluded from the matrices if no other household reported having received plants from them. In Pucacuro, three households which are reported as source by at least one garden caretaker were not visited; one such household is found in Valencia, and one in Santa Rosa. In Pucacuro, a fourth household does not have a home garden. These six households were included in the analyses of Section 3.4.2.2 that are concerned strictly with the role of households as *source* of planting material (outdegree and outreach centrality regressions), but were neither included in the analyses of Section 3.4.2.2 which relate to the role of households as *sinks* of planting material or to their connectedness (indegree, plants from outside and size of ego network regressions), nor in those of Section 3.4.2.3, which are concerned with the behaviour of actors as sources *and* sinks simultaneously.

Kinship is a key element of analysis in Sections 3.4.1 and 3.4.2.3. In the former section, kinship outside the village is loosely defined by informants' own recognition of kinship bonds, since extracommunity ties cannot be verified. The term is thus used loosely to refer to anyone designated as "family", "sibling", "parent", "uncle/aunt", "grand-parent", "in-law", etc. Kinship also includes social kin (*compadrazgo*).[23] In Section 3.4.2.3, genealogical trees allow for a more strict definition of kinship (see specifications in Section 3.4.2.3). *Compadrazgo* bonds are ignored because complete *compadrazgo* trees were not mapped.

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[22] Density of a network corresponds to the total number of ties between actors - or, in the case of valued matrices (i.e., matrices containing non-binary data), the total value of all ties between actors - divided by the number of pairs in the network. In a binary matrix, a density of 1.0 indicates a fully connected network, where all actors have ties to all others. In a valued matrix, however, the density can exceed one (Borgatti *et al.* 2002).

[23] *Compadrazgo* is an important social practice in Latin America that establishes relationships both between a child and its godparents, and between parents and godparents.

3.4. Results

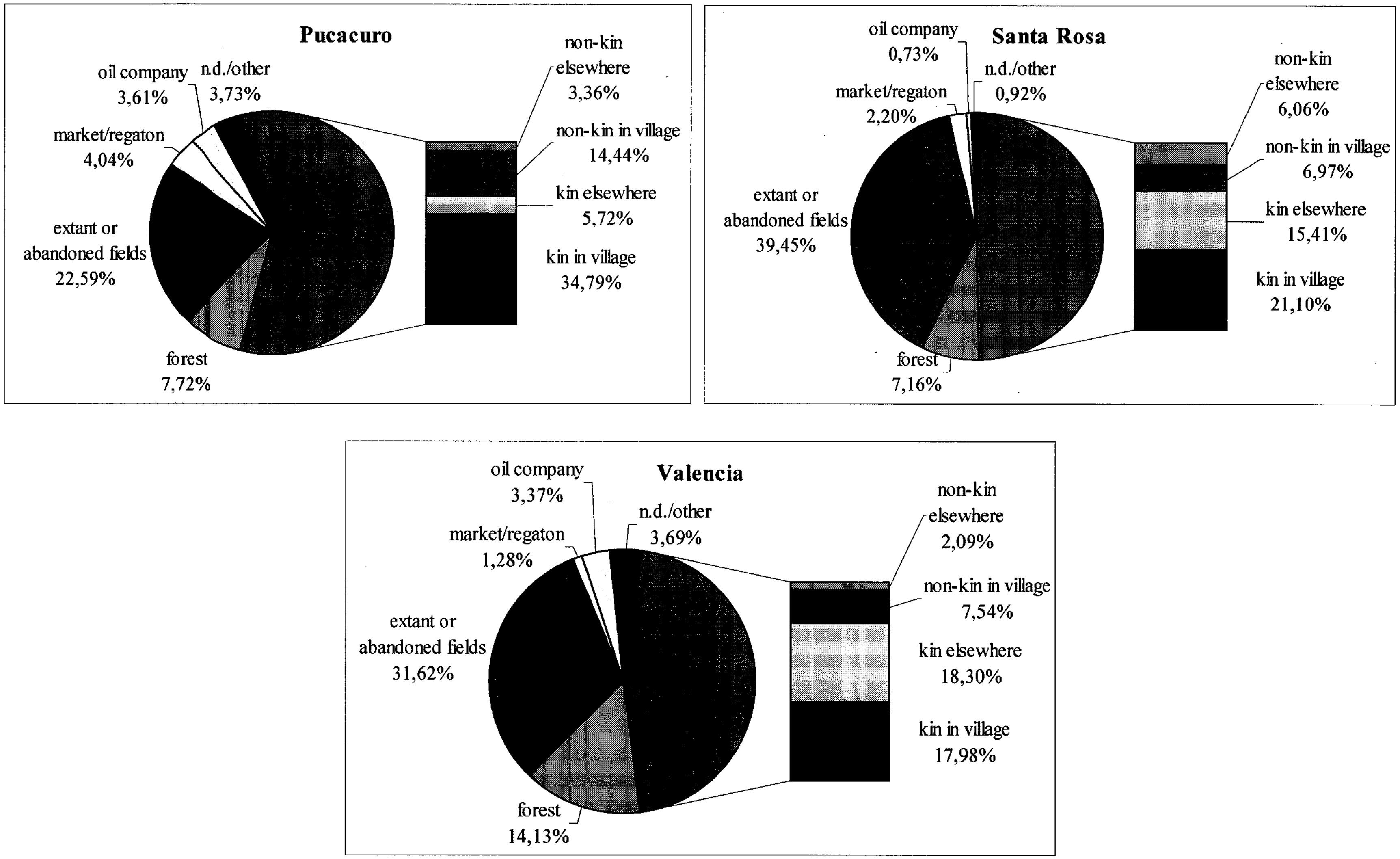
To supply their gardens with a variety of plant species, people use a wide range of sources and means to obtain planting material. They are resourceful and, even when planting material is not readily accessible, they find inventive ways to furnish their living environment with the necessary crops. Indeed, in spite of the informants' widely repeated comment that seeds are hard to find, many villagers manage to cultivate lush gardens and use all the resources at hand to enrich them with new seeds and cuttings. Plentiful anecdotes illustrate the swiftness of home garden tenders to seize any opportunity to gather planting stock. During a short stay in the village of San Ramón, for example, the teacher's wife caught me throwing away rotten tomatoes and pressed me to give her what was left of the shapeless fruit so that she could collect the seeds and plant them in her garden. In Nueva Vida, I was enjoined to bring fruit from Canada on my next visit to the river to furnish the chief's garden with exotic plants.[24] Someone even showed me a hot pepper plant grown from the seeds of a fruit found floating on the river.

Planting material reaches a garden from a number of sources – from locally resident kin and non-kin, from family and friends living on the Corrientes or in distant rivers and towns, from strangers met at the bend of a path, from the market in Iquitos and in Villa Trompeteros, from itinerant traders or travelers passing through the village, from the oil company workers and flowerbeds, from the forest, from communal land (the school yard, the cemetery) and from abandoned fields and fallows. In addition, many plants from forested areas adjacent to the house find their way to the garden naturally. Some weedy species are even preserved because of their medicinal or dietary properties. Other plants - wild forest species or vestiges of old-forgotten fallows - remain in the garden after clearing and are carefully managed.

The provenance of home garden species in Pucacuro, Santa Rosa and Valencia is summarized in Figure 3-1. Overall in the three villages, the proportion of plants acquired through informal exchange networks (i.e. kin and non-kin in village and elsewhere) is approximately 50%, revealing the importance of the social nexus in the dynamics of home agriculture. Of these plants, less than 2% were purchased; the others were received

[24] Descola reports similar requests during his fieldwork among Ecuadorian Achuar families (Descola 1986).

Figure 3-1 : Source of crop species in home gardens of Pucacuro (n =1607), Santa Rosa (n = 545) and Valencia (n = 623).



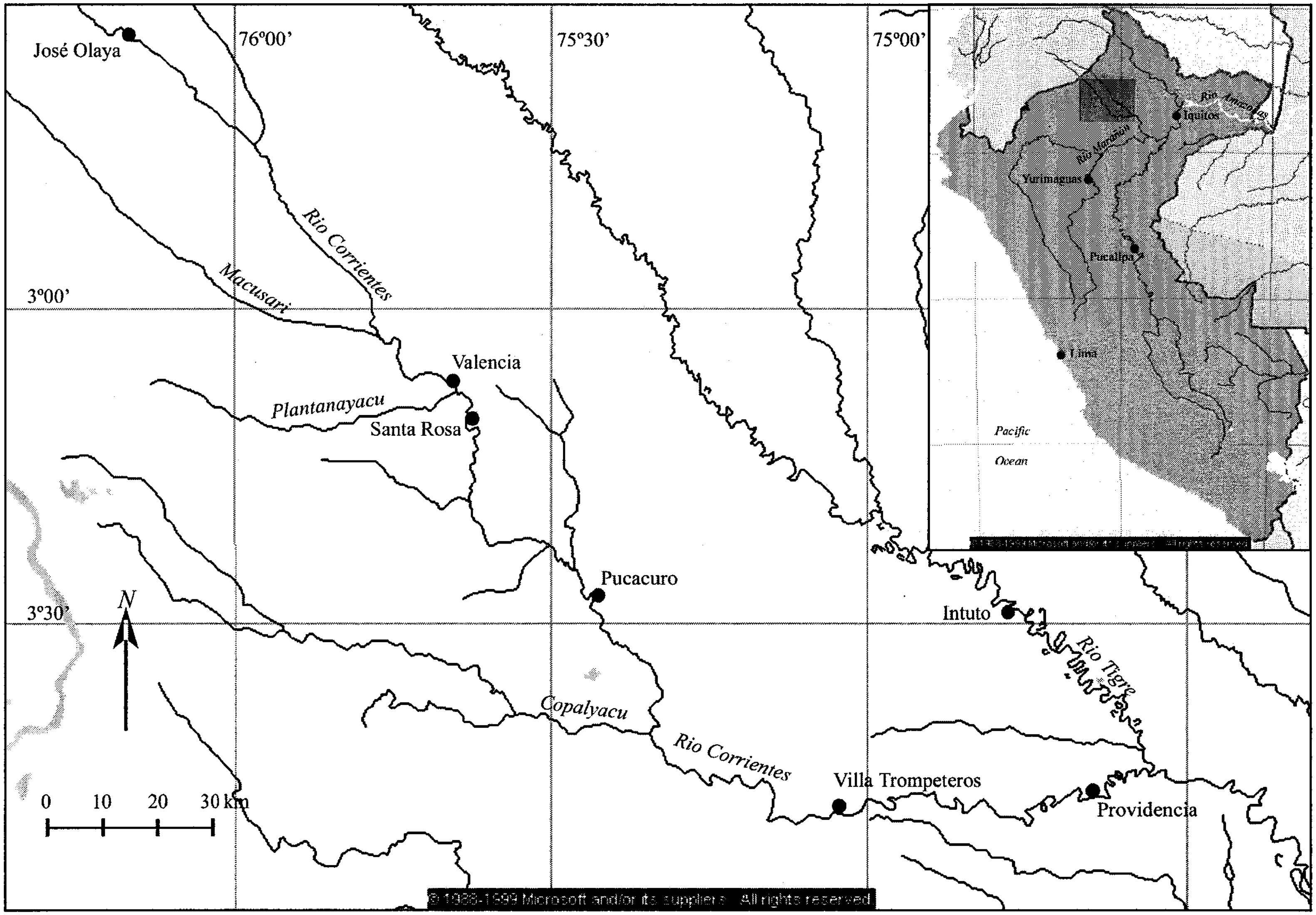
as gift, bartered or taken without permission. Kin, in all three villages, are the most important source of planting material, while acquaintances and chance encounters play only secondary roles. Families stretch out spatially well beyond the community and make up networks that reach out to the confines of the river and extend into the Tigre river and beyond. While plants are more readily exchanged within the village, for the obvious reasons of propinquity and frequency of contact, the intricate kin and social webs that surround each household result in an extensive geographical planting material flow system.

The second most important category, that of specimens extant in the garden or self-procured from natural sources, nears 40%. This category includes the plants transplanted from the forest or fields, where they grow without human design, those that occur naturally in the garden or that grow spontaneously from seeds thrown away, those that are collected in fields and fallows deemed abandoned, and the inherited plants extant at the time of garden takeover. Markets and itinerant traders, on the other hand, have little weight overall and are comparable in proportional importance to oil company sources (plants picked from company flowerbeds or given by employees). Each of these two source categories constitutes no more than 3% of home garden species. The remaining plants could not be linked to their provenance by their owner or originate from miscellaneous sources (e.g. found floating on the river, given by mayor during electoral campaign, etc.).

3.4.1. Regional geography of informal networks

The Corrientes networks reach out as far north as José Olaya on the upper Corrientes near the Ecuador border and as far south as Providencia at the mouth of the river (Figure 3-2). Plant acquisition is not limited to the main river as almost 20% of garden plants obtained outside the village are reported to originate from small tributaries of the Corrientes: the Macusari upriver of Valencia, the Plantanayacu between Valencia and Santa Rosa and the Copalyacu flowing into the Corrientes near the village of Copal. The Tigre river, and in particular its district town, Intuto, as well as the departmental capital of Iquitos, three days downstream from Villa Trompeteros by public riverboat, are commonly reported source areas. Other rivers of the Peruvian Amazon occasionally

Figure 3-2 : Map of Corrientes river, Peruvian sector.



serve as supplies: the Marañón, the Tamshiyacu and the Amazon river upstream of Iquitos. Some plants can even be traced back to Yurimaguas, to Pucallpa and to the city of Lima on the remote coast! Whereas people often take advantage of trips to acquire plant specimens in other villages, some receive them at home from visiting family members or travellers. For instance, the seeds of one informant's *achira* (*Canna indica*), a herbaceous species used by children as musical instrument when dried, were received from Pucallpa as a gift from evangelists travelling on the Corrientes river. While the geographical origin of each plant species in each garden and the social ties between donor and receiver are thoroughly recorded, the data does not always specify the location where the exchange took place, i.e., whether it is the informant who travelled to obtain a plant or whether it is the donor who brought it. The cases of plants from Lima and Yurimaguas are likely to be similar to that of the *achira* seeds where the donor – a grand-daughter and an uncle, respectively – *brought* seeds and tubers on a visit to the Corrientes river. In general, however, planting stock is *brought back* from trips much more frequently than it is carried from home as gift or instrument of barter.

The seemingly evident implications of such a far-reaching network are that villagers who travel far or receive visits from travellers will contribute new and sometimes "exotic" species to their community. The size and extent of extra-Corrientes networks should theoretically be a factor contributing to the species diversity of gardens on the Corrientes. In reality, however, informal networks outside of the Corrientes river play virtually no role in the formation of rich species portfolios; instead they seem to serve a primary function as supply of *infraspecific* diversity. Of the 38 plants obtained through informal networks beyond the Corrientes (and representing 34 different species), most are very common and easily accessible plants. In fact, only 13 of the 308 species inventoried in 15 villages of the Corrientes occur in half or more of the 300 home gardens. Of these 13 species, nine are found in the list of 34 species obtained outside of the river! More than one half of the 38 plants are common species that grow in at least 25% of the 300 gardens studied on the Corrientes. Guava, manioc, mango, turmeric, avocado are some of the plants acquired on the Tigre river, in Iquitos or elsewhere. One could wonder why someone would bother to bring as a souvenir from a far-away trip the seeds of a plant that all his neighbours cultivate. Because this study did not focus on varietal diversity, data on within-species diversity is not available, but one can strongly suspect that the desire to furnish the garden with well-known, common plants from far-off lands arises from people's will to diversify the gustative and aesthetic characters of their main staples, and the curiosity to discover these new properties and to compare. The exotic component of one's plant portfolio may also serve to display agricultural prowess.[25]

3.4.1.1. Kinship networks

Over 70% of plants acquired through informal networks are reported to have been given by kinfolk. These come mostly from upriver areas. In the three villages taken together, 167 acquisitions from family members upriver are reported, compared to only 32 downriver (Figure 3-3). Of the 167 upriver family-originating plants, 4% came from kin of a younger generation (e.g. niece, daughter), 53% from kin of an older generation (e.g. mother, grandmother, uncle, etc) and 31% from same-generation kin (e.g. cousin, parents of daughter-in-law, sister). Downriver, the proportions between younger and older are more equal: 15% of plants were acquired from younger kin and 24% from older kin. The marked hierarchical directionality of exchanges between kin reflects fundamental differences in the nature of Corrientes Achuar settlements. Overall, plants seem to follow a downriver movement in accordance with the movement of families settling closer to the mouth and thus closer to market. A close examination of the birthplace of male and female heads of households in the three villages reveals population displacement downstream along the river: when considering only birthplaces on the Corrientes, the ratio of heads of households born upriver to those born downriver of the village under study is between four and nine (Figure 3-4). Those that have moved from upriver communities oftentimes have left behind older family members and they acquire plants from them when they go on visits. The opposite is seemingly less frequent. Older family members have a lower propensity to collect planting material from younger kin.

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[25] Descola describes the Achuar women's interest for agronomical novelty: "Savoir faire pousser une riche palette de plantes, c'est montrer sa compétence d'horticultrice, c'est assumer pleinement le rôle social principal attribué aux femmes, en témoignant d'une grande virtuosité agronomique. Certaines variétés cultivées en un nombre très restreint d'exemplaires, le sont surtout d'une manière quasi expérimentale, afin de tester jusqu'à la limite les capacités de pouvoir symboliques qui sont au fondement de l'activité horticole." (Descola 1986).

Figure 3-3 : Origin of planting material from kin sources on the Corrientes river by generation and geographical area, for Pucacuro, Santa Rosa and Valencia.

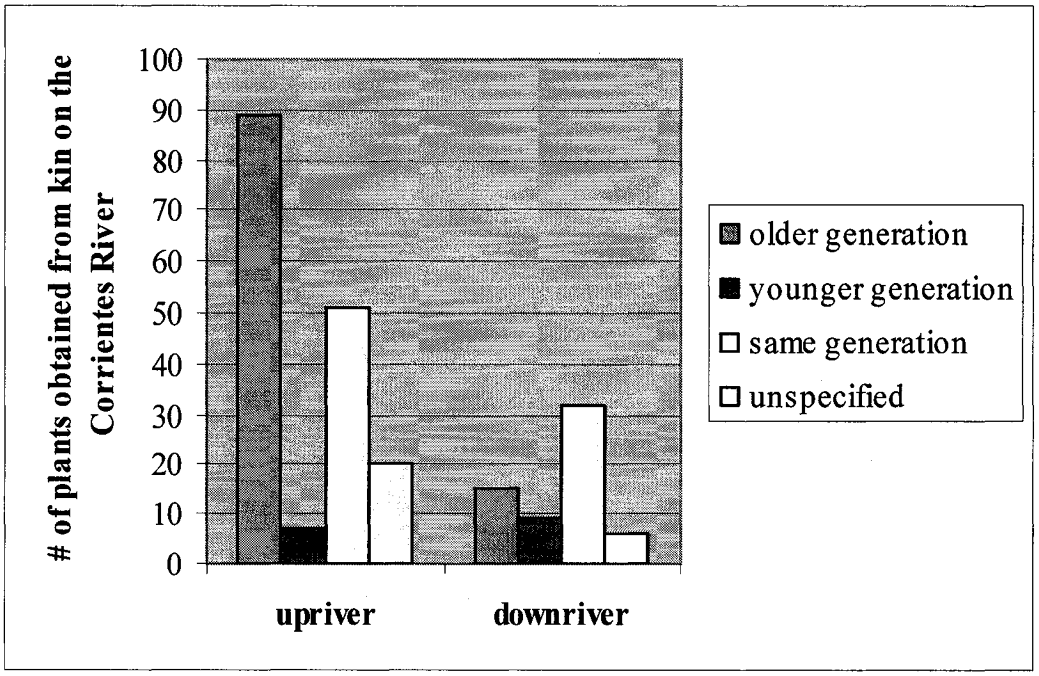
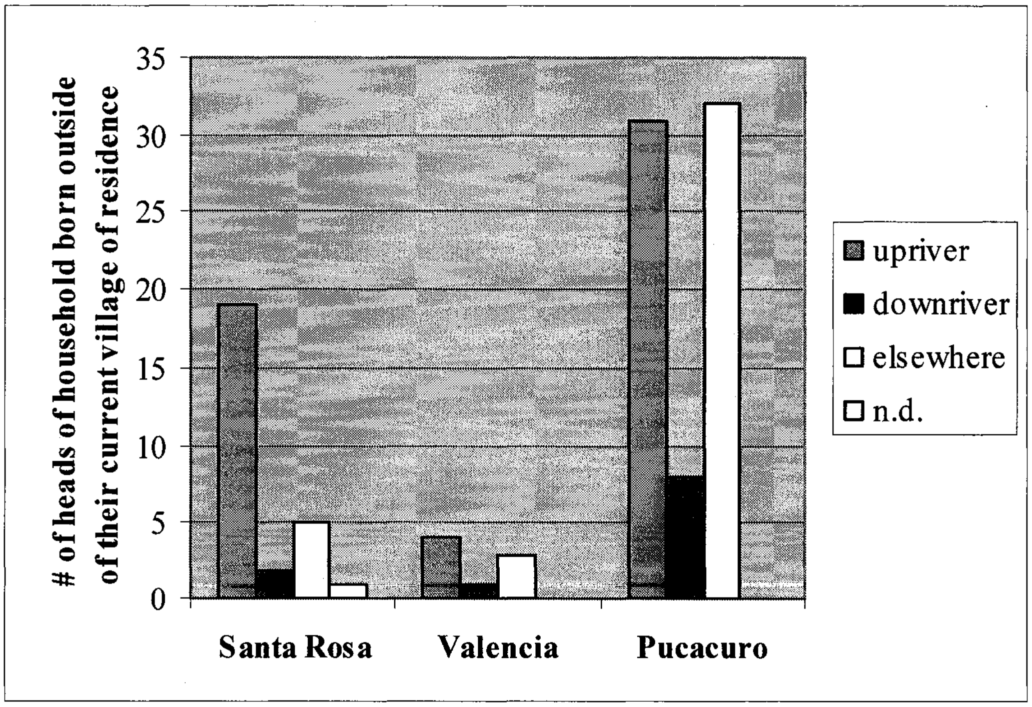


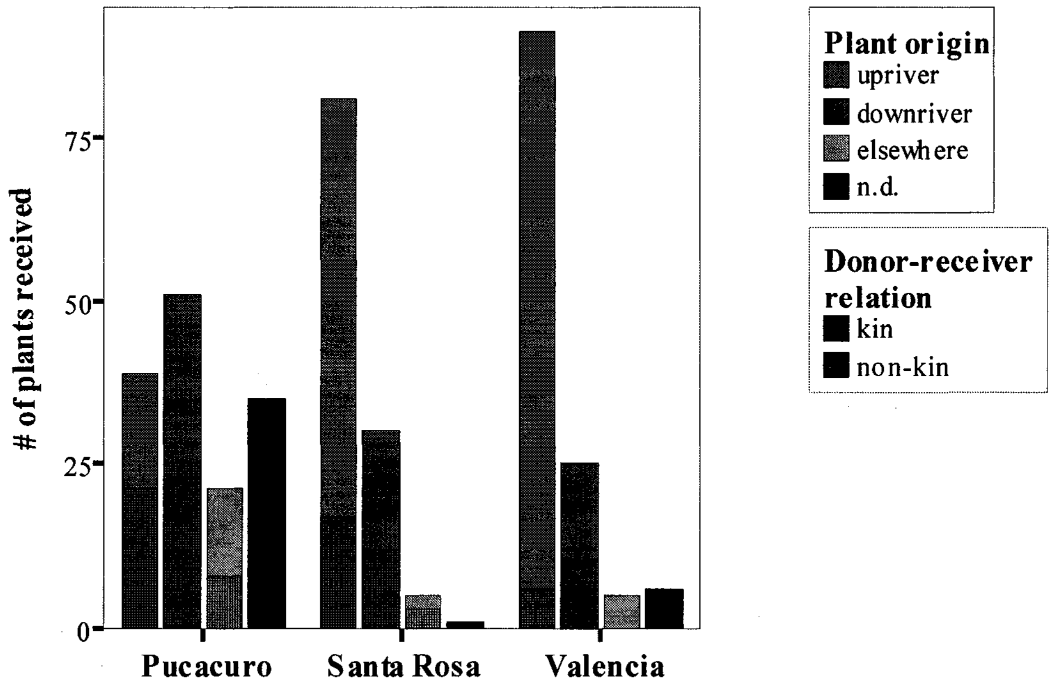
Figure 3-4 : Origin of household heads in Pucacuro, Santa Rosa and Valencia.



Thus, the classical hierarchical pattern of directed exchanges from the older to the younger along kinship lines seems to be maintained when communities split or family members settle away – generally downriver. The upper Corrientes, is the "mother area" to many households; just as older generations act as begetters of planting material, so does the upper Corrientes, dispensing its plants in a motherly fashion and being, as such, the primary source of planting material for Santa Rosa and Valencia, and an important source for Pucacuro, all three located in the nebulous zone between upper and lower Corrientes.

Striking geographical differences appear when comparing plants obtained from kin upriver and downriver in each of the three villages. Whereas most of the plants procured by Valencianos and Santa Rosinos through regional kin exchange networks come from upriver communities, most of the plants that Pucacuro obtains from kin come from downriver, Iquitos and other rivers (Figure 3-5). This pattern reflects the more "cosmopolitan" nature of Pucacuro and its close ties with the oil company since the 1970s. Nearly 38% of Pucacuro's household heads were born downriver or elsewhere, particularly on the Tigre river and in Iquitos, and they maintain some contact with their family. In addition, the proximity of the oil company bases, which offer daily river transport opportunities from the village to the district town Villa Trompeteros, and emergency air travel to Iquitos from its small airbase in Percy Rozas, allows for better embedding with the larger extra-district networks and for easier integration downriver than upriver. Residents of Valencia and Santa Rosa find themselves in the opposite situation, as travelling to the town or to Iquitos is made more difficult by the larger distance to Trompeteros and by the irregularity of travel opportunities with Pluspetrol's subcontracting fluvial transportation provider. Furthermore, the schedule of the itinerant trader on that reach of the river is unreliable; upriver villages thus have a more urgent need to trade with each other and to preserve their strong ties of communal work and mutual help through frequent contact and tight social and kin networks.

