

**Reforestation feasibility study around the Los Cedros Biological
Reserve North- Western Ecuador**



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Abstract

This study was conducted between May to August 2006 in the surroundings of the Los Cedros Biological Reserve, North Western Ecuador to assess the feasibility of a large scale reforestation project. The study area is a part of the Choco floristic region which is the focus of a lot of international attention due to its extremely high biodiversity and levels of poverty. The brown headed spider monkey (*Ateles fusciceps fusciceps*) critically endangered with an estimated 250 individuals. This is, mainly due to the degradation of its habitat. This situation is closely linked to human land uses resulting from increasing poverty and population growth. In order to save the species, urgent measures must be implemented combining direct habitat improvement and reduced deforestation.

I have set up a nursery and direct seeding plots to investigate the most suitable and cost-efficient propagation techniques for four native tree species. The species were chosen according to their utility by primates and humans. The limited time of the research did not allow conclusive results but it seems that direct seeding and wildling cultivation are promising techniques for further investigation. Experiments and additional reforestation techniques were filmed to produce a reforestation video guide, accompanied with a printed handbook to provide local communities and volunteers at the Los Cedros Reserve with accessible and concise knowledge needed for the initiation of reforestation.

I also surveyed people's ideas and attitudes towards economic alternatives and their use of trees. I have encountered high enthusiasm levels within the local communities but also helplessness resulting from the lack of opportunities. This seems to be incompatible with the fact that the area is considered a high priority for conservation and the number of large-scale conservation projects in the area. I have concluded that reforestation in the area is feasible and desirable if started at grassroots levels by initiating community based nurseries and promoting economic enterprises that include reforestation. The Los Cedros Reserve is expected to become a research centre for reforestation techniques, information distribution and a seed bank for the neighbouring communities.

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Figure 1. Vicky Hughes (left), Sam Shanee (inside) and Fionn Magnusson (Right) helping to build the nursery. (Photo: Noga Shanee)

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1 General introduction

The following study describes research into the feasibility of different reforestation methods conducted in the surroundings of the Los Cedros Biological Reserve, Northwestern Ecuador. The long term goal of the research was to assist the survival of the brown headed spider monkey *Ateles fusciceps fusciceps*. Experiments of different plant propagation techniques and a survey of the local anthropogenic situation were conducted in order to develop a strategy for reducing forest lost and rehabilitating degraded lands. Information about conservation and reforestation techniques was produced as a video guide and a printed handbook for the use of local land owners and volunteers at the Los Cedros Reserve.

1.1 The Choco-Darien floristic region

The Los Cedros reserve is located in the Choco-Darien floristic region, which is one of the most threatened ecosystems in the world. It is known as a biogeographic hotspot and conservation priority because of its species richness, high endemism and stress from human activities (Dodson and Gentry 1991, IUCN 2004, Myers et al. 2000, WWF 1997). For avian fauna, it is considered the earth's highest bird endemism area (Terborgh & Winter, 1982). There is an extremely high number of tree species per hectare even compared with lowland Amazonia. Nine thousand vascular plant species are estimated to exist in the area with 90% of these plant species dispersed by animals (Gentry 1986, Jorgensen and Leon-Yanez 1999). Only 4% of the original forest still remains (Conservation International 2006) which serves as refuge for the great number of endangered species which are being marginalized by the destruction of forests at lower, more accessible elevations (Aldrich et al. 1997). Only 0.3 % of the Ecuadorian Chocó is protected, and the ongoing deforestation is mainly the result of extraction of timber for local and international demands, this jeopardises the future of both humans and monkeys living in the area (Scherr et al. 2003, Sierra et al. 2002). In the year 2001 the governments of Ecuador and Colombia signed an agreement called Vision 2010 which was initiated by the Critical Ecosystem Partnership Fund (CEPF) to create a conservation corridor in the Choco area of Colombia and Ecuador. The agreements were designed to maximize investments and

strengthen alliances among national, regional, and local stakeholders to protect biodiversity while improving the quality of life of communities within the corridor (Conservation International 2006).

Most of the efforts are currently directed towards the protection of existing forest patches and less to developing reforestation projects to recover the huge areas of lost forest (GEP 2000, Dudley 2005a). To allow the essential connectivity between the forest fragments, a large scale forest restoration project that will take into account biodiversity and migration patterns must be included. My research aimed to assess the feasibility of a long term reforestation project, which will address the issues of immediately supplementing native fruit trees to assist the survival of primate species. This should be done in conjunction with providing sustainable alternatives for local communities to reduce deforestation. I have tried to assess Los Cedros' potential role in the project and to identify stakeholder groups and communities interested in cooperating.

1.2 The brown-headed spider monkey *Ateles fusciceps fusciceps*

The Los Cedros Reserve is home to one of the most threatened species in South America; the brown-headed spider monkey *A. f. fusciceps*. Even though the population numbers are still not fully assessed it is clear that the species is critically endangered with less than 250 individuals surviving (Groves 2001, IUCN 2004, Madden and Albuja 1986, Mittermeier et al. 1997, Tirira 2005). According to research done on the species, habitat loss and degradation are the main causes of its decline. It is currently restricted to the Cotacachi-Cayapas Reserve, Awa Indigenous Reserve (where hunting still occur) and Los Cedros Biological Reserve, a total area of about 100,000 ha (Madden and Albuja 1986, Mittermeier et al. 1997, Tirira 2005), occurring in low densities throughout its range. Low densities may be due to the poor quality of remaining habitat and low primary production that results from its high altitude (Defler 2004 Djojosedharmo and van Schaik 1992, Tirira 2005).

Madden and Albuja (1986) describe the species as a large-bodied, diurnal primate with a complex social structure. Extreme dietary specialisations of 80% mature fruits, and very large home range. Combined with high arboriality and special brachiation locomotion these characteristics make them dependent on intact, primary

forests (Johns and Skorupa 1987). Like all *Ateles* species they are very sensitive to habitat disturbance and hunting (Collins 1999, Sorenson and Fedigan 2000). Historical hunting pressure strongly influences *Ateles* densities even after 25 years because of their slow life histories (Freese et al. 1982, Chapman et al. 1989). All these requirements make this species a very good indicator of habitat quality (Collins 1999). Their large charismatic appearance, endemism and important ecological role make this species highly suitable to be the flagship representative of this very unique and endangered hotspot (Dietz et al. 1993). *A. f. fusciceps* can also function as an ‘umbrella species’; its demanding site requirements ensure that efforts directed to saving this species will benefit numerous other, less specialized ones (Roberge and Angelstam 2003). *Ateles* play a keystone ecological role as seed dispersers (Russo et al. 2005) and seem to be the best dispersers for lipid-rich fruit species like *Virola* spp, *Oenocarpus* spp, *Inga* spp. and several species of Lauraceae. Therefore their possible extinction from the wild would add another threat to the stability of the whole ecosystem (Capman 1995, Chapman and Onderdonk 1998). Information about home and day ranges and dietary preference is still not fully resolved (Rowe 1996, Tirira D. pers. comm.).

A. f. fusciceps’ low numbers and fragmented population suggest that its survival could be only temporary and the species might not be viable in the long term. Hence an urgent intervention is required; improving its current habitat and re-creation of larger, better connected areas of additional habitat (Karjalainen 2005).

1.3 Howlers and capuchins

White-faced capuchin monkey (*Cebus capucinus*) are distributed from Northwestern Ecuador through west Colombia north to Honduras, within altitudinal ranges from sea level to about 2000m (Defler 2004), IUCN Red-List (www.redlist.org) categorized this species as lower risk, mainly because of their large geographic range. They live in multi-male multi-female groups, numbering from a few to twenty individuals (Fragaszy et al. 2004). Habitat preference is primary and mature secondary forests and their diet is very broad, including fruits, insects and leaves. Freese and Oppenhiemer (1981) listed 200 species of plants eaten by the species Terbourgh (1983) and Fragaszy et al. (2004) list the most important fruit tree families as; Moraceae

(including *Cecropia* and *Ficus*), Annonaceae, Palmae, Anacardiaceae (mango), Leguminaceae (*Inga*), Rubiaceae. Rowell and Mitchell (1991) investigated seed dispersal by the species and found that they deposit intact seeds up to a thousand meters from the source tree with high germination and survival probability, making them good dispersals of many tree species.

The mantled howler monkey (*Alouatta palliata*) is distributed from Northwestern Ecuador through Central America into Southern Mexico, in a wide variety of forests including mangrove, highland and secondary forests, (Defler 2004). They are also categorized as Lower Risk by the IUCN. Groups normally include two to three males and up to ten females (Defler 2004), but in a study carried out at the Los Cedros reserve they seem to live in smaller groups of up to six individuals (Huges pers. comm.). They are known to be highly folivorous with a diet consisting of large amounts of young and mature leaves (Milton 1980). However, in times of fruit abundance their diet can comprise up to 95% fruits (Altman 1959). Howler monkeys are behaviorally and morphologically adapted to the low nutrients levels of the folivorous diet; they spend up to 65% of the day resting and their home and day ranges are relatively small (Estrada 1982, Milton 1980). Fruits consumed by this species are mainly of the families Moraceae, Lauraceae and Leguminaceae (Neville et al. 1988). They are important seed dispersers of a wide variety of species with some seed species showing improved germination rate after passing through their digestive system (Capman 1989, Stevenson et al. 2002). Both sexes of howler monkeys disperse from their natal group which enables them to spread out to new territories by establishing new groups. They also have a relatively fast life history. Therefore they are usually the first to return to regenerating forests after human disturbance (Crockett, 1998, Fedigan and Jeck 2001).

1.4 Reforestation

Forest loss world wide was estimated to be 9.4 million hectares annually throughout the 1990s, mainly in the tropics (FAO 2001). This alarmingly high rate makes a compelling argument for making reforestation and forest restoration (see definitions in Table 1) high conservation priorities (WWF and IUCN 2001). Management of most degraded tropical lands still use plantations of only a handful of

exotic tree species like *Eucalyptus*, *Pinus* and *Acacia spp.*, partly because the knowledge of efficient techniques for the reestablishment of native forest cover on degraded lands has not been fully understood (Camargo et al. 2002, Knowles and Parrotta 1995, Florentine and Westbrooke 2004). There are two main reforestation techniques used today are first the Framework Species Approach with mixed plantations of secondary and primary trees on highly degraded areas. The technique was developed in Australia as a method for large scale reforestation schemes (Goosem and Tucker 1995, Lamb et al. 1997, Parrotta et al. 1997). The seconded is enrichment planting of secondary forests with trees that are attractive to fruit eating animals or have commercial value (Martinez-Garza and Howe 2003). For both of these techniques, careful research should screen the most effective species for propagation. Trees should be promoted due to 1) Rarity in the forest due to over exploitation or naturally, 2) trees that are ecologically important, e.g. provide food or habitat for wildlife, 3) important timber trees 4) trees that provide human food or medicine 5) multiple use trees (Butterfield 1995, Knowles and Parrotta 1995). The species and propagation technique screening should be in conjunction with research to aid understanding of the biology of the ecosystem, which enables design of the most efficient reforestation strategies with consideration of where best to allocate efforts on a large scale (Holl et al. 2000).

Table 1. definitions of important restoration concepts

	Definition	Defined by
Reforestation	“The direct human-induced conversion of non-forested land to forested land through planting, seeding and/or human induced promotion of natural seed sources on land that was forested but that has been converted to non-forested land”	UNFCCC (2003 p. 8)
Forest landscape restoration	“A process that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest landscapes”. Rather than returning forests to their previous ‘pristine’ condition, forest landscape restoration aims to create more functional forests to provide for the needs of biodiversity and humans	(WWF and IUCN 2001). (ITTO 2005).
Agroforestry	“a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land-users at all levels”	(ITTO 2005 p. 140)

Buffer zone	“peripheral to a national park or equivalent reserve, where restrictions are placed upon resource use or special development measures are undertaken to enhance the conservation values of the area”	Sayer, 1991, p. 2).
Ecological corridors	“A corridor is a linear landscape element that provides for movement between habitat patches, but not necessarily reproduction”.	Rosenberg et al. (1997, p. 678)

1.5 PRIMENET

The Darwin initiative, PRIMENET (www.primenet.org.uk), is coordinated by the University of Sussex. The organization aims to capacitate local people to conserve the critically endangered brown headed spider monkey and other primate species in North Western Ecuador. The Organization’s Main activities are monitoring primate populations, education of local communities and promoting sustainable livelihood. To achieve these aims the organization developed a research centre in the Los Cedros Biological Reserve to train indigenous people as parabiologists, a play on the word para-medic e.g. non academic local people that are trained to collect basic biological information, with practical skills in monitoring and protecting primate populations.

1.6 The local population and deforestation patterns

Many studies have been carried out on the human population of the Ecuadorian Choco region and its changing land uses, aimed at comprehending the excessive deforestation rate of the area (Arroyo and Poats 2002, Báez et al. 1999, Clay 1992, GEF 2000, Jan et al. 2004, Jolits and Thomas 2001, Flora 2002, Mecham 2001, Rice et al. 2003, Rival 2003, 2004, Rudel 2000, Sierra 1999, 2002 Sierra and Stallings 1998, Walker 2004). The Choco region is one of the poorest and least developed areas in Ecuador (CEPF 2004, Rival 2004). The indigenous population includes communities of Chachi and Awa. Afro-Ecuadorian communities have also occupied the area for over three centuries. Colonizing groups, ‘Colonos’, started arriving in the early 1960’s from other rural areas of Ecuador and Colombia (GEF 2000). Indigenous land uses include cultivation of small parcels of about one to five hectares per family

with subsistence (corn, rice, cassava, etc.) and commercial agroforestry (banana, coffee and cacao) (Mecham 2001). Most of the family land is kept as a forest reserve for hunting and gathering practices (Sierra 1999). Non-agricultural cooperatives have claimed land titles of communal lands traditionally held by Chachi or Afro-Ecuadorians groups. These cooperatives re-sell the land to incoming colonists, in return for harvesting the timber (GEF 2000). Growing networks of roads and pipelines built by the government and the oil industry make the last large forested areas accessible for logging and colonization (Rice et al. 2003). Increasing poverty and aggressive governmental promotion push indigenous and colonizing landowners to clear new areas for logging and monoculture (palm oil, bananas, coffee, sugar cane, etc.). Slash and burn, and cattle ranching are also fast growing practices in the area. sixty percent of Ecuador's timber is extracted from the Choco floristic region (Palacios and Jaramillo 2004, Sierra, 1999). Ecuador's state system lacks resources and personnel to control illegal logging (Gamboa 1999). Logging in the area occurs by felling all trees in a few hectares of forest, and timber of commercial value is carried to the road to be sold. Other woody parts that can be used for construction and furnishing are taken for the owner's personal use and the rest is left to rot. These spaces are then planted with crops (beans and corn) which in turn followed by pasture (Mariscal A. pers. comm.). Land in the area is often impossible to use for agriculture and cattle farming as over half of the farms are located on mountain slopes with gradients up to 70%. The high erosion and low nutrients in the soil mean farmers have to start over and over again by cutting back more forest (Rainforest Concern 2006). Local communities often lack economic alternatives to non-sustainable timber harvesting or land conversion resulting in increased poverty, excessive soil erosion, watershed collapse, desertification and flooding (Aldrich et al. 1997, GEP 2000, Rice et al. 2003).

