PAPERS

How successful is tree growing for smallholders in the Amazon?

L. HOCH[1], B. POKORNY[1] and W. DE JONG[2]

[1] *Institute of Silviculture, Albert-Ludwigs University of Freiburg, Tennenbacherstrasse 4, 79106 Freiburg, Germany*
[2] *Center for Integrated Area Studies, Kyoto University, 46 Shimoadachi-cho, Yoshida, Sakyo-ku, Japan 606-8501*

Email: lisahoch@web.de

SUMMARY

Growing trees outside forests can generate rural income and rehabilitate degraded lands. The characteristics of existing smallholder tree growing in the Amazon and how much it contributes to livelihoods, however, remains largely unknown. Field surveys in Brazil, Bolivia, Peru and Ecuador were conducted of smallholder tree growing initiatives. Of the studied initiatives, 61% were smallholder initiated and 39% established in donor driven programs. Smallholder schemes generally showed a higher species diversity (85 species) than initiatives in donor driven schemes (52 species). The performance of smallholder tree growing, in terms of growth, health, commercialisation options and contribution to recuperation of degraded areas is limited. Only in 30% of the cases reviewed could smallholders commercialize tree products. Cultivated non-timber forest products had the highest commercialisation rates. The growing of single trees within farm holdings, and the management of natural stands and homegardens showed the highest production efficiencies while depending on minimal inputs. Timber plantations are the least successful. More successful reforestation in the Amazon requires a more realistic view on the limitations of promoting smallholder tree growing, should emphasize non timber products, and better capture local knowledge and experiences.

Keywords: Smallholders, Amazon, forest plantations, Agro-forestry, single tree growing, local tree growing initiatives

Quel est le succès de la culture des arbres pour les petits agriculteurs de l'Amazonie?

L. HOCH, B. POKORNY et W. DE JONG

Cultiver des arbres hors des forêts peut générer des revenus ruraux et réhabiliter des terres dégradées. Les caractéristiques de la culture existante des arbres pour petits agriculteurs en Amazonie, et le degré de sa contribution à leurs revenus demeurent cependant largement inconnus. Des études sur le terrain sur les initiatives de culture des arbres ont été conduites au Brésil, en Bolivie, au Pérou et en Equateur. 61% des initiatives étudiées avaient été crées par des petits agriculteurs, et 39% avaient été établies par des programmes soutenus par donations. Les projets des petits agriculteurs avaient en général une plus grande variété d'espèces (85 espèces) que ceux établis par les programmes de donations (52 espèces). La performance de la culture des arbres est limitée, en termes de croissance, de santé, des options de commercialisation et de contribution à la réhabilitation des zones dégradées. Ces petits exploitants ne pouvaient faire commerce de leurs produits dérivés des arbres que dans 30% des cas étudiés. Les produits cultivés autres que le bois avaient le plus fort taux de commercialisation. La culture d'arbres isolés au sein des fermes, et la gestion des peuplements naturels et des jardins obtenaient la plus grande efficacité de production, tout en nécessitant des soins minimaux. Les plantations d'arbres sont les moins rentables. Pour une reforestation à même d'avoir plus de succès en Amazonie, il faut qu'une vision plus réaliste des limitations de la promotion de la culture des arbres par les petits exploitants soit adoptée, que les produits autres que le bois soient encouragés, et que les expériences et la connaissance locales soient comprises.

El exito del cultivo de árboles para los pequeños productores en la Amazonía

L. HOCH, B. POKORNY y W. DE JONG

El cultivo de árboles fuera de los bosques puede generar ingresos para la comunidad rural y rehabilitar las tierras degradadas. Sin embargo, las características actuales del cultivo de árboles en la Amazonía por parte de pequeños productores y su contribución a los medios de vida siguen siendo en gran parte desconocidas. Se realizaron encuestas de terreno en cuanto a las iniciativas de cultivo de árboles por parte de pequeños productores en Brasil, Bolivia, Perú y Ecuador. De las iniciativas estudiadas, un 61% fueron puestas en marcha por parte de los pequeños productores y un 39% establecidas en el contexto de programas impulsados por donantes. Los proyectos de pequeños agricultores mostraban en términos generales una mayor diversidad de especies (85 especies) que las iniciativas organizadas por donantes (52 especies). En cuanto al crecimiento, a la salud, a las opciones de comercialización y a la contribución a la recuperación de zonas degradadas, el

rendimiento del cultivo de árboles es limitada, ya que los productores pudieron comercializar sus productos en solamente 30% de los casos examinados. Los productos forestales cultivados de tipo no maderero mostraban las tasas de comercialización más altas, y el cultivo de árboles individuales en el minifundio y la gestión de rodales naturales y huertas presentaban la mayor eficiencia de producción, dados los factores de producción más reducidos. Las plantaciones de madera muestran el rendimiento más bajo. Una reforestación exitosa en el Amazonas requiere una perspectiva más realista sobre las limitaciones del fomento del cultivo de árboles por parte de pequeños productores, y debería poner énfasis en los productos no madereros y en la captación de conocimientos y experiencias locales.

INTRODUCTION

In the Amazon region, most forest products commercialized in local, national and international markets are extracted from natural forests (Homma 1993, Lentini*, et al.* 2003, Galarza and La Serna 2005). During the last decade, however, the ongoing destruction of primary forests has reduced roundwood production and natural forests are unlikely to be able to meet the growing national and international demand for forest products (Homma 2002, Varmola and Carle 2002, Caetano Bacha 2006). As a consequence growing of trees outside natural forests becomes more and more important in the region for the production of forest products and the provision of environmental services. Tree growing is defined as to include tree planting, tending and cultivation.

Many studies confirm that smallholders in tropical forest regions produce tree products by managing natural single-species stands and tending or transplanting trees in homegardens, agricultural fields or secondary forests (Peck 1982, Hecht 1982b, Posey 1985, Nair 1987, Alcorn 1990, Landauer 1990, Peck 1990, FAO 1998, Kleinn 2000, Byron 2001, de Jong 2001, Pinedo-Vasquez*, et al.* 2001, Schroth*, et al.* 2003, Michon 2005, Sears*, et al.* 2007). For example, Peck (1982) estimated that one million ha of *Cordia sp.* stands had been planted or regenerated in tropical America in the early 1980s; Summers et al. (2004) estimate that more than 30 per cent of recent settlers in Rondônia engage in tree planting; and Smith et al. (1996) and Almeida et al. (2006) identified more than 100 small farmer-driven tree planting initiatives in the Brazilian Amazon. In particular, recent settlers are known to plant trees in small plots or to enrich coffee, cocoa or pepper gardens with tree species (Subler and Uhl 1990).

Smallholder tree growing initiatives are described as highly diverse (Alcorn 1990, Budowski 1990, Byron 2001). Single region studies found, for example, that Quichua families in the Napo lowland in Ecuador grow 24 palm and shrub species (Peck 1990), families in the Peruvian village of Tamshiyacu planted 60 tree species (Hiraoka 1986) and settlers in the Brazilian Amazon managed 70 tree species (Smith*, et al.* 1996, Almeida*, et al.* 2006). While fruit trees are of major importance, many smallholders also plant or protect slow-growing but valuable tropical hardwood species, such as mahogany or tropical cedar (Browder*, et al.* 1996, Smith*, et al.* 1996, Pichon 1997, Simmons*, et al.* 2002, Almeida*, et al.* 2006).