Figure 3-5 : Origin of home garden crops in Pucacuro, Santa Rosa and Valencia, by geographical area, kin vs. non-kin sources.



3.4.1.2. Kin vs. non-kin acquisitions

Although kin remain the main source of plants on the Corrientes for Valencianos and Santa Rosinos, family members are much less important in exchanges downriver. Indeed, the proportion of non-kin suppliers of plants is much larger downriver than upriver. This difference can be explained in terms of the nature of trips to the Upper and to the Lower Corrientes. People's main motive for Ecuador-bound travel is family visit. Indeed, all the upstream villages where non-kin have given plants are also kin sources. Villagers use the occasion of family motivated trips to collect plants from old friends or from family's acquaintances. The motives of downriver trips are much more varied. Beside the family motivated trips, people travel downstream to the district town or to Pluspetrol stations for health, commercial or administrative reasons. They may, for example, seek medical assistance with the oil company's medical team, or travel to town to sell or buy produce at the market or to embark on the Iquitos-bound public riverboat. Some have children at the Trompeteros or the Intuto (Tigre river) boarding schools and occasionally visit them. Village authorities have to travel frequently to meet district officials, oil company staff or representatives of the indigenous federation.

Some downstream villages are reported as sources strictly because of planting material acquisition from non-kin, in contrast to the region upstream of Valencia and Santa Rosa where no such "strictly non-kin" source exists, reflecting the more diversified motives of trips downstream.

Pucacuro, on the other hand, has a downstream configuration of kin and non-kin exchanges similar to upstream. Indeed, Pucacuro is structurally different from Valencia and Santa Rosa. With over 30% of family heads born outside of the Corrientes river, Corrientes extra-village kin networks are less developed. Plant gathering is thus more opportunistic: Pucacurinos glean planting material from family members, from the flowerbeds of strangers in distant villages and from friendships established over countless visits to town. In addition, life in Pucacuro follows the pace of the oil company's activities. Through the influx of workers from outside and the injection of money in the village, Pucacurinos are more exposed to modern commodities and to some amenities of urban life. Perhaps as a result, many seem to turn more readily to their acquaintances in the town and the city for social motives and use the occasion to enrich their plant portfolio.

3.4.1.3. Location of source villages

The relative importance of various geographical source areas differs between Pucacuro and Valencia / Santa Rosa. The three most important source villages for Valencia and Santa Rosa are located within a two to three-villages radius of the study communities. For Pucacuro, on the other hand, the main source area is Trompeteros, located some 5.5 hours away by motorboat, followed by Belén, about four hours upstream of Pucacuro. Only the third most important source area is a neighbouring village. Even more revealing, the Tigre river and Iquitos are almost as important sources as the next-door village of San Ramón. The figures are striking - Valencia and Santa Rosa receive, respectively, 80% and 81% of the plants obtained through extra-village informal exchange networks from the area circumscribed by a radius of three villages. Pucacuro, on the other hand, receives only 14% of these plants from the six nearest villages.[26]

3.4.2. Internal exchange networks

As the pie charts in Figure 3-1 show, intravillage exchange is a very important source of planting material. In Pucacuro, 49% of plants are obtained from informal networks within the village, much more than in Santa Rosa (28%) and Valencia (26%), though the numbers remain substantial even for the latter villages.

How these internal exchanges are achieved, according to what formal or unspoken rules, what their underlying mechanisms are, are questions that will be addressed in this section. To understand the dynamics of exchanges within the three villages, conventional multiple regression analyses testing socioeconomic data against indices representing

[26] The area encompassing the three-village radius consists of six villages for Pucacuro but of eight villages for Valencia and Santa Rosa because of the Achuar communities of Sion and Belén on the Plantanayacu river, a tributary of the Corrientes that flows into the main river at Valencia. It therefore can be expected that Pucacuro receive fewer plants from its nearest neighbours. Nevertheless, the same percentages calculated over a weighted average yield results just as striking: 60% for Valencia, 61% for Santa Rosa and 14% for Pucacuro.

network roles is used at first, and matrix correlation and regression quadratic assignment procedures are subsequently applied to network data.

3.4.2.1. Overview of intravillage exchange networks

The underlying structure of within-village exchanges is not evident at first glance. Exchanges are far from balanced, with different households occupying different positions, some receiving much and giving little, others giving much and receiving little, and some marginalized actors being little involved overall in these exchange processes (see for example the sociogram in Figure 3-6, where households are represented by nodes and planting material flow by connecting lines, with arrows showing the direction of flow and line thickness the relative number of plants exchanged). The number of exchange partners (size of ego network) in Pucacuro is eight on average (ranging from 0 to 20), four in Santa Rosa (range: 0-9) and five in Valencia (range: 0-10). The difference between Pucacuro and the other villages is due to village size. In Pucacuro, the average number of plants given locally is ten (range: 0-104), equal to the average number of plants received (range: 0-37). In Santa Rosa, average numbers are the same but ranges are smaller, with plants given varying from 0 to 36 and plant received from 0 to 23. In Valencia, plants given/received are much lower, with an average of four and a range of 0 to 12 for plants given and 0 to 10 for plants received.

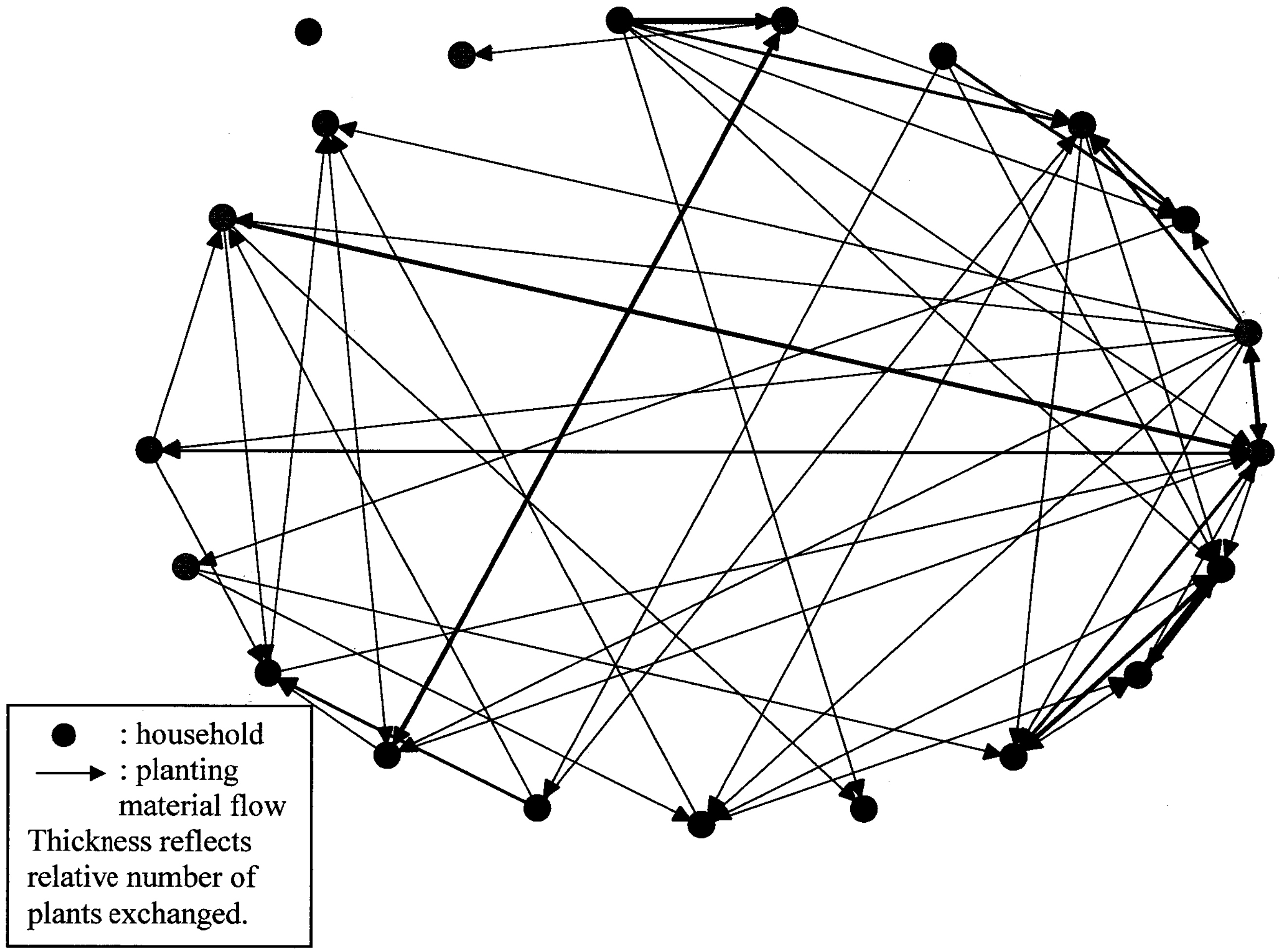
The density of Pucacuro's binary exchange network[27] is 0.08. Santa Rosa and Valencia, on the other hand, have densities of 0.18 and 0.14 respectively, indicating that households are somewhat more integrated in the exchange system, in great part because of the smaller size of the villages and therefore the possibility of greater daily interactions.

3.4.2.2. Exchange roles

Positions within the networks were examined using conventional multiple regression analysis on dependent variables derived from a social network analysis of exchanges in the three villages. The following measures of centrality were retained as

[27] The binary exchange matrix contains non-valued, i.e., binary data; it indicates which household gave to or received from which household, but not how many plants were exchanged.

Figure 3-6 : Planting material exchange sociogram for Valencia.



key indicators of exchange roles: outdegree, outreach centrality, size of ego network and indegree. These indices are calculated for each village separately, but to increase the power of the regressions and avoid problems of small sample size, regressions were performed for Valencia and Santa Rosa combined. Both villages have a similar sample size, which allows for the combination of the two without necessitating a normalization of the indices. A dummy variable for Valencia was added in all the regression models to control for the small differences in the range of the indices between Valencia and Santa Rosa resulting from the slightly higher sample size in Valencia.

Six independent variables are regressed in three separate multiple regression analyses against the dependent variables outdegree, outreach centrality and size of ego network. Five of these apply to Pucacuro and the Valencia/Santa Rosa village cluster: species richness (number of different crop species present in each home garden), household age (years), land assets (hectares of cultivated fields and of fallows), productive capital (valued in soles), and a dummy for households who have been in charge of their garden for less than one year at the time of the interview ("newly acquired garden"). The sixth variable, a dummy for households where at least one member is employed with the oil company, only applies to Pucacuro, as the oil company does not recruit local workers in Valencia and Santa Rosa. The regression model explaining indegree only consists of five independent variables as "species richness" is endogenously related with the dependent variable and can therefore not be used.

The independent variables were chosen based on the findings of previous work on planting material exchanges in the Peruvian Amazon (Ban & Coomes 2005; Coomes & Ban 2004) and in Mexico (Louette *et al.* 1997), and on theoretical expectations. A set of other important variables were excluded from the analysis because of the potential for multicollinearity: size of garden, number of years that the caretaker has tended the garden and in-house labour. Size of garden is highly significantly correlated with species richness ($r = 0.539$ overall, $p < 0.001$), years of caretaking with land assets ($r = 0.463$ overall, $p < 0.001$), and in-house labour with household age ($r = 0.489$ in Valencia/Santa Rosa, $p = 0.003$). Number of years in charge of the garden seemed a crucial variable to keep in the model because of the time dimension otherwise absent. The problem of time depth was significant; we circumvented this problem with the addition of the dummy variable for recently acquired gardens. The function of that dummy variable is to control for the new garden tenders who, in many cases, have inherited gardens with high species richness although they have not contributed themselves to the make-up of their species portfolio, and who have not yet fully integrated the local exchange networks.

All five regression models yield significant results for both Pucacuro and the Valencia-Santa Rosa set. Each network role will be discussed in turn, with a presentation of specific results and assessment of the socioeconomic factors that affect the dependent variable.

Planting material source

The main variable affecting outdegree – plants given in village – is household age (Table 3-1). In Pucacuro as well as in Valencia/Santa Rosa, a two year increment in household age is associated with one extra plant given. Older households are in general more generous plant providers and act as source for the community. In the three villages, 86% of the households that have given more plants than they have received locally, being as such net distributors of planting material within their village, are at least ten years old. It is interesting to note that older households also are the ones that acquire most planting material from informal exchange networks outside of their village (Table 3-2). There is a similar link between household age and number of plant species transplanted or brought from the forest (Pucacuro: $R^2 = 0.078$, $p = 0.057$; Valencia/Santa Rosa: $R^2 = 0.267$, $p = 0.001$). As the primary plant providers of their villages, older households thus contribute to the re-distribution of planting material, but they are also the main "importers" of vegetal material. Discussion of this role will be taken up in Chapter 4.

A regression analysis of the proportion of plants given that were originally acquired outside of the village against household age indicates that the older the household, the greater its propensity to distribute within its village planting material procured elsewhere.[28]

In Pucacuro, land holding is also a strong predictor of plants given (Table 3-1). Each hectare of land owned relates to a 2.4 increment in the number of plants given to

[28] Pucacuro: (plants given acquired outside / outdegree) * 100 = 1.316 + 0.475 (household age); $R^2 = 0.134$, $p = 0.006$. Valencia/Santa Rosa: (plants given acquired oustide / outdegree) * 100 = 0.351 + 0.551 (household age); $R^2 = 0.167$, $p = 0.013$.

Table 3-1 : Regression models for outdegree[a], Pucacuro and Valencia/Santa Rosa.

Outdegree	Pucacuro	Valencia / Santa Rosa
	Coefficient (Std. Error)	Coefficient (Std. Error)
(Constant)	-10.716 (6.076)*	-0.381 (4.734)
Species richness	0.196 (0.172)	0.127 (0.105)
Household age	0.483 (0.162)***	0.471 (0.129)***
Ha. of fields and fallows	2.427 (0.859)***	-0.211 (0.411)
Productive assets (value in S./)	0.001 (0.001)	0.000 (0.001)
Newly acquired garden (< one yr)	-0.610 (6.671)	0.256 (4.761)
Household member working for oil company	-3.428 (4.324)	--
Valencia dummy	--	-6.426 (2.946)**
R^2	0.421	0.494
F	5.695	4.549
P(F)	<0.001	0.002
df	47	28

*** $P(F) \leq 0.01$; ** $P(F) \leq 0.05$; * $P(F) \leq 0.10$.

a. Outdegree = number of plants given to other household in the network.

Table 3-2 : Regression models for plants received outside village, Pucacuro and Valencia/Santa Rosa.

Plants received outside village	Pucacuro	Valencia / Santa Rosa
	Coefficient (Std. Error)	Coefficient (Std. Error)
(Constant)	-1.886 (1.200)	2.891 (2.976)
Species richness	--	--
Household age	0.157 (0.046)***	0.177 (0.101)*
Ha. of fields and fallows	0.776 (0.245)***	0.734 (0.328)**
Productive assets (value in .S/)	0.000 (0.000)	0.000 (0.001)
Newly acquired garden (< one yr)	-1.553 (1.871)	0.814 (3.941)
Household member working for oil company	1.811 (1.290)	--
Valencia dummy	--	-3.802 (2.233)*
R^2	0.372	0.301
F	5.691	2.501
P(F)	<0.001	0.053
df	48	29

*** $P(F) \leq 0.01$; ** $P(F) \leq 0.05$; * $P(F) \leq 0.10$.

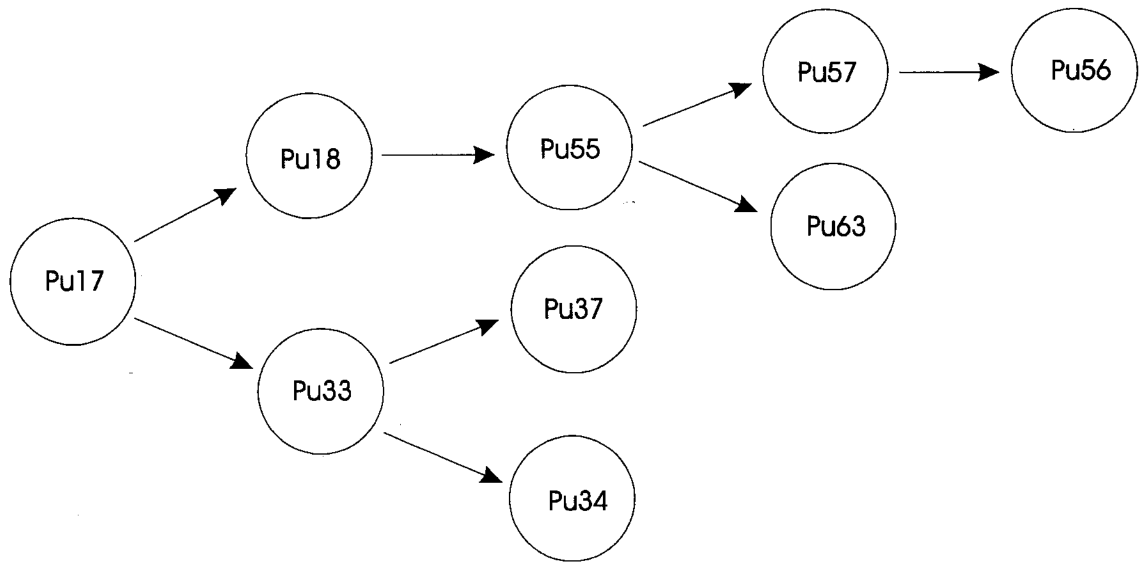
other villagers. In Valencia and Santa Rosa, land holding has no predictive power. As with household age, however, the relationship between land-wealth and plants acquired outside the village is positive and highly significant both in Pucacuro and in Valencia/Santa Rosa (Table 3-2). This suggests a different role for the land-wealthy in the two areas: in Pucacuro, the land-wealthy play a similar role as the old households in the introduction in the village of species from elsewhere and the re-distribution of these species while upriver, the land-wealthy import species without the ensuing redistribution.

As the above results show, acquisition of plants outside the village and plant distribution within the village are correlated, highly so in Pucacuro ($r = 0.720$, $p < 0.001$) and significantly though less so in the Valencia-Santa Rosa cluster ($r = 0.385$, $p = 0.022$). More specifically, there exists a strong relationship between number of species procured outside the village and the number of such species given inside the village (Pucacuro: $r = 0.740$, $p < 0.001$; Valencia/Santa Rosa: $r = 0.541$, $p < 0.001$). In other words, the more plants one imports, the more one spreads these plants in the village.

Centrality

Centrality is measured with two indices: outreach centrality and size of ego network. These indices serve to indicate how well a household is connected to the others in the network. Outreach centrality measures how easily a household can reach other households through planting material exchange. This measure assumes that the ties between non-adjacent actors that are connected to one another through links of two or more steps constitute non-trivial ties (i.e., actor A gives to actor B, actor B gives to C; therefore A is tied to C). In other words, one may be a source not only to the households to which one is directly connected, but to all actors with whom one is indirectly connected. Of course, in many cases, if A is a source to B and B to C, then different species are shared between each pair of actors. There are, however, many instances where a single species can be traced through a chain of connected actors. Chains of three and four households are frequent in the three villages (no four-household chain in Valencia). The longest chain appearing in the data is one consisting of five Pucacuro households who shared the medicinal plant mucura (*Petiveria alliacea*). In this case (Figure 3-7), Pu17 was a direct source for Pu16 and Pu33, but an indirect source for Pu55, Pu57, Pu56, Pu63, Pu37 and Pu34. These chains underestimate the actual

Figure 3-7 : Flow of *Petiveria alliaceae* from household Pu17 in Pucacuro.



interconnection between households because species that are grown in the garden by some may be cultivated in the field by others. In the data, the chain then appears to be broken because only gardens, and not fields, were inventoried.

Despite the fact that many indirect links between actors represent exchanges of different species, the notion of indirect interconnectedness is conceptually attractive. A source household, by contributing to another household's species portfolio, increases its ability to become itself a source of planting material to others. In addition, planting material does not move from household to household in a vacuum, but is often accompanied with information or advice sharing (see Chapter 4) and is perhaps associated with the tightening of social bonds and creation of social obligations. Outreach centrality is then a measure of how fast a household can reach the highest number of other households in the network.

In Pucacuro, outreach centrality is significantly and positively correlated with species richness, household age, land holding and productive assets, and negatively correlated with the dummy representing households receiving wage from the oil company. Results are similar in the Valencia-Santa Rosa set, except that land holding is not a significant predictor. These results are presented in Table 3-3.

The most influential actors are those best endowed with species, experience, land and extractive capital. Socially, they are more centrally located, perhaps because their age and wealth assigns them to higher positions in the social hierarchy, thus surrounding them with an aura of prestige. In particular, households with species-rich gardens have the greatest ability to reach others. As was noted in Chapter 2, there is an evident link between agrobiological capital and social capital, and that link does not reside so much in the heightened ability to gift planting material in large quantities (indeed, species richness is *not* a strong predictor of outdegree) but in the ability to reach many different actors through planting material gift. For example, one couple, patriarchs of the Piñola family, one of Pucacuro's largest kin groups, has given plants directly to 28% of Pucacuro's households and lies within 4 steps of 79% of households. This does not mean, of course, that 79% of households have received plants that were originally given by the Piñola couple, but that 79% of households lie in exchange channels through which planting material originally gifted by the Piñola could potentially transit. In reality, 40% of

Table 3-3 : Regression models for outreach centrality[a], Pucacuro and Valencia/Santa Rosa.

Outreach centrality	Pucacuro	Valencia / Santa Rosa
	Coefficient (Std. Error)	Coefficient (Std. Error)
(Constant)	-0.095 (2.263)	-1.507 (1.664)
Species richness	0.340 (0.064)***	0.083 (0.037)**
Household age	0.169 (0.060)***	0.165 (0.045)***
Ha. of fields and fallows	0.870 (0.320)***	0.030 (0.144)
Productive assets (value in .S/)	0.001 (0.001)**	0.001 (0.000)*
Newly acquired garden (< one yr)	-3.268 (2.484)	-0.081 (1.674)
Household member working for oil company	-3.222 (1.610)*	--
Valencia dummy	--	2.869 (1.036)**
R^2	0.677	0.621
F	16.427	7.641
P(F)	<0.001	<0.001
df	47	28

*** $P(t) \leq 0.01$; ** $P(t) \leq 0.05$; * $P(t) \leq 0.10$.

a. Outreach centrality = measure of how easily a household can reach other households through planting material exchange.

households grow garden plants that are likely to have been given by the Piñola at some point along the chain of exchanges.

A second measure of centrality is the size of ego network. This variable represents the number of households that have directly given to or received from the focal household. When considering immediate ties between actors, size of ego network is revealing of an actor's dynamism. It is predicted most strongly by garden species richness, as shown in Table 3-4. The question of prestige here is again prominent: having a lush garden confers on the caretaker a position of centrality in the exchange networks. But the presumed link between agrobiodiversity and social capital raises again the chicken-and-egg problem: does species richness increase social capital or vice versa? Certainly, the two are interwoven. To some extent, well connected households have species-diverse gardens because they have more opportunities to trade, but the prestige issue seems to be of primary importance. Indeed, when controlling for indegree, size of ego network and species richness remain highly correlated (Pucacuro: $r = 0.479$, $p < 0.001$; Valencia/Santa Rosa: $r = 0.304$, $p = 0.081$) which suggests that it is species richness first that begets rich social networks. Notwithstanding, the relationship, in all its complexity, cannot be fully untied with the available data: analyses in the previous chapter and sections attest to the tightness of the enmeshment of the two variables.

In Pucacuro, productive assets are a secondary predictor of ego network. Ownership of extractive tools such as shotguns and fish nets is positively associated with the number of exchange partners. Livestock, though not included in the full regression model, is also correlated with size of ego network ($r = 0.394$, $p = 0.003$).

The Pucacuro households who receive wages from Pluspetrol or a subcontractor are less central actors. They are connected with fewer households through exchange of planting stock (two fewer than the other households, on average) and they can reach fewer households through planting material gift (three fewer on average).

Planting material sink

Indegree in Pucacuro – the number of plants received in village - is determined primarily by household age (Table 3-5). The relationship is negative, with a five year increment in age resulting in a one unit decrease in the number of species received from the local informal network. Not surprisingly, caretakers of new gardens are not sinks;

Table 3-4 : Regression models for size of ego network[a], Pucacuro and Valencia/Santa Rosa.

Size of ego network	Pucacuro	Valencia / Santa Rosa
	Coefficient (Std. Error)	Coefficient (Std. Error)
(Constant)	1.995 (1.495)	1.595 (1.496)
Species richness	0.147 (0.042)***	0.056 (0.033)*
Household age	0.019 (0.040)	0.067 (0.040)
Ha. of fields and fallows	0.331 (0.210)	-0.004 (0.127)
Productive assets (value in .S/)	0.001 (0.000)**	0.000 (0.000)
Newly acquired garden (< one yr)	-2.658 (1.645)	-2.065 (1.494)
Household member working for oil company	-2.180 (1.083)*	--
Valencia dummy	--	1.597 (0.992)
R^2	0.482	0.372
F	7.282	2.766
P(F)	<0.001	0.031
df	47	28

*** P(t) ≤ 0.01; ** P(t) ≤ 0.05; * P(t) ≤ 0.10.

a. Size of ego network = number of households that have directly given to or received planting material from the focal household.

Table 3-5 : Regression models for indegree, Pucacuro and Valencia/Santa Rosa.