1.7 Objectives

Given the considerations noted above the main aims of this study are:

1. To assess the feasibility of a large scale reforestation project in the Choco region of North Western Ecuador as a means for immediate supplementation of native fruit trees to assist in the survival of the critically endangered brown-headed spider monkey.
2. To assess the role of Los Cedros Biological Reserve in the project.
3. To identify potential collaborators and groups in neighbouring communities and evaluate their level of interest and possible incentives.
4. To encourage the communities to adopt alternatives to logging to slow the high levels of deforestation in the area.
5. To design a set of experiments to test direct seeding, vegetative propagation and nursery procedures for native tree species known as food source for the endangered primate species and as a food/economic resource for people.
6. To develop user-friendly and location-specific guidelines for plantations with native species to be distributed to local farmers.

1.8 Study area

The project took place in the Los Cedros Biological Reserve in North western Ecuador which started as a protected reserve under the stewardship of Centro de Investigación de Bosques Tropicales (CIBT). Now it is a nationally protected forest is administrated by Mr. Jose deCoux, one of the reserves founders. The 6400 hectare reserve was established on the 19th of October 1994 (Resolucion 057) and officially registered Protected Forest the ministry of environment (Publicado No. 620) on the 26th of January 1995. Ecotourism and private volunteers provide most of the financing. The reserve is located 60 km north west of Quito in the province of Imbabura (0° 19' N and 78° 47' W). It borders the Cotacachi-Cayapas National Park. The vegetation was broadly classified by Holdridge (1971) as very humid premontane and very humid low montane with an average forest height of 30-35 meters. The reserve ranges between 1100-2700 meters altitude with very steep slopes. Annual precipitation is 2800-3300 mm with a mean temperature of 19-22°C. Dry season is

July to August with low rainfall most afternoons. The peak of the rainy season is February - March (Jørgensen and León-Yáñez 1999 pp.11). Soil is thin, silicified volcanic with very strong runoff (Madden and Albuja 1986).

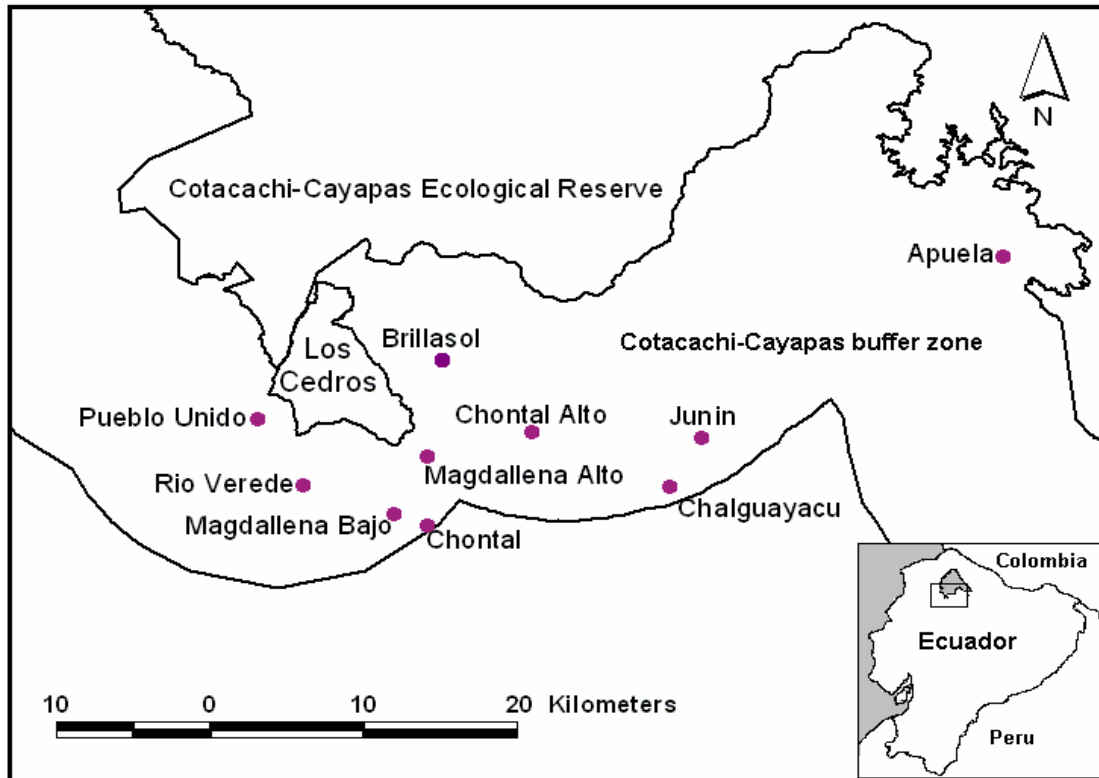


Figure 1. Study area is located around the Los-Cedros Reserve within the 15 km buffer zone of Cotacachi-Cayapas Ecological Reserve.

2 Plant research

2.1 Introduction

Research took place between the 22nd of May and the 6th of August 2006, I developed a greenhouse to propagate native vegetation characteristic of the Choco-Darien area and conducted a series of small scale experiments using different propagation and reforestation methods. I concentrated on the species: *Ocotea* sp. (Lauraceae) *Cedrela odorata* (Meliaceae), *Gracinia madruno* (Gutiferae), *Otoba gordonifolia* (Myristicaceae) and *Cecropia monostachya*, (Moraceae). Other species propagated in the nursery but not mentioned further because of small samples are *Caryodaphnosis theobromifolia*, (Lauraceae), *Inga edulis* (Leguminoseae from cutting), *Pouteria* sp. (Sapotaceae). Detailed information about these species uses and common propagation methods can be found in Appendix 3.

Due to the limited time scale of my project, all experiments were done mainly in order to develop a standard methodology for more detailed experiments in the future. These kinds of applied research and pilot plantings are necessary for selecting the best locally adapted plants and techniques (Ladarch 2002). Simple techniques that were proven to yield good results in other tropical reforestation and agroforestry projects were chosen:

- Wildlings are seedlings that were naturally established in the forest, they can be collected when seeds are not available to be transplanted elsewhere. They are also shown to perform better in the field compared to nursery grown seedlings (Ådjers et al. 1998).
- Enrichment planting as a complementary strategy to aid natural regeneration is the adding of selected tree species to secondary forest, usually to attract frugivores or for the economic upgrading of the forests so they will be more valuable, and therefore conserved (ITTO 2002, Ramoz and del Amo 1992). Enrichment planting of fruit trees in large secondary forest areas should be done in patches up to 100 meters apart, which will encourage the movement of animals between patches, leading to further seed dispersal. This can bypass hundreds of years of passive succession (Martinez-Garza and Howe 2003).

- Direct seeding of seeds to their ultimate location is the most cost-effective technique due to the dramatic reduction of labour and the much shorter timescale involved (Caramago et al. 2002) - this can involve simply throwing seeds to the forest floor (Ganade 2001). Large primary forest seeds are the most successful for direct seeding, and are also the most desirable for enrichment planting as they are less likely to reach new areas (Baraloto et al. 2005, Parrotta et al. 1997). Since the success of such operations depends on so many unforeseen factors, small-scale preliminary experiments should be conducted before large scale sowing (ITTO 2005).
- Assisting natural regeneration by strategic selection of different methods for each case and stage. This can include: eliminating barriers such as grazing cattle and invasive grasses, stimulating seed dispersers by protecting remnant trees and planting pioneer fruit trees, or planting a mix of economically important native trees etc. (Holz and Placci 2005)

Botanists from PRIMENET are conducting a three year field survey of the distribution and abundance of plants species that are associated with the different primate species. Started in 2005, this Rapid Habitat Assessment and a one hectare permanent plot inventory are used to study forest regeneration dynamics (Mariscal 2005).



Figure 3. Brown-headed spider monkey (*A. f. fusciceps*) male on an *Otoba gordonifolia* tree. (Photo: Noga Shanee)



Figure ...Mantled howler monkey (*Alouatta palliata*) on a copal blanco tree (*Dacryodes copularis*). (Photo: Noga Shanee)

2.1.1 The importance of *Cedrela odorata*

Spanish cedar (*Cedrela odorata*), a relative of mahogany, it is the most sought after timber in Latin America. The easily worked, aromatic wood is both rot-resistant and highly termite-resistant. Spanish cedar is widespread, but never very common, throughout moist tropical American forests; its numbers are rapidly dwindling through exploitation without successful regeneration, and it is classified as vulnerable throughout its range (IUCN 1997, Mexal et al. 2002, Patino Valera 1997). The Los Cedros Reserve is named after this species (Cedros) and uses it as a ‘flagship species’. According to deCoux (2006 pers. comm.) cedar trees have not seeded since he started living in the area 17 years ago. This year there was extremely large amounts of viable seeds under every cedar tree in the reserve. Normally for this species, high seedling densities are common near fruiting trees, but most of these seedlings disappear in under a year; this high natural mortality may be due to shade, competition or root problems (Porrás and Luyano 1974, Janzen 1970). Seed collection began more than two months after the first observation of seeds in the reserve (beginning of April). We have tried to collect as many seeds as possible and use them extensively. This accounts for the high numbers of *C. odorata* planted in the nursery and in the direct seeding plots.

2.2 Methods

2.2.1 Seed collection

Seeds were mainly collected between the fifth and seventh of June 2006 by walking on existing trails of primary forest in Los Cedros reserve, where primates are reported to exist (Magnesson, F., Gavilanes, M. Pers. comm. 2006). Botanists and experienced local guides identified all seeds, and their use by wildlife and humans in the area was evaluated. We chose tree species that are known to support primates and/or that are over-exploited by logging (see list in 2.1). Seeds of *Cedrela odorata* were collected in high quantities (1100 seeds) under all known individuals of the species to ensure genetic variation (Butterfield 1995). Seeds were collected from the floor or from fruit traps that were placed under individuals which were still fruiting (Schmidt 2000).

Back in the nursery, seeds were cleaned by rinsing in running water and separated for immediate planting or for drying and preservation (Lippitt et al. 1994). Faeces of fugivorous animals that were found in the area were collected and checked for seeds; these were then cleaned and sown in germination beds (Andersen 1999, Stevenson et al. 2002, Chapman 1989).

2.2.2 Wild seedling cultivation

Small seedlings of *Gracinia madruno* and *Cedrela odorata* were collected for propagation by gently removing them from the moist forest soil when they were 10-15 cm tall and carefully transported them in plastic bags filled with wet moss (local technique) to the nursery for immediate re-planting in pre-filled nursery bags (Ådiers et al. 1998). I subsequently monitored their survival and development.

2.2.3 Nursery work

I have established the nursery in an accessible place close to the house with an existing water source and was covered with commercial shading mesh (Kumar 1999). Seeds arriving to the nursery were placed in germination beds for about two weeks and later transplanted to commercial nursery bags of size 15x23 cm, filled with nearby forest soil (Longham 2003). Seeds and wildlings of *Cedrela odorata* were separated according to their parent trees. This was done to select superior parent trees based on nursery performance, and to ensure that they will be equally distributed for planting so that genetic variation is maximized. Twenty seeds were sown after being dried and preserved in room temperature for 60 days. Another twenty seeds were sown in un-shaded beds.

O. gordonifolia seeds have hard coats and did not seem to germinate in the nursery or the forests, therefore I tried two treatments that usually enhance germination; five seeds were stratified (a method involving etching of the hard surface coat) and then soaked in water for 24 hours. Another five were just stratified and further five were only soaked for 24 hours (Longman 2003).

Cut worms (*Noctuidae* spp.) and inch worms (*Geometridae* spp.) were treated with biological pesticide, *Bracillus thuringiensis*, whenever they appeared (twice).

Height measurements were recorded as distance from the soil surface to the apical meristem, with a precision of 0.5 cm. (Hooper et al. 2002).

2.2.4 Direct seeding

A mix of seeds of *Gracinia madruno*, *Cedrela odorata*, *Otoba gordonifolia* and *Ocotea* sp. were sown at four meter intervals in six experimental secondary forest plots, each 16m². The plots were placed in areas of different stages of secondary succession; three plots in *Cecropia* dominated areas (early succession) and three plots in areas where primary forest species had already started to settle; advanced succession areas. To protect the seeds from predation and to retain moisture, seeds were buried under a few centimetres of soil (ITTO 2005, Orchner 2001, Woods and Elliot 2004) except seeds of *C. odorata* that were positioned vertically with only the embryo half buried. This position was recommended by Navarro et al. (2002). A pair of sticks was stuck in the ground to form an arch for protection from falling leaves. For *C. odorata* two seeds were sown in each interval a few cm apart, 20 in each plot, total of 120 seeds, In Plots one, two and six seeds of *C. odorata* were sown after they started to open, 0.1-1 cm roots, in plots three, four, and five non-germinated seeds were sown. Of the other three species, five non-germinated seeds were planted in each plot; a total of 30 seeds.

Germination and early performance were monitored every three weeks to track their sprouting and survival. Germination was defined as the appearance of the hypocotyls above the soil surface. Damage and cause of mortality were recorded. On the last survey I randomly picked six non germinated seed of each species and checked their progress. Heights and percentage survival were compared between plots and with nursery grown individuals of the same species.

2.3 Results

2.3.1 Results from nursery work

Cedrela odorata: Germination under different conditions: 1) Twenty seeds were sown in un-shaded beds, none germinated. 2) 20 planted after drying and preservation of 2 months, in shade, 3 germinated 15%. Results of germination, survival and mean height for seed and wildling propagation are presented in table 1.

Table 2. Results of seed and wildlings propagation from different parent trees of *Cedrela odorata*

Tree no.	1	2	Wildlings of 1 and 2	3	4	mix	Total
Date	6.6.06	7.6.06	6.6.06	7.6.06	7.6.06	8.6.06	
Height, Diameter	20m, 35cm	30m, 45cm		35m, 50cm	25m, 30cm		
trail	Bracilargo	Inside plot		cascada	Above plot		
altitude	1550	1250		1200	1300		
No. planted	110	115	60	330	100	265	980
% germination	90%	80%		96%	54%	60%	79%
No. germinate	97	92		318	54	159	780
survival After germination	92 (95%)	88 (96%)	54 (90%)	307 (96%)	51 (94%)	158 (99%)	750 (96%)
Mean height	8.4	5.9	10	7.6	6.2	6.4	7.4

O. gordonifolia: No seeds germinated. However one of the seeds that were soaked in water but were not stratified opened to start germinating and then aborted. Faeces were classified as belonging to fruit bats *Pteropodidae*, howler monkeys *Alouatta palliata* and 'others'. Out of all the seeds extracted from frugivores' faeces only seeds of *Cecropia monostachya* and *Ficus* sp. were identified. However, none of these germinated.



Figure 5. Two month old Lauraceae seedlings in the nursery. (Photo: Noga Shanee)



Figure 6. A two month old Spanish cedar (*Cedrela odorata*) seedling in the nursery. (Photo: Noga Shanee)

2.3.2 Results from direct seeding

Results of the direct seeding experiment in enrichment planting plots and the nursery are described in Table 3. Comparison of the mean height of the *Ocotea* sp., *Cedrela odorata* and *Gracinia madruno* with 95% confidence around the mean are presented in Figure 7.