However, critics state a lack of commercial production potential of subsistence oriented local tree growing (Subler and Uhl 1990, Varmola and Carle 2002, Mercer and Pattanayak 2003, Almeida*, et al.* 2006, Caetano Bacha 2006). In response, nearly all Amazonian countries have established plantation programs to increase incomes in rural areas, to rehabilitate degraded areas, and to reduce pressure on the remaining natural forests (Homma 2005, UNFCCC 2005, Almeida*, et al.* 2006, MINAG and INRENA 2006, Ministerio del Ambiente 2006a). These programs usually rely on extension agencies providing guidelines and trainings on site selection, soil analysis and preparation, planting design, site preparation, planting technique, pest management, and monitoring. Most programs establish nurseries to produce seedlings for distribution. Some prominent examples of national reforestation and plantation programs are the "Plantaciones forestales" (1975) in Bolivia, the "Canon de reforestación " (1982 – 2001) in Peru, the "Planfor" (1985-89) and "Planbosque" (1993-96) in Ecuador, and credit programs for cocoa, coffee and oil palm plantations in Ecuador, Peru and Brazil (Alvim 1982, Raña 1987, Peck 1990, Ministerio de Agricultura y Ganadería and INEC 2000, Teixeira 2005, 2006, Ministerio del Ambiente 2006b).

Since the Rio Earth Summit in 1992, also international donors and NGOs have increasingly promoted fruit and timber tree planting in pure stands or intercropped with agricultural products. Well-known examples are the internationally funded coca cultivation substitution projects in Peru and Bolivia, and the program to establish pilot demonstration projects to conserve the Brazilian Amazon forest (Brienza Junior and Gazel 1991, Browder*, et al.* 1996, UNDCP 1997, Martins 2002, Pena-Claros*, et al.* 2002, Simmons*, et al.* 2002, Moreira 2003, Chapin 2004, Almeida*, et al.* 2006).

Few data is available on the real performance of both, local tree growing initiatives and donor promoted tree planting programs (Landauer 1990, Byron 2001, Varmola and Carle 2002), but a handful of studies point towards serious difficulties of the donor programs (Subler and Uhl 1990, Browder and Pedlowski 2000, Simmons*, et al.* 2002, Varmola and Carle 2002, Mercer and Pattanayak 2003, Summers*, et al.* 2004, Almeida*, et al.* 2006, Caetano Bacha 2006). Plantations suffer from high mortality rates caused by insect attacks, fires and floods, or are abandoned (Raña 1987, Aguirre 2005, Terán*, et al.* 2005). Consequently, very few smallholders ever capture the benefits that were promised at the beginning of projects (Peck 1982). For instance, in the Rondonia Agroforestry Pilot Project (RAPP) over 60 per cent of the established agroforestry fields survived after 10 years, but less than one-third of these plots

had generated any monetary income, apart from agricultural crops cultivated during the first two years. The smallholders who commercialize some of their produce, sold only small quantities in local markets (Browder*, et al.* 2005). Assessments, however, are limited to early project years and mostly relate to planted areas, the number of seedlings distributed, and early growth rates (INRENA 2002). Data on environmental outcomes of smallholder tree growing are even rarer.

Recent national and departmental reforestation programs in Brazil (*Plano nacional de silvicultura com espécies nativas e sistemas agroflorestais*; Pensaf, 2007), Ecuador (*Plan de forestación y reforestación*; PNFR, 2006) and Peru (*Programa de reforestación*; 2006) continue to promote tree planting of up to one million ha or one billion trees, targeting more than 100 000 smallholders (Terán*, et al.* 2005, MINAG and INRENA 2006, Ministerio del Ambiente 2006b, MMA*, et al.* 2007, Governo do Estado do Pará 2008). New rural credit programs have been launched to regenerate deforested areas, for instance the 2002 Brazilian *Pronaf florestal* (Caetano Bacha 2006). In this situation, a critical review of past efforts and its success deems necessary to find out how successful these initiatives in fact are.

This paper, based on the comparative assessment of donor-driven and smallholder initiated tree growing in the Amazon basin,[1] will show that donors promote tree plantations with little success, neglect the limitations of externally supported tree management schemes, and underestimate the potential of locally initiated tree growing to meet economic and ecological objectives. Experiences from 80 smallholders with locally developed and donor supported tree growing demonstrated that (1) local practices are rarely considered in externally supported initiatives; (2) smallholder initiatives encompass a larger diversity of species than externally supported initiatives, (3) up to date externally supported plantation initiatives have not resulted in higher commercialisation rates than local initiatives, and (4) the environmental outcomes of tree growing is overestimated and can be improved through the management of natural regeneration.

METHODOLOGY

Concepts

The term *smallholder* as used in this paper represents farmer families in the rural Amazon, whose livelihoods depend on family labour, natural resource management, and small capital investments. They include indigenous or quasi-ethnic groups (Chibnik 1991), locally-born non-tribal residents and recent migrants. Typically, smallholders in the Amazon live either in small, often remote villages on collectively-held land or on individual plots along roads with better access to markets. Smallholder private holding sizes in the Amazon vary from around 25 ha in Ecuador to up to 150 ha in Brazil (Alterações no código florestal 1965/2001, Bilsborrow*, et al.* 2004) and indigenous communities may hold up to several thousand ha of communal land (D'Antona*, et al.* 2006).

Smallholders plant or tend high value timber, fast-growing timber or non timber forest products (NTFP) in single or few species plantations or natural stands, intercropped agroforestry fields, enrichment plantings in residual and secondary forests, homegardens, or as dispersed trees with no clearly identifiable arrangement (Anderson 1950, Nair 1985). These different ways of growing trees are called here tree growing types. Smallholders grow trees under various establishment schemes: (1) local or smallholder devised tree growing schemes (smallholders schemes) , where smallholders implement tree growing as traditional practices or locally developed management systems; (2) donor programs or projects (donor driven schemes), where tree planting is promoted by NGOs or governmental extension agencies, often financed by international donors, governmental programs, research organizations or banks; and, (3) forest company outgrower-schemes, where a company under contractual agreements provides smallholders with technical assistance to grow trees on their own land to be sold to the company (Mayers and Vermeulen 2002, Varmola and Carle 2002). Because long-term experiences with outgrower schemes in the Amazon do not exist, the paper only deals with smallholder and donor driven schemes.