Indegree	Pucacuro	Valencia / Santa Rosa
	Coefficient (Std. Error)	Coefficient (Std. Error)
(Constant)	18.129 (2.336)***	12.978 (2.688)***
Household age	-0.200 (0.090)**	-0.058 (0.091)
Ha. of fields and fallows	-0.460 (0.477)	-0.147 (0.296)
Productive assets (value in .S/)	-0.001 (0.001)	0.000 (0.001)
Newly acquired garden (< one yr)	-8.459 (3.641)**	-6.785 (3.559)*
Household member working for oil company	-2.430 (2.511)	--
Valencia dummy	--	-6.124 (2.016)***
R^2	0.214	0.321
F	2.614	2.737
P(F)	0.036	0.038
df	48	29

*** P(t) ≤ 0.01; ** P(t) ≤ 0.05; * P(t) ≤ 0.10.

a. Indegree = number of plants received from other households in the network.

that is, *not yet*. They are likely to become the greatest sinks in the years to come, as they begin to put together actively a plant portfolio and as they enter fully the web of planting material exchange. As yet, however, their gardens are made up of species they did not acquire themselves; as such they cannot be formally considered as sinks.

In contrast to Pucacuro, household age does not appear to play a particular role in explaining plants received in Valencia and Santa Rosa. The only significant variable is the dummy for newly acquired gardens. A much more appropriate measure of plant reception is a variable representing net sinks, i.e. indegree minus outdegree. Correlated against household age and controlling for newly acquired gardens, it yields a highly significant Pearson correlation coefficient ($r = -0.673$, $p < 0.001$).

Part of the difference between Pucacuro and Valencia/Santa Rosa lies in the dissimilar link between plants given and plants received. In Pucacuro, the relationship between the two variables is negative ($r = -0.285$, $p = 0.037$) and is driven by a small number of source households who give generously but receive no or few plants from the local network (Figure 3-8). In the upriver villages, in contrast, the correlation is positive ($r = 0.424$, $p = 0.011$) because the main source households give planting material as well as receive many plants from local networks (Figure 3-9). Roles seem to be clearly defined in Pucacuro: there are sinks and there are sources. In the other two villages, there are, rather, more or less active traders. The active traders give and receive, thus creating the statistically observable trend. The difference between the two areas reflects perhaps size differences. Pucacuro, consisting of almost twice as many households as the other two villages combined, has a far larger network, which allows more niches and more social specialization. In Valencia and Santa Rosa, people are constrained, by force of circumstance, to be more interconnected and to depend more on all other actors.

3.4.2.3. Structure of exchange networks

The previous section served to identify the socioeconomic and demographic variables that define exchange roles within villages. Age and wealth are found to be primary determinants of positions within the exchange networks. This first step in drawing the outline of the structure underlying seed flow raises more specific questions: How does vegetal material flow between different age and wealth categories? Are other

Figure 3-8 : Indegree[a] vs. outdegree[b] in Pucacuro.

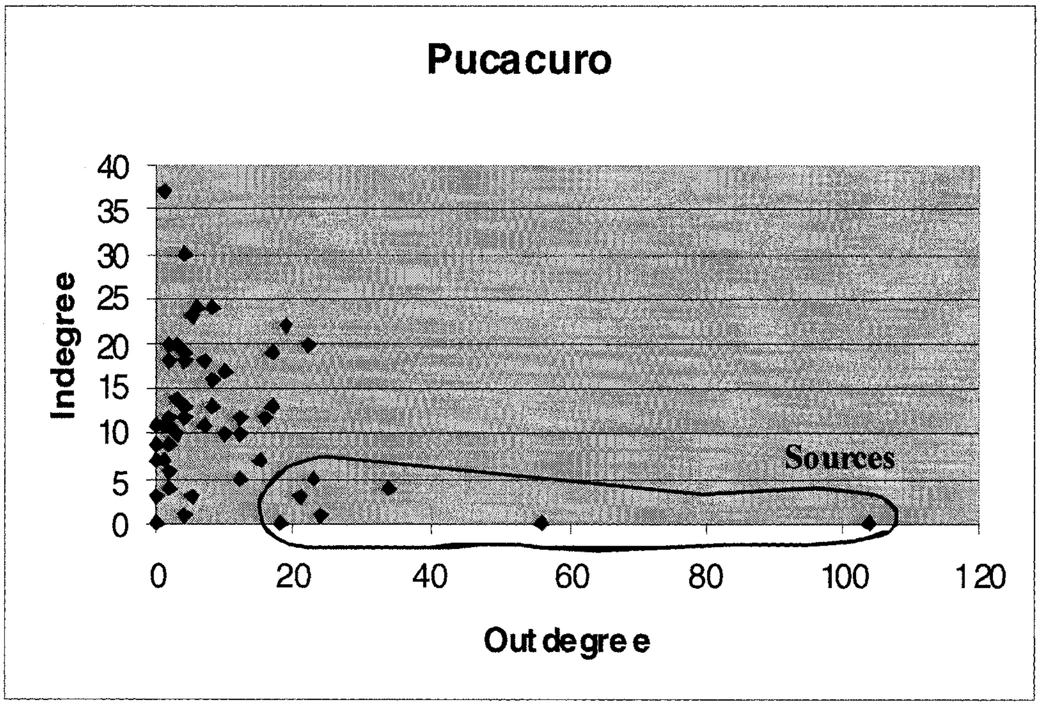
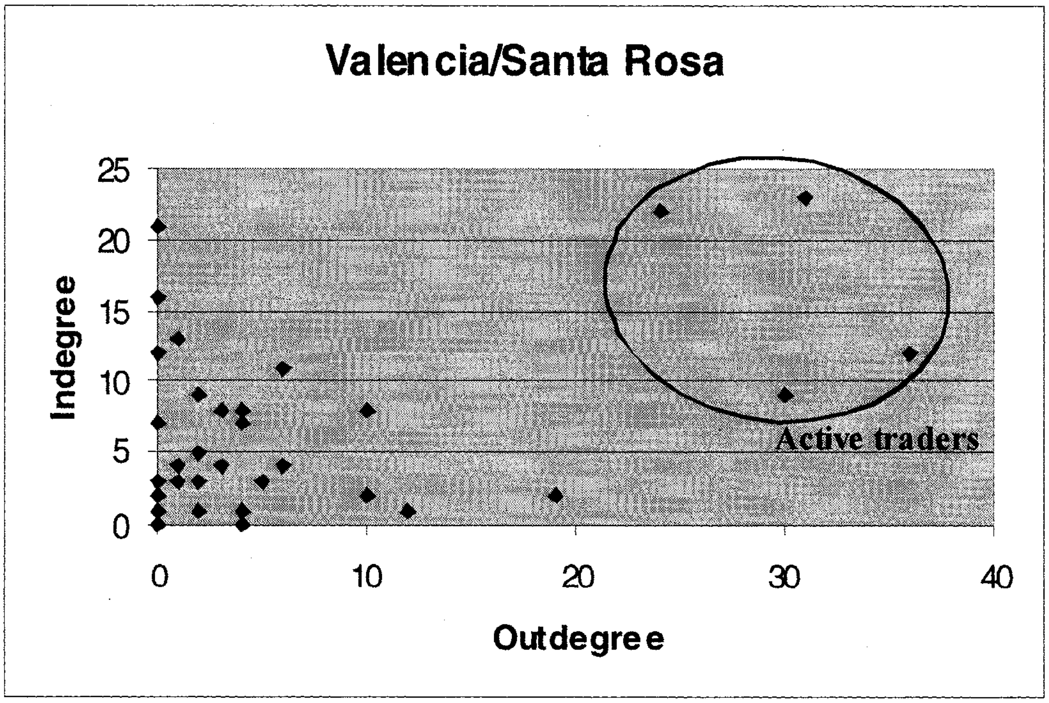


Figure 3-9 : Indegree[a] vs. outdegree[b] in Valencia/Santa Rosa.



a. Indegree = number of plants received from other households in the network.
b. Outdegree = number of plants given to other households in the network.

cultural bonds such as kinship and knowledge ties structuring elements in the flow system? In brief, what are the overall patterns of plant circulation in the three villages under study?

Kinship, expertise and geographical matrices were set against exchange matrices in multiple and, when relevant, simple regression analyses. ANOVA autocorrelation tests between exchange matrices and various actor attribute matrices were performed in order to break down analytically the structure of exchange and the multiple dimensions of the networks (see Section 3.3.2). Kinship, expertise, household location, wealth and age each proved, through various measures, to be significantly related to exchanges in Pucacuro, Santa Rosa and Valencia, with the exception of expertise in Santa Rosa. Specific results will be presented for each of these cultural and socioeconomic variables with discussion of their particular relevance.

Kinship

A strong link exists between kinship affiliation and exchanges. Table 3-6 indicates that there is a positive and highly significant correlation between exchange matrices and kin matrices in all three villages: a significant proportion of planting material follows kinship channels. In other words, Pucacuro, Valencia and Santa Rosa garden tenders tend to acquire plants more frequently from next-of-kin than from more distant relatives and neighbours.

In the absence of a truly anthropological analysis of kinship ties,[29] the predictive power of different models is compared in order to identify the underlying kinship patterns that structure exchanges. Six different kinship matrices were designed:

- sibling group: a symmetric matrix linking siblings. X(i,j) = 1 when a head of household i is brother or sister to a head of household j.

[29] Seymour-Smith's (1988) detailed description of kinship terminology among the Achuar of the Corrientes no longer seems relevant because of the strong external influences which have completely reshaped the communities and toppled traditional kinship structures. The prescription of bilateral cross-cousin marriage (Descola 1986), for example, is rarely, if ever, respected. Sororal polygyny (Descola 1986) is similarly disappearing: in the three villages, only three households are polygynous, and only one through sororal polygyny.

Table 3-6 : Regression models for exchange matrices in Pucacuro, Valencia and Santa Rosa.

	Pucacuro	Valencia	Santa Rosa
(Constant)	0.072	0.064	0.304
Expertise	0.413***	0.143***	0.205
Direct filiation	5.223***	0.709***	6.784***
Neighbourhood	0.342***	0.436***	
R^2	0.378	0.187	0.370
P(F)	<0.001	<0.001	<0.001

*** P(t) ≤ 0.01; ** P(t) ≤ 0.05; * P(t) ≤ 0.10.

- direct filiation: a non-symmetric matrix that links parents to their children. X(i,j) = 1 when the heads of household i are the parents of one of the heads of household j. To account for second generation ties, X(i,j) = 0.5 represents grandparent to grandchild relationships. Hierarchical kin relationships are embedded in the matrix through its non-symmetric character.
- immediate kin: an aggregation of the first two matrices (although omitting second generation ties). It links siblings and parents in a non-hierarchical (symmetric) manner. All ties between members of the nuclear family are weighted equally. X(i,j) = 1 indicates that one of the heads of household i is one step away (child, parent or sibling) from one of the heads of household j.
- collateral kin: an expansion of "direct filiation" that includes parents' siblings. In other words, uncles, aunts and parents are given equal weight in a non-symmetric and therefore hierarchical matrix.
- matriline: a subset of "direct filiation" representing one-step hierarchical links between females: mother-daughter relationships (maternal grandmother-granddaughter ties are assigned the value 0.5).
- matrilateral ties: a symmetric matrix additionally accounting for sister-sister and aunt-niece relationships in a non-hierarchical fashion. The value of 1 is assigned to one-step ties (sister-sister, mother-daughter) and a value of 0.5 to two-step ties (niece-aunt, granddaughter-grandmother).

A demonstration of how these matrices are constructed is presented in Appendix 2.

Our approach here borrows from the PGRAPH (parental graph) representation of kinship relations, where couples are represented as nodes and individuals as the lines that link nodes together (Schweizer & White 1998), but here the unit of analysis is the household rather than the couple: exchanges are construed as occurring between households, not individuals. Different actors in the household, male or female, may have been involved in the transaction; however, interpretation of results is based on the most direct kinship tie linking one or both heads of households to one or both heads of the counterpart household. For instance, when drawing conclusions on the exchange patterns between two households that are linked by matrilineal filiation ties (ex: head of household one is the daughter of head of household two), the exchange is considered to occur via the matriline and therefore to have a female-female linkage, although the actual agents of the transaction may in reality have been members of the household that are not directly concerned by the specified kinship tie (ex: male head of household two giving planting material to grand-daughter in household one). Assessment of gendered roles is thus limited since the available data restricts analysis to between-household flows.

The six matrix models are regressed against the exchange data. Results are presented in Table 3-7, where each column represents a different kinship model.

Significant differences appear between models. Matrilineal filiation seems to be the best predictive model overall for intra-village exchanges. In Pucacuro and Santa Rosa, directed planting material exchanges through the matriline occur more frequently than exchanges through any other channel. Indeed, there is on average six to 11 more plants given by (grand-)mothers to their (grand-)daughters than plants exchanged between random actors. In Valencia, the matriline coefficient is only slightly above one, indicating proportionately fewer nuclear family intergenerational exchanges than in the other two villages. Nonetheless, the matrilineal medium remains one of the most important.

The other models shed light on the structure of exchanges inside the village. Exchanges between siblings is positive and significant but of relatively little importance in Pucacuro and Valencia, and not significant in Santa Rosa. The comparison of direct filiation, immediate kin and collateral kin results indicate that even the frequent exchanges between close kin take place neither evenly nor arbitrarily between relatives. The hierarchy of generations is a strong structuring element: exchanges are directed from older to younger generations. Parents, grand-parents are primary sources, and uncles and aunts play an important part in exchanges, though secondary.

The woman to woman link is important beyond the nuclear family. As the last regression model shows, undirected exchanges through female links – mother, daughters, aunts, sisters, etc. - play a predominant role in the flow of planting material. These exchanges, in Valencia and Santa Rosa, are more frequent than gender-undifferentiated exchanges between members of the nuclear family. In Pucacuro, however, the model only accounts for 8% of variability, a comparatively small R^2. In contrast to the two

Table 3-7 : Regression models for exchange matrices against six kinship models in Pucacuro, Valencia and Santa Rosa.

		Sibling group (a)	Direct filiation (b)	Immediate kin (c)	Collateral kin (d)	Matriline (e)	Matrilateral ties (f)
Pucacuro (2862 observations)	Constant	0.123	0.096	0.068	0.075	0.109	0.101
	Kin coefficient	0.567***	5.992***	1.094***	1.728***	6.351***	1.409***
	Geographical coefficient	0.331***	0.356***	0.390***	0.530***	0.508***	0.507***
	R^2	0.031***	0.354***	0.101***	0.128***	0.237***	0.077***
Valencia (420 observations)	Constant	0.138	0.116	0.112	0.112	0.132	0.112
	Kin coefficient	0.070	0.909***	0.291***	0.521***	1.102***	0.672***
	Geographical coefficient	0.456***	0.455***	0.361***	0.423***	0.378***	0.299**
	R^2	0.066***	0.139***	0.092***	0.110***	0.132***	0.135***
Santa Rosa (182 observations)	Constant	0.848	0.383	0.439	0.383	0.455	0.430
	Kin coefficient	-0.681	7.228***	2.302***	3.617***	10.761***	4.244***
	R^2	0.006	0.363***	0.095***	0.181***	0.457***	0.186***

*** $P(t) \leq 0.01$; ** $P(t) \leq 0.05$; * $P(t) \leq 0.10$.

upriver villages, immediate kin and matrilateral ties explain about equally well the variability in exchanges in Pucacuro.

Expertise

Expertise matrices were built based on the responses to knowledge questionnaires. Questions asking respondents to cite people they consider knowledgeable, skillful, or helpful in matters of agrobiodiversity were used to build expertise matrices, where the households who are cited are tied through "expertise links" to the households who cite them (see Section 3.3.1 for specific expertise-defining questions and Section 3.3.2 for matrix design).

Expertise, like kinship, is linked to exchanges. To assess that link while controlling for the perhaps slightly confounding effect of kinship, a multiple regression quadratic assignment procedure was employed with the independent direct filiation, expertise and neighbourhood matrices set against the dependent exchange matrix. Direct filiation is chosen here rather than matriline because the expertise variable is not gender specific. The regression analysis reveals significant and positive relationships between the expertise and the dependent variables in Pucacuro and Valencia.

As can be seen in Table 3-6, expertise is an explanatory factor of exchanges in Valencia and Pucacuro, but it is much less powerful than kinship. People do receive plants from those they consider experts, but their primary source remains parents. On average, the flow of plants from advice giver to advice taker is superior to the flow between random actors by less than half of a plant when controlling for kinship. Experts are both advice and plant providers, even if their role as planting material begetters is slight in comparison with that of parents. Expertise and knowledge will be discussed further in Chapter 4 and the role of experts will be examined in greater detail.

Household location

The variable "neighbourhood" was designed to account for the effect of geographical proximity between households. Households were discretionally grouped into clusters of neighbouring houses according to my perception of the local geography of social activities. These clusters are, by nature, artificial for the central dwellers, as no true obstacle other than distance separates central households. Landmarks such as churches, schools, soccer fields, important bends in the path, exceptional spacing between houses were used, when deemed appropriate, as boundary elements in the configuration of "neighbourhoods". Pucacuro was divided in this way into ten clusters consisting of two to eight households each, in addition to five isolated households, and Valencia was divided into six clusters of two to four households each, in addition to two isolated households. As for Santa Rosa, the smallest village, the concept of neighbourhood has little relevance to the understanding of the geography of exchanges, and as such, the variable is ignored.[30]

In Pucacuro in particular, there were obvious geographically divided factions signaled by developed social intercourse, enhanced awareness of neighbours and strong kinship ties. The boundaries of these "neighbourhoods" are in no way clear-cut nor impermeable to "outsiders", and social exchanges extend very frequently beyond them. Nevertheless, these geographical elements have palpable existence in Pucacuro, especially as five different pathways or roads mark clear spatial divisions within the village. It is no surprise, then, to note the positive and significant coefficient of the geographical variable, which indicates a higher incidence of planting material exchange between close neighbours.

The clustering together of close kin is a potential confounding factor. In Pucacuro and Valencia, families, especially siblings, often tend to live close by, as revealed by the correlation of immediate kin and neighbourhood for Pucacuro ($r = 0.178$, $p < 0.001$) and for Valencia ($r = 0.368$, $p < 0.001$). However, the Pearson correlation coefficient for the neighbourhood variable and the direct filiation variable used in the model in Table 3-6 is lower in Pucacuro ($r = 0.115$, $p < 0.001$) and not significant in Valencia ($r = 0.059$, $p = 0.194$). The results in Table 3-6 indicate that, when controlling for household location, filiation still has strong predictive power in models explaining local exchanges of crop planting material.

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[30] An attempt at partitioning Santa Rosa into two "neighbourhoods" was made, but the division seemed excessively artificial and the model yielded only very low significance levels, reinforcing the idea that location of households inside a small, rather spatially centralized village plays in fact no role in exchange networks. Moreover, kinship and neighbourhood were found not to be related (direct filiation: $R^2 = 0.000$, $p = 0.537$; immediate kin: $R^2 = 0.019$, $p = 0.102$).

Age

An ANOVA autocorrelation test was performed on the exchange matrix of each village with age of the household as the partitioning variable. For each village, the dataset is partitioned into three sets assembling, in group 1 (young) the households formed in the nine years before the interview, in group 2 (middle-aged) those formed between ten and 19 years before the interview, and in group 3 (old) those formed at least 20 years before the interview. Santa Rosa does not have any household in group 2. Exchanges among the middle-age group (2-2) are taken as the reference point. For Santa Rosa, the reference point is exchanges among the young group (1-1). The overall ANOVA is significant for Pucacuro and Santa Rosa but not for Valencia. Results of the analyses are reported in Table 3-8.

The results indicate that planting material flows most frequently from old to young households (in Pucacuro and Santa Rosa), old to middle-aged households (in Pucacuro) or within the group of oldest households (in Santa Rosa). Exchanges of planting material are thus strongly patterned by household age in Pucacuro and Santa Rosa, where the old households play the most active role.

The case of Santa Rosa is striking: only one plant was reported to have been given by a young household to an old household. On the other hand, 75 plants flowed from old to young! The same figures for Pucacuro are as eloquent: 364 plants were given to younger households by older households against 125 plants flowing in the reverse direction. Even in the case of Valencia, the figures are notable: 42 plants from older to younger against 13 from younger to older.

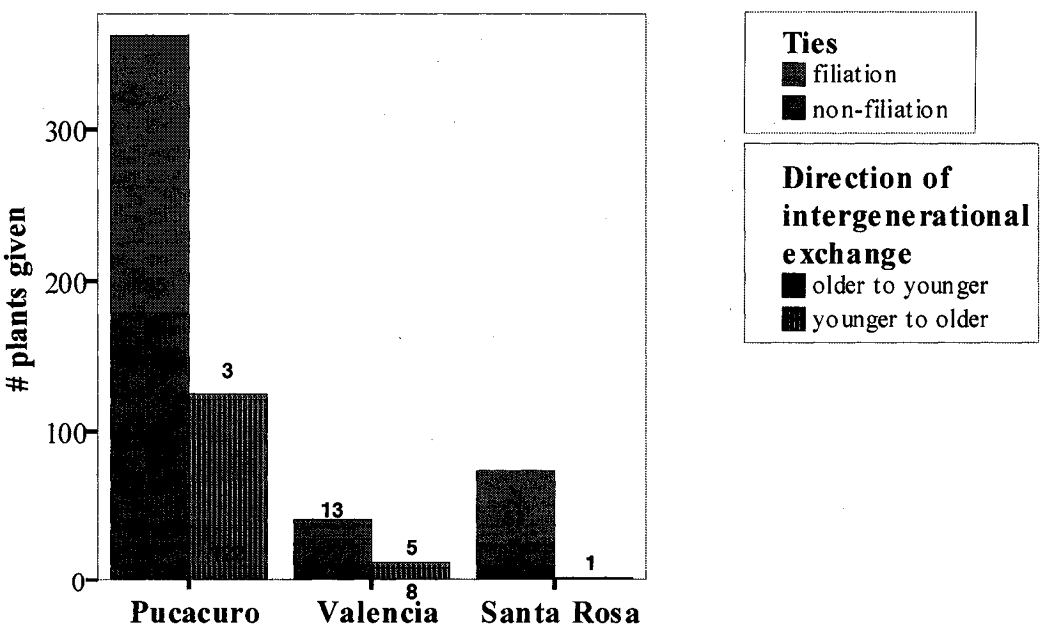
These results are in accordance with the kinship analysis above. Intergenerational kinship ties were identified as the most important social link that patterns planting material exchange. As can be seen with the present ANOVA tests, age hierarchy is indeed important. Although 33 to 67% of the exchanges between household age categories are in fact exchanges through direct filiation ties, the flow from older to younger households (old to young, old to middle-aged and middle-aged to young) remains much more important than that in the reverse direction, regardless of filiation, as is demonstrated by Figure 3-10.

Table 3-8 : ANOVA autocorrelation tests for exchange matrices partitioned by household age groups in Pucacuro, Valencia and Santa Rosa.

	Pucacuro coefficient	Valencia coefficient	Santa Rosa coefficients
R^2	0.028	0.029	0.175
P(F)	<0.001	0.289	<0.001
Constant	0.100***	0.222***	0.014
1-1 (young to young)	0.000	-0.089	--
1-2 (young to middle-aged)	0.025	-0.111	--
1-3 (young to old)	-0.054	-0.167	0.008
2-1 (middle-aged to young)	0.050	0.130	--
2-3 (middle-aged to old)	-0.071	-0.130	--
3-1 (old to young)	0.420***	-0.083	1.653***
3-2 (old to middle-aged)	0.501***	0.111	--
3-3 (old to old)	0.137	0.044	3.236***

*** $P(t) \leq 0.01$; ** $P(t) \leq 0.05$; * $P(t) \leq 0.10$.

Figure 3-10 : Planting material exchanges among household age groups by filiation in Pucacuro, Valencia and Santa Rosa.



Older households thus play a pivotal role in planting material exchange networks. Indeed, they are better embedded in the local networks, as is demonstrated by the linear regression of size of ego network (i.e., number of people who receive plants from or give plants to the focal household) against household age in each village. For Pucacuro and Santa Rosa, the older the household, the larger the network (Pucacuro: $R^2 = 0.083$, $p = 0.034$; Santa Rosa: $R^2 = 0.704$, $p < 0.001$). In Valencia, the regression does not yield significant results (Valencia: $R^2 = 0.045$, $p = 0.341$).

Wealth

ANOVA tests similar to those presented in the previous section were performed with wealth measured in terms of land assets, productive capital, durables and livestock as partitioning factors. For each partitioning variable used, households were divided into two sets: the richest half versus the poorest half. Exchanges among the poorest half (1-1) were taken as the reference point. A summary of results is presented in Table 3-9, where group 1 represents the poorest and group 2, the richest households. Consumer durables were not found to be significant in any case. The results using other measures of wealth indicate a tendency for the richest households to trade among themselves, a movement of planting material from rich to poor and a low level of trade among the poor, but the results are not generalized and so only provide anecdotal evidence of the structuring function of wealth in the exchange networks.

One slight variation of the livestock measure, hen ownership, yields more conclusive results (see Table 3-10). Hens are found in 72 of the 92 households visited and are the primary livestock bred. The other livestock found in the three villages, ducks and pigs, are either much less valuable and less frequent (ducks) or uncommon (only four pigs in total). The groups displayed in Table 3-10 represent the three hen-poorest quartiles (group 1) and the hen-richest quartile (group 2). The reference category is the poor-to-poor group (1-1).

Results suggest a close link between agrobiodiversity and chicken breeding. The sign of the coefficient for each group-to-group relationship is the same in the three villages even if significance levels vary. Those who breed few hens thus trade consistently less among themselves and give fewer plants to those who breed many hens

Table 3-9 : Summary of autocorrelation tests for exchange matrices partitioned by wealth variables in Pucacuro, Valencia and Santa Rosa.