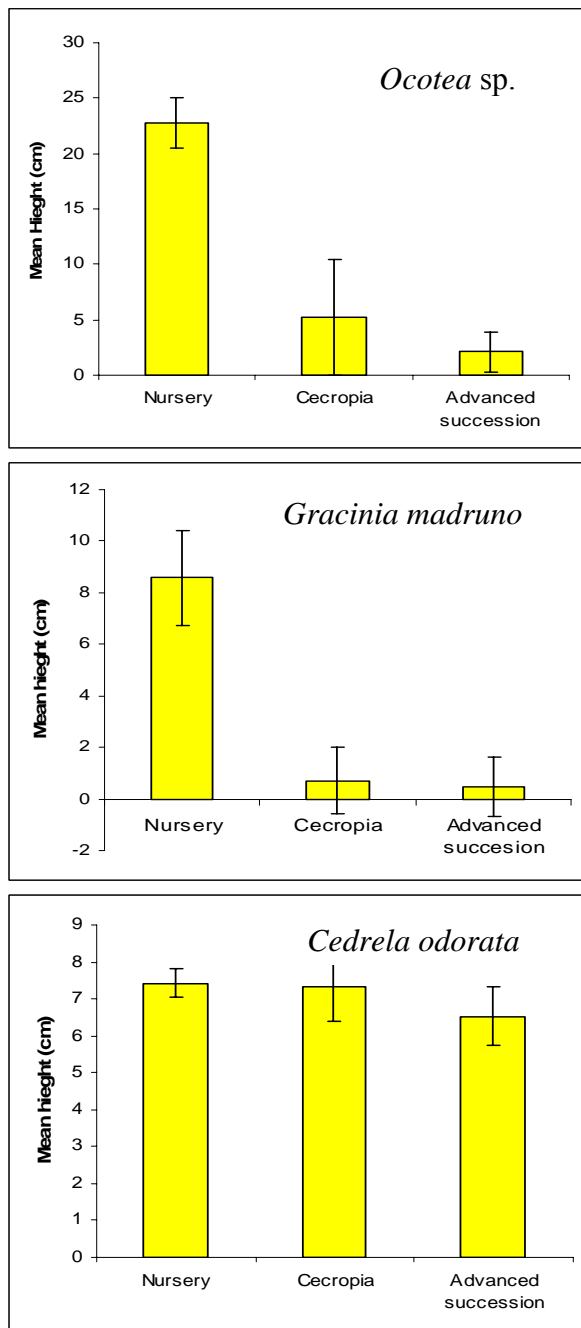


Figure 7. Mean height of the three species in direct seedings and nursery with 95% confidence around the mean.

Table 3. Results of direct seeding experiment in enrichment planting plots and nursery

	Plot characteristics	<i>C. odorata</i>					<i>Ocotea</i> sp.				<i>G. madruno</i>				<i>O. gordonifolia</i>	
		Seed sowed	% Germination	% Survival	average height cm	damages	% Germination	% Survival	average height cm	damages	% Germination	% Survival	average height cm	damages	Germination	damages
Plot 1	Advanced succession	G	90	76	7.1	2xe 1xd	20	0	0	1xsp 1xf 1xe	20	0	0	1xe	0	1xsp
Plot 3	Advanced succession	NG	20	75	5.7	5x sp 1xe	80	100	1.5	1xf	60	100	0.5		0	
Plot 5	Advanced succession	NG	30	83	6.6	4xsp 2xe	40	100	2.7	1xsp	0	0	0		0	
Total			46 n=27	78 n=21	6.5	5xe 1xd 9xsp	47 n=7	66 n=6	2.1	2xsp 2xf 1xe	20 n=4	75 n=3	0.5	1xe	0	1xsp
Plot 2	Cecropia	G	75	53	8.3	4 x e	60	66	6.5		20	100	1		0	
Plot 4	Cecropia	NG	40	88	6.7	4xsp 1xe	0	0	0	1xsp 1xf	20	100	0.1		0	
Plot 6	cecropia	G	80	69	6.9	2xd 1xe	20	100	4	1xsp	40	100	1		0	
total			65 n=39	70 n=26	7.3	6xe 4xsp 2xd	26 n=4	55 n=3	5	2xsp 1xf	26 n=4	100 n=4	0.7	0	0	0
Nursery		mix	79 n=78 0	96 n=75 0	7.4		89 n=64	86 n=62	22.8		90 n=29	68 n=22	8.6		0	

Seed sowed: G- germinated, NG- non-germinated. Damages: sp- seed predation, e- eaten after germination, d- dried, f- attacked by fungus.

2.4 Discussion

2.4.1 Nursery work

Nursery grown seedlings propagated from seeds require substantial labour and capital inputs (Florentine and Westbrooke 2004) including seed collection, germination treatments, raising seedlings in the nursery, planting and maintaining saplings until they are established. In a 15 year study of cost efficient restoration techniques in the Amazon, experiments with 160 taxa showed that 22% of the total could be raised from seed in the nursery and not by any other more economical means (Parrotta and Knowles 2001). Some of the results of the experiments I have conducted seem to be promising as techniques to be used in the future; wildlings of *Cedrela odorata* had 90% survival and showed good growth rates. People in the area were familiar with wildling collection techniques and seemed to prefer it to working with seeds in many cases. Collection of the wildlings is very quick and efficient, they have fast turnover in the nursery and they are available for longer periods than seeds (ITTO 2005, Moura-Costa et al. 1993). According to Ådiers et al. (1998) wildlings that are collected from forest will show better future performance in the forest compared to nursery grown seedlings. Probably because seedlings have undergone process of selection in the wild and experience considerable stress when removed from their original site, which may result in some hardening; however a short nursery period is necessary for the rehabilitation of the root system from possible damage during movement (Ådiers et al. 1998).

Pakkad et al. (2003) defined standards for selection of superior seed trees as: 40% or greater germination and 70% or higher seedling survival in the nursery. All *C. odorata* parent trees exceeded these standards within the two months of observation. Still, they had lower germination rates than offered by the species propagation protocol; 90% on average (Wightman 2001). Tree number four had the lowest germination probably because we collected the remaining seeds after the tree had terminated seeding. No correlation was found between the germination, survival or height of seedlings and the altitude or size of the parent tree.

Seeds of *C. odorata* did not germinate in full sun. Whitmore (1971) found a minimum of 10% of seeds germinated in the sun under different test conditions. The low germination rates of seeds preserved for two month can be explained by the low viability of *C. odorata* seeds under ambient temperatures (Rocas 2002). Unfortunately there is no

refrigerator in the Los Cedros reserve and therefore the maximum preservation period for the species should be further investigated.

Otoba gordonifolia : There were many *O. gordonifolia* seeds under each tree for the entire time I was in the reserve but none of the seeds in the forest or in the experiment germinated. This could be due to low productivity this year (Kumar 1999), or because seeds were already dehydrated when collected from the ground. These seeds are known to dehydrate rapidly and die when their water content drops (Flores 2002). According to Flores (2002) *Otoba*'s sp. germination is normally 85% within the first 10 to 12 days. They do not require pre-germinative treatments. Because *O. gordonifolia* compose an important part of the canopy of the Los Cedros forest and seem to be a part of *A. f. fusciceps* diet (pers. obs.) it is important to find means of propagate this species. It may be necessary to collect seeds directly from the trees or by seed traps to ensure freshness.

None of the seeds extracted from frugivore's faeces germinated. According to Zorrilla (pers. comm. 2006) *Cecropia* seeds cannot germinate without passage through frugivore's gut system. I could not find any other mention of this phenomena in the literature, probably because of the lack of propagation information about this species. On the other hand, a positive effect on *Cecropia* sp. germination dispersed by fruit bats was found by Fleming (1988) and howler monkeys, by Estrada and Coates-Estrada (1986).

2.4.2 Direct seeding as enrichment planting

I have compared germination rates and early performances of four late-succession trees in two different stages of secondary forest; areas of early succession dominated by *Cecropia* trees and areas where remnant and newly recruited late-succession trees started to form higher species richness. The process of succession is accompanied by abiotic changes. Early succession areas have higher light availability, lower moisture in the soil, lower basal area and root biomass, lower soil nutrients, higher runoff, and more under-story growth than advanced succession areas (Guariguata and Ostertag 2001). *Ocotea* had better germination and survival in the advanced succession than in the *Cecropia* plots. So did the germinated seeds of *C. odorata*. *Gracinia madruno* and non-germinated seeds of *C. odorata* showed opposite trends. Increased height of all three species in *Cecropia* plots compared to advanced succession plots in the last survey was non-significant because of small sample size (due to low germination) but could, nevertheless, be due to the better light availability under the less developed succession. Forget and Goldberg (2005) and

Ramos and del Amo (1992) also showed that survival and growth were enhanced with increased light levels.

Seeds of *C. odorata* sown in the plots after they had started rooting under parent trees (but were not yet established in the ground) had 78% germination compared to 30% of the closed seeds. This might be because the latter were subjected to seed predation for a longer period (Woods and Elliot 2004) or because they were seeds from the end of the seeding season and therefore had lower viability (Vozzo 2002). The surveys of survival rates I have undertaken in three weeks intervals may have underestimated the germination rate, if germination and death occurred between observations and remnants of seedlings were not found. Out of the six seeds I picked of each of the species. Four *G. madruno* and three *Ocotea* seeds had developed roots. This implies that a longer observation time might have shown higher germination rates for these species. *O. gordonifolia* could be in a state of dormancy and germinate in the next rainy season, even though the phenomenon is not mentioned in the literature.

In central Amazonia, Camargo et al. (2002) found that the success of direct seeding may depend on the level of seed predation. A very high percentage of the seeds sown in hillsides of Northern Thailand are reported to be removed by rodents (Hau 1997). Imakawa (1996) observed that the rate of seed predation varies with the micro site at which a seed is dispersed. The plots placed in advance succession forest in Los Cedros suffered slightly higher rates of predation for all species. However, a total of only 10% of the seeds were damaged or removed. Non-germinated seeds of *C. odorata* were the main target of seed removal or predation probably due to the fact that this is the only small seed species I used in the plots and is therefore more prone to predation. This is compatible with other research recommending large seeds for direct seeding. The seedlings of larger-seeded species typically tolerate extreme conditions, they are not removed by ants and they contain greater reserves so they can resprout following partial predation (Baraloto et al. 2005, Green and Juniper 2004, Caramago et al. 2002, Parrotta and Knowles 2001). According to Forget and Goldberg (2005) larger-seeded species had a survival advantage and maintained a size advantage over smaller-seeded species. The fact that seeds of *C. odorata* were not completely buried in the soil might also have aggravated the problem (Woods and Elliot 2004). However, the high establishment of germinated seeds, ones that started rooting or very young seedlings of *Cedrela odorata* could be an efficient technique for enrichment planting.



Figure 8. Spanish cedar (*Cedrela odorata*) seedlings emerging in germination beds in nursery. (Photo: Noga Shanee)



Figure 9. Seedlings of *C. odorata* in direct seeding experiment. Sticks were placed to protect the seedlings from falling Cecropia leaves. (Photo: Noga Shanee)

Seeds were sown at the beginning of the dry season because of the project's time limitation. In research carried out in cloud forest in Mexico, seeds sown in the dry season took much longer time to germinate and achieved lower germination percentages than ones that were sown in the rainy season (Pedraza-Pérez and Williams-Linera 2005). Accordingly the results obtained in my research could be improved if repeated in wetter conditions. The recommended sowing time for direct seeding is the beginning of the rainy season, so that the seedlings are already strong enough to survive the heavy rain later in the year and have long roots before the next dry season to improve their chance of survival (ITTO 2005, Orchner 2001). Seedlings in the nursery were spared the stressful dry conditions during the initial phase of development and were protected from seed predators and herbivores. They had higher germination, survival and growth rates. The differences were significant for *Ocotea* and *G. madruno* but not for *C. odorata*. Catalan et al. (1994) recorded improved seedling performance for planted seedlings in Argentina. Survivorship rates were 60 to 80% for planted seedlings, versus 35 to 45% for directly sown seeds. It was also reported that directly sowed trees had slower growth rates compared to transplanted seedlings (Vanderwoude et al. 1996). On the other hand in the highlands of Central Laos seedlings in direct seeding experiments performed at a comparable rate to planted nursery grown seedlings (Lamb et al. 2005).

The lower survivorship among directly sown seeds may be overcome by sowing more seeds or selecting for more vigorous seeds, although this will obviously increase the costs of seed collection, and competition between future seedlings within seed spots (Caramago et al. 2002). In the case of *Cedrela odorata*, seeds were sown in pairs to give a better chance for establishment. Out of the sixty original pairs only seven were growing together in one spot, in most spots only one seed germinated or the other disappeared in the early stages of the experiment.

Characteristics of species most suitable for direct seeding are: they produce plenty of seeds that are easy and cheap to collect, they germinate and grow fast in their early stages, they have large seeds with plenty of reserves, they produce a long tap root at an early age and their seeds have a high germinative capacity (Mansourian et al. 2005, Pakkad et al. 2003, Woods and Elliot 2004). Parrotta and Knowles (2001) observed seedlings during the first 2 years after sowing and set the suitability of a species meeting these requirements as $\geq 75\%$ survival.

Seedlings in nurseries have to be maintained for a year so that they are planted in the following rainy season after collection. Many species will reach a fair size by then and

will be hard to carry (Orchner 2001). At one of the watersheds being restored by DECOIN that I visited, the workers could carry up to ten seedlings on their backs at once. The trip from the nursery to the planting area was 1 hour long on rugged terrain. This obviously makes reforestation work tedious and expensive. In an afforestation program in Tanzania, the nurseries were full of seedlings, but they lacked vehicles to deliver them to the planting site (Skutsch, 1983). In addition, transplanting of the trees when they are too big can inflict mechanical injuries, root deformities, desiccation damage and acclimation problems (FAO 1971). Therefore, it should be simpler, easier and more economically attractive to sow seeds directly in the field (Camargo et al. 2002; Hooper et al. 2002). 'Direct seeding is particularly recommended when rural communities are planting on steep hill sides, are less concerned about seedling growth rate, have available labour for field maintenance, and lack resources for establishing tree nurseries' (Woods and Elliot 2004 pp. 257).

Experiments at Los Cedros, within the limitation of scale and sowing season, showed optimistic results for the use of these techniques. Future field experiments with longer monitoring periods are necessary to assess its effect on seedling growth.

3. Identification of interested groups and conservation opportunities

3.1 Introduction

Restoration will usually be efficient in the long term only if it has the support of the local stake holders (Vallauri et al. 2005). Therefore, it is necessary to strengthen local organization and participation and to consider the socioeconomic needs at every step of planning and implementing reforestation (Chokkalingam 2005). Farmers often hesitate to invest in tree planting because the initial costs can be high, whereas the direct financial benefits are delayed, especially if people have insecure land and tree tenure and are therefore unwilling take the risk (Lamb et al. 2005, Oviedo 2005). In addition, landowners may lack the necessary knowledge and skills for propagating native trees (Mangaoang and Pasa 2003). Therefore a body of information needs to be built up in the region to provide information and technical assistance to landowners or communities about which species are suitable for planting, their handling requirements, and their market values (Lamb et al. 2005).

Information repackaging (IR) refers to collecting, remodeling and transforming scientific and printed information into usable forms to different audiences (Aina 2006). There is a growing body of knowledge throughout the world relating to forests and reforestation techniques acquired from numerous studies. However, this information does not often reach landowners in rural areas; high levels of illiteracy and semi-literacy, language barriers and information overload, makes it difficult for them to access information that is relevant, recent and comprehensive. The use of non-printed media, such as audiovisual materials, can overcome barriers of illiteracy and can enhance understanding and learning through the demonstration of complicated activities and processes (Weston 2005). By making a video guide describing various simple reforestation techniques, with a complementary written guide, I hope to give the communities enough information and encouragement to start small-scale reforestation projects. I made another video, "Saving our Spider-Monkeys" to present the scientific work done in the Los Cedros Reserve, aimed at enhancing good relations and information exchange between Los Cedros and the local communities (see attached DVD).