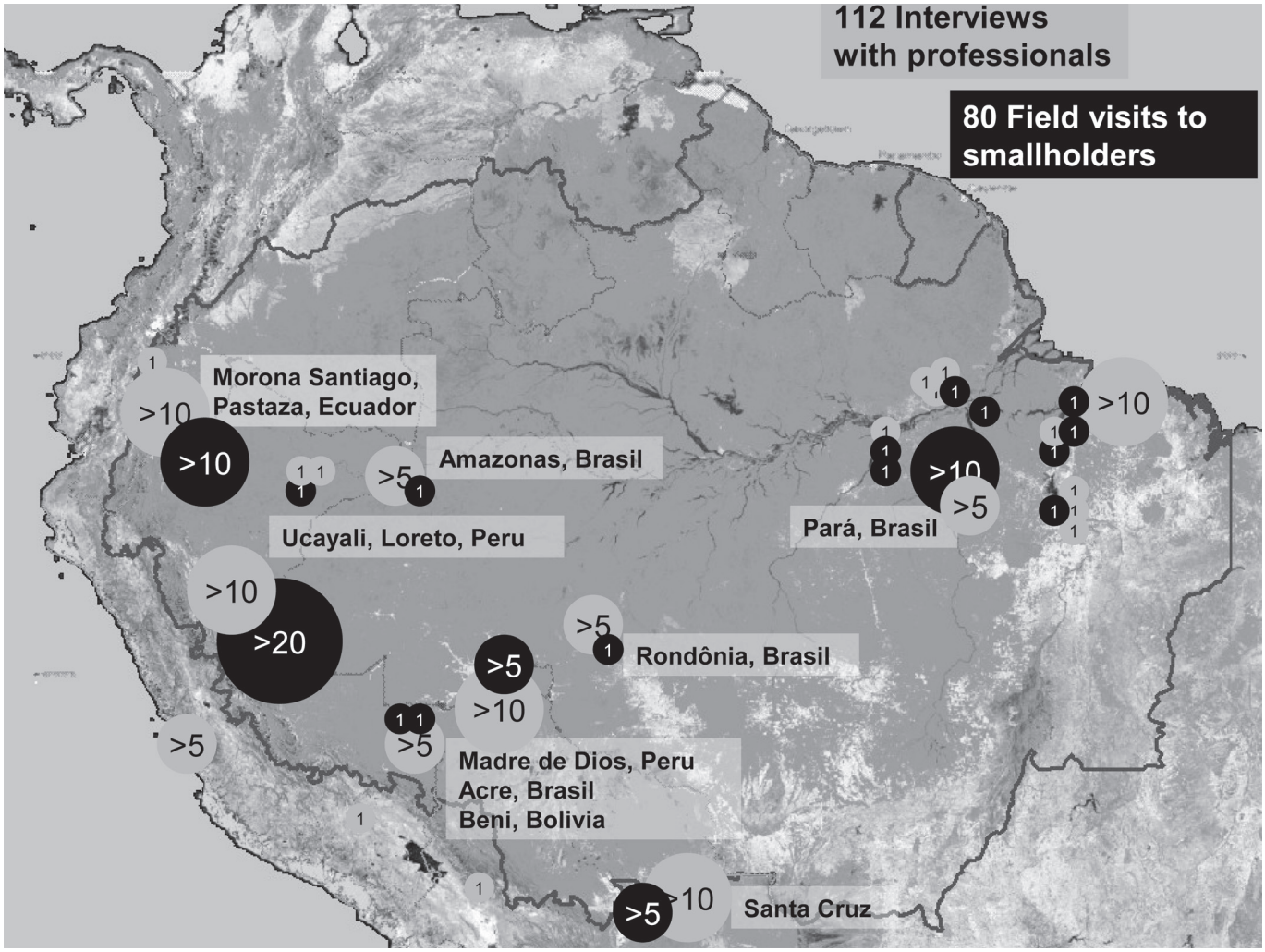
Information sources

The paper is based on three explorative field surveys carried out in 18 regions in 11 Amazonian states between 2005 and 2007 (Figure 1). The study regions were selected based on institutional arrangements with partner organizations and to be geographically representative. A total of 112 forestry and rural development professionals were interviewed on donor driven programs, to record the nature of the tree growing that was promoted and to evaluate the overall success, based on subjective assessments of the interviewees. In addition, based on information from the interviews, 71 smallholders with promising tree growing initiatives in the Amazon regions of Bolivia, Brazil, Ecuador and Peru were selected for in-depth studies in the field. For comparison, nine additional smallholders were visited indicated as never having planted trees (Table 1).

The sampled smallholders included long-time residents, indigenous communities (*Shuar* in Ecuador, *Shipibo* in Peru) and communities in Bolivia and Brazil who settled into the Amazon during the rubber boom of the early 20th century, as well as more recent settlers. The field visits lasted from 10 minutes to one day, but averaged 1-2 hours, depending on the relevance, accessibility and interest of each smallholder.

[1] The study was part of an EU-financed international research project: Forest management by small farmers in the Amazon – An opportunity to enhance forest ecosystem stability and rural livelihoods – ForLive (http://www.waldbau.uni-freiburg.de/forlive/Project.html).

FIGURE 1 *Location of interviews and field visits. The paper is based on three explorative field surveys carried out in 18 regions in 11 Amazonian states.*



Map source Eva and Huber (2005)

The 80 smallholders together had 225 distinguishable tree growing initiatives.

Information was collected about the smallholder's family (composition, age, culture) and property (size, land uses). Each tree growing initiative was categorized according to establishment scheme (smallholder or donor driven) and tree growing type (plantation or natural stand of high-value timber, fast-growing timber, or NTFP; intercropped agroforestry field, enrichment planting, homegarden or single tree growing). Observations were made on site characteristics, area under cultivation, species composition and species provenance (local or external; Amazonian or exotic), establishment techniques (planted, naturally regenerated, transplanted or remnant trees), management regime (frequency and techniques of weeding, other treatments) and the age, size and quality of the trees. Each initiative's performance was classified as *good* if principally healthy; *medium* if some problems had occurred; and *poor* if many trees were dead or almost dead. Data was also collected about any products harvested to date, products sold or used for subsistence needs, as well as problems that occurred with commercialization. Finally, the smallholders were asked to assess the positive or negative environmental effects of each tree growing initiative.

RESULTS

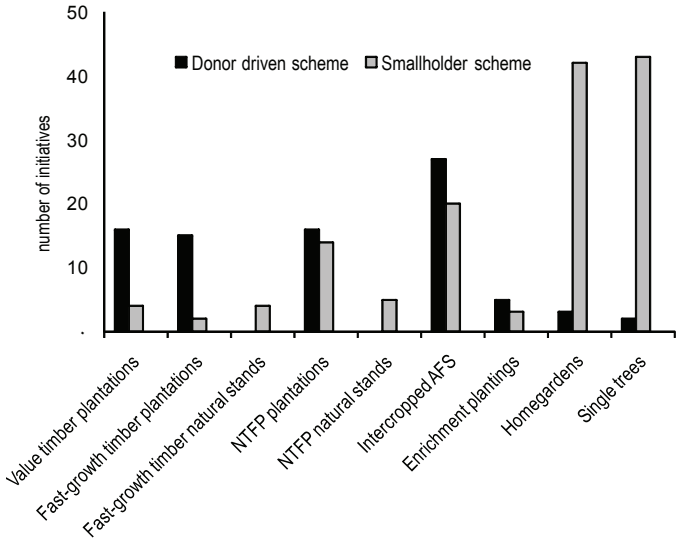
How do smallholders grow and donors promote trees in the Amazon?