	Pucacuro coefficient:			Valencia coefficient:			Santa Rosa coefficient:		
	1-2	2-1	2-2	1-2	2-1	2-2	1-2	2-1	2-2
Land assets (ha of fields + fallows)	-0.013	0.229***	0.217***	--	--	--	--	--	--
Productive capital	-0.012	0.219***	0.110	--	--	--	--	--	--
Consumer durables	--	--	--	--	--	--	--	--	--
Livestock	--	--	--	--	--	--	0.021	1.042*	1.625**

*** P(t) ≤ 0.01; ** P(t) ≤ 0.05; * P(t) ≤ 0.10; -- overall ANOVA not significant.

Table 3-10 : Autocorrelation tests for exchange matrices partitioned by categories of hen ownership in Pucacuro, Valencia and Santa Rosa.

	Pucacuro coefficient	Valencia coefficient	Santa Rosa coefficient
R^2	0.007	0.050	0.093
P(F)	0.057	0.005	0.032
Constant	0.160	0.143	0.527
1-2 (poor to rich)	-0.065	-0.026	-0.012
2-1 (rich to poor)	0.162*	0.254***	0.594
2-2 (rich to rich)	0.024*	0.607**	4.473**

*** P(t) ≤ 0.01; ** P(t) ≤ 0.05; * P(t) ≤ 0.10.

and the latter trade consistently more among themselves. In addition, the hen-rich are a source of planting material to the poor.

To conclude, there are specific patterns of planting material exchange among and between wealth categories as demonstrated by the consistence of the results, but the evidence provided is rather fragmentary. These analyses therefore suggest that age is a much stronger and more stable structuring element of intravillage exchanges than land and physical assets among the Achuar of the Corrientes.

3.5. Discussion and conclusions

Both a striking dissimilarity and a remarkable similitude between the more "cosmopolitan" Pucacuro and the remote Valencia and Santa Rosa emerge from the analyses in this chapter: dissimilarity in the regional structure of vegetal material flow and a parallelism in the functioning of the internal circulation of planting material.

Unlike Pucacurinos, Valencia and Santa Rosa dwellers procure a considerable proportion of their plants in regional networks; indeed they get almost as many plants from informal networks outside the village as inside. Overall, Pucacuro relies proportionately less heavily on informal seed flow systems outside the village. This difference lies first in the different sizes of villages. Valencia and Santa Rosa, because they consist of fewer households and families, must rely more heavily on suppliers of planting stock outside the village. Indeed, their inhabitants are limited in the number of trading counterparts they can turn to internally. Pucacurino households, each surrounded by 64 other houses with home gardens, have greater potential for exchange. Second the relative difficulty, for many Pucacuro inhabitants, of integrating regional flow systems may be key to understanding why Pucacuro depends more on internal networks. Indeed, planting material is considered by many Pucacurinos a sometimes inaccessible resource. Many of the in-coming families have only recently arrived and have not had sufficient time to integrate into an already vibrant network. Time may be a key element in stabilizing the exchange systems around Pucacuro and allowing newcomers to find their niche therein. Unfortunately, the precariousness of employment with Pluspetrol and its subcontractors and the large turnover of unskilled workers reduce the potential for stability in the foreseeable future.

The two upriver communities of Valencia and Santa Rosa have similar sourcing patterns. Their primary source areas are nearby villages but they also trade actively with upriver communities, in particular those where they maintain strong kin ties, and oftentimes, where their family originates. Downriver, kin remain a primary source, but non-kin also become important. While Valencianos and Santa Rosinos are attached through social and cultural bonds to the nearby villages and those located towards the Ecuador border – family ties, village celebrations, communal work, etc. - their ties to downstream settlements have more practical or material foundations: their trips towards Trompeteros and beyond are often motivated by administrative or commercial reasons. Pucacurinos, on the other hand, tend to source their planting material further away, in Trompeteros, in Iquitos, on the Tigre river, for example. Their ties to surrounding villages are tenuous in comparison. Unlike inhabitants of the other two study villages, they acquire as readily from kin as from non-kin, even when travelling upstream, a pattern of plant acquisition that could be qualified as opportunistic. Moreover, Pucacuro inhabitants are drawn to urban sources: almost 31% of the plants acquired from informal networks outside of the village originate from either Trompeteros or Iquitos. This reliance on distant urban sources certainly follows from and is facilitated by the strong presence of the oil company within Pucacuro, which has modified, beside the demographic composition of the village, local lifestyles and, in particular, access to and means of regional transport.

Overall however, the regional seed flow networks of all three villages are far-reaching, extending far beyond the river basin. Historical considerations render so vast a web of trading partners quite plausible. Indeed, Steel (1999), drawing from the work and travel accounts of a number of scholars and explorers, traces a picture of the Shuar and the Achuar in the 20th century as a collective actively involved in regional trade, in his case referring particularly to trade of manufactured goods and ammunition. He traces back the emergence of intertribal trade for these Western goods to the crash of the rubber boom, at the turn of the 20th century. Interethnic trade networks between the Achuar and the Quichuas are similarly long established. A group that has been deeply engaged in the securing of regional trading partnerships for over a century is, naturally, successful in the diffusion of planting material across large regions. With such a complex nexus of exchanges, that includes distant Quichua, Murato and *mestizo* trading partners, the absence of Urarina exchange counterparts is striking. The closest Urarinas are only four villages downriver of Pucacuro, yet not a single informant in the village reported plant acquisitions from the neighbouring group. Understanding the barriers to Achuar-Urarina interethnic exchanges is left for further field investigation. Are unwillingness to establish plant exchange partnerships on one side or the other, or important socioeconomic divides, at the root of this inequality? The discrepancy between distant yet vigorous Achuar-Quichua and Achuar-*mestizo* exchanges and inexistent Achuar-Urarina trade indeed raises important questions about the dynamics of interethnic systems of planting material exchange.

Surprisingly, the geographical extent of the provisioning networks does not result in the diversification and "exotification" of home garden species collections, as the plant species procured in the remotest localities are among the most common and easily accessible locally. The seemingly odd choice to acquire common species far away probably demonstrates an interest in varietal diversity. Indeed, gift of a species reciprocated by gift of the same species were reported by informants. Crépeau (1989) similarly observed an exchange of *huayusa* (*Ilex guayusa*) branches between an Achuar of the Huasaga river and an Achuar of the Pastaza river. Long-kept varieties that have been passed on through generations among families of the Upper Corrientes, some of them perhaps originating from Achuar and Quichua regions of Ecuador, and varieties from the southeast, brought in by *mestizos* and Quichuas from the Tigre river, Iquitos and beyond, probably intermingle in individual gardens. Coexistence of ancient and recently arrived varieties might be stronger in Pucacuro because of its strategic location near a large and active Pluspetrol oil well and halfway between the mouth of the Corrientes and the Ecuador border. These conclusions unfortunately remain conjectural since they cannot be verified because of the orientation of the data collected in this study strictly towards interspecific diversity. A parallel can nevertheless be drawn with the work of Zimmerer (2003), who found that Andean farmers of eastern Cuzco source many of their seeds, principally for potato and ulluco varieties, outside of their community to ""freshen" their seed", perhaps a risk-averting strategy (extrafield seed procurement is, the author says, an attested means of reducing crop diseases).

The above description of regional sourcing patterns underscores the findings of Chapter 2 (Section 2.4.1.4), where the comparison of home garden plant species in 15 villages of the Corrientes river revealed similarity between groups of neighbouring villages. Valencia and Santa Rosa, in particular, were shown to share a high proportion of species and were thus assigned a separate cluster. Of the four clusters, a single one did not group together geographically near villages: the so-called "Pluspetrol cluster", comprising of three of the five communities located near active oil company stations: Santa Elena, San José de Nueva Esperanza and Pucacuro. The analysis of regional seed flow systems sheds further light on the findings of Chapter 2. Indeed, observations in Valencia and Santa Rosa show that extra-village exchanges occur most frequently with near villages, for obvious reasons especially in zones where transportation means are scarce. The analyses of Section 2.4.1.4 suggest that these observations are pertinent to most other villages on the Corrientes river. Yet Pucacuro diverges from the norm with its more remote sourcing patterns. As was demonstrated above, much of this difference lies in the social composition of the village: with a large proportion of people coming from outside the Corrientes basin, the social nexus is more diffuse but extends further into the larger region. In a sense, Pucacuro benefits from a wider array of planting material sources. However, acquiring plants outside the village is particularly difficult for those who are not well integrated in regional kin networks. For those whose local networks are not well developed, procuring plants can imply long and tedious travel home, or the unpleasant and sometimes slightly humiliating task of asking a complete stranger to share a plant. Perhaps most revealing, complaints about the scarcity of seeds were loudest and most generalized in Pucacuro, the village that has, paradoxically, the largest overall species richness.

Unlike the structure of regional seed flow systems, that of intravillage exchange networks is remarkably similar across villages, despite the size, livelihood and ethnic differences between Pucacuro and Valencia and Santa Rosa. The networks of planting material exchange were found to be based primarily in the social nexus. In particular, wealth, age, kinship and species diversity affect the flow of planting material in a similar fashion in all three villages and define positions within the networks.

Several factors are shown to influence patterns of exchanges of planting material among residents of a village. While propinquity is undoubtedly a proximate determinant of exchanges, case studies in Pucacuro, Valencia and Santa Rosa show that the primary predictor of exchanges is kinship. Geographical location nonetheless contributes to the structure of seed flows, with indeed more frequent exchanges between close neighbours. Knowledge of a neighbour's plants is likely to be more extensive in a circle of closely located households. When asked to identify particularly diverse gardens or to name plants found in other home gardens, informants were reluctant to answer and justified their real or feigned ignorance with remarks such as: "I don't visit other gardens than my own.", particularly in Pucacuro, the largest of the three villages. Coomes & Ban (2004) have also noted similar expressions of unawareness. It is improbable that villagers are not aware of the diversity found elsewhere in their village, especially as passersby can catch sight of most gardens from the communal pathways, and as garden tenders organize *mingas* (communal work parties) at least yearly to clear or weed their garden. Yet the comments reveal the somewhat private character of the garden and the impropriety of displaying one's interest for others' plants. Indeed, in the Achuar tradition, the garden is considered to be the woman's intimate property and entering the domain is deemed dangerous and almost sacrilegious (Descola 1986). Though much transformed today, this tradition still bears upon the Corrientes dwellers' perception of privacy. It is unquestionably easier to publicly admit awareness of a neighbour's garden plants and thus to ask for a seed or a cutting in the intimacy of close neighbourhood.

The spatial organization of the village in part reflects its social structure, as kin for example tend to cluster together. The principal frame that circumscribes exchanges is in fact kinship and social ties. Indeed, studies have shown the importance of kinfolk as mediators of germplasm exchange (Caillon 2000; Coomes & Ban 2004). The incredulous laugh of gardeners who replied, when asked if they had ever been given a plant by farmer X: "How could I?! She's not in my family!" demonstrates well the strength of kin bonds in the study communities. In fact, kinship proximity and, more precisely, gender and generational distance, structure the flow and direction of planting material exchanges.

In the Achuar tradition, the business of subsistence agriculture principally falls within the competence of the woman. In the past, it was the woman who cared for manioc, sang to ward off insects and birds or to attract them to an enemy's field, and sang to the manioc or to the Nunkui *nuwa*, female protector of the field, to ensure its good graces and manioc productivity. The woman was the intermediary between the familiar world of the house and the magical world of the fields (Descola 1986). In the study villages today, little is left of the woman's field rituals, besides the scattered recollection of elderly women whose mothers used to sing *anents* to the manioc. A few of the oldest women still know the ancient songs, but evangelical prohibition has consigned these magical incantations to clandestinity or oblivion. The younger women are unaware of the songs. Men are now an integral part of the horticultural system, often devoting labour time to garden upkeep and plant collection in the forest, and are occasionally the primary caretakers of the garden. Nevertheless and despite the loss of traditions relating to crops and agricultural practices, women remain at the center of horticultural activity. They are assisted in some of their simplest gardening activities by their children, and in particular their daughters. It is not surprising, then, that planting stock transits mainly through matrilineal channels. Having grown and learned with mother and sisters, a woman will turn first to her mother, her maternal grandmother, her sisters and her mother's sisters for planting material, more readily that she would ask mother-in-law and sisters-in-law, with whom she has shared little of her early gardening experiences.

Thus, mothers and daughters are not only linked by a blood relation, but also by a bond of knowledge and experience sharing on the one hand, and plant sharing on the other hand. More generally, the bond between donor and receiver of planting material is often coupled with a knowledge sharing bond. Indeed, knowledge networks and exchange networks were seen to be related. Those who know, or are perceived to know, are sources of planting material for those who consider them knowledgeable. Advice givers and advice seekers are tied through complex and endogenous links. Experts may be preferred sources because of their putative knowledge but it is likely that, conversely, plant providers are seen as experts because of their propensity to provide planting material. An attempt to disentangle these questions will be made in Chapter 4 where the issues of knowledge and its link with agrobiodiversity will be explored in greater depth.

Old households are at the center of exchange networks. Their networks are wider and they tend to exchange frequently among themselves and with younger households. In the latter case, exchanges are virtually unidirectional, with plants flowing almost exclusively from the oldest households to the rest of the community. These results tie back to the discussion in Chapter 2 on the general determinants of species diversity on the Corrientes river. Older garden tenders were found to hold more diversity, in part because age is associated with experience and knowledge, and in part because of lifelong plant accumulation. In the present analyses, species diversity and household age are found to be highly correlated in Pucacuro and Santa Rosa (Pucacuro: $r = 0.233$, $p = 0.090$; Santa Rosa: $r = 0.625$, $p = 0.017$), but lose significance when controlling for size of ego network (Pucacuro: $r = 0.107$, $p = 0.447$; Santa Rosa: $r = 0.386$, $p = 0.193$). This result implies that the primary link between household age and species diversity resides in the number of exchange counterparts in the village. Key to understanding how age affects diversity lies, in other words, in the strength of the social networks through which planting stock is transferred. The older the household, the wider its social network, and the more species it has and is able to give. The importance of the social network is further emphasized by the fact that the advice-giver/advice-seeker nexus discussed in the previous paragraph is driven in large part by household age:[31] social cohesion may be forged by knowledge-sharing as much as by material gifts.

Old households are thus the primary plant begetters in their villages. New species enter the village through their endeavours. They act as bridges between external and internal networks, by "importing" plant species to their garden and then redistributing them through the local informal network. Similarly, the older households tend to acquire more plants from the forest. They may, as such, be the most actively involved in processes of domestication. In contrast, young households are major sinks, receiving more plants than they give, actively gathering plants from neighbours and family and contributing little novelty to their village's species portfolio.

People engage in exchanges for a variety of reasons, and as the old to young households relationship indicates, it is not always for material reasons or for plant accumulation purposes. Older, more species diverse households give plants to younger households without the direct benefit of a plant countergift. Most exchanges reported in

[31] The correlation between number of expert citations received and household age is strong in all three villages. For Pucacuro, $r = 0.601$, $p < 0.001$; for Santa Rosa, $r = 0.865$, $p < 0.001$; for Valencia, $r = 0.674$, $p = 0.001$.

the study were said to be gifts. Plants flow from old to young without a flow of planting material, money or gifts in the other direction. However, as older households engage in more exchanges, so they extend the size of their networks and reciprocation may take other, unreported forms, such as future advice sharing and participation in *mingas*. The unidirectional flow of planting material here points to a reason for exchange that emerged from informal conversations during the fieldwork: giving planting material is, for some, a form of savings or security against risk. Plants are given with the tacit understanding that they will be returned once they flourish if the donor incurs loss in his garden. Planting material gift can also be construed as a loan which the debtor will reimburse with the same plant once it reaches maturity. One may conjecture that plant "lending" is also a way to diversify one's own garden in the case of space constraints. As was seen in Chapter 2, one of the main constraints to boundless diversification of species portfolio is the size of the garden. Some households are constrained to cut down trees or stop growing certain plants to allow space for other plants. Giving a neighbour planting material of the species they have to relinquish may entitle them in the future to seeds of that plant.

The disparity between old and young households can be paralleled with that between rich and poor. Households that are better endowed with land, extractive capital and livestock have a propensity to exchange with one another and with poorer households. Like the older households, the land-wealthy are key sources and importers of planting material in Pucacuro and central actors in the exchange network.

In contrast to Valencia and Santa Rosa where land has little economic importance because of the absence of a market for agricultural produce, land holding may be of particular importance in Pucacuro because fields in this village can yield economically valuable produce, sold to the oil company or to the itinerant trader. Those who have larger areas under cultivation can earn more revenue from the sale of manioc and plantain. It is often the same households that have land under fallow, where fruit trees and sometimes useful forest species grow. Thus, on the one hand, the land-wealthier households occupy a higher social position because they earn money and have the prestige of selling to the oil company, and on the other hand, they have access to a wider range of agroecological habitats and are thus able to gift a wider range of species.

The most consistent measure of wealth in this study is hen breeding, with a clear pattern of plant flow from rich to rich and from rich to poor and comparatively little trade among the poor. This exchange structure stems from two phenomena. First, there is a synergy between chicken and agrobiodiversity. Hens are often free to roam about the garden – though gardens, in part or in totality, and individual plants are sometimes fenced in with exclosures, and some villagers choose to breed their chicken in special fields outside the village. Nonetheless, hens generally provide manure for the garden, either because they are bred around the house, or because the farmer deliberately chooses to collect chicken excrement to manure the garden. There is unfortunately no statistically significant evidence to corroborate this synergy: the correlation between species diversity and number of hens owned, though positive, is not statistically significant ($r = 0.140$, $p = 0.190$). The synergetic link between chicken and agrobiodiversity may reside not so much in interspecific diversity but in the vigour and abundance of the plants that are cultivated. Plants that grow abundantly are, of course, more readily gifted. Second, chicken are an instrument of barter. One household in Santa Rosa reported acquiring a valuable *Cyperus* species in exchange for a hen. This same household produces bottles of medicinal plants – roots and leaves macerated in alcohol – which it barters for hens. In the entire three village sample, only two other households reported barter transactions, with an unspecified barter counter in one case, and with another species in the other. No other household reported hens as barter counter; however, it is likely that many exchanges be in reality reciprocated, but the lack of immediacy in the reciprocation results in underreporting of barter exchanges. One can well imagine that the practice of bartering valuable planting material against hens is widespread, though little reported. If so, it explains why the hen-rich are more active planting material traders than the hen-poor, as indeed is shown by the positive relationship between hen ownership and number of trading counterparts in Pucacuro.

The link between social capital and hen ownership ties back to a similar link reported in Section 3.4.2.2: that between social capital and species richness. Social and agrobiological capital are tightly interwoven. The formation of a rich garden very much depends on the richness of interpersonal connections. But the link goes well beyond the simple one-way cause-and-effect relationship. Analyses suggest that species richness itself greatly contributes to the formation of exchange networks. In a sense, the prestige of tending a diverse garden is indissociable from a certain social duty to share and distribute planting material.

There is one main difference between the internal exchange network of Pucacuro and of Valencia and Santa Rosa. Pucacuro, by its size, allows for a certain level of specialization, with some actors occupying absolute source positions. On the other hand, Valencia and Santa Rosa, as a single entity, are characterized by active traders, who are not only main sources of planting material, but also receivers. This "active trader" role may be indicative of a network that has not yet reached full equilibrium. The four "active traders" are all inhabitants of Santa Rosa, which is a young village created in 1996, only six years before the field study. The source households are possibly still in a phase of species acquisition, which explains their ambivalent position as plant providers and plant receivers. It is also interesting to note the comparatively low explanatory power of demographic and socioeconomic factors in Valencia in light of the β diversity calculations of Chapter 2. While age and wealth are important structuring elements of exchanges in Santa Rosa and Pucacuro, their role in Valencia is not attested. In Section 2.4.1.1, Valencia was found to have the highest β diversity of the nine Achuar villages considered ($\beta = 3.18$). If we compare only the three case study villages and enlarge the random sample to 14 gardens (i.e., the number of gardens in Santa Rosa, the smallest of the three villages; see methodology in Section 2.3.2), Valencia again has by far the highest beta differentiation between gardens ($\beta = 3.45$ against $\beta = 2.15$ for Santa Rosa and $\beta = 2.91$ for Pucacuro). These results hint to either greater specialization in Valencia, or more impediments to the fluid flow of planting material. Indeed, the parallel between high β diversity and low explanatory power of demographic and socioeconomic variables in Valencia is strongly indicative of the importance of the social structure for the smooth functioning of informal systems of planting material exchange.

In Chapter 2, the influence on local agrobiodiversity of the oil company Pluspetrol was assessed. It was found that it has a positive effect on overall species richness but that the species diversity introduced by means of company sources is entirely dissociated from the knowledge substratum that generally forms the cultural basis of cultivation. The exchange networks in Pucacuro are dynamic and, when compared to those of Valencia and Santa Rosa, seem to function relatively well. Indeed, exchanges are structured similarly as in Valencia and Santa Rosa, villages that do not currently undergo direct influence from the oil company. The strong presence of Pluspetrol thus does not strongly affect the overall structure of exchanges in Pucacuro. Nevertheless, negative effects of the oil company on single households are patent. Employment with the company results in the ostracism of certain households. In households where the husband or a son works for Pluspetrol, labour that can be allocated to agriculture is obviously reduced. Indeed, the correlation of agricultural production (value in soles) and a dummy for households employed with Pluspetrol is negative and significant ($r = -0.281$, $p = 0.040$). The focus in these households slightly shifts away from agricultural activities and explains why they are less central in exchange networks. In addition, the presence of the oil company creates a sense of destitution among local residents and a feeling of dependence which is not confirmed by villagers' actions, but may be a forewarning of social disruptions to come. To the questions "Who would you turn to for help if you were confronted to such and such problem in your garden?" and "If you wanted to acquire type of plant X, who would you ask?" in a questionnaire on plant acquisition, many responded: "The oil company". Steel (1999) reports accounts describing the breakdown of traditional trade networks for manufactured goods among the Achuar when missionaries set up shops in settlement centers. As seen in the case of manufactured goods, the emergence of easy points of access for the coveted goods may result in the disintegration of previously established social structures. Pucacuro has not been the scene of such changes, although the oil company is a vector of social transformation and, more concretely, a direct source of planting material. However, as the pace of change in communities directly affected by large-scale extractive activities is rapid, special attention and consideration should still be bestowed on the impact of these changes on social cohesion, especially since social structures pattern the transmission of knowledge and resources.

Chapter 4. High-diversity, Source and Expert Households among Achuar Communities of the Corrientes River

4.1. Introduction

The endeavour to conserve agrobiodiversity *in situ* relies heavily on traditional agricultural practices, local selection processes and local cultural complexes. *In situ* conservation, accessibility of planting material and knowledge diffusion lie in the hands of the individuals who practice agriculture locally. Many studies on agrobiodiversity in traditional agricultural systems have pointed to the existence of exceptional farmers with distinguishing features such as outstanding species richness, uncommon expertise or propensity to innovate (Ban & Coomes 2005; Padoch & de Jong 1991; Salick *et al.* 1997; Subedi *et al.* 2001). To date, little is known about these farmers, their present or potential role in their communities as agrobiodiversity conservationists and as disseminators of planting material and knowledge. The term "expert farmer" is becoming increasingly popular in the *in situ* conservation literature, but it remains a poorly defined concept, an amalgamation of anything that makes a farmer special, from exceptional crop portfolio, to exceptional technique (e.g. Ban & Coomes 2005; Brookfield *et al.* 2002; Pinedo-Vasquez *et al.* 2003). The purpose of this chapter is to disentangle these notions by identifying the farmers who hold distinguishing characteristics and assessing their various roles in agrobiodiversity conservation.

Three exceptional characteristics or functions of "expert farmers" were brought to the fore in the preceding chapters. The first and most immediately recognizable is the high-diversity function fulfilled by the farmer whose garden is outstandingly rich in species, making him/her a *de facto* curator of agrobiodiversity. The second is the source function, fulfilled by the farmer, who, as a source of planting material or as an active trader, helps make plant genetic resources accessible to the rest of the community. The third is the expert function, fulfilled by the farmer whose agronomical and ethnobotanical knowledge is recognized among fellow villagers and who helps make his expertise accessible. These three roles are distinct, although they may be embodied in a single person: the assumption that agrobiodiversity goes hand in hand with knowledge and sharing appears to be reasonable. However, as the reality of Amazonian agricultural societies is complex, the concept of the so-called "expert farmer" must be deconstructed and the question asked: are those who hold great diversity also those who know and share most? The distinction between having and sharing may be crucial, as it does not necessarily follow that those who *hold* plants *share* them and that those who *hold* knowledge *share* it.

The present chapter proposes to answer these questions by identifying the high-diversity, source and expert households in villages of the Corrientes river and examining each of the three functions separately. We hope to refine the concept of "expert farmer" and to deepen our understanding of the link between having and giving by assessing the degree of overlap between functions. The role of exceptional households in planting material networks will be examined. The interconnection between knowledge- and germplasm-sharing, some mechanisms of knowledge transmission and the role of gender in forming exceptional households will be discussed in light of qualitative field observations.

4.2. Study Area

Field research was undertaken in 15 villages on a 150-km reach of the Corrientes river of northeastern Peru (see details on each village in Section 2.2 and map of study area in Figure 2-1). Particular focus is given in the analysis to ten communities because of the presence of outstandingly diverse home gardens: San Juan campesino, San Juan nativo, Santa Elena, Paraíso, Copal, Peruanito, Pucacuro, San José de Nueva Esperanza, Santa Rosa and Valencia. Paraíso is an Urarina village, though one of its dwellers, the focal household and village authority at the start of the research project (ousted from power by the end of the field season), is Achuar. The other communities are recognized by district authorities as Achuar, except for San Juan campesino, which is officially designated as *mestizo* but resembles Pucacuro, an upstream Achuar village, in ethnic composition.