3.1.1 Financing reforestation initiatives

Reforestation and forest protection schemes should be financially attractive to get the cooperation of local communities (Schuyt 2005, Sierra 1999). This requires understanding of the economic value of the forest, the increased value of restored forests (Pagiola et al. 2002) and development of mechanisms to transfer money into the project (CFA 2002). The main financing opportunities are:

- Watershed protection: landowners upstream are paid to manage their forest in a way that ensures good quality water to communities down stream. Funds channel payments from beneficiaries (domestic water users, municipalities or donors) to those who protect their water source. This was tried successfully in several projects in Ecuador (see Gutman 2003, Dudley and Stolton 2003 and DECOIN; www.decoin.org).
- Direct payments for conservation of community lands (Ferraro and Kiss 2002). The quick transparent results of this method can increase awareness of the economic value of biodiversity. Payment can be given in cash or invested in education, health care or support for income generating activities (Rice et al. 2003). Direct payments were tried in the Esmeraldas province with different levels of success (Rival 2003).
- Carbon offset projects transmit money from developed countries and firms that are committed to reduce their carbon emission by the terms of the Kyoto Protocol into reforestation initiatives mainly in the tropics (Orrego 2005, Pagiola et al. 2002). The legal frameworks to allow trading are yet to be established in most tropical countries, and many of these markets are likely to have high transaction costs. This is particularly the case in landscapes containing many smallholders (Scherr et al. 2004). This means that the service of carbon sequestration might be most easily provided by large industrial plantations working with exotic species rather than by many small farmers. Such a market might then displace smaller farmers and thus generate significant social and ecological costs (Lamb et al. 2005, Stier and Siebert 2002).
- Reforestation Farming: Reforestation with the objective of planting sustainable, natural, multi species ecosystem which is economically beneficial. After 4-5

years, harvests of low-quality timber of pioneer trees and fruit can start generating income. From 10-12 years on, hard woods can be harvested. (Goltenboth and Hutter 2004, Brunner; www.tropicaltreefarms.com).

- Non-Timber Forest Products (NTFP) are increasingly used due to their compatibility with conservation objectives and contribution to household and national economies (Arnold and Perez 1998, Regato and Barrahmouni 2005). Sustainable harvest of secondary forests could generate more income per acre than agriculture depending on the accessibility to markets (Clay 1992).
- The Choco-Andean Corridor started as a Global Environmental Facility and World Bank project in the year 2000 (GEF 2000). This three year project is now maintained by Rainforest Concern (www.rainforestconcern.org). They carry out land purchase, community education and create economic alternatives for communities, such as ecotourism, organic agriculture etc. with the aim of conserving biodiversity through connectivity between the Choco and Andean forest fragments. An initial connection was started between CIBT (Los Cedros Reserve) and GEF in the year 2000, to cooperate in supporting conservation in the adjacent community of Brillasol (GEP 2000).

3.2 Methods

During the first week of research I visited to two reforestation projects in the area of Imbabura; DECOIN and Santa Lucia, in order to learn about different propagation techniques that have been successfully used in the region, and to develop a network of information and seed sharing between the projects.

I used Rapid Rural Appraisal (Nichols 1991) as a method of learning the local situation and possible solutions to the increasing poverty and forest lost. This approach is quick and flexible; it does not rely on large sample sizes and statistical analyzes. Through semi-structured interviews, direct observations, key informants and existing written material, the research seeks to develop practical action priorities for local problems (Nichols 1991).

A semi-structured interview (see Figure 10) was designed in cooperation with Ana Mariscal, PRIMNET's botanist, to investigate peoples' use of wood and their interest in community-based development projects. The data were collected to be used in developing an alternative to logging. The interviews were conducted on the 8th of August

2006 in the Agricultural Crafts Musical and Cultural Fair in Chontal as the fair was a good opportunity to engage with people from all the neighbouring communities. To avoid language and cultural misunderstandings, I had the aid of students from the National Herbarium, Quito, whilst conducting the interviews (Devereux and Hoddinot 1992). I also carried out unstructured interviews and ad-libitum conversations with the reserve's director, scientists working in Los Cedros, tour guides, activists from other environmental initiatives and local tradesmen, combined with personal observations and document reviews, to give a more holistic overview on the problems of the area and optional solutions (Denscombe 2003). Results of the interview were entered into ECXEL and analysed as descriptive statistics. All names of trees given by people were identified to species or genus level by the National Herbarium in Quito and by using reference tables in the literature (Orejuela 1992, Gentry 1986). Other publications and information gathered in interviews were used to determine wildlife exploitation and local uses of the tree species and favoured propagation techniques. I also collected information on equipment and labor needed for setting up a small-scale tree nursery with a turnover of a thousand trees per year

Semi-structured questionnaire

1. Where do you live?
2. What do you do for living?
3. For you and your family, is the work of cutting trees easier, harder or the same as in the past? Why?
4. What species of trees you cut for personal uses and for selling?
5. In a year, how many trees do you bring down with the mules to sell?
6. If there was a possibility to plant trees for the future, what type of trees do you think would be important to consider?
7. If there was a possibility to start a small community enterprise, would you have liked to participate?
8. What kind of activity do you think will be good for the community enterprise?

Figure 10. Questionnaire used to assess local people's timber uses and their ideas about community-based enterprises.

Information that was collected during the work and the experiments themselves was used to produce a video reforestation guide for local communities, in Spanish. With an English version for volunteers (both versions are attached). It includes instructions for seed collection, nursery work, wildling cultivation, direct seeding techniques, seed

preservation and seed viability tests and pasture rehabilitation techniques. A more detailed printed handbook was made to compliment the video. Additional information for the video was collected by reviewing the literature, consulting the botanist Ana Mariscal and using local knowledge gathered in different reforestation projects in the area. Another video was produced to present the work at Los Cedros to local communities. This involved the different research components of the PRIMNET project. Both videos were edited on the computer programs 'Windows Movie Maker' and 'Ulead Video Studio 9¹'. I also collected information about the price of nursery equipment to try to evaluate the minimum costs of running a small scale community nursery in case no external funding is available.

3.3 Results

3.3.1 Interviews

Seventeen semi-structured interviews were conducted with people from six different communities. The four women interviewed were housewives, twelve of the men worked in agriculture and one with livestock. One hundred percent of the people said that logging is harder than in the past, giving reasons including; there are no trees, it is far, deforestation and lack of conservation. The number of trees that they sell a year: 26 trees, 6 trees. The rest saying: don't know, a little bit or none. Species of trees used for domestic consumption and for trade are summarized in Figure 11 (species mentioned in both semi-structured and unstructured interviews) and their scientific names are presented in Table 4. During observations I carried out on the main mule routes from the villages to the road I have recorded mule convoys carrying trees that were identified by the guides as three *Cedrela odorata*, one *Dacryodes copularis* and one unknown species of Lauraceae.

¹ Movies were made in the Los Cedros Reserve to be ready for distribution in the area. The low quality of the movies is due to insufficient equipment in the reserve.

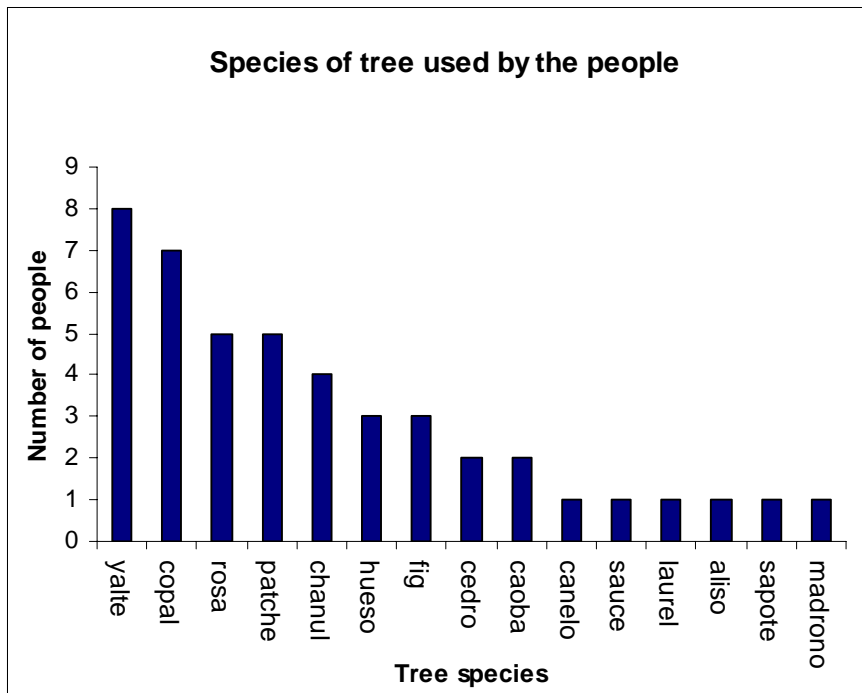


Figure 11. Species of trees given in the interviews as being used for domestic and commercial purposes.

Species that were suggested by the people as important for planting in the future are summarised in Figure 12. Two people said that the most important thing is to plant fast growing trees and one said that it is important to know the elevations where those species grow.

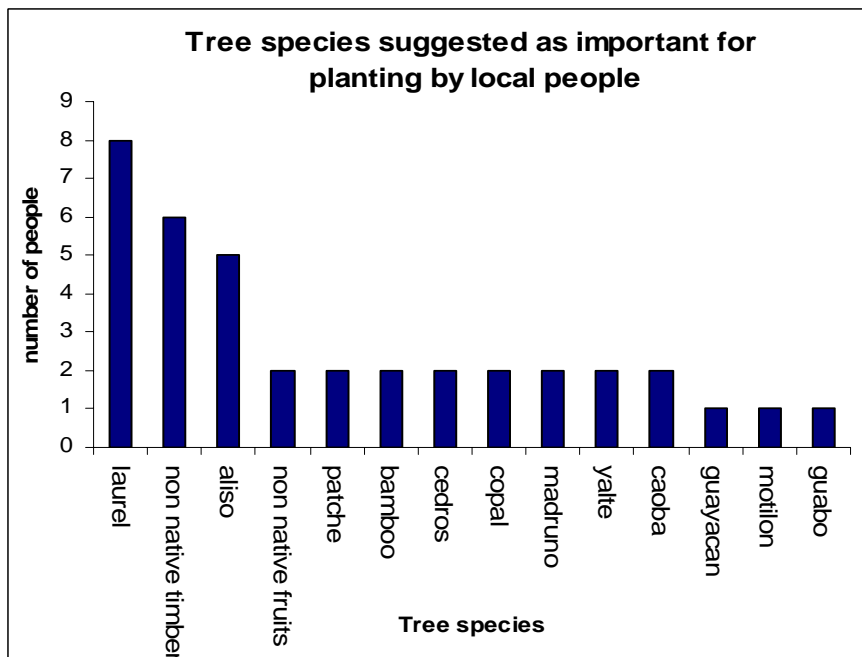


Figure 12. Species of trees important to plant for the future according to interviewees

All but one interviewee said that they would like to participate in a community based enterprise. The other said yes, depending on the type of work. As a community enterprise activity, people suggested that the most important to consider where food production and tourism. See Figure 13.

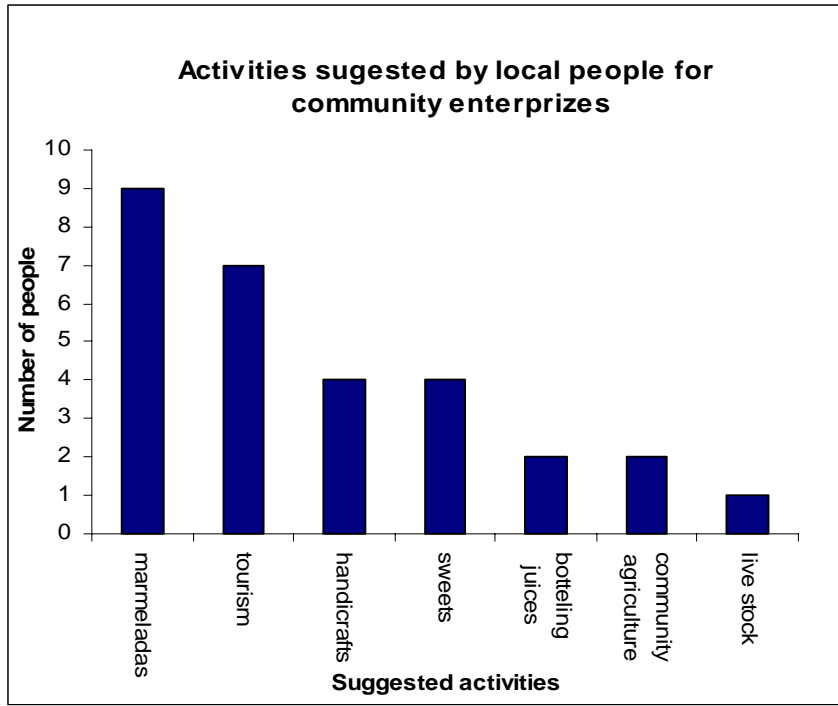


Figure 13. Optional activities for community based enterprise offered by local people

I investigate the uses and special characteristics of plant species that were identified to be used by, or important for, people and species that were observed to be primate dietary component. The results are summarized in Table 4 and in Appendix 3.