All visited smallholders, even those indicated by the interviewed local professionals as *non-planters,* grew trees, independent of cultural background, geographical location or land tenure situation. Figure 2 indicates that the visited smallholders preferentially established homegardens, tended, planted or transplanted single trees, but also intercropped tree species in agroforestry fields, planted NTFP species and managed natural tree stands, such as for example in the case of *Euterpe oleracea* Mart. along river banks in Brazil, *Aphandra natalia* Balslev & A.J. Hend in Ecuador and *Mauritia flexuosa* L. in Peru. Data also indicates that in

TABLE 1 *Characteristics of interviewees and tree planting initiatives*

Aspect	Category	N	%
Type of professional (112 professionals from 88 organizations)	Researchers	28	25%
	NGO workers	28	25%
	Government employees	25	22%
	International development experts	9	8%
	Industrials	9	8%
	Smallholder representatives	8	7%
	Civil society	5	4%
Type of smallholder (80 case studies)	Long-time residents	27	34%
	Recent settlers	53	66%
Access of small holder residence	River sites	17	21%
	Road + river access	4	5%
	Road sites	59	74%
Initiatives held by 80 smallholders		225	
Classification of initiatives in implementation schemes	Smallholder initiatives	138	61%
	Donor initiatives	87	39%
Year of establishment of initiatives	Before 1980	25	11%
	1980s	38	17%
	1990s	86	38%
	From 2000 on	77	34%

FIGURE 2 *Initiatives found in the case studies. Smallholders preferentially establish homegardens, tend, plant or transplant single trees. Donor driven schemes focus on single-species plantations of timber and NTFP as well as intercropped agroforestry fields.*



donor driven schemes, single-species plantations of timber and NTFP as well as intercropped agroforestry fields were most common, in addition to the occasional promotion of enrichment planting. In contrast, homegardens or single-tree growing were seldom promoted in donor driven schemes.

Homegardens and single tree growing were found even among the remotest smallholders who in some cases needed to travel more than 40 hours to the nearest urban centre (Figure 3). Also intercropped agroforestry fields were not limited to any specific distance from urban centres. Only managed single species stands, tree plantations and enrichment plantings were more frequently found closer to urban centres.

The size of single plots under tree production varied between 0.25 ha and 135 ha. There was no marked difference in size between tree growing initiatives under donor driven or smallholder schemes, nor between settlers and long-time residents (Figure 4). The overall single plot average (median) was 3.75 ha and the most typical size varied from 1 to 3 ha. The largest tree growing plots were enrichment plantings in Peru, cocoa plantations along the Transamazonian highway in Brazil, and dense stands of natural regenerated pioneer species in the higher elevations of the Ecuadorian Amazon. In all study regions, some smallholders were found who planted exceptionally many trees.

The field assessment revealed that the different establishment schemes correlated with specific specific tree establishment techniques. In 91 per cent of the initiatives under donor driven schemes seedlings came from nurseries and were transplanted in polyethylene bags. In contrast, smallholders planted seedlings from nurseries in only 26 per cent of the cases. In 32 per cent of the cases they protected or transplanted naturally regenerated seedlings and in 42 per cent they combined planting and protecting natural regeneration. In both schemes single-species plantations were often combined with agricultural crops like cassava (*Manihot esculenta* L.), sweet potato (*Ipomea batatas* (L.) Lamb) and corn during the first one to two years.

FIGURE 3 *Distances of visited smallholder initiatives to the nearest city (>200 000 inhabitants). Homegardens, single tree growing and intercropped agroforestry fields were not limited to any specific distance from urban centres. Managed single species stands, tree plantations and enrichment plantings were more frequently found closer to urban centres.*

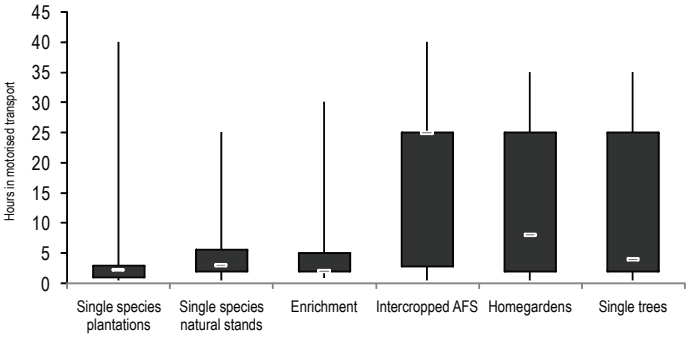
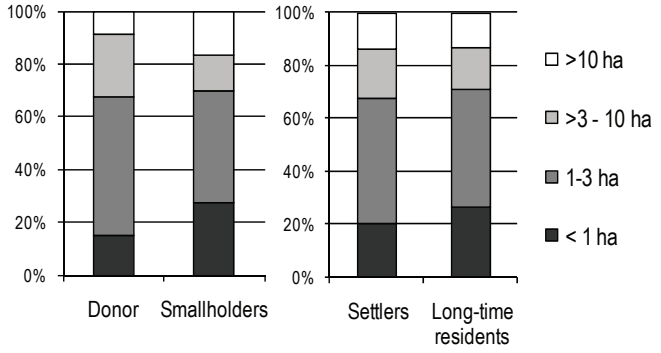


FIGURE 4 *Areas used for tree growing by establishment scheme and smallholder type. The size of single plots under tree production varied between 0.25 ha and 135 ha, with no marked difference in size between tree growing initiatives under donor driven or smallholder schemes, nor between settlers and long-time residents.*



Smallholders generally tended to avoid time consuming silvicultural treatments. In their own schemes, in more than 85 per cent of the studied initiatives, smallholders invested time in regular slash-weeding of their plots, however only between one and four times per year. In many single-tree growing initiatives, smallholders considered slash-weeding unnecessary or did so only directly around the single trees. Smallholders joining donor driven schemes generally tended to not follow the recommendation given by the technicians to do slash-weeding three to four times per year during the first two to three years, and carried out this activity only occasionally or until donor support stopped. Only smallholders engaging in agroforestry and NTFP planting projects which provided long-term support (22 per cent of the studied initiatives under donor driven schemes) followed more strictly the technical guidelines.

In both establishment schemes, once the trees were firmly established after three to five years, smallholders avoided treatments such as pruning or thinning, except in cases of cash crop production (such as cocoa, coffee, cupuaçu (*Theobroma grandiflorum* (Willd. Ex Spreng.) K.Schum). Generally, smallholders did not use pesticides except in the case of oil palm cultivation. They seldom used chemical or natural fertilizers (leaf litter, pig or cattle dung). However, in particular in agroforestry fields, they seeded leguminous plants to improve soils and control weeds. Smallholders also grew trees in secondary forest or tolerated regeneration around planted trees in order to avoid pests.

How many and which species are grown?

During the field visits 101 species were recorded in the visited initiatives (Table 2). Overall, smallholder schemes showed a higher diversity than the donor driven schemes, which however also showed a wide variety of species. This high species diversity was found in all tree growing types, but was highest for planting and tending of single trees (Table 3).

More than 75 per cent of the species identified in the field were native to the Amazon. In both establishment schemes about 66 per cent of the species were principally grown for NTFP and not for the production of timber. The most common fruit-producing species were citrus (*Citrus sp.)*, cocoa *(Theobroma cacao* L.*)*, Brazil nut (*Bertholletia excelsa* H.B.K.) and copuazú (*Theobroma grandiflorum* (Willd. Ex Spreng.) K.Schum). Smallholders also planted or protected a variety of palms, in particular peach palm (*Bactris gasipaes* Kunth.) and asahi (*Euterpe oleracea* Mart., *E. precatoria* Mart.*)* and medicinal trees such as copaiba (*Copaifera reticulata* Ducke). The most common timber species were mahogany (*Swietenia macrophylla* King*)* and cedar (*Cedrela odorata* L.*)*. Technicians pointed out that the latter two species are often explicitly demanded by smallholders participating in donor driven schemes. Also fast-growing pioneers such as *Schizolobium amazonicum* Huber ex Ducke or *Guazuma crinita* Martius were commonly grown for timber.