San Juan campesino, San Juan nativo and Santa Elena are located near the regional headquarters of the oil company Pluspetrol. The former two villages formed a single community until a recent split in 2003. They are within walking distance from the district and market town Villa Trompeteros. Santa Elena lies directly across the river from San Juan nativo. The other villages are located further upriver but most are well connected to Villa Trompeteros through the fluvial transportation services offered by the oil company. San José de Nueva Esperanza, though located near one of the company's bases upriver, does not have access to as regular a service. Santa Rosa and Valencia are only served by company motorboats on an irregular basis. All villages are located upland and their residents practice swidden-fallow agriculture as their main livelihood activity.

4.3. Methodology

4.3.1. Data collection

Data for these analyses were collected from July to November 2003 on the Corrientes river. All data were collected with the participants' informed consent and pseudonyms are used to protect respondents' anonymity. Garden inventories were conducted in 300 households of 15 villages and brief socioeconomic questionnaires were administered to heads of households (see Section 2.3.1). Information on planting material acquisition and exchanges as well as more comprehensive socioeconomic data were collected in three villages - Pucacuro, Santa Rosa and Valencia - capturing 89 households overall (see Section 3.3.1). In these 89 households, a questionnaire relating to garden history, knowledge, expert networks and access to planting material was administered to all garden caretakers. The questionnaire asked informants to identify the people they considered most knowledgeable or most helpful in situations relating to agrobiodiversity management, identification or access. Examples of questions are: "Who would you ask for help if there was a pest outbreak in your garden or fields?", "Who could identify this plant?" or "Who has taught you most about garden tending?" Expertise networks were constructed based on responses to these questions. Socioeconomic data are available for an additional three households in Pucacuro and Santa Rosa who responded to the interview but did not wish to show their gardens or answer knowledge- and garden-related questions, or, in one case, did not have a garden.

In Valencia, where many gardeners understood Spanish but did not speak it, a fully bilingual young Valencia woman accompanied the investigator in some household and garden visits. When she was unavailable, a bilingual, adult member of the household acted as interpreter. The latter solution to language barriers was adopted in Santa Rosa.

Eleven farmers with exceptional species richness and two with exceptional socially recognized expertise were visited at greater length (repeated visits of several hours and/or overnight stay in informant's house): one in San Juan campesino, one in San Juan nativo, two in Santa Elena, one in Paraíso, one in Copal, one in Peruanito, three in Pucacuro, one in San José de Nueva Esperanza, one in Santa Rosa and one in Valencia. The 11 high-diversity farmers were chosen among the 17 exceptionally species-rich households identified in the study area (for determination of the 17 households, see Section 4.3.2) for practical and logistic reasons.[32] The two expert households were chosen because they were the two most cited experts in Pucacuro. Qualitative data on their life history, horticultural practices, livelihood activities and perception of their role were gathered through informal and semi-formal interviews (see Appendix 4) and participant observation. These farmers were administered the same socioeconomic, plant acquisition and garden knowledge questionnaires as those of Pucacuro, Santa Rosa and Valencia and their gardens were thoroughly surveyed.

4.3.2. Data analysis

The notion of "exceptionality" is one that is difficult to define and can yield discordant interpretations. For our purpose, to avoid any confusion and any grey area, "outstanding" or "exceptional" farmers are defined here following the use of the statistical terms "outlier" and "extreme point" in the software SPSS 11.5 for Windows. Outliers exceed the median by between twice and 3.5 times the interquartile range. Extreme values lie at least 3.5 times the interquartile range above the median. The focal cases of this chapter are the outlying cases (outliers and extreme values); that is to say, all cases exceeding the median by at least twice the interquartile range. Because exceptional households are, by definition, "unusual", their numbers are low. To be as inclusive as possible in our definition of outlying cases, exceptional households are drawn from two scales: the village distribution and the global distribution. For a specific target variable,

[32] In one case, for example, a failure of the boat engine a little upriver of Paraíso provided unplanned but very opportune occasion to stay overnight in the house of the Paraíso high-diversity farmer and engage in participant observation.

some households fall at the extreme upper end of the village interquartile range. However, when all villages are pooled together, the same households fall out of the interquartile range and become "global outliers". Our definition of "exceptional" households thus encompasses both the "local" and the "global" outliers (e.g., Figure 4-1).

The typology of "exceptionality" here consists of three elements: high-diversity, source and expert households. High-diversity households are defined by garden species richness. Source households are defined by outdegree and/or outreach degree one. Being an outlier with regard to one or the other of these two variables is a sufficient criterion. Outdegree corresponds to the number of plants given to other households in the village (see Section 3.3.2). Outreach degree one corresponds to the proportion of same-village households who grow one or more garden plants that were given by the focal household. A value of 1 indicates that all households have received planting material from the focal household. Expert households are defined by the proportion of same-village households who cite them as experts. The proportion is not calculated over the entire sample but over the number of households who responded to the expertise network questions (all households in Valencia and Santa Rosa samples, 50 households in Pucacuro).

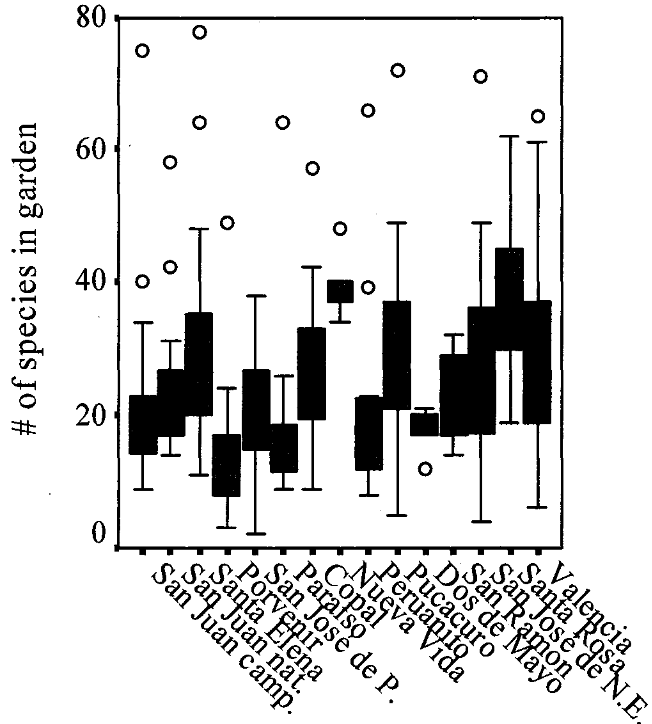
Outlying households are compared to non-outlying households and among themselves with t-tests, Pearson correlation analysis and logistic regression using SPSS 11.5 for Windows. Social network data (outdegree and outreach degree) are calculated with the help of Ucinet 6 for Windows (Borgatti *et al.* 2002).

4.4. Results

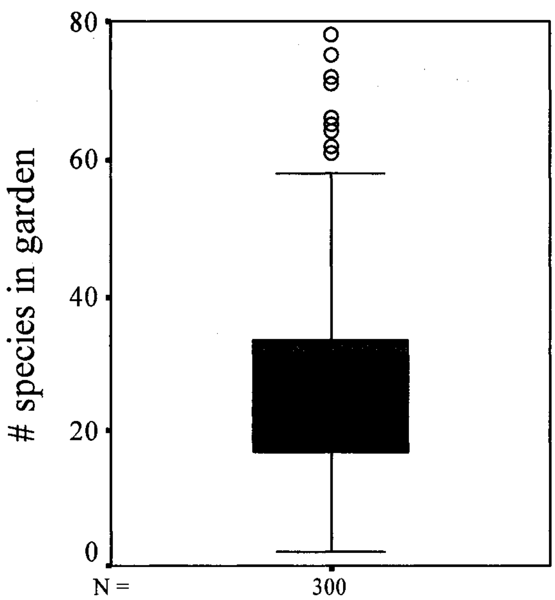
In order to deconstruct the multiple roles of garden caretakers, households belonging to each of the three categories of the typology will be examined in turn. To better understand the nature of outlying households and the roles they play in their communities, particular emphasis will be laid on the variables that set these households apart from the rest of the population. The three categories of the typology, namely high-diversity, source and expertise, are by no means mutually exclusive and may well, in fact, highly overlap. The degree to which each of these functions is performed by the same or by different actors will be assessed.

Figure 4-1 : Boxplots showing « local » and « global » outliers of species richness variable, Corrientes river, Peru.

a) local outliers:



b) global outliers:



Note : O = outliers and extreme values.

4.4.1. High-diversity farmers

Of the three key functions of *in situ* conservation, that of high-diversity is the most easily observable. In most villages, the distribution of home garden species diversity is uneven, with standard deviations varying from 3.2 to 15.7. Some people lie at the upper end of this distribution, with species richness far above that of even the most species-rich of their neighbours. Based on village-level and global distribution curves, 17 high-diversity farmers were identified in the study area. Some of their main household characteristics are summarized in Table 4-1.

The six demographic and land holding variables presented in Table 4-1 for high-diversity households were compared to non-outlying households using t-tests performed on the 300-household sample. Results show that high-diversity households stand out from the rest of the population on all but one variable, the "years in charge" variable (Figure 4-2 and Figure 4-3). In other words, high-diversity gardens occupy larger areas than other gardens, their caretakers are older, and the households to which the gardens belong are larger, have more working age members, and cultivate more fields. On the other hand, though high-diversity garden caretakers have, on average, cultivated their garden for a longer period of time, this result is not statistically significant.

These findings substantiate those of Chapter 2, where the same variables were observed to be significantly and positively correlated with species richness.[33] The high-diversity farmers are part of a continuum, being older, land-wealthier and belonging to larger households, as expected from the results of Chapter 2. They do not break from the socioeconomic logic of garden diversity or fall into a category apart.

The contrast between the two types of households in terms of number of years of caretaking is sharp, but owing to the presence of extreme values on both sides of the distribution, t-tests do not yield an acceptable significance level. As would be expected, many of the exceptionally rich gardens are old, acquired more than ten years prior to the inventory. Yet even more were tended for as little as five years! Such horticultural celerity bespeaks the exceptional character of gardeners, who, in as little as one to two

[33] Household size was not a significant predictor of species richness in the global regression model of Chapter 2, but the relationship was positive, as is seen here.

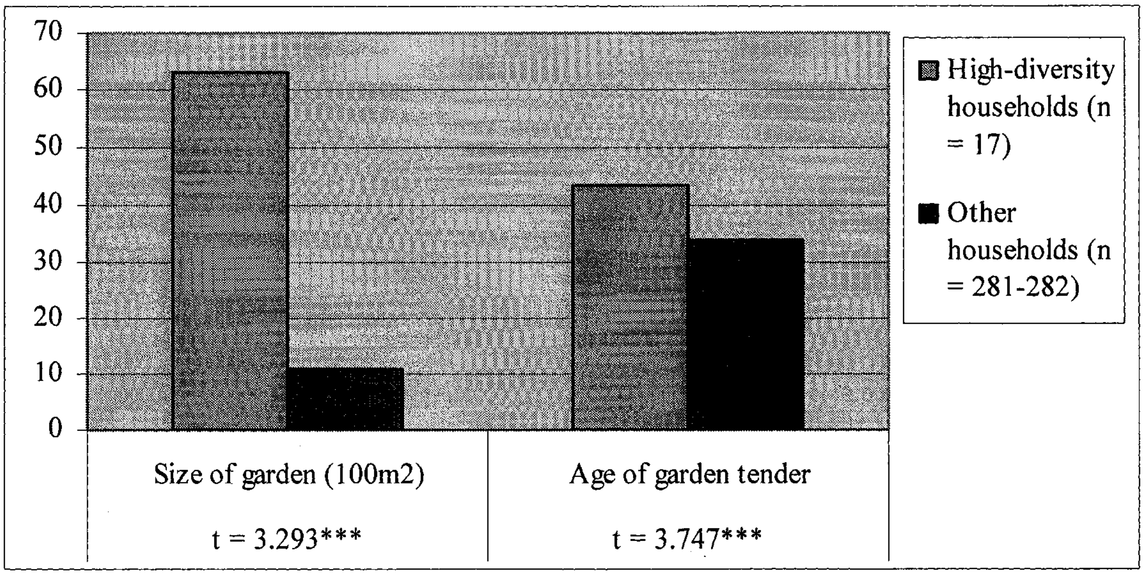
Table 4-1 : Characteristics of "high-diversity" households in study communities, Corrientes river, Peru.

House-hold code	Village	# of species	Size of garden ($100m^2$)	Age of tender[a]	House-hold size[b]	# of years in charge of garden	# of culti-vated fields
Jc1	San Juan campesino	75	200	43	11 (5)	19	2
Jc2	San Juan campesino	40	48	33	8	1	0
Jn1	San Juan nativo	58	36	48	5 (2)	5	3
Jn2	San Juan nativo	42	100	29.5	2	2	3
SE1	Santa Elena	78	4.5	47	7 (5)	22	1
SE2	Santa Elena	64	48	34	11 (4)	17	5
P1	Porvenir	49	100	39	1	18	1
Pa1	Paraíso	64	200	59	3 (3)	2	3
C1	Copal	57	24	56.5	6 (2)	10	3
NV1	Nueva Vida	48	12	40	6	4	2
Pe1	Peruanito	66	150	31	9	1.5	4
Pe2	Peruanito	39	12	35	8 (3)	7	2
Pu1	Pucacuro	72	9	62	7 (4)	5	3
SJ1	San José de N.E.	71	12.25	55	10 (7)	18	4
Ro1	Santa Rosa	62	8	48	10 (7)	8	3
V1	Valencia	65	50	34	5 (2)	2	2
V2	Valencia	61	60	46	10 (6)	5	3

a. When the garden is co-tended by both heads of household, the age is given as the average of the man's age and the woman's age.

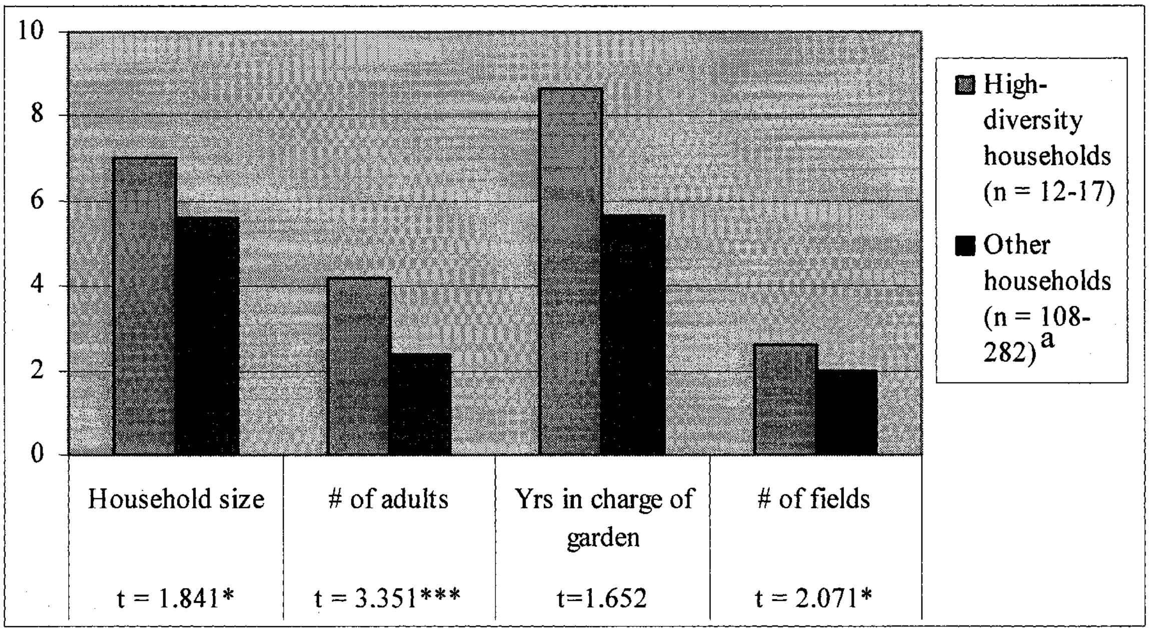
b. Measured in number of people living in the household (in brackets is the number of adults (between the ages of 15 and 64 inclusively) in the households where such information is available).

Figure 4-2 : Average size of garden and age of garden caretaker of high-diversity vs. normal households in study communities, Corrientes river, Peru.



*** P(t) ≤ 0.01; ** P(t) ≤ 0.05; * P(t) ≤ 0.10.

Figure 4-3 : Household size and composition, years of caretaking and land holdings of high-diversity vs. normal households in study communities, Corrientes river, Peru.



*** P(t) ≤ 0.01; ** P(t) ≤ 0.05; * P(t) ≤ 0.10.

a. n=108 for variable "# of adults" because household labour data were only collected in four villages.

years, were able to collect more plants than any of their neighbours in sometimes as much as 30 years. Interestingly, four of the caretakers who have been in charge of their garden for two years or less live geographically isolated from the rest of their village. The manioc and plantain grown around their houses for daily use liken their "gardens" to fields.[34] The use of the peridomestic area by these four households is akin to the traditional Achuar horticultural practice: before the nucleation of households into villages, the Achuar lived in dispersed settlements; houses were isolated and built in the midst of the so-called "garden", a swidden field that met daily dietary as well as medicinal needs (Descola 1986). The fast-attained diversity in the four swidden-like gardens is largely a result of the dual function of the peridomestic cultivated area as both a swidden field and a garden: the staples, vegetables and seasonings typical of the swidden are immediately planted, alongside the medicinal and fruit species more often found in the garden.

4.4.2. Source farmers

In Chapter 3, the analysis of the flow of plant genetic material through social channels revealed the existence of a number of specialized source farmers and active traders. Data on exchange of planting material are available for three study villages: Pucacuro, Santa Rosa and Valencia. The results of this section will focus exclusively on the comparison of the 12 outlying source farmers identified in the three villages with the remaining 80 households on which socioeconomic data are available.

In addition to the household demographics, garden characteristics and land holding variables examined in the previous section, a more comprehensive set of data allows us to consider other wealth indicators such as livestock breeding and ownership of productive capital. Results of t-tests comparing source and non-source households are shown in Table 4-2. Land holding, age, years of schooling, livestock, and, in the specific case of Pucacuro, employment of one or more household members with the oil company differentiate source farmers from their neighbours. On the other hand, ownership of productive capital, size of garden, household size and years that the caretaker has been in

[34] In contrast, in the more widespread "garden-like" home gardens, scattered manioc and plantain individuals are bred for emergency situations, i.e., to supply the family with food when getting to the field is too difficult.

Table 4-2 : Characteristics of source households and other households in Pucacuro, Valencia and Santa Rosa.

	Source households[a]	Other households (n)	t value for t-test
Mean age of garden tender	47.42	32.08 (80)	5.139***
Mean yrs of schooling of tender	0.33	2.90 (80)	-6.778***
Mean # people living in household	5.83	5.51 (80)	0.438
Mean cultivated fields (ha)	2.05	1.41 (79)	2.440**
Mean productive capital (value in S./)	1806.75	1158.50 (80)	1.318
Mean livestock (value in S./)	443.25	211.24 (80)	2.375**
Mean employment with Pluspetrol (dummy with 1 = household member employed, 0 = no employment)	0.00	0.27 (52)	-4.335***
Mean garden size (100 m^2)	9.60	8.83 (77)	0.303
Mean years in charge of garden	8.50	5.31 (77)	1.594

*** $P(t) \leq 0.01$; ** $P(t) \leq 0.05$; * $P(t) \leq 0.10$.

a. n=12 except for Mean employment with Pluspetrol, where n=4 because this variable only applies to Pucacuro households.

charge of the garden are not distinguishing features of source households. In fact, gardens of these outlying households do not have unique characteristics.

The findings that the central households are older, land-wealthier and better endowed with livestock than average households, and that, in Pucacuro, they do not take employment with the oil company, reinforce the findings of Chapter 3. Additionally, source gardeners have a lower degree of education than the average villager, which hints to the fact that these households occupy a position of traditional importance in their communities. The fact that the four source farmers of Pucacuro all declared Achuar to be one of their best-spoken languages further demonstrates this continuance of tradition among source households. Although Achuar is the vernacular language of the Upper Corrientes, many Pucacuro Achuar no longer use it and most recently arrived *mestizos* have not learnt it; only 38% of Pucacuro garden tenders consider Achuar as one of their best languages.

4.4.3. Expert farmers

In a questionnaire on expertise networks, Pucacuro, Santa Rosa and Valencia informants were asked to cite the villagers they considered to be most knowledgeable or most helpful with horticultural matters. In total, 58 households were named; the most often cited household received a total of 25 mentions! Only those cited by the greatest proportion of households were given the "expert" label, according to the procedure laid out in Section 4.3.2; sixteen households are thus defined as experts: five in Pucacuro, five in Santa Rosa and six in Valencia. Their main socioeconomic characteristics are compared to the remaining 76 households in Table 4-3.

The outlying expert households are characterized by age and education of tender, household size, land holding, livestock ownership and years of garden caretaking. Indeed, gardeners will turn for help and advice to their older, more experienced neighbours, who have tended their gardens for a longer period of time. Experts are paradoxically among the less educated, which suggests that the type of expertise that is most socially valued is rooted in tradition and transmitted outside of institutional

Table 4-3 : Characteristics of expert households and other households in Pucacuro, Valencia and Santa Rosa.

	Expert households[a]	Other households (n)	t value for t-test
Mean age of garden tender	49.25	30.88 (76)	5.626***
Mean yrs of schooling of tender	0.25	3.05 (76)	-8.177***
Mean # people living in household	6.88	5.28 (76)	2.607**
Mean cultivated fields (ha)	2.42	1.30 (76)	4.479***
Mean productive capital (value in S./)	1291.94	1232.76 (76)	0.242
Mean livestock (value in S./)	431.44	201.51 (76)	2.378**
Mean employment with Pluspetrol (dummy with 1 = household member employed, 0 = no employment)	0.40	0.24 (51)	0.653
Mean garden size (100 m^2)	13.84	7.86 (73)	1.606
Mean years in charge of garden	9.25	4.97 (73)	2.665**

*** $P(t) \leq 0.01$; ** $P(t) \leq 0.05$; * $P(t) \leq 0.10$.

a. n=16 except for Mean employment with Pluspetrol, where n=5 because this variable only applies to Pucacuro households.

frameworks.[35] Nonetheless, during interviews, some villagers were attributed a superiority in agronomical knowledge expressly because they had undergone years of schooling outside of the community. However, this type of expert citation remains uncommon. The attachment to tradition is emphasized by the fact that expert gardeners, like source gardeners, all declare Achuar to be one of their best-spoken languages, while this is the case for only 33% of the other Pucacurinos. In Valencia and Santa Rosa, where Spanish is less spoken than further downriver, 55% of experts do not speak Spanish, compared to a mere 16% among the non-expert garden tenders.

4.4.4. Coincidence of multiple functions

In the previous sections, the intrinsic variables defining outlying households were purposefully left out of the analysis of each type of farmers. Nothing was indicated of the species richness of the source and expert farmers, the propensity to give of the high-diversity and expert farmers, and the expertise of the high-diversity and source farmers. How high-diversity, centrality and expertise overlap remains to be described.

In Figure 4-4, Figure 4-5, Figure 4-6 and Figure 4-7, contrast between outlying farmers and other Pucacuro, Santa Rosa and Valencia dwellers is stark. For each variable, high-diversity, source and expert households are strikingly different from the other households: the former are characterized by species richness, propensity or ability to disseminate planting material, and perceived expertise. Farmers belonging to each of the three types thus seem to play important functions as curators and distributors of agrobiodiversity, and as disseminators of knowledge.

If we pool together the population of Pucacuro, Santa Rosa and Valencia, the four variables – species richness, outdegree, outreach centrality degree one and expert citations – are in fact significantly correlated, as shown in Table 4-4. Nevertheless, despite the high concurrence that these correlations suggest, overlap is by no means complete. The Venn diagrams in Figure 4-8 show the extent of overlap between functions. Coincidence is strong in Santa Rosa, where the high-diversity household is

[35] The importance of the education variable here and in the preceding section may also be the consequence of the nucleation of indigenous communities around schools and the consequent increased schooling of Achuar youth in the past decades. Source and expert households represent the older segment of Achuar society, where literacy rates are much lower for historical reasons.

Figure 4-4 : Species richness of outlying vs. other households in Pucacuro, Santa Rosa and Valencia combined.

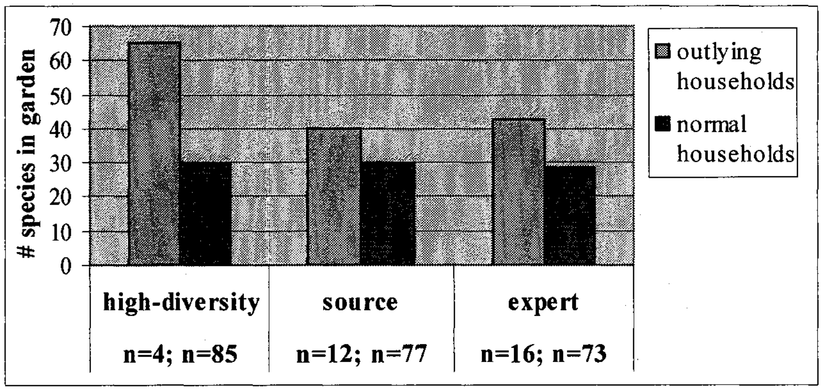


Figure 4-5 : Outreach (planting material network) of outlying vs. other households in Pucacuro, Santa Rosa and Valencia combined.

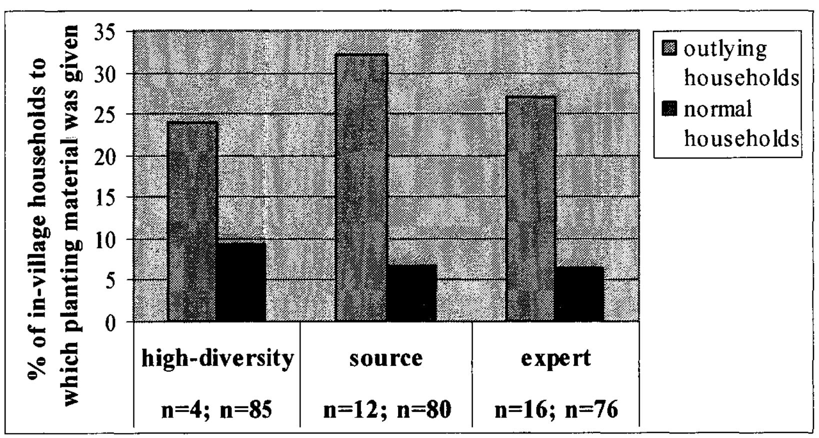


Figure 4-6 : Outdegree of outlying vs. other households in Pucacuro, Santa Rosa and Valencia combined.