Table 4. Tree species identified in interviews, and their uses by people and primates

Common name	Family	Genera	Species	Uses	Special characteristics
Aguacatillo	Lauraceae	<i>Nectandra</i>	<i>laevis</i>	Construction, wildlife, Alouatta D (6,7), Ateles (3) Cebus (8)	1200-2800m
Aliso	Betulaceae	<i>Alnus</i>	<i>acuminata</i>		1300-3000m Good for pasture: fix Nitrogen and does not shade much
Annona, Cherimoya	Annonaceae	<i>Rollinia</i>	<i>mucosa</i>	Construction. Edible fruits Wildlife. Cebus (1,2)	
Canelo	lauraceae	<i>Ocotea</i> spp.		Construction, Wildlife	Irregular rare fruiting
Caoba	Lauraceae	<i>caryodaphnosis</i>	<i>theobromifolia</i>	Construction, wildlife	
cedro	Meliaceae	<i>Cedrela</i>	<i>odorata</i>	Construction, utilitarian. Alouatta (1)	0-3000m Problem with insects when planted too crowded . IUCN- vulnerable
Chalvinde	Myristicaceae	<i>Virola</i> spp.		Construction, wildlife, medical Ateles D (3,13,14) Cebus (4)	
Chanul	Humiriaceae	<i>Humiriastrum</i>	<i>rocera</i>	construction	
Chonta	Palmae	<i>Bactris</i>	<i>gasipaes</i>	Edible fruits, multiple purpose, Chontal	0-1200m
Copal blanco	Burseraceae	<i>Dacryodes</i>	<i>copularis</i>	constaction, incense, medicine for infection and flue. wildlife. Alouatta (1), Cebus (1)	IUCN-rare
guabo	Leguminoseae	<i>Inga</i>	<i>edulis</i>	Fire wood, edible fruits, wildlife Alouatta (12) Ateles D(1, 3,12) Cebus (2,4)	1000-2500m nitrogen fixer fast growing good for coffee shading
Guadua, bamboo	Graminae	<i>Guadua</i>	<i>angustifolia</i>	Construction, utalitarian, artesanía	
guayacan	Lauraceae	<i>Minuartia tebebuia</i>	<i>chrysantha</i>	constraction	

Gwarumbo, yarumo	Moraceae	<i>Cecropia</i>	<i>monostachya</i>	Wildlife, firewood, Alouatta D (6, 9,11), Ateles D (3, 14), Cebus (1,2,4)	1000-2000m Grows fast. Hard to collect seeds. Endozoochorouse.
higueron	Moraceae	<i>ficus</i>	<i>racunata, or mutissi</i>	Wildlife, some species construction. Alouatta D (6,9,11), Ateles D (1,3,12,14) Cebus (1,2,4)	600-2500 Some species are good for vegetative propagation
Hueso	Lauraceae	<i>Ocotea sp.</i>		construction	
laurel	Boraginaceae	<i>Cordia</i>	<i>alliodora, or columbiana</i>	Construction, firewood.	fast growing
Lechero	Euphorbiaceae	<i>Euphorbia</i>	<i>laurifolia</i>		
madrono	Gutiferae	<i>Rheedia, gracinia</i>	<i>madrano</i>	Edible fruit, wildlife. Ateles D, (1,3) Cebus (1,2,4)	
motilon	Euphorbiaceae	<i>Hieronyma</i>	<i>Chocoensis</i>	Contraction, firewood, medicinal, edible fruit, wildlife	2100-2800 High germination rates
Patche	Lauraceae	<i>Belismedia spp.</i>		construction	
Rosa	Lauraceae	<i>Aniba spp.</i>		construction	
Sangre de gallina, cuangare	Myristicaceae	<i>Otoba</i>	<i>gordonifolia</i>	Constraction, firewood, wildlife Ateles (1), Alouatta (1)	
Sngre de drago	Euphorbiaceae	<i>Croton sp.</i>		Medicine, soap, good for pasture.	Gravity dispersed Propagation of wildlings
sapote	sapotaceae	<i>Poutaria sp.</i>		Construccion, edible fruit wildlife. Ateles D (3,10,12) Alouatta (5), Capuchin (1)	
Souce	Lauraceae	<i>Caryodaphnopsis</i>		Construction	
Yalte	Lauraceae	<i>Ocotea</i>	<i>leucoxylon</i>	Construction	

D- dispersal, 1- Observations in Los Cedros by Gavilanes, 2- Terbourgh 1983, 3- Van Roosmalen 1985, 4- Oppenheimer 1982, 5- Julliot 1996, 6- Estrada 1984, 7- Estrada and Coates Estrada 1986, 8- Freese and Openheimer 1981, 9- Milton 1980, 10- Klein and Klein 1977, 11- Yumoto et al. 1999, 12- Stevenson et al. 2001, 13- Russo and Augspurger 2004, 14- Russo et al. 2005

3.3.2 Unstructured interviews and ad-libitum conversations

A few important issues were raised in ad-libitum conversations:

- Communities only realize the need for forest protection and reforestation when there is a real danger to their livelihood.
- People are not attracted to reforestation and tourism as alternatives for logging because they see them as a long term investment with insecure results.
- There is no enforcement of logging restrictions in the area.
- There are plans to open a road that will reach Magdalena Alto. There is also a mining concession that jeopardizes a big part of the Cotacachi-Cayapas buffer zone.
- *Cebus capucinus* monkeys are still seen in close proximity to Chontal. In Brillasol *Ateles fuciceps* are still seen occasionally on private lands, and around Pueblo Unido there is high density of *Alouatta palliata* in primary and degraded forests.

3.3.3 Related reforestation projects

Following is a description of two projects I have visited:

Santa Lucia (www.santaluciaecuador.com)

Supported by Rainforest Concern, the community of Santa Lucia conserves a seven hundred hectare reserve (of which 80% is primary forest) as part of the Choco-Andean Corridor. The reserve focuses mainly on ecotourism as an alternative sustainable income. With the help of 'British Trust for Conservation Volunteers' they started a small scale afforestation and reforestation program. Old, highly degraded pastures were planted with mixed species such as *Croton* sp., *Hieronyma* sp., *Cedrela Odorata*, *Euphorbia laurifolia*, and *Alnus* sp. (a nitrogen fixer). Most of which are secondary forest species that grow in high levels of sun. Trees are planted at four to five meters intervals. Most planting took place 2-5 years ago. According to Jorge Morales, the nursery supervisor of the project, the soil quality has improved dramatically from compacted and yellow with unusable grass to high quality pasture (Morales, J. Pers. comm. 2006). This kind of treatment, known as silvo-pastoralism, was experimented scientifically and was found to reduce the high degradation levels of tropical pastures and allow long term use of the pastures while

providing habitat for wildlife (Montagnini 1995, 2001, Rhoades et al. 1998). This information is very valuable for local communities because of the fast rates of pasture degradation in the area (Ganade 2001) which leads to a continuing need to convert forest into pasture. Other projects in the reserve are accelerating regeneration of natural secondary forest by enrichment planting and the creation of an orchid garden for research and education purposes.

DECOIN (www.decoin.org)

A project started in 2002 as a grassroots organization² aimed at conservation of watersheds and biodiversity in the Intag region. With the help of the communication company O2, the Rufford Maurice Laing Foundation and Rainforest Concern twenty-six community reserves were initiated, varying in size from 2-130 hectares. All the nurseries are run by the community and so is transplanting in the reserves. Planting emphasizes on high quantities and diversity of trees; 20,000 trees of 37 native species were planted during the project with a tree survival of more than 80%. Project director Mr. Zorrilla is collecting information about the propagation of all species to develop a database for reforestation in the area, some of the information is already published in a reforestation manual (Zorrilla C. 2005). Communities are joining the project after securing land titles from the government. They are trained by DECOIN to protect and improve their land and to monitor their water quality. In all cases water quality and flow were improved, and some of the springs that dried up in the past are now running again. Wildlife is quickly migrating into these reserves, mainly a high density of birds and bats that use the reserves as refugias (Zorrilla C. pers. comm. 2006).

² Organization that aims to involve people at local level in decision making rather than relying on central control.



**Figure 14. Deforestation in Intag province. Landslides are a common hazard.
(Photo:Noga Shanee)**



**Figure 15. Two years old forest stand at one of the DECOIN watershed reforestation sites. Barb wire fence is to protect from neighbouring cattle.
(Photo: Noga Shanee)**

3.3.4 Nursery costs

Table 5 shows the estimated costs of running a small-scale nursery with a turnover of a 1000 trees.

Table 5. Cost of nursery infrastructure and equipment

Equipment	Price per unit (\$)	Price per thousand trees (\$)
Fence	0.2/ meter	50
Shading cloth (not necessary)	1.5/ meter	75
Hoes	0.5/ meter	20
Secateur	8	16
Machetes	5	15
Shovels	10	30
Spades	10	30
Bags	0.06/ hundred	6
Wheelbarrow	20	20
Biological pesticides	5/ pack	20
Labor	6/ day	300
Total		582

3.3.5 Outcomes of community networking

- A local eco-tourism NGO, Eco-Aldea Chontal, and the Chontal tourism committee have initiated a nursery that will propagate native trees to be planted around trails that are used by tourists.
- Two of the guides from the Santa Lucia Project came to help on two days of seed collection for the experiments. In return they received a large proportion of the *Cedrela odorata* and *Ocotea* seeds collected.
- Spanish versions of the video reforestation guide and printed handbook (See DVD attached for English version and narrative in appendix 3) were distributed to the 14 participants of the first para-biologists training course run by PRIMENET in Los Cedros, September 2006.
- The video: “Saving Our Spider-Monkey” (see attached, narrative in appendix 3), describing the work carried out in the reserve was shown in the Agricultural, Crafts, Musical and Cultural Fair in Chontal. Unfortunately, because of a technical problem, this was only shown to a small audience.

3.4 Discussion

3.4.1 The interviews

I could only conduct 17 interviews; this is not an ideal situation as the recommended sample sizes for Rapid Rural Appraisal is 30-50 interviews (Nichols 1991). Therefore there might be additional important aspects or ideas that were not revealed in the interviews. Most people did not give a direct answer as to the number of trees they sell annually and the answers given do not seem to reflect the real logging situation. This could be a result of the sensitivity of the issue, people were aware of the restrictive logging laws in Ecuador (Forestry and conservation law 1981, 1999, Navarro et al. 2006) and might have been afraid that their answers will be used against them to jeopardize their livelihood (Christensen 1992). It could also be a result of the small sample size of interviewees. According to a study based on supervised classification of LANDSAT images; within the fifteen kilometer buffer zone around the Cotacachi-Cayapas Ecological Reserve approximately 56% of the forest cover was lost between the years 1987 to 2001, this adds up to a loss of 704 ha/year in the buffer zone (Peck M. Pers. comm.). The method by which logging occurs (See section 1.5) mean that it is hard to assess how much land was deforested simply according to the amount of trees sold. The species of timber identified by people to be exploited for their personal use or for trade are mostly slow growing primary forest species with high preference to Lauraceae species. Cedros, (*Cedrela odorata*), canelo (*Ocotea* sp.) and caoba (*Caryodaphnopsis theobromifolia*) are becoming increasingly rare in the area because of over exploitation and low regeneration (Obando M. pers. comm.). They are found only in the most remote places and therefore decreasingly used despite their relative high value (Hetch 2004). Hetch also investigated the timber used in carpentries in the Pastaza province of Eastern Ecuador and found canelo and cedro to be the most utilized species. The levels of deforestation in the area and people's concerns about it are reflected through their expressions describing the increasing difficulties of logging.

The tree species most sought after to be planted for the future were laurel (*Cordia alliodora*, or *Columbiana*), exotic species namely pine (*Pinus* sp.) and eucalyptus (*Eucalyptus* sp.) and aliso (*Alnus acuminata*); all fast growing pioneer trees. These results represent the local's need for immediate solutions for the poverty they are facing.

Indigenous tree species often show lower growth rates than the exotic species mentioned above and many have specific site requirements (Mansourian et al. 2005). Another hindrance to propagating native species is the lack of plant material; while exotic species' seeds are sold in big, inexpensive quantities and with easy instructions, native species require a greater knowledge base (Lawrance 1997). On the other hand, indigenous species are usually more valuable than exotic species (Lamb et al. 2005). Monoculture or a mixture of a few species of native timber species or even exotic ones can facilitate successional development in extremely degraded land and poor soil if they are not too far away from primary forest and if the undergrowth is left uncut (Carnus et al. 2006, Feng and Peng 1997, Lugo et al. 1993, Lamb and Gilmore 2003). However a mixed plantation of native species combined with enrichment planting of fruit trees to attract wildlife, will accelerate succession; primary forest species will take over with time and eliminate pioneer species (Parrotta et al. 1997). This goes along with local's preferences of late succession trees demonstrated in the results of the interviews. Additionally, smallholders who plant native tree species often prefer to use more than one species because they are interested in producing a variety of goods (Lamb and Gilmore 2003). This reforestation mechanism needs to be managed in a way that will balance production and biodiversity gain; to generate income while creating a favourable environment for plant and animal species. Plantations can not only reduce logging pressure on existing forests but can provide buffer zones to native forest remnants, and ecological corridors³ between areas of native ecosystems (Carnus et al. 2006).

An interesting point is that according to local people *Cedrela odorata* is an extremely slow growing tree that takes more than a hundred years to be ready for cutting. Conversely, scientific resources describe the species as a fast growing tree that is recommended for plantations, and grows in both secondary and primary forests (Citron 2005, Mexal 2002). This disagreement could be due to a site specific restriction of the species or that locals concluded the growth according to the species slow initial growth rates (Rocas 2002). This should be investigated and people should be encouraged to use the species because of its rarity and high value. De Coux's observation about the rarity of the species seeding (see section 2.1.1) is also interesting for investigation in the future

³ Ecological corridors link isolated protected areas. Ecological corridors are not under intensive land-use, are distinctly different from surrounding areas, and allow the movement of plant and animal species between the protected sites (ITTO 2005)

because most publications say they have regular seeding bouts (for example; Rocas 2002, Patino Valera 1997).

Community based micro-enterprises can provide economic alternatives to forest logging and generate income for reforestation projects (Gaoba 1999, GEF 2000). In addition, helping the communities to organize production can result in strengthening their abilities to defend their lands, forests and ways of life (Clay 1992). I tried to determine, through the interviews, what were the locals' ideas and interests towards communal activities. The complete agreement to participate in activities suggests that people are longing for economic alternatives but can't find suitable opportunities. This assumption is substantiated by GEF suggesting that the lack of alternatives in the Choco communities is a result of inefficient technical assistance, limited access to credit, and insecure land tenure (GEF 2000). Activities suggested by the interviewees were mainly fruit related food production and tourism.

Enterprises should be encouraged to use native fruits for production. Native fruits can be obtained in two ways; 1) Non-Timber Forest Products (NTFP) which will involve gathering of harvest from secondary or primary forests. This will justify the need to protect those forests and even to invest in enrichment planting of useable species (Regato and Berrahmouni 2005). 2) Reforestation farming; planting a variety of productive species like *Gracinia madrono*, *Inga edulis*, *Ficus* spp., *Poutaria* sp. etc. These can be mixed with other income generating species like *Croton* sp, *Cordia alliodora*, and higher quality timber species. The method will ensure continuing revenue and will offer high quality habitat for biodiversity (Goltenboth and Hutter 2004). The high density of fruit trees will attract animals to the farms. Howler monkeys are likely to move to those farms because of their migration patterns (see section 1.3) and because they are relatively tolerant low levels human disturbance (Gradwohl and Greenberg 1988 and McCann et al. 2003). In both cases training should be given in the collection and processing of the fruits to the final products. Also, before promoting such alternatives for livelihood one must undertake feasibility and market studies, to avoid engaging people in activities when there is no appropriate market for them (Mansourian 2005).

Nature-based tourism has expanded rapidly over the last two decades, in some cases creating financial incentives for landscape or biodiversity conservation and the income generated can benefit local people significantly (Honey 1999). WWF is encouraging community based ecotourism as it provides a more sustainable form of

livelihood for local communities, encourage communities to be more directly involved in conservation and generate more goodwill towards, and benefit from, conservation measures such as protected areas. (Denman 2001). Ecotourism directed towards the brown-headed spider monkey as a flagship species could, if successful, elevate the species' value in the eyes of local people and reduce hunting pressures (Horwich 1998). The existence of primates in the degraded forests nearby the different settlements will potentially allocate efforts into upgrading these habitats for use by tourism. This will also lessen the pressures tourism inflicts on primary forests.

The tourism committee of Chontal offers tourists stays for a few days with local families in different communities according to their choice. Some tourist groups are also brought to Los Cedros through the committee. Profits are distributed between the different families and the comity (Nogales J. pers. comm.). The tourism committee and Eco-Aldea's request for our help in initiating a reforestation project illustrates the positive influence of ecotourism on conservation in the area. Part of the planed project is to involve schools and tourists in the process of nursery and planting work which will add high educational value to the project. PRIMENET provided shading cloth, are thousand nursery bags, and the reforestation guide video. The committee was also invited to the Los Cedros Reserve for seed collection.

Another option for a community based enterprise that did not come up in the interviews but is successfully done in the area is the development of wood processing industry and carpentry. A project in the community of Christobal Colon, focuses on providing higher income from lower intensity timber harvests, by adding value to wood through processing it in the community itself and promoting sustainable forest management practices (Pinchot Institute 2006). This initiative gets around the problem of international market policies that discriminate against community producers by keeping low prices and therefore forcing them to over log the forests (Scherr et al. 2003). This option is currently being promoted to the communities around the Los Cedros Reserve by PRIMENET (Mariscal A. pers. comm.).