How successful is market oriented forestry production?

Market oriented forestry production appears to be only moderately successful. Only one third of the visited smallholders had commercialized tree products, independently of whether they received or not external support. More than half the smallholders participating in donor driven schemes had not yet produced any consumable or marketable products at all, although indicated by the supporting organisations as most promising examples. Most commonly, the successfully commercialized tree products came from NTFP plantations, natural fruit stands or naturally regenerated fast-growing species and intercropped agroforestry fields (Figure 5). In more than 10% of the cases, perishable fruits and lack of market access frequently resulted in the complete loss of the harvest. In contrast to market oriented plantations established under donor driven schemes, smallholders in own schemes regularly benefited from the grown trees for subsistence use (Table 4).

TABLE 2 *The 25 most common species found in the fields of 80 Amazonian smallhold*

Scientific name	Family	Local names (BR=Brasil, PE=Peru, EC=Ecuador, BO=Bolivia)	Type*	Planted or natural regernation	Origin	N
Swietenia macrophylla King.	Meliaceae	Mogno (BR), Caoba (PE), Aguano (EC), Mara (BO)	VT	Planted	Amazon	41
Cedrela odorata L.	Meliaceae	Cedro	VT	Both	Amazon	28
Tabebuia serratifolia (Vahl) Nichols.	Bignoniaceae	Ipê (BR), Tauari (PE), Tajibo (BO), Guayacán (EC)	VT	Both	Amazon	19
Cordia sp.	Boraginaceae	Freijó (BR), Picana (BO), Laurel (EC)	VT	Both	Amazon	12
Tectona grandis L.F.	Verbenaceae	Teca	VT	Planted	exotic	9
Cedrelinga catenaeformis (Ducke) Ducke	Leg.-Mimosoideae	Tornillo (PE), Mara macho (BO), Seique (EC), Cedrorana (BR)	VT	Both	Amazon	7
Bertholletia excelsa H.B.K.	Lecythidaceae	Castanha (PE), Almendra (BO), Castanheiro (BR)	NT+VT	Both	Amazon	15
Dipteryx odorata (Aubl.) Willd.	Leg.-Papilionoideae	Almendrillo (BO), Shihuahuaco (PE), Cumarú (BR)	NT+VT	Both	Amazon	10
Carapa guianensis Aubl.	Meliaceae	Andiroba (BR)	NT+VT	Both	Amazon	8
Amburana cearensis A.C. Sm.	Leg.-Papilionoideae	Roble, Tumi, Ishpingo	NT+VT	Both	Amazon	7
Citrus sp.	Rutaceae	Citricos	NT	Planted	exotic	29
Theobroma cacao L.	Malvaceae	Cacau, Chocolate	NT	Planted	Amazon	19
Bactris gasipaes Kunth.	Arecaceae	Pupunha (BR), Chonta dura (EC), Pijuayo (PE)	NT	Planted	Amazon	19
Theobroma grandiflorum (Willd. Ex Spreng.) K.Schum	Malvaceae	Copoaçú (BR), Copoazú (BO)	NT	Planted	Amazon	16
Euterpe oleracea Mart./precatoria Mart.	Arecaceae	Açaí touceira (BR), Asahi solteiro (BO)	NT	Both	Amazon	15
Inga sp.	Leg.-Mimosoideae	Guaba, Inga, Pacay, Shimbillo (PE)	NT	Both	Amazon	15
Coffea arabica L.	Rubiaceae	Café	NT	Planted	exotic	10
Copaifera reticulata Ducke	Leg.-Caesalpinoideae	Copaibo, Copaíba (BR)	NT	Both	Amazon	9
Mangifera indica L.	Anarcadiaceae	Mango, Mangueiro (BR)	NT	Planted	exotic	9
Attalea speciosa Mart. Ex. Spreng.	Arecaceae	Babaçu (BR), Motacú (BO), Shebon (PE)	NT	Regenerated	Amazon	8
Chrysophyllum sp.	Sapotaceae	Caimito (PE, EC)	NT	Both	Amazon	7
Croton draconoides Müll. Arg.	Euphorbiaceae	Sangre de grado (PE), Sangre de drago (EC)	NT	Both	Amazon	7
Schizolobium amazonicum Huber ex Ducke	Leg.-Caesalpinoideae	Cerebó (BO), Paricá (BR), Pachaco (EC)	FG	Both	Amazon	18
Guazuma crinita Martius.	Malvaceae	Bolaina (PE)	FG	Both	Amazon	16
Calycophyllum spruceanum (Benth.) Hook	Rubiaceae	Capirona (PE), Pao mulato (BR)	FG	Both	Amazon	13

*VT: High value timber; FG: Fast Growth timber; NT: Non timber forest products

For the interpretation of the above observations, it should be taken into account that many of the visited donor driven schemes had not yet reached the stage in which marketable products could be harvested. However, frequently technical difficulties and poor performance of the plantations were already visible in the field (Figure 6). Especially valuable timber plantations and enrichment plantings showed strong deficits and low growth rates, while single-tree growing as

TABLE 3 *Comparison of number of grown species between schemes and tree growing typ*

Number of species	Smallholder initiated	Donor driven	Any scheme
Single species stands	28	29	40
Intercropped AFS	38	35	49
Enrichment plantings	11	16	20
Homegardens	34	4	36
Single trees	50	3	50
Any tree growing type	85	52	101

well as natural stands and plantations of fast growing species performed comparatively well, independent of the age of the trees. Experts with extensive experience in reforestation projects confirmed these field observations in the interviews. They estimated that only approximately 5-10 per cent of smallholders continued to maintain plantations once project support stopped.

FIGURE 5 *State of production and commercialization of different initiatives. Most commonly, the successfully commercialized tree products came from NTFP plantations, natural fruit stands or naturally regenerated fast fast-growth species and intercropped agroforestry fields.*

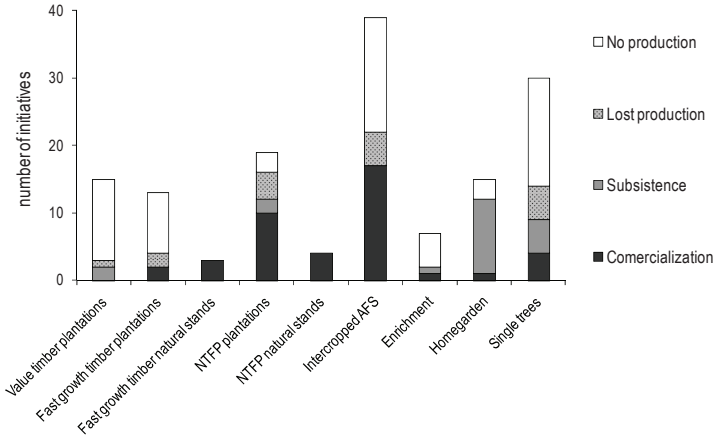
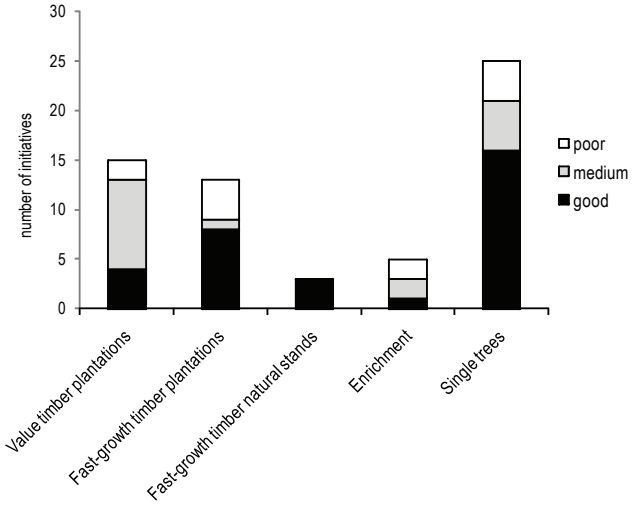