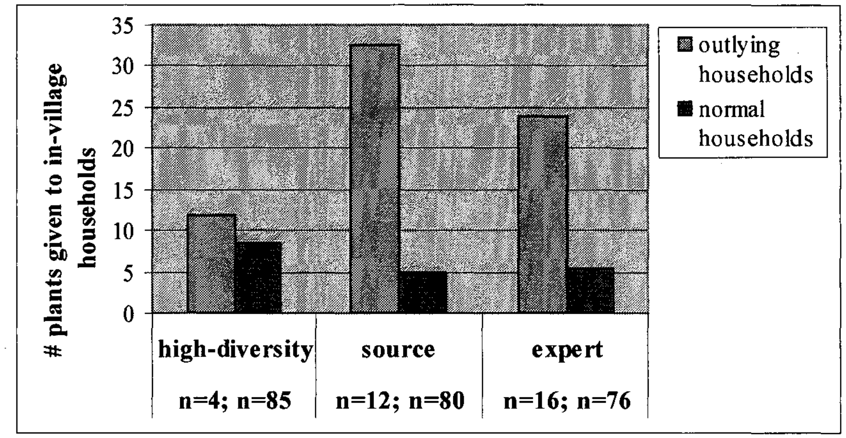


Figure 4-7 : Outreach (expert network) of outlying vs. other households in Pucacuro, Santa Rosa and Valencia combined.

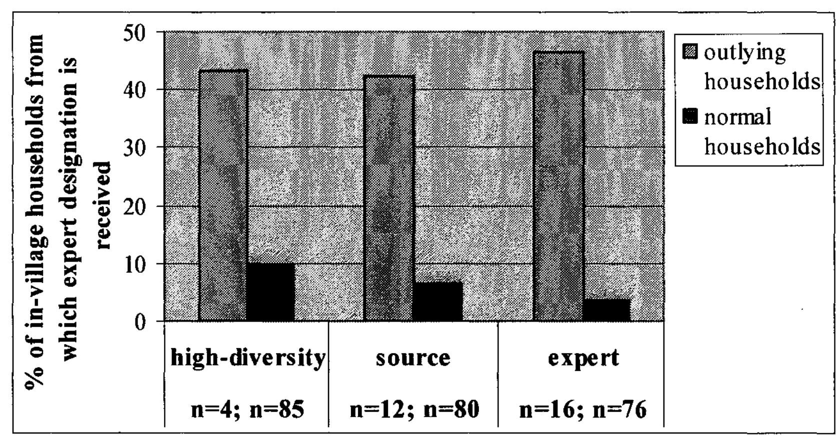
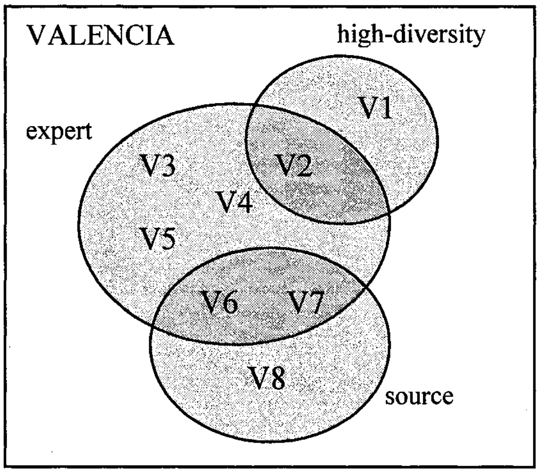


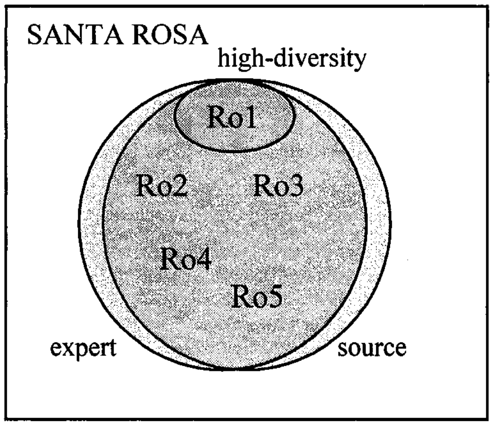
Table 4-4 : Pearson correlation for diversity, source and expertise variables among all households of Pucacuro, Santa Rosa and Valencia combined (n=89-92).

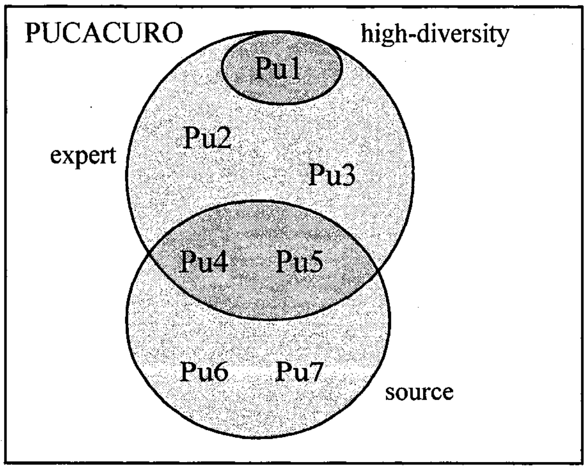
	# species	Outreach centrality degree one	Outdegree	% households giving expert designation
# species	1	0.456***	0.302***	0.453***
Outreach centrality degree one	0.456***	1	0.595***	0.752***
Outdegree	0.302***	0.595***	1	0.389***
% households giving expert designation	0.453***	0.752***	0.389***	1

*** P(t) ≤ 0.01.

Figure 4-8 : Three Venn diagrams of high-diversity, source and expert households in Valencia, Santa Rosa and Pucacuro.







also a source and expert household. In Pucacuro and Valencia, functions are often performed by distinct actors. Of the 20 households represented, just above half belong to at least two categories, and these households are found in greatest concentration in Santa Rosa.

As the correlations in Table 4-4 demonstrate, there is a tendency for the experts, the source households and the high-diversity farmers to play multiple functions. The experts are generally species-rich and generous in planting material; the source households are often species-rich and recognized for their knowledge, etc. However, the coincidence of exceptionality in species diversity, giving behaviour and expertise cannot be taken for granted. In particular, exceptionally rich gardens do not, except in the case of Santa Rosa, have an outstandingly high propensity to give planting stock; those who have do tend to share, but those who have most are not generally those who share most. Only in the smallest village, where connectedness is greatest because of the size of the community, is there an almost perfect overlap between having and giving.

The Venn diagrams in Pucacuro and Valencia show that expertise is the only function that intersects with both the source and the high-diversity functions. The link between expertise and the other two functions is explored through a logistic regression that controls for important socioeconomic variables. In this model, the discrete dependent variable is expert households, where the value 1 is assigned to households recognized as top experts and 0 to all other households. It is set against the six independent socioeconomic and garden-related variables that were found to be statistically significant in Section 4.4.3, as well as to the two dichotomous variables representing outlying source and high-diversity households. Results are presented in Table 4-5.

The model results indicate that, aside from age and wealth factors, it is the role as source and not the fact of being a high-diversity household that predicts socially recognized expertise. In fact, the estimated odds ratio for the source households is 18.58 while that for the high-diversity households is only 2.61 and is not statistically significant. In other words, source households are approximately 19 times more likely than other households to be recognized as top experts whereas high-diversity households are only about three times more likely than other households to be attributed exceptional expertise.

Table 4-5 : Logistic regression for dependent variable expert.

	Coefficient	Standard. Error	Wald statistic
(Constant)	-15.024***	5.694	6.963
Age of garden tender	0.140**	0.062	5.141
Yrs of schooling of tender	-0.776	0.587	1.747
# people living in household	0.467	0.370	1.594
Cultivated fields (ha)	1.436*	0.777	3.414
Livestock (value in S./)	0.003*	0.002	3.436
Yrs in charge of garden	0.056	0.119	0.222
Source household (1 = yes; 0 = no)	2.922*	1.567	3.477
High-diversity household (1 = yes; 0 = no)	0.958	4.059	0.056
Model chi-square	60.927		
df	8		
% correct predictions	94.4		

*** $P(t) \leq 0.01$; ** $P(t) \leq 0.05$; * $P(t) \leq 0.10$.

Thus, an exceptionally rich garden does not necessarily make for an expert, but expertise and propensity to give planting material are closely interconnected.

4.4.5. Sourcing patterns of the outlying households

Sourcing patterns are important distinguishing features of outlying households. For the species richest gardens, data on planting material acquisition is available for only a subset of the total sample, which captures 12 of the 17 high-diversity households. T-tests reveal striking differences between the provisioning networks of these 12 households and that of normal villagers (data for "normal" households are available for Pucacuro, Santa Rosa and Valencia only). The results are presented in the two bars on the left of Figure 4-9 and in Table 4-6. To acquire planting material, high-diversity households turn more readily to informal networks outside their village than inside, a pattern quite opposite that of normal households. Indeed, while high-diversity gardeners only procure 18% of their plant species from friends and relatives in the village, their neighbours get almost 44% of their plants from such circles. Overall, they are proportionately less reliant than their neighbours on informal networks (a difference of nine percentage points), acquiring a larger percentage of their plants from forest sources.

Acquisition patterns of the source and expert households, also in Figure 4-9, are analogous to those of the high-diversity households in the relative importance given to extravillage provisioning. Reliance on extravillage informal networks and forest sources is similarly heavy among all outlying households. For example, acquisitions by expert farmers outside of the village exceed those of the non-experts by 20 percentage points. In contrast to high-diversity households, however, the reliance of source and expert households on informal networks in general is not statistically distinguishable from that of normal households. In addition, source farmers rely proportionately more on intra- than on extravillage sources, although less so than the other households in the sample.

With their practice of acquiring planting material outside of the village, outliers play a redistribution role: between 21 and 48% of the plants they give to other gardeners are originally acquired outside of the village (48 % for high-diversity farmers, 22% for source farmers and 21% for expert farmers). The contribution of non-outlying households to the dissemination in their village of plants acquired elsewhere is

Figure 4-9 : Sourcing patterns of high-diversity, source and expert households in ten villages of the Corrientes river vs. normal households in Pucacuro, Santa Rosa and Valencia.

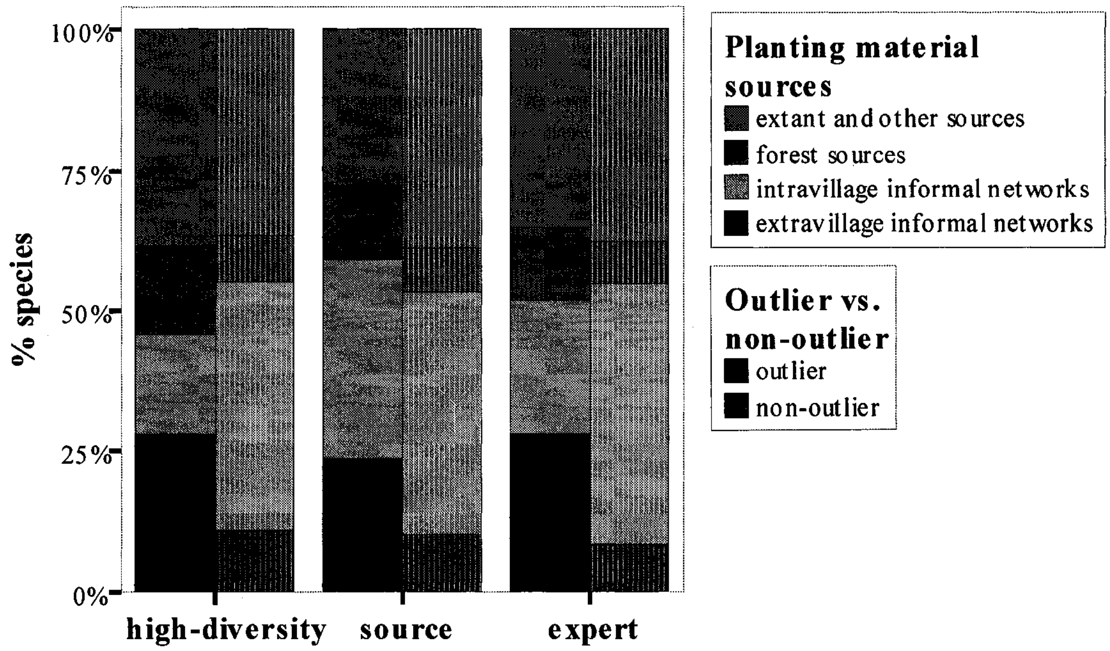


Table 4-6 : Comparison of sourcing patterns between outlier and non-outlier households in ten villages of the Corrientes river.

	Extravillage informal networks	Intravillage informal networks	Forest sources
Household type (outliers vs. non-outliers)	t -values		
High-diversity	4.123***	-5.825***	2.644**
Source	2.439**	-1.059	2.138**
Expert	5.206***	-4.594***	2.905***

*** P(t) ≤ 0.01; ** P(t) ≤ 0.05; * P(t) ≤ 0.10.

comparatively negligible: only 5 to 6% of the plants they give can be directly associated with extravillage sources.

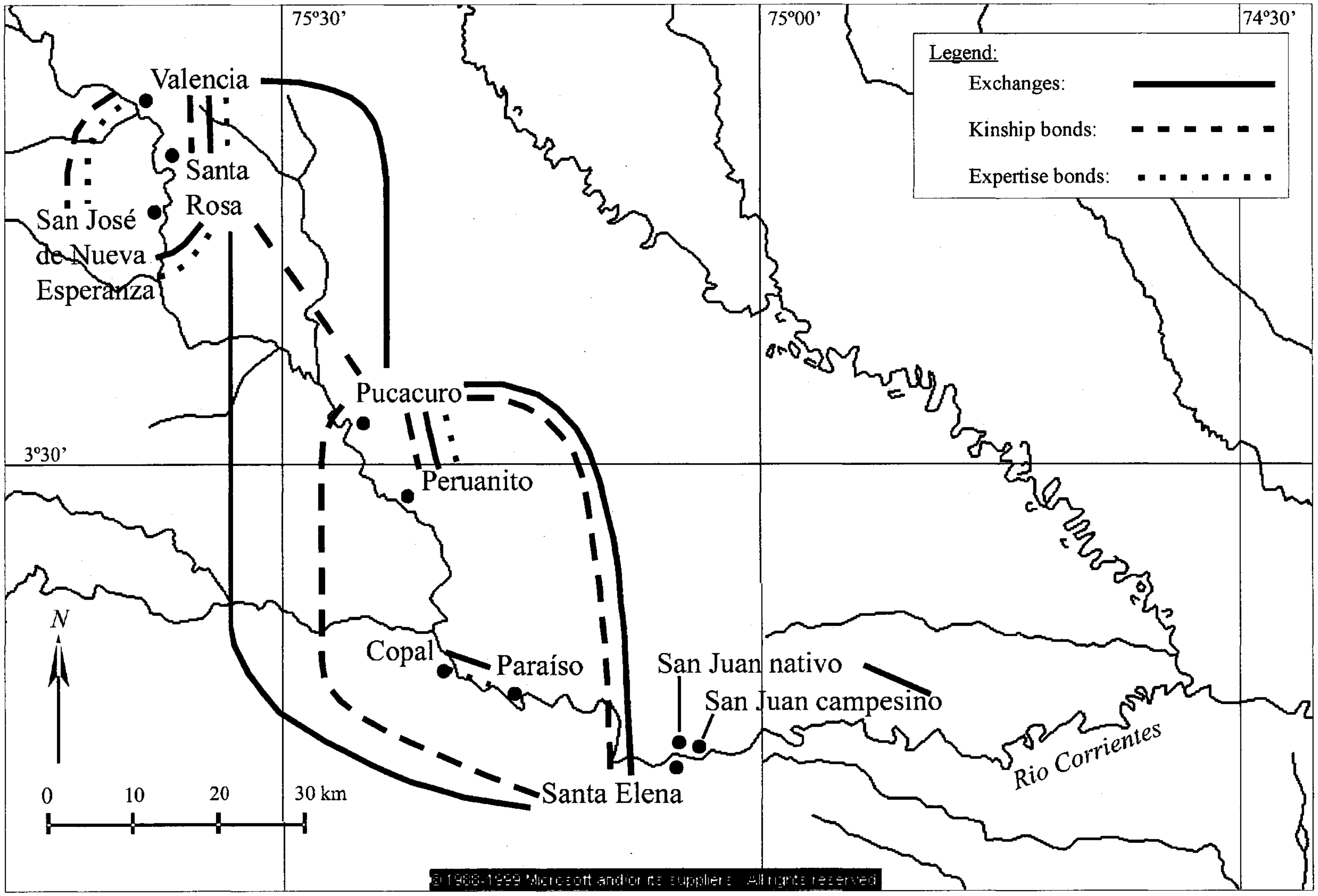
The reliance of the outlying households on extravillage sources suggests the existence of regional expertise/exchange networks. Figure 4-10 shows the ties between outliers (high-diversity, source and/or expert households) of each village (for Santa Elena, Paraíso, Copal, Peruanito and San José de Nueva Esperanza, data are only available for high-diversity households). The villages included are those where I engaged in participant observation and conducted informal interviews with outlying farmers. The expertise tie represents cases where an outlier from one village spontaneously mentioned, during informal interviews, an outlier from another village as someone he/she learned from or someone he/she taught to. The exchange tie represents planting material exchanges (uni- or bidirectional) between one or more outliers residing in different villages. The kinship tie represents kinship bonds (next-of-kin, extended family and *consuegro/a*, i.e., parents of son/daughter-in-law) linking one or more outliers from one village with one or more outliers from another village.

As the figure demonstrates, outlying households are well connected regionally, especially in the upstream villages. While they are often relatives, expertise ties exist between non-kin as well as between kin. Between-village exchanges of planting material occur more frequently between non-kin than between kin outliers.

4.5. Discussion and conclusions

High-diversity, source and expert farmers have a set of common distinguishing characteristics. Most of these farmers are old, wealthy and less schooled than the average villager. However, despite socioeconomic similitude, these three types of farmers cannot be amalgamated into one. In some communities, namely Valencia and Pucacuro, different roles tend to be played by distinct people, with some degree of overlap. Santa Rosa is a case apart: overlap is complete, with all sources being recognized as experts and the high-diversity farmer being both a source and an expert.

Figure 4-10 : Exchange, kinship and expertise bonds between outliers of ten villages of the Corrientes river.



4.5.1. Species richness, propensity to give and expertise

Much to our surprise, the exceptionally rich gardens were not found to be those of the exceptional source farmers. Possession, though tied to gift,[36] is not as closely linked to the source function as would be expected: possessing much does not necessarily result in liberality. Clara, the Pucacuro high-diversity garden caretaker, for example, explained her alleged unwillingness to share planting material in terms such as: "if one had to work hard during a lifetime to gather plants, why wouldn't others work as hard?" Her actions somewhat contradict her discourse, as she does give plants to many Pucacurinos, but her particularly rich garden does *not* make her an outlying supplier for the village. Thus, in terms of crop diversity, having and giving are not necessarily closely linked.

Neither is high-diversity a clear predictor of expertise. Table 4-4 does indicate a highly significant correlation between number of species and expertise citations, but the high-diversity function is not significant when controlling for socioeconomic characteristics of the households (see Table 4-5).

The link between having and giving knowledge is not clearly discernible. An assessment of the agrobiological knowledge of garden caretakers was attempted, unavailingly, through a "knowledge test" asking questions pertaining to plant identification, garden management and medicinal uses of plants. The measure was too imprecise to be used for analytical purposes. Some of those who appeared to be most knowledgeable, for example, achieved low scores. Problems such as the difficult recognition of pictures by the least schooled Achuar women and whispering of answers by the crowd of children following me from house to house, biased the scores. The thorniest problem encountered, however, is one of theoretical import: distrust and secrecy. Clara, the high-diversity expert garden tender in Pucacuro was reluctant to reveal any information about her plants, even manioc, and even more so to speak about medicinal plants and their use. The following exchange is typical of our encounters:

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[36]There is indeed a positive relationship between garden species richness and plants given, as shown in Table 4-4. Note however that the regression models for outdegree (Section 3.4.2.2) in Pucacuro and in Valencia/Santa Rosa yield non-significant coefficients for the species richness variable, another demonstration of the tenuous link between agrobiodiversity and giving behaviour.

Author:- What is this plant good for?
Clara: - Nothing
A: - Does it have any medicinal use?
C: - I don't know.
A: - So why do you grow it?
C: - *En vano he sembrado.* (I planted it for no reason.)

Victor, head of the high-diversity expert household in Valencia, was more approachable. During one garden visit, he divulged some secrets and, to my question about his willingness to share such secrets with neighbours, he answered, echoing Clara: "If they ask me why I grow such and such a plant, I reply: "*En vano siembro*" (I plant for no reason.)" The *en vano* answer, rather than being an indicator of ignorance, seems to denote unique expertise. Traditionally, Achuar women sang secret cultivation *anents* – magical songs - to foster plant growth and protect the fields. They used secret magical stones, the *nantar*, in planting rituals (Descola 1986). The realm of the garden was wrapped in secrecy. The endeavour to conceal manifested by Clara and Victor is thus revealing of agricultural practices still very much imbued with Achuar tradition. What it shows, moreover, is that sharing knowledge beyond the closest kin circle does not always follow from being knowledgeable.

Propensity to give and expertise are closely related roles. Sharing knowledge and sharing plants are highly complementary activities, often carried out by the same people. In Santa Rosa in particular, there is no distinction between expert and source household. Knowledge, it seems, is shared concomitantly with planting material. This coincidence of functions is also described by Brown (1986) who notes that young women turn to older women for new manioc varieties because their expertise is a promise of productivity. While having and giving constitute two separate notions, giving plants and giving knowledge are two inflections of a single dissemination function.

4.5.2. Plant and knowledge sharing

The dual function of plant and knowledge sharing is achieved through diverse means and in varied social and physical settings. During the five-month field season, exchanges of planting material were occasionally observed. In one case, a woman from Villa Trompeteros walked by a house in San Juan campesino and asked the owner, who was showing me her plants, to give her a cutting of an ornamental that attracted her attention. The gardener immediately complied and answered laconically but affirmatively to a question about planting technique. The gift of a cutting was thus accompanied by information, though scant.

On another occasion, a young couple befriended with Violeta, my host of the day in Paraíso, asked her for planting material of garlic vine (*Mansoa alliacea*) as it left the house after a morning visit and walked into her lush garden. She replied from the house: "Take some!" and explained where in the garden they could find the specimen. The two visitors were at a loss to identify the plant. "*¡Como no vas a conocer!*" ("How can you possibly not know?"), she said with a snore. She made no further effort at helping the couple and the two went away empty-handed. This contemptuous attitude towards advice-seekers is not uncommon. Many informants claimed to be too ashamed to ask anyone for help on plant identification. An elderly woman in Pucacuro asserted that neighbours, if asked the name of a plant, would respond: "*¿De dónde vienes?*" ("Where do you come from?"). And so she never dares to consult them. This response from neighbours is revealing of the importance bestowed on ethnobotanical knowledge as an identity-defining competence. Exposing one's ignorance in matters of agrobiodiversity amounts to repudiating one's cultural roots. Most of the Achuar high-diversity and expert gardeners interviewed claimed to learn by observation and by listening rather than by asking questions.[37] To my query: "Who taught you most about garden matters?", the most common response was "one learns alone" and "nobody taught me anything." Insisting a little, most admitted mothers, grand-mothers and aunts to play a major role in knowledge transmission. Nevertheless, the initial response demonstrates the degree to which knowledge of plants is considered inherent to the Achuar identity.

These observations and interview responses suggest that the learning process among the Achuar is a very intimate one. Agrobiodiversity knowledge is transmitted along close kin bonds; beyond them, the person who asks a question or shows uncertainty is subject to humiliation. Patricio, the head of Pu4 (see Venn diagram Figure 4-8), provided the clearest verbalization of how exchange of planting material and information

[37] Descola (2003), during a conference at the Collège de France, confirmed the absence of a process of formal knowledge transmission among the Achuar and referred to observation and listening as the two main means of learning.

are interrelated in a cultural context where knowledge is almost construed as a family property. In his view, he explained, knowledge must circulate only within a close family circle or among good friends. When he gives propagation material, the gift is supplemented with instructions on how to plant it and use it. To avoid misuse, he refuses to give planting material without providing the appropriate instructions. But since he prefers to contain knowledge within his close family, Patricio is reluctant to share planting stock with non-kin.[38] Perales, Benz and Brush (2005) observed a similar phenomenon at a different scale in Chiapas, Mexico: maize diversity remains very differentiated between two communities of different ethnicity despite frequent contact because the cost of interethnic knowledge transmission is too high. Clearly, the tight link between knowledge and planting material exchange constrains the free flow of plants.

There is one particular circumstance where concealment of knowledge and secrecy surrounding gardens are broken: the communal work parties, or *mingas*. Caretakers of gardens sometimes invite friends and relatives to participate in a morning or a day of communal work to weed their garden. During these *mingas*, most crop plants are exposed to the view of even the least prying of participants. The garden and its botanical contents lose their secret character. The supervising gardener, during her *minga*, must give careful instructions to the *mingueros* in order to spare valued but less known species. If she considers a weedy or naturally occurring wild species to be worth preserving, she must coach the participants not to pull out the plant. For the *mingueros*, these discoveries may arouse interest; asking questions about use and cultivation techniques is likely to be more opportune in the *minga* context. How much and what kind of information is shared is not known, however. The *minga* may periodically reproduce at a larger social level the type of intimate learning process that occurs in the garden and fields between mothers and children: during these communal work parties, the social restrictions on knowledge sharing soften and the temporary tie that is established between organizer and participants may be, to some extent, paralleled to the learning bond between the mother and her helping child.[39]

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[38] There is, as often, a discrepancy between discourse and action, as 27% of the plants that were declared to have been given by Patricio were given to non-kin.