Community based development as a method of reducing forest destruction can potentially create new, additional problems for conservation (Sayer et al. 2000). Oates (1999) broadly describes causes and consequences of development projects that failed to help wildlife or human populations in West Africa. Money generated from those initiatives could be utilized for roads construction, additional hunting and logging instrumentation etc. locals in the Choco area utilized the income generated from a few of

the environmental initiatives to purchases cattle when the project came to an end, and this way that intensified land conversion (Mariscal A. pers. Comm.). According to Ascher (1995) successful management of forest resources by communities is conditioned by; 1) local groups perception of forests as important and valuable, 2) property rights developed so groups can benefit from resource management 3) groups are organized enough and authorized to regulate the use of the resources (Ascher 1995). One example for a community that failed to sustainably protect its forest is Loma Alta in Western Ecuador, even though initially compliant with the conditions above, the community was reported to fail to create institutions to regulate their forest use and therefore maintained deforestation patterns (Gibson and Becker 2000). However, these risks are unavoidable and need to be accepted as human influences will never be eliminated from forest ecosystems (Poteete and Ostrom 2001).

3.4.2 The video and printed guides

The guides are made to be simple and are aimed at capacitating local communities in starting their own reforestation projects. I paid special attention in the videos to the brown headed spider monkey. This is due to the species' suitability as a target species for active restoration. According to Karjalainen (2005) a target species should be endangered and/or endemic, play a keystone role for its habitat, and be an umbrella and/or flagship species. *A. f. fusciceps* meets all these requirements (see section 1.2). The Spanish versions of the guides are meant to be distributed to local communities and NGOs. The high levels of illiteracy and semi-literacy in those rural communities (Bermudez 2003, Decoux J. pers. comm.) make videos the most efficient media for disseminating of information. Usually there is at least one TV and VCD/DVD set in each community running on electricity or a generator and the projection of movies is an enjoyable communal event. At any case the Los Cedros Reserve has a LCD projector that can be brought to social meetings. Showing the movies to groups will facilitate conversation and exchange of ideas. Handbooks are available for people that want more detailed information.

The English versions of the video and written guides were made for the use of volunteers in Los Cedros. Usually, volunteers that arrive to the reserve get insufficient guidance regarding conservation activities they could carry out and therefore do very little (pers. obs.). The guides are meant to supplement the need for directions. Most experiments offered in the guide require long term observations but some of the activities

could be beneficial even if they are done on a short term basis like encouraging and helping communities to start nurseries, collecting seeds to distribute to existing nurseries, or clearing grasses around emerging trees in abandoned pastures.

3.4.3 Estimated opportunities and conflicts

Following issues are essential for the success of a reforestation project:

Local perception of the project- Successful forest restoration relies on achieving a broad consensus among a variety of stakeholders who may have different perceptions of what forests should provide. In this case the main obstacle for reforestation seems to be people's perception of reforestation initiatives as a "long shot". Because of local peoples' total dependence on forests for their livelihood, negotiation and trade-offs⁴ will be a necessary to persuade them that reforestation and alternative initiations will permit gradual transfer to the use of planted trees without impediments to their livelihood (Jones and Dudley 2005). Through immediate poverty alleviation actions like restoration of riparian forest and planting commercial timber, large scale reforestation and biodiversity conservation will be possible (Sayer and Elliot 2005, Scherr et al. 2003, 2004).

Governmental restrictions- There is little or no Enforcement of the Ecuadorian forestry laws in the area. Governmental enforcement aimed to protect the forests must only be in conjunction with providing economic alternatives to avoid a rise in poverty which could lead to resentment (McCarthy 2000). Another problem with enforcement of these restrictions is that they are usually focused on the poor rural loggers and not on the large logging companies which force overexploitation by disobeying the laws and by setting low prices (Contreras-Hermosilla 2001, Rival 2004, Kaimowitz D., 2003).

Adjusting the project to local needs- Direct payments for biodiversity protection or payments through the Choco-Andean corridor (see section 3.1.2), seem to have never been offered to any of the communities visited. Flora (2002) mentions that no reforestation program was ever introduced to the four communities located in the Cotacachi-Cayapas buffer zone she studied. That seems odd in the light of the international acknowledgement of the area as a conservation priority and high abundance of large scale multi-million dollar conservation initiatives taking place in the area.

⁴ Trade off- a situation where a balance needs to be reached when choosing between two desirable but incompatible objectives or outcomes (ITTO 2005)

Deforestation rates and poverty levels are ever increasing, attested to by the constant sounds of chainsaws that can be heard from all sides of Los Cedros. The impression I got from my experience with communities was one of helplessness, high enthusiasm for a change and understanding of environmental issues. This impression is strengthened by DECOIN's inability to cope with the high level of demand for inclusion in the project from local communities (Zorrilla C. prss.comm.). Therefore, I believe that the efforts and funds invested in the area are failing to achieve their targets. International conservation agencies seem to be over ambitious to "rescue" the area and its inhabitants; projects are too big while overlooking local situation, farmers' needs, available resources, indigenous knowledge and working habits (Chokkalingam et al. 2005). For example, SUBIR was the largest USAID-financed integrated conservation and development program (ICDP) in the world. It ran in the north of Cotacachi-Cayapas from 1991-2002 in order to develop sustainable alternatives to promote conservation (Rival 2004). The project was reported to fail to address local needs and values; adequate provision of health and education service, and therefore ended abruptly due to low levels of cooperation from the communities (Rival 2004, Walker 2004).

Development- Currently trunk roads reach the communities of Chontal and Magdalena Bajo. The plans to open a road to Magdalena Alto could cause acceleration in the deforestation process as the transport of logged wood from the forest will become easier. According to Chomitz and Grey (1996) road building in areas with agriculturally poor soils and low population densities can be especially destructive, causing habitat fragmentation and providing low economic returns. On the other hand a road could make it easier to develop ecotourism and a sustainable extraction of NTPF by giving the communities better access to markets (Maki et al. 2001). Oil and mining companies offer people jobs and services, by that attracting them to participate and support the development of the mine. A new mining concession has been given inside the Cotacachi-Cayapas buffer zone. The project is supported by the World Bank and the Canadian government and is one of the main concerns of DECOIN as it will have a devastating effect on the ecosystem as a whole and the communities in the buffer-zone (Zorrilla 2002, 2003). Therefore the critical time to start developing economic alternatives for the communities is now, before further development will cause irreversible damages.

Land tenure- Land tenure insecurity is one of the most serious constraints to development of local forestry enterprises (Scherr 2003). In Ecuador, generally only indigenous communities have common land tenures, but it is possible to get land rights

recognized directly by the governments or through a trust that is managed by the colonos communities (deCoux pers. comm.).

Local education- Environmental education programs will be a necessary component of all proposed conservation action (Palmer 1998, Jacobson and McDuff, 1998). It is aimed at increasing people's environmental knowledge in order to change their attitudes and therefore behavior towards nature (Caro et al, 1994, Rose, 2001). A painting contest with the theme of "forest and wildlife" was made in the Agricultural Crafts Musical and Cultural Fair in Chontal by the Los Cedros' volunteers for the children of the communities. The activity attracted literally all the children that were present in the fair at the time as well as many of the adults. School teachers and parents were present and assisted the volunteers at all times (pers. obs., see Figures 16, 17). This demonstrates a high willingness of the local population to participate in extra-curricular and environmental education activities.

Nursery costs- Small-scale tree nurseries are essential in fulfilling the goals of reforestation and agroforestry implementation schemes in developing countries (Indqvist and Ong 2005). Initiating a tree nursery will have to take into account logistics such as site location, seedling species, care taking responsibilities, protection, ownership, all year water availability, weeding, root pruning, good fertile soil close by and space of future planting. Commercial shading cloth might be the most expensive equipment but could be replaced by bamboo, palm leaves or remnant trees for shade (Kumar 1999). Barb wire fencing is a must for nurseries to keep out unauthorized people and animals. I have tried to estimate the minimum costs of initiating a nursery with a turnover of a thousand trees. Estimated cost was around US\$0.60 per tree. DECOIN is paying nurseries one dollar for each tree they produce and plant in the community's watershed. Despite the relatively high costs of nursery establishment, they are an important part of reforestation because their operation requires skill and cooperation and because they can be used for educating children and tourists.

Labour- Labour in the area if done for communal purposes, such as trail improvements and the construction of bridges etc. is typically done by communal work units called '*Minga*' (Orejuela 1992). These '*mingas*' are extremely efficient work forces which could take a grate amount of the labour expenses if done for a collective goal like reforestation of a communal watershed. They are part of a community's social interaction and by that strengthen the community and facilitate exchange of ideas (pers. obs.). Degrande et al. (2006) investigated private native tree nursery production in Cameroon

and found that even though the farmers master the propagation techniques, most of the nurseries were running well below capacity. The main reasons were: complicated techniques and lack of motivation within the farmers groups. They recommended simplifying propagation techniques, upgrading farmer's skills by trainings and strengthening groups by demonstrating the potential benefits of increased production.



Figure 16. Winning paintings from the contest made by Los Cedros' volunteers with the theme of forest and wildlife. (Photo: Sam Shane)



Figure 17. Painting of a monkey eating papaya. Saying "Protect the lives of the monkeys" (Photo: Sam Shane)

3.4.4 Assessment of the Los Cedros Reserve's possible role in reforestation

The Los Cedros Reserve is geographically isolated from surrounding communities. The poor trail system and steep mountains make it impossible to distribute plants grown in the Los Cedros nursery to be transplanted out of the reserve where they are most needed. Large scale planting in the reserve itself is unnecessary since more than 90% of it is primary forest. Therefore, Los Cedros should not focus on providing nursery services. On the other hand, the comfortable accommodation and scientific facilities offered by the reserve are attracting increasing amounts of researchers and volunteers that come to study different aspects of this well preserved ecosystem. As mentioned above (section 2.1), botanical inventory to assess primate related vegetation abundance, and regeneration has already started. The high level of protection in the Los Cedros forest makes it a great reference forest that will provide information about natural species mix, ecology and succession and could be used as guidelines for planting and measuring success (Dudley 2005b). Therefore, it is possible that the reserve will evolve to be a research center for reforestation methodologies and techniques. Information gathered will be spread to local communities. This complies with the main objective of PRIMENET, which trains indigenous people as para-biologists, capacitating them to conserve their own land. The training takes the form of a week long course; key local people from different communities and environmental initiatives in the buffer zone of the Cotacachi-Cayapas Reserve learn different techniques of monitoring and conserving the forest and its fauna from biologists and botanists. The parabiologists are supposed to constitute a link between the scientific world and the local communities. The videos and information distributed in the course will hopefully percolate to the communities and will encourage them to initiate reforestation.

Another possible role that could be taken by the reserve is to be a seed bank for the neighbouring communities. As mentioned before, lack of planting materials can be a major hindering factor to using native species for reforestation. Volunteers could collect seeds from the reserve and distribute them to the nurseries. This will require detailed research on the best storage practices for the different species to prolong their viability. The available hydroelectric electricity will allow the purchase of a small refrigerator for storing seeds that need low temperatures.

All botanical experiments, including those that were offered in the reforestation guide are based on long term observation after planting, usually of many years. Most volunteers come to the project for a period of a few weeks and therefore it is hard to keep experimental continuity of treatments and data collection, which could bias results. For that reason it is very important to have a local student or to train one of the reserve's guides to supervise the experiments so continuity is retained.

There is a severe lack of communication between the Los Cedros Reserve and the local communities. This is a result of the reserve manager's poor social skills and a deficiency of educational programs. Hence communities' insufficient understanding about the reserve, which sometimes leads to resentment (pers. obs. 2006). The movie "Saving the Spider Monkeys" was made in order to show people through a mixture of scientific facts and humour, some of the aims and research of the reserve.

4 Project's outcomes and recommendations

These are the major outcomes of the research regarding the project's aims:

About a thousand trees were propagated during the study. Seedlings from the nursery will be distributed to interested communities or will be planted inside the Los Cedros Reserve for enrichment planting. Reforestation projects in the Choco floristic region will be feasible as long as it takes into consideration the needs of local communities. At the first stage efforts need to be focused on alleviation of poverty and creation of economic opportunities through grassroots organizations. Only then will it be possible to extend to directing reforestation efforts solely toward conservation. Luckily many of the reforestation schemes aimed at economic benefit, if done from an ecological perspective can benefit wildlife by providing habitat and reducing logging in primary forests. Due to *A. f. fusciceps* requirements for old growth primary forest additional to the slow mammal migration rates into reforested areas (Parrotta et al. 1997), it is of greater necessity to ensure that the primary forests in which *A. f. fusciceps* still exist will stay intact.

Los Cedros can fulfil the role of an experimental centre which distributes reforestation information and training to local communities, and a seed bank that will

offer seeds and seedlings to neighbouring projects. To be able to do this a supervisor should be found who will facilitate communication between interested parties.

The communities surveyed expressed concerns about the levels of deforestation and showed interest in participating in community-based economic alternatives. Eco-Aldea Chontal, and the Chontal tourism committee showed high interest in the project and initiated a nursery to propagate native trees for reforestation of tourist trails. These projects are run by local people and work with tourists and children so they are valuable partners for implementing environmental education. The para-biologist training courses ensure continuous connection with the communities through those highly motivated key individuals.

People are very interested in economic alternatives and should be given all possible help to initiate them. To make people aware of the dangers of deforestation and the eco-friendly alternatives, I suggest producing a video, shot in Intag province, where reforestation was started after water supplies were jeopardised and in other communities where people are still suffering from desertification. A locally made video will attract more attention by showing the concrete dangers they are prone to.

I have tested propagation methods for four native tree species. Direct seeding results showed promising trends and should be further investigated. Due to the high establishment of germinated seeds of *C. odorata*, its high economic value, and the rarity of the species, I recommend planting seeds that have started rooting or very young seedlings of the species' as an efficient technique for enrichment planting. All sowing for direct seeding should be done during the first few months of the rainy season. *C. odorata*, *Gracinia madruno* and *Ocotea* had high germination and survival rates in the nursery. *C. odorata* was also successfully propagated from wildlings. I recommend investigation of further species and techniques in a longer term experiment that will allow follow up on survival and growth rates after transplanting saplings to the forest. I produced a video reforestation guide accompanied with a handbook as user-friendly and location-specific guidelines for native species reforestation which are being distributed to local communities to capacitate and encourage them to initiate reforestation. I recommend the making of seed identification leaflets which will include pictures of seeds and information about their collection to be added to the reforestation handbook.