TABLE 4 *Forest product generation and commercialization*

State of production	Donor initiatives	Smallholder initiatives
Commercializing (some products)	29%	30%
Generation of subsistence products	4%	23%
Not producing (yet)	57%	34%
Lost production	10%	13%

FIGURE 6 *State of health of different timber based tree growing. Value timber plantations and enrichment plantings showed strong deficits, single-tree growing, natural stands and plantations of fast growing species performed comparatively well.*



How important are environmental outcomes?

Very few of the smallholders interviewed stated environmental outcomes to be the main reasons for growing trees. Plantations of NTFP and fast-growing species were even seen as not providing any environmental services. Only five per cent of the smallholders considered positive environmental outcomes when selecting sites for tree planting. However, two-thirds considered their trees to have positive environmental outcomes. Smallholders identified shade for perennial crops, fresh air, better working conditions and the protection and improvement of soils as the most important environmental benefits (Table 5). Some smallholders highlighted positive health effects of shade to their perennials. No smallholders observed clearly quantifiable effects of trees on the productivity of the agricultural crops cultivated in the shade of the trees. Soil improvement was principally attributed to leguminous plants incorporated in agroforestry systems, but not to the trees. This rather low perceived contribution of trees to soil improvement partly reflects that smallholders rarely establish tree plantations or agroforestry fields on degraded soils. Instead, more than two-thirds of the visited smallholders grew their trees near houses and roads on more fertile soils with good production conditions, to diminish risk and ensure an adequate performance.

Generally, smallholders assessed secondary and primary forests to be more important for soil and also water protection than the trees they grew outside these natural forests. One-fifth of the interviewed smallholders, however, mentioned the general importance of trees for water protection. Quotations regarding the protection from wind or erosion was nearly absent as not being of major concern in the region. Several smallholders mentioned the aesthetic value of trees. Occasionally other benefits such as pest control and

TABLE 5 *Provision of environmental services through tree growing as mentioned by the farmers*

Environmental service	Proportion of farmers who mentioned the service
Shade	34%
Soil improvement	32%
Water protection	22%
Aesthetic value	15%
Protection from wind	10%
Erosion control	7%

education opportunities were identified.

Only 15 per cent of the visited smallholders mentioned some negative environmental effects of tree growing. One interviewee stated a modest decline in agricultural productivity due to shading, however pointing out that this effect could easily be avoided by reducing the density of the planted trees. In cases, dense stands of pioneer species were mentioned as sometimes causing excessive soil moisture or some exotic leguminous trees spreading out of control. Smallholders engaged in agroforestry stated that the felling of trees in agricultural fields is almost impossible as this may damage other cash crops. Some assessment of environmental benefits appeared to be influenced by how satisfied smallholders were in general with their tree plantations.

Some environmental organizations promote tree planting to reduce pressure on primary forests by generating alternative sources of income. But, the study did not find evidences for plantations influencing the way smallholders deal with primary forest. Obviously, tree growing was mostly not financially rewarding enough to have either positive or negative effects. Only eight per cent of the visited smallholders had planted trees in recently cleared natural forests. Most smallholders (68 per cent) combined trees with their agricultural production and did not substitute any other land use. Substitution of other land use did happen principally in donor driven schemes (67 per cent) where plantations were established on former agricultural land or had replaced secondary forests.

DISCUSSION

The study confirms that smallholders in the Amazon grow trees as an intrinsic component of their complex production systems. Trees are grown by all types of smallholders independent of geographic, cultural, institutional and environmental circumstances, in different intensities applying different practices for varying purposes. The area, amount of labor and capital investment dedicated to tree growing depend to a large extend on the specific motivation and background of the tree grower, independent of belonging to indigenous groups, traditional communities or settlers (Smith, *et al.* 1996). As most smallholders establish homegardens or grow single trees in their agricultural fields, most initiatives under smallholder schemes do not appear in official statistics. Probably this is one of the reasons why organizations and technicians promoting tree plantations tend to assume that smallholders lack a cultural disposition or have little knowledge of tree growing (INRENA 2002, Varmola and Carle 2002, Wightman, *et al.* 2006).

Smallholders apply a wide range of techniques to grow trees, including planting, transplanting, leaving remnant trees and protecting natural regeneration. Donor driven schemes concentrate on the planting of seedlings from nurseries. Smallholders tend to provide a regular low-input maintenance in their own schemes. In donor driven schemes they rarely continue regular plot maintenance, once external support stops.

The study demonstrated a high diversity of species (85) in smallholder tree growing schemes, and donor driven schemes (52). Under both schemes particularly native species for the production of NTFP are grown. Considering also other studies from the Bolivian lowlands, the Ucayali region in Peru and colonization regions in Brazil (Almeida, *et al.* 2006, Montero 2007) smallholders grow more than 150 tree species outside of forests.

The study revealed that the trees grown tend to have a rather poor performance. Smallholder schemes provide the significant advantage of requiring very low inputs while providing important contributions to subsistence needs. In several cases (30% of the studied sample), some of the generated tree products could be sold mainly on local markets and thereby generating attractive additional incomes. For this purpose, local markets seem more compatible with smallholders' priorities and livelihoods than regional, national or international markets (Browder, *et al.* 2005, Ortiz Camargo 2007, Serra, *et al.* 2007). Donor driven plantations promoted in the last decades do not show a better commercial performance than low input smallholder schemes. Only 30 per cent of the sampled initiatives had resulted in the commercialization of products. Being intended as a commercial alternative to unsustainable cattle ranching or market oriented agriculture, these plantations have not fulfilled the expectations. The same plantations are also intended to rehabilitate degraded lands to restore forests, which can more easily be achieved by favouring natural regeneration.

One very concerning insight gained in this study was that externally promoted tree plantation initiatives seem to widely ignore local capacities and knowledge. Almost none of the development agencies involved in the plantation projects considered traditional tree growing practices. This is even more surprising, as many researchers have identified and acknowledged the richness and comparatively high potential of local knowledge and tree growing initiatives (Hecht 1982a, Padoch, *et al.* 1985, Budowski 1990, Landauer 1990, Sears, *et al.* 2007). Even highly qualified extension agents still have difficulties with adequately considering smallholders' requirements and capacities as observed by Byron (2001). Lack of feedback on the assistance provided and top-down transfer of technology packages likely contribute to this situation.