[39] Descola (1986) similarly notes that technical information on crops is transmitted between co-wives during communal work in the garden/field.

Garden *mingas* are not reported elsewhere in the literature on agrodiversity in the Amazon basin. Several informants in different villages declared that they organize *mingas* one to four times per year, but the information is not verifiable. To my knowledge, only two *mingas* were organized during my stay in Pucacuro, Santa Rosa and Valencia. A third was much talked about but I never saw it materialize. The first took place in an 11 year old garden of Pucacuro. The working party consisted of a small group of women and children, mostly members of the gardener's kin group. While women maneuvered their machetes to root out weeds, men were busy replacing roof beams. The *minga* lasted a morning, but most of the time was spent chatting in the house and drinking *masato* – manioc beer – waiting for the rainstorm to lull. The second *minga* was organized by an elderly couple of Valencia who had recently abandoned its old garden following the death of a child because of suspicions that the site was inhabited by evil spirits. Participants spent the day clearing the site where the new garden was to be established. The party was much more numerous this time and consisted of members of various kin groups. While all were busy cutting small trees and weeding the ground, someone approached one of the recognized village experts with a leafy branch to ask him for the name of the plant, which he was able to give after a quick look at the specimen. The *minga* was used as an occasion to pass information between participants: the organizer, because the garden was not yet fully established, had few plants to preserve and little knowledge authority over the participants.

Field *mingas* are more common than garden *mingas*. They provide important opportunities for plant acquisition because they allow participants to identify interesting plants in fields that they do not usually enter. Many garden species originate from others' fields; the *minga* is a good moment to ask the field owner for a cutting or a sucker, and also a good occasion to cut a coveted plant unnoticed when the owner is unwilling to share, as one woman in Santa Elena admitted to me.

4.5.3. Gender synergy

Although most gardens are declared to be tended by only one or the other head of household, in some cases tasks related to the garden are shared between the man and the woman. In the three Pucacuro, Valencia and Santa Rosa high-diversity households that are concomitantly expert households, man-woman complementarity is strong. While the woman was the declared caretaker, in all three cases the man was more prompt and enthusiastic to show the garden, unveil its secrets and explain plant use. When other villagers mention the household as expert, the man receives recognition for pest management techniques, plant identification skills, knowledge of medicinal uses and ability to acquire planting material outside of the village social network. In fact, the three men fulfill *médico vegetalista* or *curandero* (traditional healers) functions in their respective villages, with varying degrees of social legitimacy, and they are known as healers beyond their village. The woman, on her part, is recognized for her knowledge of manioc and her teaching. When the household is mentioned as a source, it is the woman who receives most citations.

The secret of high-diversity expert households partly lies in task- and knowledge-sharing. The synergy of gender-specific knowledge and gendered roles permit more efficient acquisition of planting material, perhaps better agricultural techniques, and more widespread knowledge diffusion. In the three cases examined, men have specialized knowledge of forest plants, in particular medicinal species, thus allowing the transplantation of forest species in the garden. In addition, they travel more frequently than their wives, thus securing planting material sources outside the village. Meanwhile, the women are more knowledgeable of traditional landraces, those of manioc in particular, their intravillage kin and/or social connections allow them to acquire planting material from local sources, and they play nodal roles as disseminators of genetic material within the community. Thus, the men are recognized for their knowledge of wild species and proto-domesticates; the women, for their knowledge of true cultigens. The men are active plant gatherers; the women, active plant traders.

The high-diversity household in Santa Rosa is a particularly interesting case, for it fulfills at once the three key diversity functions – high-diversity, expertise and plant genetic material source. Even though the "official" garden caretaker is the woman, it is her husband, Santiago, who spent most time showing me the plants of the garden, most of which he had acquired himself. When asked about the origin of the garden species, he was the only informant in the entire study who could trace each plant back several exchange nodes to its origin outside the village or even outside the river: not only did he give the names, social ties and provenance of the people who gave him the plants, but also detailed information on where these people had acquired them themselves. His precision demonstrates a keen interest and involvement in his wife's garden. On my first visit to the garden, Santiago named a few forest species which he wished to plant in his garden. "I already have *estoraque* (*Myroxylon balsamum*)", he added, meaning that he had already located and appropriated a sapling of the medicinal tree in the forest beyond the village. Five days later, Santiago called me into the garden to show me three newly planted forest species which he had transplanted following our conversation about plans to enrich the garden. He had previously brought one of these plants from the forest and transplanted it a few meters into the forest edge for readier access until the plant was ready for final transplant in the garden. Acquisition and management of wild species is Santiago's specialty in the garden, certainly because of his role as a traditional healer.

While Santiago is as involved as his wife, if not more, in putting together a diverse garden, she is a prime supplier of planting material in Santa Rosa. Half of the gardens surveyed contain species given directly by Rosa and more than half of the garden caretakers cite her as an expert on manioc.

4.5.4. Importers of genetic material

Source and expert households play a particularly important role in the regional diffusion of planting material. Indeed, it is mostly through them that new species find their way into a village. As experts, their interest in novelty and their will to experiment probably motivates them to broaden the geographical extent of their provisioning networks. As sources, they locally redistribute planting material acquired elsewhere. One striking example is that of the fruit tree *mamey* (*Syzygium* sp.) in Valencia. The tree grows in 16 gardens, eight of which were supplied by one of Valencia's expert and source households, whose heads acquired the plant at the oil company station downriver of San José de Nueva Esperanza.

The same may be true of varietal diversity: in Valencia, an expert gardener explained how she acquired from another household a variety of coconut in exchange for the variety she originally grew in her garden, which she had purchased in the Iquitos market. According to one Pucacuro informant, Clara, the high-diversity farmer, grows uncommon varieties of medicinal plant species, a *mucura* (*Petiveria alliacea*) variety acquired in Trompeteros, for example, which she has given to others in the village. Thus, with their particular behaviour of extravillage acquisitions, outlying households serve to enrich and refresh village plant portfolios. In addition, their propensity to breed forest species may make their gardens loci of experimentation and domestication processes.

In the formation of new villages, source and expert farmers may play particularly dynamic functions. In Santa Rosa, a village founded in 1996, several villagers remember acquiring their first plants from Rosa, who originally transferred many of her plants from her garden in Valencia.

The networks linking experts and suppliers from different villages are impressively dense. Expert, source and high-diversity households are connected with their counterparts in other villages. This interconnection attests to the exceptional embededness of these households in regional networks and their key role as planting material bridges between villages.

4.5.5. Concluding remarks

The use of the notion of "expert farmer" as a broad, all-encompassing concept in the literature on tropical agrobiodiversity may be problematic as it leads to an overly simplified vision of the social dynamics of traditional agriculture. As we have demonstrated in this chapter, the locally recognized experts are not necessarily those that can be identified at first glance because of their exceptional palette of plants. Recognized experts do generally hold high diversity, but not always outstandingly so. Expertise and centrality in exchange networks are more closely related than species richness is related to either expertise or centrality. Information and plants are transmitted alongside and are subject to social restrictions on the dissemination of knowledge. *Mingas*, however, offer a context where plants and information can flow more freely. Unfortunately, little is known about the social organization of garden *mingas* and further study of this practice may yield interesting insights into the mechanisms of plant and knowledge transmission.

Chapter 5. Conclusion

The purpose of this research was to identify the central actors of *in situ* conservation in traditional agricultural societies and to explore the socioeconomic context in which horticulture is practiced in indigenous communities of northeastern Peru. In so doing, the study helps understand the causes of local and regional home garden heterogeneity. The regional distribution of plant species cultivated in home gardens was examined on the Corrientes river, with home garden surveys in 15 Achuar and Urarina villages, and findings were compared to those of previous studies in the Amazon basin in order to assess the role of various indigenous groups in the conservation of agrobiodiversity. The study thus contributes to a larger macro-scale assessment of agrobiodiversity distribution in the Peruvian Amazon. The home garden species surveys and socioeconomic questionnaires in the 15 villages, especially in three focal villages, help understand why different households have varying degrees and types of involvement in home garden horticulture. Answering these questions implied examining closely how plant propagation material is exchanged between households, what socioeconomic factors affect the flow of planting stock, and how garden tenders form their species portfolios. Nodal plant dissemination agents were identified through these analyses. Networks of expertise and knowledge sharing were similarly examined, and local experts were identified. The study allowed us to draw a complex picture of the distribution of agrobiodiversity, of exchange roles and of expertise, which showed that species richness, plant sharing and knowledge dissemination are not as indivisible as may be believed.

5.1. Summary of key findings

Eight findings emerge from the research:

1. The number of home garden crop species cultivated in indigenous communities of the Corrientes river is highly variable at the local scale (between households) and at the regional scale (between villages). On average, a home garden consists of 26 useful plant species. The most diverse garden found in the sample held 78 species. However, whether the owner is rich or poor, Achuar or Urarina, home gardens play similar functions across the sample, with fruit species being the most common type of plant

grown, followed by non-fruit food species and medicinal plants. Other needs are met by garden plants, such as aesthetic pleasure, food seasoning and house construction, but plants used for these purposes are secondary in quantitative importance.

2. The total number of plant species inventoried in the 300-household sample, 308 species, is very large in comparison with findings of previous studies in the Amazon basin. This may be explained in part by the particularly large sample size in the present study. Species diversity is unequally distributed between Achuar and Urarinas, with a total of 297 species encountered in Achuar gardens and 94 in Urarina gardens. The average number of species per Achuar garden (28) compares with the highest diversity groups reported in the literature, the Yaguas and neighbouring *mestizo* communities studied by Lamont, Eshbaugh and Greenberg (1999), whereas the Urarinas, with an average of 14 species per garden, compare with the lowest diversity *mestizo* groups reported (Coomes & Ban 2004; Lerch 1999).

3. Micro-level differences in species richness can be explained in terms of socioeconomic differences between households. Garden size, land assets, garden tender age and gender, and inhouse labour are determinants of species diversity. Wealth in the form of land assets, social capital and cultural capital favours the formation of rich gardens, through access to various agroecological microhabitats (land holding), experience (age), knowledge (age and gender) and labour (inhouse labour).

4. Provisioning networks for planting material are far-reaching and extend well beyond the river basin. Interethnic exchanges are frequent, but plant sharing between the Achuar and the Urarina occurs very infrequently. Villages vary in their geographical patterns of plant acquisition, with Pucacuro, the larger and more ethnically diverse village, relying less on kinfolk outside the village to accumulate species than Santa Rosa and Valencia, the smaller and more homogeneously Achuar villages. Pucacuro, with many of its residents originating outside of the district and with access to better means of regional transportation, sources its plants further away and relies more on urban sources than the other villages. In contrast, inhabitants of Santa Rosa and Valencia turn more readily to relatives in nearby locales, especially upriver where many originate.

5. Intravillage informal networks of exchange are of primary importance in all villages studied. Exchanges are highly uneven and patterned by cultural and

socioeconomic variables. Flow of planting material follows intergenerational kinship channels; in particular, plant gifts are more frequent along the matriline. Spatial proximity and expertise are also predictors of plant flow, with frequent exchanges among close neighbours and gift from expert to advice-seeker. Social and physical capital differentials structure within-village planting material flow. Older and wealthier households generally give germplasm to the younger and poorer households. Indeed, the connectedness and propensity to give of households is closely related to household age, land assets, productive capital and garden species richness.

6. The presence of an oil company in the study region has two-edged impacts on local horticulture. Villages in the vicinity of oil extraction stations are endowed with particularly diverse species portfolios because of the plants provided to local inhabitants by company workers and because of the diverse social landscape of these villages. However, the essential link between a cultivated species and the relevant ethnobotanical and agronomical knowledge seems broken in the case of some of the species originating from oil company sources. In addition, while the oil company has a *positive* impact on the total species diversity of the villages located in its proximity, it has a *negative* impact on the individual households it employs, as these households are generally marginalized actors in the local planting material exchange networks.

7. In many of the villages visited, one or two households stand out with exceptional garden species diversity. The heads of these households are often cited as experts by fellow villagers; however, exceptional high-diversity is not a predictor of exceptional expertise. Source and expertise are more closely related functions, with planting material gift and knowledge transmission going hand-in-hand and occurring preferentially in close kin groups or in the more open social context of the communal work party.

8. Whereas horticultural tasks generally lie with the woman, especially in traditional Achuar communities, task sharing between man and woman occurs in certain exceptional households. Indeed, households that simultaneously have exceptionally species-rich gardens and play outstanding roles as disseminators of planting material and/or knowledge occupy key positions in their village, in part because of a synergy between male and female heads of household, where the man imports planting material to

the household, the woman re-distributes to the village, and each is recognized for specialized, gendered knowledge.

5.2. Implications and conclusion

There is a danger to consider indigenous peoples as generic "stewards" of agrobiodiversity (e.g. Bellon 1996). The findings in this study serve as a warning of caution against the arbitrary equation of "indigenous peoples" with "stewards of agrobiodiversity". On the Corrientes river, two indigenous groups live in close proximity, yet while one holds high garden species diversity, the other is relatively species-poor. The cases examined where Achuar-denominated communities are in fact very mixed groups of Achuar, *mestizos* and Quichuas, suggest rather that the more pertinent relationship is one that links species diversity with social diversity. The ethnic and cultural idiosyncrasies and unique life histories of households rather than their similarities give rise to high species diversity. The Achuar do hold high diversity overall, but between-household differences in the socially mixed so-called "Achuar" villages drive the particularly rich agrobiodiversity observed. Indeed, paying exclusive attention to isolated indigenous communities may not be the most efficient manner to identify hotspots of agrobiodiversity. Our findings rather suggest that agrobiodiversity is found in its widest spectrum in locales that are rich in social and cultural differences.

The impacts of oil activity on agrobiodiversity and agricultural livelihoods in isolated rural communities are not well documented, perhaps because one thinks of oil extractive activities in terms of environmental pollution, which has little direct relevance to agriculture, rather than in terms of impacts on social cohesion. The literature suggests that market integration and the emergence of income-earning opportunities bear negatively on agrobiodiversity, but here the money injected by the oil company in proximate communities, the services offered, especially regional transportation, and, surprisingly, the species it contributes directly, result in an *increase* in local cultivated species diversity. The purported threats to crop diversity posed by market integration must thus be qualified in the light of these findings, which show the resilience of traditional farmers to change in their social and economic environment and their ability to make these potentially adverse changes profitable. At the micro-scale, however, individual households who choose to work for the oil company have less opportunity to get involved into the local networks of plant acquisition. Given the social importance of planting material exchange to forge and consolidate social relations, the marginalization of these actors in plant networks may be detrimental to social cohesion. What is more, unstable employment creates a constant population flux which impedes the firm integration of households into the between-village networks of planting material exchange. These issues deserve special attention, especially today as the involvement of large-scale extractive firms in village life takes the shape of daily interactions with villagers and provision of direct services to the community.

In situ conservation is concerned primarily with the preservation of agrobiodiversity in sites where diversity is high. The focus lies on *where* to promote conservation and *who* to target. While these are indeed essential questions, as addressed here, a critical first step, especially if *in situ* conservation strategies are construed as options to better the well-being of farmers, is to understand in the first place *how* species portfolios are formed. Agrobiodiversity as an asset in livelihood formation is often overlooked. Many informants were willing to cultivate more species but were unable to acquire planting material for the desired plants. Local wealth inequality is not necessarily an obstacle to the smooth exchange of germplasm because the structure of local exchanges favours flow from rich to poor and old to young. However, this flow follows kin pathways and it may be that the smaller, less integrated kin groups have more difficulty forming rich gardens (e.g. Coomes & Ban 2004). Identifying the agents capable of reaching the most marginalized households and those acting as bridges between kin groups would shed further light on patterns of exchanges and would help understand the roots of inequality. Additionally, the mechanisms of interethnic exchanges are still poorly understood. Urarinas appear to have little interest in and/or difficult access to agrobiodiversity, despite their proximity to species-rich Achuar households. Poverty alleviation for more marginalized groups such as the Urarinas may require that obstacles to the free flow of germplasm between ethnic groups be identified and mitigated.

In discourse on *in situ* conservation, the interrelatedness of species richness, willingness and ability to exchange planting material, and expertise, is typically taken for granted (Bellon *et al.* 1997; Tapia 2000). The findings of the study, however, suggest that expertise and species diversity are not as indivisible as would be expected. The implication of this finding is that conservation initiatives that target exceptionally species-rich households may be efficient only in conserving diversity within the targeted household. To ensure that conservation strategies benefit the greatest number of farmers, targeting exceptional source households is more appropriate, especially if these households' knowledge is also widely recognized, as is often the case, because recognition of expertise will ensure that the nodal role played is socially legitimized. Expert and source households import germplasm to their villages and are thus key agents of plant dissemination between communities. As attested by their between-village interactions, regional exchange networks already exist, they are far-reaching and dynamic. The potential role of expert and source households in regional exchange networks is great as these households could be instrumental to the design of regionally integrated conservation strategies. Patterns and mechanisms of intervillage exchange deserve to be described in detail in other regions of the Amazon basin and descriptions need to answer first and foremost the question: *who* are the nodal agents of between-village exchanges?

Perhaps one of the greatest impediments to the freer flow of plant genetic material is the tight link observed between plant dissemination and knowledge transmission. The cultural prescription to contain knowledge within close circles of family and friends prevents propagation material from entering certain gardens. Paradoxically, it is the strength of this association that constitutes the very foundations of *in situ* conservation: knowledge and plant species/varieties survive because they are transmitted alongside one another. The cultural institution of communal work parties, however, provides a way out of this constraining yet essential association because information seems to be exchanged more freely on these occasions. Further study into the role of *mingas* as events fostering exchanges may yield interesting insights into the link between knowledge and plant agrobiodiversity.

Finally, the finding that between seven and 14% of garden species are transplanted from or collected in the forest suggests strongly that some households are engaged in the process of plant domestication. The case of an informant who transplanted the medicinal plant he wished to breed from the forest to the forest edge, and later, when the plant was "ready" for cultivation, to his garden, is a clear example where forest species appropriation and management is a step in the long process of domestication. The place occupied by home gardens at the interface of natural and fully anthropic systems makes it an interesting observatory for the study of domestication. Further description of these processes will provide insights into how Amazonian societies interact with their forest environment and how they restructure natural spaces and resources into socialized agricultural spaces.

Since the prime actors and the most direct beneficiaries of *in situ* conservation are the local farmers, the strategies that will have greatest success and legitimacy are those that are best designed to tailor local needs and that best take into account the local constraints and context. We hope that the contributions of this research towards a greater understanding of the socioeconomic context of *in situ* conservation in traditional Amazonian societies will be a significant step in this direction.

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Appendix 1: List of plants in 300 home gardens of the Corrientes river

Vernacular names are in Spanish unless they were only available in Achuar (italics) or in Urarina (italics with asterisk*). Plants were identified by gardeners and scientific names corresponding to the vernacular terms were compiled from the following sources: Descola (1986), Duke & Vasquez (1994), Kalliola (1998), Krogrstrup (1994), Mejía (1995), Mejía & Rengifo (1995), UNAP & Pluspetrol (1997) and botanists at the Instituto de Investigaciones de la Amazonía Peruana.

Vernacular name	English name	Scientific name (family in brackets when sp. unknown)
Abuta		*Abuta grandifolia*
Aceituna	sweet olive	*Syzygium cuminii*
Achiote	annatto	*Bixa orellana*
Achira		*Canna indica*
Adam con Eva		?
Agengibre	ginger	*Zingiber officinale*
Aguaje	Moriche palm	*Mauritia flexuosa*
Ají dulce	sweet pepper	*Capsicum spp.*
Ají piquante	hot pepper	*Capsicum spp.*
Ajo sacha	garlic vine	*Mansoa alliacea*
Albaca	basil	*Ocimum basilicum*
Alberja		?
Algodón	cotton	*Gossypium barbadense*
Almendras	almond	*Terminalia catappa*
Amapola		?
Amasisa		*Erythrina fusca*
Ambara		?
Andara		?
Andumusisa		?
Anona	sweet sop	*Annona squamosa*
Apach		?
Arbol para bronchio		?
Arroz	rice	*Oriza sativa*
Atadijo		*Trema micrantha*
Aucabombo		?
Ayahuasca	soul vine	*Banisteriopsis caapi*
Ayahuma		*Couroupita guianensis*
Azucar huayo		*Hymenaea courbaril*
Barbasco	Derris plant	*Lonchocarpus nicou*
Barbasco de hoja menuda		*Phyllantus acuminatum*
Bijau		*Calathea lutea*
Bijau grande		(Marantaceae?)
Bijauillo		*Calathea sp.*
Bolaina	West Indian elm	*Guazuma ulmifolia*
Bolsa mullaca	ground cherry	*Physalis angulata*
Bombonaje	Panama hat palm	*Carludovica palmata*
Buseta hembra		*Anthurium sp.*
Buseta macho		*Anthurium sp.*
Caballo caspi		?
Cacahuillo		*Theobroma speciosum*
Cacao	cocoa	*Theobroma cacao*

Vernacular name	English name	Scientific name (family in brackets when sp. unknown)
Cacao del monte		?
Cactus		(Cactaceae)
Café	coffee	*Coffea arabica*
Cahuena		?
Caigua		*Cyclanthera pedata*
Caimito		*Pouteria caimito*
Camote	sweet potato	*Ipomoea batatas*
Camu-camu		*Myrciaria dubia*
Caña brava	uva grass/ giant cane	*Gynerium sagittatum*
Caña de azucar	sugar cane	*Saccharum officinarum*
Candza		?
Cañillas		?
Caoba	mahogany	*Swietenia macrophylla*
Capirona		*Calycophyllum spruceanum*
Carambola	star fruit	*Averrhoa carambola*
Carriso		?
Cashapona	stilt palm	*Socratea exorrhiza*
Cashú	cashew	*Anacardium occidentale*
Catalan		?
Cebolla		*Allium cepa*
Cebolla china	shallot	?
Cedro	tropical cedar	*Cedrela odorata*
Chambira	fiber palm	*Astrocaryum chambira*
Chanca piedra	stone-breaker	*Phyllanthus spp.*
Chanchak		*Miconia* sp. or *Leandra* sp.
Charichuelo		*Rheediaa gardneriana*
Chiclayo	cowpea	*Vigna unguiculata*
Chicle huayo		*Lacmellea peruviana*
Chicorico		*Mangifera indica*
Chimi		?
Chimicua		*Batocarpus amazonicus*
Chirisanango		*Brunfelsia grandiflora*
Chopé		*Gustavia sp.*
Chuchuhuasha		*Maytenus sp.*
Chungamachari		?
Ciruela	spanish plum	*Spondias purpurea*
Coco	coconut	*Cocos nucifera*
Cocoazú		*Theobroma grandiflorum?*
Cocona	peach tomato	*Solanum sessiliflorum*
Coconilla		*Solanum spp.*
Corazón de Jesús	dog's ear	*Caladium bicolor*
Cordoncillo		*Piper spp.*
Cotocaspi		?
Cotohuayo		*Diclidanthera penduliflora*
Cotomicuna		?
Cresto de gallo	cock's comb	*Celosia argentea*
Culantro del país	coriander	*Coriandrum sativum*
Cumala		(Myristicaceae)
Dale dale	sweet cornroot	*Calathea allouia*
Dale dale2		?
Dalia		*Drymonia pendula?*
Dondo		?
Doquisisa		?
Enredadera		*Ipomoea quamoclit*
Estoraque	balsam of Peru	*Myroxylon balsamum*
Flor de la once_2		?
Flor de las once		*Portulaca pilosa*
Flor de Margarita		?
Frejol	bean	*Phaseolus vulgaris*
Gallinazo panga		(Chenopodiaceae)
Grama		*Eleusine indica*

Vernacular name	English name	Scientific name (family in brackets when sp. unknown)
Guaba		*Inga* spp.
Guabilla		*Inga* spp.
Guanabana	soursop	*Annona muricata*
Guarioba		*Clarisia racemosa*
Guayaba	guava	*Psidium guayava*
Guayaba brasilera		*Eugenia stipitata*
Guineo	dessert banana	*Musa acuminata*
Guisador	turmeric	*Curcuma longa*
Hierba Luisa	lemon grass	*Cymbopogon citratus*
Hierba santa	holy weed	*Cestrum spp.*
Huacambillo		?
Huaica		?
Hualocaspi / Hualo		?
Huamansamana		*Jacaranda copaia*
Huasai	heart palm	*Euterpe precatoria*
Huayusa	guayusa	*Ilex guayusa*
Huevo de sachavaca		?
Huicungo		*Astrocaryum macrocalyx*
Huimba		*Ceiba samauma*
Huingo / Pate	calabash	*Crescentia cujete*
Huito	genipap	*Genipa americana*
Iliunga		?
Inchahui		*Syagrus tessmannii*
Inchinda		?
Ishanga		(Urticaceae)
Itininga		*Philodendron megalophyllum*
Kundzekundze		?
Kundzitsik		?
Lancetilla		*Peperomia rubea*
Leche caspi	cow tree	*Couma macrocarpa*