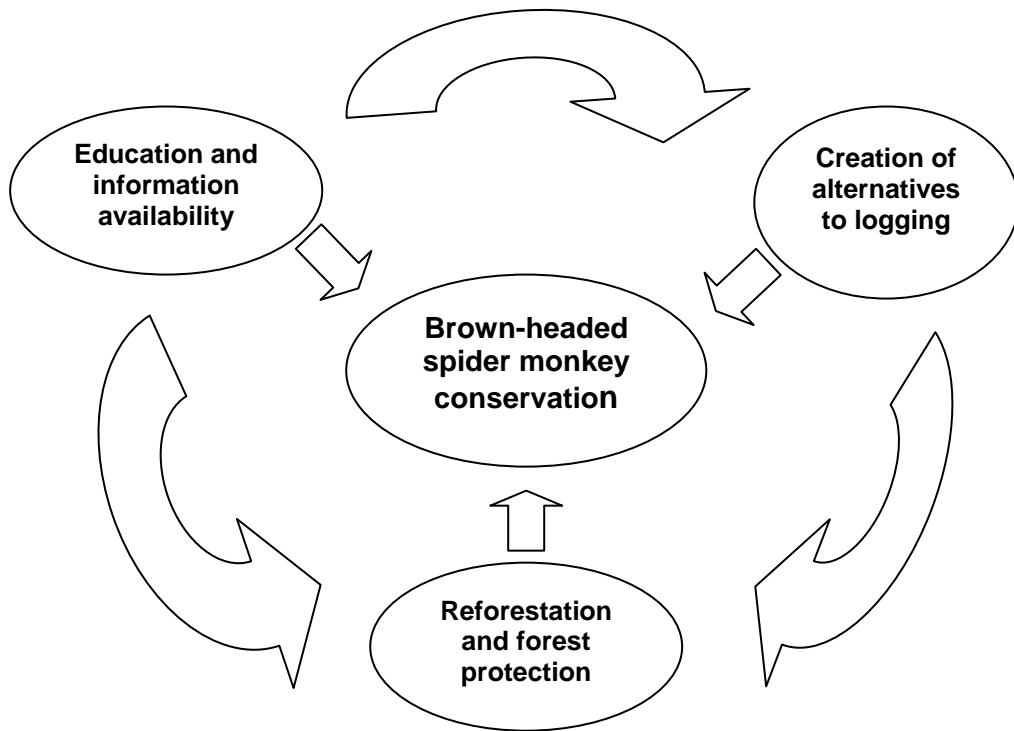


Figure 18. Graphic representation of processes involved in the conservation of *A. f. fusciceps*.

5 Conclusions

This study had a very limited time scale which inevitably restricted sample sizes and observation period. Therefore, the results are not conclusive. Nevertheless, they suggest that a large-scale reforestation project in the area surrounding the Los Cedros Reserve is necessary, and feasible. Using low input techniques such as direct seeding alongside the creation of a nursery and usage of suitable trees to improve soil fertility on pastures, and the creation of economic alternatives could lead to real improvement in local land use and, by that, aid the survival of the brown-headed spider monkey and other locally endangered species.

A long term study in the area should explore the ways in which funds are distributed into environmental projects in the Choco and try to understand the possible obstacles and faults that create the enormous gap between the efforts and money invested and the results on the ground. The research should critically look at the activities of large conservation agencies such as IUCN, the World Bank, WWF etc. as they are the most powerful forces in the areas' conservation. A parallel study should investigate tree propagation techniques to learn the most suitable and efficient techniques. Because of the urgency to implement conservation in the rapidly disappearing Choco floristic region, and because of the extensive amount of academic work made in the area compared to the low levels of actual effective conservation work, research must be combined with helping communities to start reforesting their land, finding funds to support the work and creating economic alternatives.

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Appendix 1: Narratives of videos

Saving our spider monkeys in Los-Cedros

Los Cedros biological reserve is an ecological primary cloud forest reserve in the Imbabura province of Ecuador. The reserve hosts a primate conservation project called PRIMENET.

This is a capuchin monkey, called *Cebus capucinus* in Latin. It is the most intelligent primate in South America due to its remarkable brain size. They live in groups of about twenty individuals led by a dominant male. They eat mainly fruits and insects

The howler monkey mainly feeds on leaves. The low energy of this nutrition is the reason for its lazy behaviour. The brown headed spider monkey is a critically endangered species. Mainly because of the rapid deforestation of its habitat. There may be as few as 250 individuals left in the whole world. Therefore, scientists from all over the world gather here to study this mysterious animal.

To protect these primates we have to know how many of them are here and what their situation is. Therefore the scientists walk slowly and silently in the forest to find them. The researchers spend long hours walking in search of the monkeys and sometimes even camp in the forest overnight. To encounter the howler monkeys the biologists listen for their morning howls. These monkeys produce such calls to communicate between groups. The biologists stand and listen on the top of the ridges waiting for these calls

When encountering the monkeys a system called GPS is used to determine the monkey's exact location. After locating the monkeys the scientists try to study their behaviour e.g. feeding habits and social relationships within groups. However, the monkeys are usually afraid of people and usually produce alarm calls and flee on contact. With a lot of work and patience, the biologists and volunteers hope to habituate the monkeys to human presence to allow in depth behavioural studies and the development of ecotourism for those people who are interested in these special, charismatic primates

Studies of the forest

To learn more about the forest, PRIMENET raised a helium balloon above the canopy. The helium gas is lighter than the surrounding air. This allows the balloon to float more than a hundred metres above the forest canopy. A small camera is attached to the balloon which takes photos every 30 seconds. These photos taken by the balloon allow the scientists to learn about the vegetation in the habitat of the primates and to learn about the characteristics of the primary forests in this area. These are some of the photos that were taken. These are some of the photos that were taken. They permit a study of the trees that are important for the survival of the primates

The fruit production of the trees that is essential for the monkeys, like ficus is measured by collecting the fruits that fall from the trees into fruit traps that are placed under the trees. By weighing the collected fruits over the whole fruiting season an exact quantity of fruit produced by each tree is established. Fruits of different trees are collected to be identified and then planted in areas specified for reforestation. Some of these trees are beneficial to animals and some for humans. The tree that you see is called cedar. These are small cedars that were collected in the forest to be grown and re-planted in the forest for the monkeys or as an alternative source of wood for the surrounding communities i.e. the need to cut the down trees within the forest is reduced.

Experimentation is taking place where the seeds of primary forest trees have been planted directly into secondary forest soil to see if they will grow. If successful, the process of reforestation is made easier and cheaper. Scientists are at present attempting to sow the seeds of different tree species for example the cedar seeds. Other experiments include the sowing and planting of Lauracea, Otoba and madrono. The scientists are hoping to get results as soon as possible.

We hope that all the work represented in this video will help in the conservation of the magnificent, unique and highly endangered forests of North West Ecuador and to protect the area and the communities from the dangers of deforestation. To end we will demonstrate the monkey's way of saying: Thanks for your attention and good bye.

Reforestation Guide Los-Cedros

Los-Cedros Biological Reserve is a primary cloud forest reserve is a primary forest reserve in Imbabura province, North Western Ecuador. The reserve is hose to a primate conservation initiative called PRIMANET. As part of the effort to conserve the resident monkey species and to help communities in the area, a reforestation project has been initiated.

This is the mantled howler monkey, *Alluata palliate*, they live in both primary and secondary forests. The howler monkeys diet consists on about 70% leaves. They need a great variety of tree species. including copal, ficus, cecropia, cedar and inga among others.

The white faced capuchin monkey, *Cebus capucinus*, is threatened with extinction. This species is found in group of 15 to 20 individuals in both primary and secondary forests. The capuchin has a broad diet that includes leaves, insects and fruits. They eat the fruits of the inga, ficus, virola, madrono, and palm.

The brown headed spider monkey, *Ateles fuciceps fuciceps*, is one of the most threatened primate species in South America. It has been estimated that less then 250 survive today. Even in protected areas such as Los Cedros this species is found at very low densities.

Spider monkeys like to eat ripe fruits and therefore need very large territories to find enough food all year round. They eat madrono, virola, inga, ficus and palm fruits and are major seed dispersers, making them very important for the future of the forest as a whole.

Reforestation in the area will help these monkey species by giving them new food sources and by giving local villages alternative sources of timber, lessening the impact on existing forests. Reforestation can also prevent some of the dangers of deforestation such as soil erosion, water scarcity, and pasture deterioration.

Seed collection

Good seed collection is one of the most important parts of successful reforestation. Seeds of trees that are important for animals and humans should be collected in the forest. When a fruiting tree is found, look for seeds that have fallen to the ground. Collect as many seeds as possible and keep visiting the tree t collect more, fresh seeds throughout the

season. Seeds should be collected in plastic bags, divided by the parent tree. Information should be collected about each parent tree such as location, species and date of collection. Seeds that are found open or germinated should be put in a separate plastic bag and protected from crushing. Another technique for seed collection is to place traps beneath fruiting trees to collect fruit fall throughout the season. Fruits should be collected every two days to ensure freshness.

When encountering seedlings that have sprouted in the forest, they should not be collected until they are about 10-15 cm tall. This is done by generally pulling the base of the stalk without harming the roots. They should then be placed in a plastic bag filled with wet moss to protect them while being transported to the nursery.

Nursery work

Rinse the seeds with running water and then dry them for a few hours. This should be done as soon as possible after collection. Plant the seeds in plastic nursery bags filled with dark forest soil or in germination beds with a few centimetres between each. Try to put the seeds in a natural position to facilitate sprouting. When the seedlings are a few weeks old and a few cm tall they can be moved to nursery bags. Grab them with enough soil around them so the roots are not harmed. Put them in nearly full bags and compact the soil around them. When the trees are about 60-70 cm tall they are ready to be transplanted in the forest. The best time to plant is during the wet season. For each area in which you are planting chose a mix of species and a mix of source trees. Plant in five to seven meters intervals. Split each plastic bag down one side and try not to break the soil. Dig a hole. Remove the bag and place the plant in the hole. Cover it with soil and give water. It is also a good idea to place a stick in the ground with a tag saying the species name and date of planting.

Vegetative propagation of cuttings

Vegetative propagation of cuttings is a technique that allows the propagation of trees that do not seed regularly or are hard to germinate. Cut a branch with new leaves from a young tree. This should be about 15 cm long. remove most foliage and plant in a nursery bag. In the nursery, cuttings should be placed under an extra roof to keep them moist until they develop roots.

Direct seeding

Secondary forests can be identified by their high density of cecropia trees. Cecropia has large leaves that appear silvery from afar. Choose 25 big primary forest seeds from a mix of species. Make plots of 16 by 16 meters and sow a seed every four meters. Place the seeds two to three cm in the ground. Two sticks will ensure that the big cecropia leaves will not cover your seedlings and kill them. Measure the seedlings every few weeks to check the progress. This will help determine the species for direct seeding. Direct seeding is the easiest and cheapest method of reforestation. especially in hard mountainous terrain.

Abandoned pasture rehabilitation

Abandoned pasture is very slow to recover. This is because of a low seed bank in the soil and the present of aggressive grasses that suppress seedlings. Here, cutting long branches from sun loving secondary forest trees such as cecropia, ficus and aliso is a good way to start. Then cut transects in the pasture and plant the branches in the soil. This method is good for two reasons; firstly the branches will act as perches for birds which will deposit seeds in their faeces and kick-start regeneration. Secondly, many of the branches will take root and grow alone also encouraging secondary regeneration. Another method is to clear the grass from around small trees in the pasture thus helping them grow. When the trees grow they will shade the grass and eliminate it.

Education

Education for local communities, especially children will ensure the understanding of reforestation and the importance of forest ecosystems, as well as gaining their support. This could be done with lectures and presentation or games such as painting competitions or role play.

Good luck protecting the forest.

Appendix 2: Reforestation handbook

Volunteer guide of reforestation techniques in the Los-Cedros Biological Reserve North-Western Ecuador

Dear volunteers

Reforestation is becoming increasingly important conservation method, since world wide rates of deforestation are getting extremely high. Los Cedros reserve is part of the Choco-Darien ecosystem, which ranges between North-western Ecuador and Southern Panama. The area is a hot spot, believed to be one of the most endangered biologically diverse places in the world. This is because of the high number of endemic species it contains and because of the fast rates at which it is disappearing mainly due to deforestation. Research done in the area had shown that more than 50% of the forests around the Cotacachi-Cayapas Reserve (the neighbouring national park) were cleared between the years 1990-2000.

This does not leave much habitat for all the endangered species that are dependent on this forest; like the Andean spectacled bear, capuchin monkey, howler monkey, tapir, puma, jaguar, an estimated 300 birds and thousands of plant species. This cloud forest is known to encompass hundreds of endangered orchid species, and many more not yet known to science. One of the most endangered species in the reserve is the brown-headed spider monkey (*Ateles fusciceps*). It is estimated that there are less than 250 individuals still living in the world. The species is totally dependent on primary forest. They eat mainly ripe fruits and need really large territories to be able to find enough food all year around.

A reforestation project is a very good way to help all these species to survive. It will do two main things; 1) add more fruit trees and habitat for the animals 2) in the long term give people alternatives for logging in primary forest and in the short term can help them economically by planting trees that are used for fruits, medicine, handicrafts, or other things that can be sold and are more forest friendly than logging and livestock.

I have collected some ideas that have been used in similar projects around the world, some of which I have tested in the short time I was in the reserve. It is very important to make many experiments before starting a large scale reforestation program so no time and energy will be spent on techniques and tree species that are wrong for this region.

Botanic experiments usually take few years to be completed. Because most volunteers only stay in the reserve for a few weeks or months, the experiments should be set in such a way that they are easy to continue by the next group of volunteers, therefore what ever you do, make clear instructions about what you did and leave them in this folder. The instructions should be clear; include a map of the sights you worked in, methods used and the results you got. People will add their results so they can be used for future reforestation work. Every species has it own 'preferences' for handling, so different propagation techniques should be tried and compared on different species until the best methods are found. Forms should be filled in with dates, height and diameter of the plant, write your observations of the trees; germination predation, dehydration etc. These are some of the things you should be aware of when starting work in reforestation or training people from local communities to start their own projects:

Setting up a nursery

There is a small nursery in Los Cedros that you can use; it is a part of the old greenhouse, near the back gate. To start a new nursery you need to find a space, which is comfortable to get to, and close to the people that are responsible for it. It needs to be on a very slight slope or flattened with a good drainage system. The most important thing is a good water source to be able to water the plants all year around.

It can be covered with black shading mesh that can be bought in Quito (about \$1.50 per meter) or put under big trees, but remember that the seedlings should not be in direct sun.

Nurseries should include 1) good trail systems that let you reach all the plants 2) germination beds; these are flat areas of prepared soil where you can sow seeds, mainly for small seeds. 3) Area to put the nursery bags with the seedlings; it should be flat with slightly raised sidewalls to support the bags.

Nursery bags can also be bought in Quito for \$0.75 per hundred need to be filled with forest soil, the darker the soil is, the better (top few inches of ground are the most fertile), so it needs to be carried from secondary forest to the nursery. There is a wheelbarrow in

Los-Cedros but it might be still broken, which means you might have to carry soil in sacs. Filling many individual nursery bags with soil is a lot of boring work!!! Try to do it in a group, it helps.

Seed collection

Seeds can be brought from the forest. Walk the trails in the reserve and try to find seeds shown in the “plants for reforestation” list at the end of this manual. Other seeds can be collected and identified, the idea is to find trees that are good for frugivorous animals and/or are useful for people. The guides in the reserve can identify most of the seeds and their uses. You can also go to pasture and secondary forest and collect seeds from there. These seeds are pioneer species that will be good to plant in degraded areas in full sun. Make sure you collect only native species.

Try to get seeds from as many mother trees as possible for each species so there is genetic variation between the seedlings. Put the seeds in small plastic bags according to the mother tree and label them with the date of collection and where they came from, so in the future people can go to the same trees in the same season and find seeds. Check all the seeds to see that they are whole and hard, don't take seeds that are soft or feel empty because they are usually rotten and not viable. Larger seeds can still germinate even if they have some holes in them.

Seeds can be taken by collecting them from the floor, picking them directly from the tree or if there are a lot of seeds still on a high tree you can make fruit traps; you can make fruit traps by cutting hessian sacs in the middle so they are square or use square plastic sheets. Tie them by the corners to trees so they are about 1.5 meter from the ground. They need to be horizontal with a concave base so they can collect as many fruits as possible. You can put several traps under each tree to get as many seeds as you need. Make several drainage holes for water but too small for seeds to fall through.