There are two options to respond to this tree growing

promotion quagmire. Donor driven schemes may consider improving extension services to provide continuous and long term assistance to local farmers, and concentrate efforts on non timber forest products with good markets (Clement 2004). A second option is that the conventional donor schemes refocus their attention to support smallholder tree growing schemes. The study shows that there is a still very much underexplored potential to further develop and improve low input, locally developed tree growing in the Amazon. More than anything, efforts to promote smallholder tree growing in the Amazon basin needs to be based on more realistic expectations, as reflected in the words of a Peruvian plantation expert about his personal lessons learnt from several decades of involvement in plantation projects (A. Ricse, pers. comm. 2005).

> "In the year 1980 we discussed that as we are planting now, we will sell timber by the year 2000. By 2005 we had not even sold one single pole. Now the same thing is discussed again as in 1980, that by the year 2020 we will sell timber. I tell you, it is easy to talk, the computer writes down anything, but we need to be very serious about that."

ACKNOWLEDGEMENT

The authors would like to thank the Forlive partners and the CIFOR editor for their valuable support as well as the highly interesting contributions of the many experts, technicians and smallholders. The valuable suggestions made by anonymous referees are gratefully acknowledged.

REFERENCES

AGUIRRE, R. R. V. 2005. Capacitación en monitoreo del desarrollo de plantaciones y su raleo (Chimore, Cochabamba), Chimore.

ALCORN, J. B. 1990. Indigenous agroforestry strategies meeting farmers' needs. *In: Alternatives to deforestation. Steps toward sustainable use of the Amazonia rain forest*. A. B. Anderson (ed.). Columbia Univ. Pr., New York.

ALMEIDA, E., SABOGAL, C. and BRIENZA, S. 2006. *Recuperação de áreas alteradas na Amazônia Brasileira: Experiências locais, lições aprendidas e implicações para políticas públicas*, Belém – Pará, Brasil.

ALTERAÇÕES NO CÓDIGO FLORESTAL. 1965/2001. Lei no 4.771.

ALVIM, P. D. T. 1982. Una evaluación en perspectiva de los cultivos perennes en la cuenca Amazónica. *In: Amazonia. Investigación sobre agricultura y uso de tierras*. S. B. Hecht (ed.). Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

ANDERSON, E. 1950. An Indian garden in Santa Lucia. *Ceiba*. **1**:97-103.

BILSBORROW, R. E., BARBIERI, A. F. and PAN, W. 2004. Changes in population and land use over time in the Ecuadorian Amazonia. *Acta Amazonica*. 34:635-647.

BRIENZA JUNIOR, S. and GAZEL, J. A. 1991. Agroforestry systems as an ecological approach in the Brazilian Amazon development. *Forest Ecology and Management*. **45**:319-323.

BROWDER, J., WYNNE, R. and PEDLOWSKI, M. 2005. Agroforestry diffusion and secondary forest regeneration in the Brazilian Amazon: further findings from the Rondonia Agroforestry Pilot Project (1992-2002). *Agroforestry Systems*. **65**:99-111.

BROWDER, J. O. and PEDLOWSKI, M. A. 2000. Agroforestry performance on small farms in Amazonia: Findings from the Rondonia Agroforestry Pilot Project. *Agroforestry Systems*. 49:63-83.

BROWDER, J. O., TRONDOLI MATRICARDI, E. A. and ABDALA, W. S. 1996. Is sustainable tropical timber production financially viable? A comparative analysis of mahogany silviculture among small farmers in the Brazilian Amazonia. *Ecological Economics*. **16**:147-159.

BUDOWSKI, G. 1990. Homegardens in tropical America: a review. *In: Tropical home gardens. Selected papers from an international workshop held at the Institute of Ecology, Padjadjaran University, Bandung, Indonesia, 2 - 9 Dec. 1985*. K. Landauer (ed.). United Nations Univ. Pr., Tokyo.

BYRON, R. N. 2001. Keys to smallholder forestry in developing countries in the tropics, chapter 16. *In: Sustainable farm forestry in the tropics: Social and economic analysis and policy*. S. R. Harrison and J. L. Herbohn (eds.). Edward Elgar, Cheltenham.

CAETANO BACHA, C. J. 2006. The evolution of reforestation in Brazil. *Oxford development studies*. **34**:243-263.

CHAPIN, M. 2004. A challenge to conservationists. *World Watch Magazine*.

CHIBNIK, M. 1991. Quasi-ethnic groups in Amazonia. *Ethnology*. **30**:167-182.

D'ANTONA, A. O., VANWEY, L. K. and HAYASHI, C. M. 2006. Property size and land cover change in the Brazilian Amazonia. *Population & Environment*. **27**:373-396.

DE JONG, W. 2001. Tree and forest management in the floodplains of the Peruvian Amazon. *Forest Ecology and Management* **150**: 125-134

FAO. 1998. FRA 2000. Terms and definitions. Working paper 1. The forest resources assessment programme, Rome.

GALARZA, E. and LA SERNA, K. 2005. Las concesiones forestales en el Perú: ¿cómo hacerlas sostenibles? *In: La política forestal en la Amazonía Andina. Estudios de casos: Bolivia, Ecuador y Perú*. R. Barrantes (ed.). Consorcio de investigación económica y social, Lima.

GOVERNO DO ESTADO DO PARÁ. 2008. 1 bilhão de árvores para Amazônia. Programa estadual de restauração florestal.

HECHT, S. B. 1982a. *Amazonia. Investigación sobre agricultura y uso de tierras*. Centro Internacional de

Agricultura Tropical (CIAT), Cali, Colombia.

HECHT, S. B. 1982b. Los sistemas agroforestales en la cuenca Amazónica: Práctica, teoría y límites de un uso promisorio de la tierra. *In: Amazonia. Investigación sobre agricultura y uso de tierras*. S. B. Hecht (ed.). Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

HIRAOKA, M. 1986. Zonation of mestizo riverine farming systems in northeast Peru. *Nat. Geogr. Res.* **2**:354-371.

HOMMA, A. K. O. 1993. *Extrativismo vegetal na Amazônia: limites e oportunidades*. Embrapa, Brasília.

HOMMA, A. K. O. 2002. Do extrativismo à domesticação - 60 anos de história, p. 137-156. *In: A Amazônia e o seu Banco*. A. D. O. Mnedes (ed.). Valer/Banco da Amazônia, Manaus.

HOMMA, A. K. O. 2005. Amazônia: como aproveitar os benefícios da destruição. *Estudos Avançados*. 19.

INRENA. 2002. Canon de reforestación Madre de Dios. Plan operativo de trabajo 2002 - borrador.

KLEINN, C. 2000. On large-area inventory and assessment of trees outside forests. *Unasylva*. 51.

LANDAUER, K. 1990. *Tropical homegardens*. United Nations Univ. Pr., Tokyo.

LENTINI, M., VERÍSSIMO, A. and SOBRAL, L. 2003. *Forest Facts in the Brazilian Amazon 2003. Dados Internacionais de Catalogação na Publicação (CIP)*. Câmara Brasileira do Livro SP Brasil, Belém.

MARTINS, S. D. O. 2002. Reflorestamento econômico conserciado adensado RECA. Um estudo sobre desenvolvimento integrado na Amazônia. *In: IIConferência Científica Internacional do Experimento do LBA (Large Scale Biosphere Atmosphere experiment in Amazonia)*, Manaus, Brasil.

MAYERS, J. and VERMEULEN, S. 2002. Company-community forestry partnerships. From raw deals to mutual gains? *In: Instruments for sustainable private sector forestry series*. International institute for Environment and Development, London.