Vernacular name	English name	Scientific name (family in brackets when sp. unknown)
Leina		?
Lengua de boa hembra		?
Lengua del perro / Paichicara	air plant	*Kalancheo pinnata*
*Lidiáne**		?
Lima dulce		(Rutaceae)
Limón	lime	*Citrus aurantifolia*
Limón de la China	Chinese lemon	*Averrhoa bilimbi*
Lucma		*Lucuma macrocarpa*
Lupuna	kapok	*Ceiba pentandra*
Lupunilla		?
Macambillo		*Theobroma subincanum*
Macambo	tiger cacao	*Theobroma bicolor*
Machihuango		?
Maíz	maize	*Zea mays*
Malva		*Malachra spp.*
Mamá nukurí		(Amaranthaceae?)
Mamey		*Syzygium spp.*
Mandarina / Tanjarina	tangerine	*Citrus reticulata*
Mango	mango	*Mangifera indica*
Maní	peanut	*Arachis hypogaea*
Maraca		?
Maracuyá	passion fruit	*Passiflora edulis*
Margarita		?
Marona		?
Mendenupa		?
Menta		*Mentha suaveolens*
Metohuayo		*Caryodendron orinocense*
Mirucun		?
Mishquipanga		*Renealmia alpina*
Mishuisma		*Hibiscus sp.*

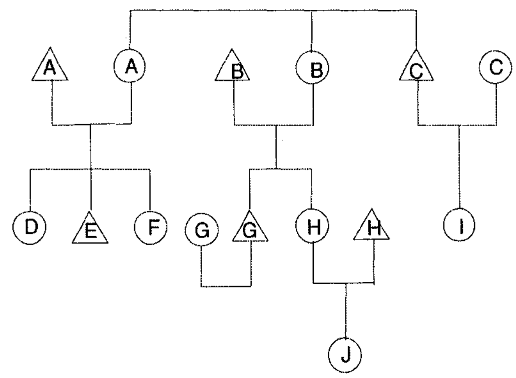
Vernacular name	English name	Scientific name (family in brackets when sp. unknown)
Moena		(Lauraceae)
Motelohuayo		?
Mucura		*Petiveria alliacea*
Muesca		?
Mulchihuayo		?
Muraiari		?
Nakar		*Inga* sp.
Naranja	sweet orange	*Citrus sinensis*
Ñejilla		*Bactris concinna*
Ñukñuk pichana		*Scoparia dulcis*
Ojé		*Ficus insipida*
Ojo de pollo		*Alternanthera halimifolia*
Oreja de conejo		?
Paico	wormseed	*Chenopodium ambrosioides*
Palillo negro		*Psidium* sp.
Palma		?
Palmera		?
Palta		*Persea americana*
Pampa orégano	oregano	*Lippia alba*
Pandishu	bread fruit	*Artocarpus altilis*
Papa china	taro	*Colocasia esculenta*
Papa mandi		(Araceae)
Papailla	bitter cucumber	*Momordica charantia*
Papaya	papaya	*Carica papaya*
Parapara		?
Parinari		*Couepia chrysocalyx*
Pashaco		(Fabaceae)
Patiquina		*Dieffenbachia spp.*
Patiquina blanca		*Dieffenbachia obliqua*
Patiquina del monte		(Araceae)
Patiquina negra		*Xanthosoma purpuratum*

Vernacular name	English name	Scientific name (family in brackets when sp. unknown)
Patiquina roja		(Araceae)
Patita de torracita		?
Pepino		*Cucumis spp.*
Piasaba		*Aphandra natalia*
Pichana / Escoba		*Sida acuta*
Pichicurunto		?
Pichirina		*Vismia angustifolia*
Pichohuayo hembra		?
Pichohuayo macho		?
Pico de perro		(Araceae)
Pijuayo	peach palm	*Bactris gasipaes*
Piña	pineapple	*Ananas comosus*
Piña del monte		?
Piñón blanco		*Jatropha curcas*
Piñón colorado		*Jatropha gossypiifolia*
Piripiri	piri piri sedge	*Cyperus spp.*
Piripiri para juanes		?
Planta medicinal		?
Plátano	plantain	*Musa spp.*
Ponilla		(Arecaceae)
Punga		*Pachira aquatica*
Purma caspi		?
Pusanga		?
Rabanito		?
Rabo de huapo		?
Remocaspi		*Aspidosperma excelsum*
Renaco		*Ficus spp.*
Renaquillo		?
Retama		*Cassia spp.*
Rinchi		?
Rosa cisa	African marigold	*Tagetes erecta*

Vernacular name	English name	Scientific name (family in brackets when sp. unknown)
Rosa cisa macho		?
Rupiña		*Myrcia fallax*
Sabila		?
Sablohuayo		?
Sacha barbasco		?
Sacha cebolla		?
Sacha costado		*Passiflora coccinea*
Sacha culantro		*Eryngium foetidum*
Sacha guaba		?
Sacha guayaba		*Eugenia patrisi*
Sacha huiro		*Costus erythrocoryne*
Sacha jergón		*Dracontium loretense*
Sacha mandi		(Araceae)
Sacha mangua		*Grias spp.*
Sacha papa	yam	*Dioscorea trifida*
Sacha verbena		*Stachytarpheta cayennensis*
Sandía	water- melon	*Citrullus cf. lantanus*
Sangre de grado	dragon's blood	*Croton lechleri*
Santa maría / Maria panga		*Pothomorphe peltata*
Sapahuasca		*Cissus sicyoides*
Sapote		*Matisia cordata*
Sapote del monte		*Quararibea cordata*
Sapotillo		*Manilkara zapota*
Sarahuayo		?
Sarsa		?
Sauco		*Sambucus spp.*
Sebada		?
Secana		*Sicana odorifera*
Seresa		*Eugenia uniflora*
Shacapita		?
Sharamasho		*Ocimun americana*
Shebon		*Scheelea basleriana*
Shepaja		*Scheelea spp.*
Shimbillo		*Inga spp.*
Shinbich		(Solanaceae)
Shingushingu		?
Shungarna		?
Sidra		*Citrus sp.*
Sinamillo		*Oenocarpus mapora*
Sinchina		?
Situlli		*Heliconia spp.*
Socoba		?
Soldado caspi		*Pollalesta discolor*
Suelda		*Phthirusa adunca*
Tabaco	tobacco	*Nicotina tabacum*
Tangarana		*Tachigalia tessmannii*
Taperibá		*Spondias dulcis*
Tingishnumi		?
Toé		*Brugmansia suaveolens*
Toe brasilero		?
Tomate	tomato	*Lycopersicum esculentum*
Topa		*Ochroma pyramidale*
Topa blanca		?
Toronja	grapefruit	*Citrus paradisii*
Tororunto		?
Trigo	Job's tear	*Coix lacryma-jobi*
Tsacura		?
Tsekate		?
Tsimbo		?
Tucunari		?
Tumbo	giant grenadine	*Passiflora quadrangularis*

Vernacular name	English name	Scientific name (family in brackets when sp. unknown)
Tuna		*Opuntia ficus-indica*
Ubos	hogplum	*Spondias mombin*
Umarí		*Pouraqueiba spp.*
Uña de gato		*Uncaria guianensis*
Ungurahui		*Oenocarpus bataua*
Uvilla	Amazon grape	*Pourouma cecropiifolia*
Venado sanango		?
Verbena		?
Verbena negra		*Verbena litoralis*
Verdura		?
Vino huayo		*Coccoloba spp.*
Waiambinumi		?
Waka		*Clibadium spp.*
Wererima		?
Yahuar piripiri / Ungurahuillo		*Eleutherine bulbosa*
Yahuasangan		?
Yahuasuqui		?
Yandgik		?
Yarina	ivory palm	*Phytelephas macrocarpa*
Yarinilla		*Manicaria saccifera*
Yuca	manioc	*Manihot esculenta*
Yute	jute	*Urena lobata*
Zapallo	squash	*Cucurbita moschata*

Appendix 2: Construction of six kinship models



Hypothetical genealogical tree (each letter represents a different household).

a	A	B	C	D	E	F	G	H	I	J
A	0	1	1	0	0	0	0	0	0	0
B	1	0	1	0	0	0	0	0	0	0
C	1	1	0	0	0	0	0	0	0	0
D	0	0	0	0	1	1	0	0	0	0
E	0	0	0	1	0	1	0	0	0	0
F	0	0	0	1	1	0	0	0	0	0
G	0	0	0	0	0	0	0	1	0	0
H	0	0	0	0	0	0	1	0	0	0
I	0	0	0	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0	0	0

b	A	B	C	D	E	F	G	H	I	J
A	0	0	0	1	1	1	0	0	0	0
B	0	0	0	0	0	0	1	1	0	0.5
C	0	0	0	0	0	0	0	0	1	0
D	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
F	0	0	0	0	0	0	0	0	0	0
G	0	0	0	0	0	0	0	0	0	0
H	0	0	0	0	0	0	0	0	0	1
I	0	0	0	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0	0	0

c	A	B	C	D	E	F	G	H	I	J
A	0	1	1	1	1	1	0	0	0	0
B	1	0	1	0	0	0	1	1	0	0
C	1	1	0	0	0	0	0	0	1	0
D	1	0	0	0	1	1	0	0	0	0
E	1	0	0	1	0	1	0	0	0	0
F	1	0	0	1	1	0	0	0	0	0
G	0	1	0	0	0	0	0	1	0	0
H	0	1	0	0	0	0	1	0	0	1
I	0	0	1	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	1	0	0

d	A	B	C	D	E	F	G	H	I	J
A	0	0	0	1	1	1	1	1	1	0
B	0	0	0	1	1	1	1	1	1	0
C	0	0	0	1	1	1	1	1	1	0
D	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
F	0	0	0	0	0	0	0	0	0	0
G	0	0	0	0	0	0	0	0	0	1
H	0	0	0	0	0	0	0	0	0	1
I	0	0	0	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0	0	0

e	A	B	C	D	E	F	G	H	I	J
A	0	0	0	1	0	1	0	0	0	0
B	0	0	0	0	0	0	0	1	0	0.5
C	0	0	0	0	0	0	0	0	1	0
D	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
F	0	0	0	0	0	0	0	0	0	0
G	0	0	0	0	0	0	0	0	0	0
H	0	0	0	0	0	0	0	0	0	1
I	0	0	0	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0	0	0

f	A	B	C	D	E	F	G	H	I	J
A	0	1	0	1	0	1	0	0.5	0	0
B	1	0	0	0.5	0	0.5	0	1	0	0.5
C	0	0	0	0	0	0	0	0	1	0
D	1	0.5	0	0	0	1	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
F	1	0.5	0	1	0	0	0	0	0	0
G	0	0	0	0	0	0	0	0	0	0
H	0.5	1	0	0	0	0	0	0	0	1
I	0	0	1	0	0	0	0	0	0	0
J	0	0.5	0	0	0	0	0	1	0	0

Six kinship models based on hypothetical genealogical tree, with *a)* sibling group; *b)* direct filiation; *c)* immediate kin; *d)* collateral kin; *e)* matriline; *f)* matrilateral ties.

Appendix 3: Survey instruments, Phase 1

Hoja de información – Nivel del caserío

Caserío______________________ Fecha de la visita: De________a________

Nombre del caserío aguas arriba: ______________________
Distancia: desde pueblo aguas arriba: ______ min. con fuera borde 25 hp;
desde Trompeteros: _______ min. con fuera borde 25 hp.

Frecuencia de transporte/negocio: lancha ____ x por semana ____ x por mes
regatones: ____x por semana ____x por mes

de casas: ___________ # de habitantes: ____________

Grupo étnico principal: ______________________
Religión principal: ______________ Iglesia: _____ católica _____ evangélica

Actividad principal: agricultura: __ pesca: __ actividad petrolera: __ extracción: __ otro: ____

Escuela inicial: __ primaria: __ # de profesores: ____ locales ____ destacados
Puesto de salud: ____ Promotor de salud: ____
__ Generadores __ Teléfono __ Radiofonía __ Tienda/bodega __ Motores en la comundiad

Presencia de líderes espirituales/religiosos o curanderos/chamanes: Sí ____ No ____
Detalles: ______________________________________
Tipo de autoridades: ______________________________________

Año aproximado de fundación del caserío: ______________

Inundación importante o otra pertubación en pasado reciente: Sí ____ No ____
Cuándo, qué, amplitud: ______________________________________

Presencia de ONG ahora: Sí ____ No ____ en el pasado: Sí ____ No ____
Detalles: ______________________________________

Influencia de la compañía petrolera:
1. ¿Hay moradores viviendo acá que trabajan por la compañía? Sí ____ No ____
2. ¿Hay moradores que se fueron del pueblo para trabajar por la compañía? Sí ____ No ____
3. ¿Pasan por la comunidad gente de la compañía? Sí ____ No ____
4. ¿Tiene proyectos en la comunidad la compañía? Sí ____ No ____
Detalles: ______________________________________

Hoja de información – Nivel de la casa

Comunidad: ______________________________________
Código de casa: ____________ Fecha: ______________________ 2003
Nombre del jefe: ______________________________ F ____ M ____

¿Cuantas personas viven en la casa? _________

¿Cuantos años tiene Ud.? _______ ¿Y su esposo/a? _______

¿En la casa, quién se encarga del huerto? Nombre: ______________________
Edad: ______________
Relación con el jefe: esposo/a ___ hijo ___ hija ___ madre ___ padre ___ otro: ___
Ocupación principal: agricultura __ pesca __ caza __ actividad petrolera __ otro: ___
Nivel de educación: ______________________

¿Cuál es el tamaño del huerto? __________________ m x m

¿Hace cuantos años que este huerto existe? _______ ¿Y que Ud. se encarga de este huerto? _____

¿Cuántas chacras tiene? ________________ purmas? ________________

Comentarios:
Estatuto o función especial del jardinero en el caserío? (ex. líder, curandero, etc.): ___________
____

Ubicación del huerto en el caserío: central ____ periférico: ____ entre los dos: ____ aislado: ___
¿Huerto adyacente a la casa? Sí ____ No ____

Otros comentarios:
____
____
____

Appendix 4: Survey instruments, Phase 2

Inventario de plantas

PLANTAS	Ahora	Al principio	¿Es remedio?	¿Dónde lo obtuvo? ¿De quién?

Nombre del entrevistado: ______________________

Código de casa: __________

Fecha: ______________________ 2003

Encuesta socio-económica

Comunidad: ______________ Hora de la entrevista: De ______ hasta ______
Código de casa: __________ Fecha: ______________________ 2003
Nombre jefe: ______________ Nomb. jefa: ______________

I. Demografía

Por cada miembro de la familia, inclusive sus padres y los de su esposo/a (presente o ausente):

Nombre	M/F	Edad	Relación	Dónde nació	Dónde vive	Cuándo llegó/ murió	Ocupación

Desde cuándo viven juntos? ______años Desde cuándo viven en esta casa? ______ años
Cuando llegó Ud. (M) en la comunidad? ______ Y Ud. (F)? ______
Han venido para trabajar por Pluspetrol/Petroperu o una compañía contratista? ___ Sí ___ No
Dónde han vivido Uds a parte de esta comunidad?
Juntos: Lugar: ______________ Cuando: __________
Sr sólo: ______________ __________
Sra sóla: ______________ __________

Estatuto especial o función oficial de miembro(s) de la familia: ______________

Por sus hermanos y los de su esposo/a:

Nombre	M/F	Apellidos del esposo/a	Cuántos hijos tiene	Dónde vive

II. Etnicidad

Donde nacieron sus abuelos (M)?
Abuelo paterno: ______________ Abuela paterna: ______________
Abuelo materno: ______________ Abuela materna: ______________

Y Ud., donde nacieron sus abuelos (F)?
Abuelo paterno: ____________ Abuela paterna: ____________
Abuelo materno: ____________ Abuela materna: ____________
Sus padres/abuelos y los de su esposo/a hablan/hablaban otro idioma que el castellano?
Quién: ____________ Idioma: ____________

Ud. o su esposo/a habla otro idioma? M: ____________ F: ____________
Uds., qué idioma hablan mejor? M: ____________ F: ____________

Cual es su religión? M: ____________ F: ____________

Ud. o su esposo/a se identifica con un grupo étnico? M: ____________F: ____________

III. Educación / Viajes

Cuál es su nivel de educación? ___ años de primario ___ años de secundario otro: ________

Ud. y su esposo/a sabe leer? M ___ F ___ escribir? M ___ F ___

Ud. o su esposo/a viaja fuera del caserío? M ________ F________
Cuántas veces este año? _____ Donde? ____________
Por qué razón? ____________

Quién se encarga del huerto? dueño ___ dueña ___ ambos ___ otro ____________

V. Bienes

Bienes	Cantidad	Al empezar	Bienes	Cantidad	Al empezar
Máquina de coser			Canoa (tamaño)		
Máquina de escribir			Peque-peque (hp?)		
Reloj de pared			Bote (capacidad)		
Radio			Motor fuera borde (hp?)		
Televisor			Otra casa (dónde?)		
Equipo de sonido			Pollos/gallinas		
Equipo electrónico (watts)			Patos		
Congeladora/Refri.			Pavos		
Escopeta			Chanchos		
Moto sierra			Ganado		
Tarafa (brazos)			Habilitado		
Red para pescar (m)			Habilitador		
Trapiche					

IV. Terrenos

Tipo de terreno	Altura/restinga/barreal/playa	Tipo de cultivo	Tamaño (m x m)
Actuales			
Al empezar			

VI. Ingresos

Por el año pasado (de agosto 2002 a agosto 2003):

Producto (Unidad)	Produc.	Vend.	Producto (Unidad)	Produc.	Vend.
Yuca (Saco)			Chonta (Palo)		
Plátano (Racimo)			Madera (Trozo)		
Arroz (Kg)			Crisnejas (Un.)		
Maíz choclo (Saco)			Pescado (Kg)		
Maíz grano (Kg)			Carne de monte (Kg)		
Maní (Kg)			Fauna silvestre (Un.)		
Piña (Un.)			Gallinas (Un.)		
Cocona (Sacos)			Cerdos (Un.)		
Sachapapa (Panero)			Pavos (Un.)		
Toronja (Saco)			Vacunos (Un.)		
Aguaje (Saco)			Búfalos (Un.)		
Fariña (Kg)			Artesanía (Un.)		

(Otras posibilidades: umarí, sandía, ungurahui, naranja, papaya, mamey, sapote, pijuayo, caimito, guaba, coco, uvilla, frijol, chiclayo, caigua, suri, tablas, leña vegetal, carbón)

Otras fuentes de ingreso:
Empleo con Pluspetrol o contratista: ________ meses x __________ soles/mes
Jornales: ________ días x ________ soles/día
Bodega/chingana: ____________ ganancia anual
Sueldo del estado/jubilación: __________meses x __________soles/mes
Apoyo económico de parientes: ____________

Encuesta de manejo del huerto y de conocimientos

Comunidad: ____________________ Hora de la entrevista: De ________ hasta ________
Código de casa: ____________ Fecha: ______________________________________ 2003
Nombre del entrevistado: ____

I. Huerto

¿Hace cuántos años que ... este huerto existe? __ años ...este huerto le pertenece a Ud.? __ años
... Ud. se encarga de un huerto? __ años

¿Cómo obtuvieron este huerto? librado __ comprado __ regalado __ herencia __ (de quién ____)

¿Cuál es el tamaño del huerto? ________ m x ________ m

Tipo de tierra: tierra colorada ______ tierra negra ______ otro: ________________

¿Cuánto tiempo dedica al huerto cada semana? ________ horas o cada mes? _________ días

¿Quién más se ocupa del huerto y cuánto tiempo dedica al huerto?
Quién: __________ Tipo de trabajo: ________________ ______ hr/sem. ______ días/mes
Quién: __________ Tipo de trabajo: ________________... ______ hr/sem. ______ días/mes

¿Ud. quisiera tener más plantas en su huerto? _______ sí _______ no
¿Qué les impide tener más?____
¿Cuales serían las ventajas de tener más?__________________________________

¿Puede nombrar las tres personas que le han enseñado más, en su vida, sobre el manejo del huerto y el cultivo de plantas?
1.____________________ 2.____________________ 3.____________________

II. Campesinos de alta diversidad

¿En el caserío, quién tiene más diversidad de plantas cultivadas en su huerto?

1.____________________ 2.____________________ 3.____________________

El Sr. / la Sra. ______________________________ ya le ha dado/vendido plantas a Ud.?

Planta	Fecha	Iniciativa de quién?	Tipo de intercambio	Demostró? Vinó al huerto? Dió consejos? Ud. luego necesitó consejos?

¿Ud. ya le ha dado/vendido plantas a él/ella?

Planta	Cuando	Iniciativa de quién?	Tipo de intercambio	Ud. Demostró? Fue a su huerto? Le dió consejos? Luego le pidió consejos a Ud.?

III. Conocimientos e intercambio

¿Qué variedades de yuca conoce Ud., en castellano y/o en Achuar? ¿A qué sirve cada una?
1.____________________ Uso:____________________
2.____________________ Uso:____________________
3.____________________ Uso:____________________
4.____________________ Uso:____________________
5.____________________ Uso:____________________

¿ Si le enseño una variedad de yuca que no conoce, a quién preguntaría para saber su nombre?
1.____________________ 2.____________________ 3.____________________

¿Qué variedades de plátano conoce Ud., en castellano y/o en Achuar?
1.____________________ 2.____________________ 3.____________________
4.____________________ 5.____________________ 6.____________________

¿Qué variedades de camote conoce Ud., en castellano y/o en Achuar?
1.____________________ 2.____________________ 3.____________________
4.____________________ 5.____________________ 6.____________________

¿Para cada planta que le voy a enseñar, Ud. me puede decir si la conoce y si sí, cuál es su nombre?
1.____________________ 4.____________________
2____________________ 5.____________________
3.____________________ 6.____________________

¿Si una plaga que no conoce afecta sus plantas, a quién pediría consejos?
1.____________________ 2.____________________ 3.____________________
¿Ud. ya tuvo un problema donde necesitó ayuda? __ sí __ no
Cual era el problema? ____________________________________
A quién pidió ayuda? ____________ pueblo: ____________ Relación con Ud: __________
¿Cual fue la solución encontrada?____________________________________

Para la plantas siguientes, me puede decir...

	Su nombre	¿Quién la cultiva en su huerto?		Su nombre	¿Quién la cultiva en su huerto?
1.			3.		
2.			4.		

¿Si quisiera sembrar una verdura/fruta que no se encuentra todavía en el caserío, quién podría ayudar a conseguir las semillas/raíces?
1.____________ 2.____________ 3.____________

¿Si quisiera sembrar una planta medicinal del monte que no se cultiva todavía en el caserío, quién podría ayudar a conseguir las semillas/raíces?
1.____________ 2.____________ 3.____________

¿Puede utilizar petróleo en sus plantas para abonarlas? _____ Sí _____ No

¿Ud. conoce esta planta? ___ sí ___ no ¿En el caserío, a quién...

	¿preguntaría para conocer su nombre?	preguntaría para saber su uso medicinal?
1.		
2.		
3.		

¿Ud. ya tuvo que pedir ayuda para identificar una planta o saber como utilisarla? ___ sí ___ no

A quién pidió ayuda? ____________ pueblo: ____________ Relación con Ud: ____________

Para cada planta que le voy a enseñar, Ud. me puede decir...

	Su nombre	¿A qué puede servir?	¿Qué parte se usa para estó?
1.			
2.			
3.			
4.			
5.			

¿Conoce plantas que se pueden sembrar para mejorar el suelo? ¿Me puede nombrar tres?
1.____________ 2.____________ 3.____________

¿Conoce plantas que pueden servir de veneno para matar los gusanos que atacan las plantas?
1.____________ 2.____________ 3.____________

Le voy a leer los nombres de 6 árboles frutales. ¿Me puede decir cuales tienen semillas que se pueden conservar fuera de la tierra más de tres meses sin malograrse?
____ guayaba ____ guaba ____ sapote ____ caimito ____ papaya ____ maracuyá

Interview guide for high-diversity and expert household interviews

Reconocimiento del huerto:
Por cada especie en el huerto: origen de la planta, intercambio de información, de técnicas, tipo de transacción. ¿A quién a dado/vendido?
Valor económico del huerto: ganancias, gastos, ¿dónde vende? ¿intermediaro?

Origen del huerto y de los conocimientos:
¿Dónde/con quién a crecido? ¿ocupación de los padres? ¿conocimiento de los padres respeto a las plantas?
Descripción del huerto de los padres y del aprendizaje en la niñez.
Recuerdo de huertos con alta diversidad. Descripción del huerto, del jardinero, de la relación con familia del entrevistado.
Estado del huerto al empezar. Adquisición de primeras plantas. Historia del huerto. Futuro del huerto.

Manejo de otras parcelas:
¿Quién se encarga de las chacras, toma decisiones, hace el trabajo?

Experimentación:
Plantas perdidas, abandonadas, ¿porqué?
Plantas del monte. Descripción del proceso.
Aprendizaje de nuevas técnicas durante viajes o en el caserío.

Conservación:
Ventajas/desventajas de tener muchas plantas.

Acceso:
¿Desea más plantas? ¿Cuáles? ¿Planos para adquirir más? ¿Dónde/cómo?
Adquisición de plantas durante viajes.

Transmisión de conocimientos:
Descripción de preguntas que le hace gente del caserío o de afuera sobre el huerto y circunstancias. ¿Ya hubo problemas en el caserío? ¿Quién encontró solución?

Appendix 5: Ethics certificate

McGill

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McGill University
845 Sherbrooke Street West
James Administration Bldg., rm 429
Montreal, QC H3A 2T5

Tel: (514) 398-6831
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Ethics website: www.mcgill.ca/rgo/ethics/human

Research Ethics Board I
Certificate of Ethical Acceptability of Research Involving Humans

Project Title: Agrobiodiversity in Northern Peru: The Role and Nature of Expert Farmers in Traditional Agricultural Societies

Applicant's Name: Mathilde Perrault-Archambault **Department:** Geography

Status: Master's student

Supervisor's Name (if applicable): Dr. O. Coomes

Granting Agency and Title (if applicable): FQRSC scholarship

This project was reviewed on 05/15/03 by

Expedited Review ____
Full Review ✓

15/05/03
Signature/Date

John Galaty, Ph.D.
Chair, REB I

Approval Period: May 15, 2003 to May 14, 2004

REB File #: 549-0503

cc: Geography Dept.
Dr. O. Coomes