MERCER, D. E. and PATTANAYAK, S. K. 2003. Agroforestry adoption by smallholders, p. 283-299. *In: Forests in a market economy*. S. E. and A. K. (eds.). Kluwer academic publishers, Dordrecht.

MICHON, G. 2005. *Domesticating forests. How farmers manage forest resources*. IRD, CIFOR, ICRAF, Bogor.

MINAG and INRENA. 2006. Plan nacional de reforestación (2005-2024). *In: Resolución Suprema 002-2006-AG*.

MINISTERIO DE AGRICULTURA Y GANADERÍA and INEC. 2000. III Censo Nacional Agropecuario del Ecuador, Quito.

MINISTERIO DEL AMBIENTE. 2006a. Plan nacional de forestación y reforestación (Acuerdo Ministerial). *In: No 113*.

MINISTERIO DEL AMBIENTE. 2006b. Plan nacional de forestación y reforestación (Versión ajustada). MAE, Quito, Ecuador.

MMA, MAPA, MDA and MCT. 2007. Plano nacional de silvicultura com espécies nativas e sistemas agroflorestais - PENSAF, Brasilia.

MONTERO, J. C. 2007. "From knowledge transfer to knowledge exchange": Analysis of smallholders' and professionals' perceptions on tree growing in the Amazon. *In: Faculty of Forestry and Environmental Sciences, Institute of Silviculture*. Albert Ludwigs University, Freiburg.

MOREIRA, T. 2003. *Nosso jeito de caminhar*. RECA, Brasilia.

NAIR, P. K. R. 1985. Classification of agroforestry systems. *Agroforestry Systems*. **3**:97-128.

NAIR, P. K. R. 1987. Agroforestry systems in major ecological zones of the tropics and subtropics. Icraf working paper No. 47. *In: Icraf/WMO International workshop on the application of meteorology to agroforestry systems planning and management*. Icraf (ed.), Nairobi.

ORTIZ CAMARGO, S. 2007. Potenzial von Märkten für Waldprodukte von Kleinbauern. Ein Fallbeispiel aus Riberalta, Bolivien. *In: Waldbau- Institut. Arbeitsbereich Waldwirtschaft in den Tropen und Subtropen*, Albert-Ludwigs-Universität Freiburg.

PADOCH, C., CHOTA-INUMA, J., DE JONG, W. and UNRUH, J. 1985. Amazonian agroforestry: A market-oriented system in Peru. *Agroforestry Systems*. **3**:47-58.

PECK, R. B. 1982. Actividades de investigación en bosques e importancia de los sistemas de multiestratos en la cuenca Amazónica (neotrópicos húmedos). *In: Amazonia. Investigación sobre agricultura y uso de tierras*. S. B. Hecht (ed.). Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

PECK, R. B. 1990. Promoting Agroforestry practices among small producers: the case of the Coca Agroforestry project in Amazonian Ecuador. *In: Alternatives to deforestation steps toward sustainable use of the Amazonia rain forest*. A. B. Anderson (ed.). Columbia Univ. Pr., New York.

PENA-CLAROS, M., BOOT, R. G. A., DORADO-LORA, J. and ZONTA, A. 2002. Enrichment planting of Bertholletia excelsa in secondary forest in the Bolivian Amazon: effect of cutting line width on survival, growth and crown traits. *Forest Ecology and Management*. **161**:159-168.

PICHON, F. J. 1997. Colonist land-allocation decisions, land use, and deforestation in the Ecuadorian Amazon Frontier. *Economic Development and Cultural Change*. **45**:707-744.

PINEDO-VASQUEZ, M., ZARIN, D. J., COFFEY, K., PADOCH, C. and RABELO, F. 2001. Post-Boom logging in Amazonia. *Human Ecology*. **29**:219-239.

POSEY, D. A. 1985. Indigenous management of tropical forest ecosystems: the case of the Kayapo indians of the Brazilian Amazon. *Agroforestry Systems*. **3**:139-158.

RAÑA, L. F. S. 1987. Programa "Plantaciones Forestales". Alcances y proposiciones tecnicas para la organización y funcionamiento del P.D.F. - Beni. Camara Forestal Distrital Cordebeni, Maca - CDF Regional Norte Comite Civico, Trinidad, Beni, Bolivia.

SCHROTH, G., COUTINHO, P., MORAES, V. H. F. and ALBERNAZ, A. L. 2003. Rubber agroforests at the Tabajós river, Brazilian Amazon-environmentally benign

land use systems in an old frontier region. *Agriculture, Ecosystems & Environment*. **97**:151.

SEARS, R., PADOCH, C. and PINEDO-VASQUEZ, M. 2007. Amazonia forestry transformed: integrating knowledge for smallholder timber management in Eastern Brazil. *Human Ecology*. **35**:697-707.

SERRA, M., MEDINA, G., SHANLEY, P. and HOMMA, A. 2007. O mercado invisível de espécies frutíferas e medicinais na cidade de Belém-PA.

SIMMONS, S., WALKER, R. T. and WOOD, C. H. 2002. Tree planting by small producers in the tropics: A comparative study of Brazil and Panama. *Agroforestry Systems*. **56**:89 - 105.

SMITH, N. J. H., FALESI, I. C., ALVIM, P. D. T. and SERRÃO, E. A. S.. 1996. Agroforestry trajectories among smallholders in the Brazilian Amazon: Innovation and resiliency in pioneer and older settled areas. *Ecological Economics*. **18**:15-27.

SUBLER, S. and UHL, C. 1990. Japanese Agroforestry in Amazonia: A case study in Tomé-Açu, Brazil. *In: Alternatives to deforestation. Steps toward sustainable use of the Amazonia rain forest*. A. B. Anderson (ed.). Columbia Univ. Pr., New York.

SUMMERS, P. M., BROWDER, J. O. and PEDLOWSKI. M. A. 2004. Tropical forest management and silvicultural practices by small farmers in the Brazilian Amazonia: Recent farm-level evidence from Rondônia. *Forest Policy and Economics*. **192**:161-177.

TEIXEIRA, F. A. M. 2005. A importância da cultura do cacau para Amazônia, p. 249. *In: Economia do cacau na Amazônia*. F. A. M. Teixeira (ed.). UNAMA, Belém.

TERÁN, J., FLORES, G., ZAPATA, J. and CONCHAR, V. 2005. Política de plantaciones forestales. Documento de trabajo - final (28-07-05). Mds-Vrnma-Dgdf and R. D. Bolivia (eds.), Santa Cruz.

UNDCP. 1997. Manejo, conservación y utilización de los recursos forestales en el Trópico de Cochabamba y en las zonas de transición de los Yungas de La Paz - Fase II. Ad/ Bol/97/C23-Uno/Bol/723/Dcp (ed.).

UNFCCC. 2005. Kyoto Protocol.

VARMOLA, M. I. and CARLE, J. B. 2002. The importance of hardwood plantations in the tropics and sub-tropics. *International Forestry Review*. 4:110-121.

WIGHTMAN, K. E., CORNELIUS, J. P. and UGARTE-GUERRA, L. J. 2006. Plantemos madera! Manuel sobre el establecimiento, manejo y aprovechamiento de plantaciones maderables para productores de la Amazonía peruana, p. 199. *In: Manual Técnico 04*. ICRAF (ed.), Lima.