In the nursery, take the seeds out of the fruits, sometimes they need to be soaked for a while before they come out, and clean them under running water.

Wildlings collection

Seedlings that have germinated and started establishing themselves under parents' trees in the forest (wildlings) can still be collected until they are about 15-25 cm tall.

Most seedlings will not survive under their parent tree and will have a better chance if moved to new places. Pull them very carefully from the base not to break the roots, if the soil is not wet enough give it some water and wait for it to soak. Put the seedlings in a plastic bag filled with dump moss. The moss will protect the roots of the seedlings until you get to the nursery and will keep them moist rather than soaked. Wildlings must be transplanted to nursery bags as soon as possible. Try to fill the bags with soil before you go to collect them. Wildlings can be transplanted in the forest after only a few weeks of recovery in the nursery.

Planting in the nursery

Small seeds in large quantities should be sown in the germination beds because they usually have low germination rates. Seedlings that germinate should be transplanted to bags when they are a few weeks old, they can be moved earlier but if they are left in the beds too long their roots will get tangled and are easily damaged when moved. To transplant them first wet the soil properly, try to take each seedlings with as much soil as you can so the roots stay inside the soil. However, this is not always possible. Put the seedlings in nursery bags that are almost full and pack the soil down afterwards. If the soil is not tightly packed the roots are more likely to rot. After moving the seedlings make sure that the soil is moist all the time until their roots have adapted to the change.

Arrange the bags in the nursery according to the species and the parent tree they came from. Mark them clearly with the date of planting and all information that was on the plastic bags that the seeds were collected in so it is possible to compare the performance of different trees. Watering should be done once a day if there is not much rain. If there is too much rain the small seedlings might need some extra cover so they are not damaged by the direct rain. It is important to weed about once a month or when the weeds are getting too big.

Vegetative propagation by stump cutting

Vegetative propagation is the use of cuttings of a plant that are on the right conditions develop roots and become a new plant. This method dose not work for all species but can yield up to 95% rooting success in some species and can be useful as a reforestation technique, especially for species with irregular fruiting seasons or where seed collection

is too difficult. Plants raised from cutting have better and faster growth rates and are likely to be stronger. Making stump cuttings is very quick and easy; find young trees of the species you want to propagate. Clip the top of young branches about 10-15cm from the end (where the new leaves are), it should be about three to four nodes. Remove most of the leaves, leaving only one or two at the top. Put the cuttings in nursery bags under an extra shade roof so they are not in direct sun. You can also make a mini greenhouse by spreading a transparent plastic around them. Until they develop roots they get water from the air so the air should be moist at all time. When it is hot and dry outside sprinkle them regularly.

Planting in the forest

When seedlings are 40-60 cm tall, they should be transplanted to the forest. It is better to plant trees in the rainy season. Before starting make a plan of what trees you are going to use, where you want to plant them, consult Jose and the guides. Primary forest trees like Sapotaceae, Lauracea, *Otoba* etc. need to grow in the shade of other trees. You can plant them as a form of enrichment planting in secondary forests (See page 8 'helping succession in secondary forests' for an example of how to arrange planting plots). You can always make the plots bigger and use different species but it is important that all the methods and the directions to where the trees are planted are easy to follow so their growth can be followed). Pioneer trees like alnus, cordia, cecropia etc, can be planted in pastures, before you plant them you have to cut the grass at about one meter diameter around them. You will should weed a few times around these trees before they are fully established.

It is hard to move seedlings around these mountains, try to pack them in groups of 5-10, without damage, this can be done in a box that you tie as a back-pack. Carry them to where you want to plant them. Dig a hole in the ground that is as deep as a nursery bag, cut the bag on one side and gently ease the soil out. Try not to break the soil so the roots will stay in the same position. This saves the plant a lot of stress. Give them some water and put a stick with the name of the species and the date it was planted.

Seed preservation and viability tests

Because Los-Cedros is so remote and there is such a long walk to the neighbouring communities, it will be hard to transfer grown seedlings to be planted in the surrounding communities. The best way for Los-Cedros to help communities to restore their lands will

be to collect information about species and techniques that they can use. Another thing will be to make Los-Cedros a seed bank for the communities; they will be able to come to the reserve and collect seeds or have seeds ready for them. For this there is a need to develop knowledge about keeping seeds viable long enough to get it to the communities (Things can take an extremely long time up in these mountains). If you know that the seeds are going to be sown up to 72 hours from collection you should leave them sealed in the plastic bag with a little bit of water, out of the sun.

Most tropical seeds germinate as soon as they land on the ground and can not be preserved for long, especially where there is no refrigerator to keep them cool. However, there are some methods to be used to maximise their viability; different types of seeds should be stored under different conditions. Small seeds that dry naturally at maturity can often be dried and stored in a sealed, airtight container and kept in a cool, dark area. You can use the roof above Jose's house for drying for a day or two and then put in a sealed jar or plastic bag in a dark draw. Mark the container with indelible ink including the plant and variety name, the date stored and other identification information. Cecropia and cedro are examples of seeds that can be preserved this way for one to three month. Before sowing the seeds need to be put in water for about 24 hours to soak enough water to enhance germination process.

Seeds that are bigger and contain a lot of oil in them can not be dried they need moisture and gas exchange to stay viable. The storage of such is done by putting them in a container full of damp charcoal, sawdust, or moist sand. Find a cool dark place to put the container but be careful not to seal it so the seeds will be able to breath. Most of the seeds that you are going to work with need to be stored in this way Lauracea, madrono, Sapotacea, *Virola*, *Otoba* etc. They can be stored for up to one month.

Some seeds might loose their viability after only a few days and there is nothing that can be done about it; for example inga. To determine if stored seeds are still viable, take few of them, count them and place them in a germination bed. Water the seeds well and give them plenty of light. You can do this test before and after each preservation period and calculate the differences in viability. This kind of information is very rare for native tree species so make sure you keep good record of each test you do.

Suggested experiments

Rehabilitation of pastures

Abandoned farms are very slow to recover because of 1. A very low seed bank after years of agriculture or grazing. Animals such as birds, bats and monkeys are usually afraid of open spaces and do not come to pastures and defecate seeds. 2. Seeds that arrive to the area have a hard time reaching the soil and establishing because of the competition with the more aggressive grasses.

These are some steps you can take to help pasture to recover (there are 2 big patches of pasture on the Cascada trail and some on the way down towards Magdalena).

1. Perches for birds. Most birds cannot perch on grass and therefore don't enter grasslands. To attract birds, cut long branches (more than 2 meters) from pioneer tree species (cecropia, ficus, alnus). You can try to find branches with mature fruits and seeds on. Cut transects in the grass and stand the branches in the ground every few meters. Some of the tree species will be able to develop root system from the branch and become trees. You can compare methods of preparing the sticks, for example, fruiting or not, cutting the leaves off or leaving them on. And see which methods and species are best.
2. Some pioneer plants reach pastures by themselves and manage to start growing. When you find plants that are surrounded or even covered by tall grass you can help them survive by clearing the grass around them. This will give them better access to sun and nutrients. Compare growth of young trees that the grass around them was clear and ones that were left covered with grass.
3. Cecropia propagation. Cecropia is a secondary forest tree which is easily identified due to its big hand-shaped leaves. Trees can be seen from far away as a big silvery patch. It arrives to forest gaps and abandoned farms in the initial stages of succession and grows only in direct light conditions. The fruits of Cecropia are eaten by many frugivores and seeds are distributed mainly by birds and bats. When frugivores

come to eat Cecropia's fruits they defecate seeds of primary forest species and the Cecropia provides the shade and suppresses weeds and grasses which is essential for primary forest development. Therefore Cecropia is a very important species in the process of succession. To catalyze the beginning of succession in grass lands it would be possible to plant Cecropia trees. This experiment looks into the best way to do so.

Cecropia seeds germinate only after being digested by frugivores. Faeces can be collected by placing fruit traps (see page 3, 'seed collection') under fruiting Cecropia trees or finding perches used by frugivores and collecting faeces from the floor. The faeces should be sieved and the seeds separated and dried. When an appropriate amount of seeds (more than a hundred) are collected experiments can be started.

- a. Find a patch of grass and mark a plot 15x15 meters. Cut straight transects in the plot at 3 meters intervals. Every 3 meters weed the grass in a 50x50 cm² and sow a few Cecropia seeds. Cover with a few millimetres of soil and put a little stick to flag each area. Weed around each planted area every 2-3 weeks. Make at least 3 replicate plots in different areas of grass.
- b. Make more 15x15 plots near each one of the first plots. Walk in the plot and throw some seeds on the ground at 3 meters intervals. Don't weed or bury the seeds. Flag where the seeds are.
- c. Sow seeds in germination beds in nursery.
- d. Record all stages of experiments, making sure plots are easy to find in the future and all dates are clearly marked.
- e. Record the germination rates and development of the Cecropia seedlings in all the plots and nursery in "germination and growth form" and compare them with each other.

Helping succession in secondary forests

In the method of direct seeding, seeds are placed directly into the ground in secondary forests. This method bypasses nursery work and carrying the seedlings to be transplanted in this hard terrain. Therefore, when successful this method makes reforestation work a lot easier and cheaper. There are six experimental plots of direct seeding already in the reserve. Five of them are at the beginning of the Cascada trail and one about 50 meters from the back gate. You can go and visit them to learn how they are made and to measure

the progress of the seedlings, of the species madrono, otoba, cedar and Ocotea, (see map and growth form at the end). You can also make new plots to learn about other species' suitability for this method. And this is how it works.

1. Find seeds of primary forest trees that are important for wildlife or beneficial to people. The best species for this method are ones with large seeds (more than 2cm long) because they give better support to the seedlings in the forest. Harder conditions compare to the nursery. You will need 25 seeds per plot. Try to mix seeds of at least 4 species and don't plant trees of the same species next to each other. Making a plan for planting before hand is very helpful.
2. Find a secondary forest area (dominated by cecropia) and measure a 16x16m plot.
3. Sow the seeds at four meter intervals, making a 2 cm hole in the ground and covering them with soil. This will reduce the problem of erosion and lessen the chance of animals eating them.
4. Put 2-3 sticks in the ground around them like a little tent to protect them from falling cecropia leaves.
5. Tie the sticks together with flagging tape specifying the species name and date of planting.
6. Visit the plot every few weeks to check germination and growth rates.

Sticks propagation

Some of the sticks I put in the ground to protect the seeds developed leaves and roots. It seems like a good idea to cut 15-20 centimetre long sticks from various forest trees and place them in the secondary forest using plots to be able to follow the ability of each species to root. This method will also be very cheap and easy to use in large scale reforestation programs.

Map of direct seeding plots, height and observations

Plot 1

O	C	M	O	C
C	O	C	L	M
M	C	L	C	O
C	L	C	L	M
L	C	O	M	C

plot 2

O	C	M	O	C
C	O	C	L	M
M	C	L	C	O
C	L	C	L	M
L	C	O	M	C

plot 3

	C	M	O	C
C	O	C	L	M
M	C	L	C	O
C	L	C	L	M
L	C	O	M	C

plot 4

O	C	M	O	C
C	O	C	L	M
M	C	L	C	O
C	L	C	L	M
L	C	O	M	C

plot 5

O	C	M	O	C
C	O	C	L	M
M	C	L	C	O
C	L	C	L	M
L	C	O	M	C

plot 6

O	C	M	O	C
C	O	C	L	M
M	C	L	C	O
C	L	C	L	M
L	C	O	M	C

M= *Garcinia madruno* O= *Otoba gordonifolia* L=*Ocotea* C=*Cedraledora odorata*

Appendix 3: List of trees for reforestation

Alanus acuminata: aliso- Pioneer tree that grows between 1300-3000m. Used for furniture and firewood. Very good to be grown on pastures because the roots can fix nitrogen. Cones should be collected from the tree and put on floor until opened. Seeds can then be collected. Keep in a glass container in a cool place. Wildlings can be used.

Add your observations _____

Bactris gasipaes: chonta, peach palm- Family Palmae. 0-1200. The village of Chontal is named after this species. Propagation is by seed or by suckers from a mature palm after it has produced four stems. Suckers should have produced roots and be 7 to 8 cm in diameter at the base and 1 to 1.5m high. The foliage should be cut back and the plant shaded until established. Seedlings fruit after 8 years.

Add your observations _____

Caryodaphnopsis theobromifolia: caoba- Family Lauraceae. Important timber tree. This species is protected by Ecuadorian law but still harvested at high rates. Fruiting is irregular and might be rare, recruitment of trees in the wild is very low. Fruits should be collected when they are large and yellow. No information was found about the species propagation.

Add your observations _____

Cecropia monostachya: gwarumbo, yarumo- Family Moraceae. 0 -1500m. Dominant secondary forest species growth is very fast (two to three meters a year). Produces seeds all through the year. Seeds have to be digested by animals to germinate. There is not much experience in planting these trees. In Los-Cedros seeds that were collected from frugivore's faeces did not germinate in shade or 100% sun conditions. This experiment should be repeated until the species can be propagated successfully, because it is important for restoration of degraded lands and many wildlife species love to eat it. To avoid complex seed collection you can try different methods of vegetative propagation for this species.

Add your observations _____

Cedrela odorata: cedros, Spanish cedar- Family Meliaceae. One of the most important timber tree species in Latin America. An infusion from the bark is used as a remedy for diarrhoea, fever, bronchitis, vomiting and indigestion. Grows from sea level up to 1500m, in low densities. The species is categorized as threatened by IUCN. Try to collect seeds

when they are still in pod and dry at room temperature until open. Seeds can be stored in sealed plastic bags in a cool dry place for 1-2 months, and in fridge for up to one year. It can be propagated by cuttings. Planting in the forest should be done at big intervals because the species is attacked by insects when planted in groups. Information collected about the species in Los-Cedros in 2006: Seeding April- June. Had about 90% germination and survival from seeds and wildlings. As enrichment planting in secondary forest; 80% establishment when seeds where already germinated when they were planted and much lower rates when seeds where not geminated.

Add your observations _____

Cordia alliodora: laurel- family Boraginaceae. 0-2000m. Wood is weather resistant, it is used for construction, furniture and carving. Seeds should be collected when they are brown and swollen by taking them form the tree or after they fell to the ground. Dry them in the shade and keep in hermetically sealed container in a cool, dark place. Germination should be in germination beds, seedlings start sprouting after 10-20 days. Vegetative propagation can be successful.

Add your observations _____

Croton, sangre de drago, dragon tree- Family Euphorbiaceae. 100-2500 m. Broadly used as a medicinal tree to treat diarrhea, gastrointestinal disorders, respiratory problems, skin infections and wounds, as well as other diseases , soaps are also made from this tree. This pioneer tree is good for pasture improvement. Propagation is usually by stem cuttings and wildlings.

Add your observations _____

Dacryodes copularis: copal blanco- Family Burseraceae. Used for construction, incense, and as medicine for infection and flu. Howler and capuchin monkeys were seen eating the young leaves and fruits of this tree. It is harvested extensively in the area, Categorized as a rare species by the IUCN. No propagation information was found, but vegetative propagation should be tried as it is recommended for other species of this genus.

Add your observations _____

Ficus racunata or Ficus mutissi: higoron, fig- Family Moracea. elevation of 600-2500m. Fruits are very important for wildlife and known as a key stone food resource for many species because of their irregular, long and high quantity fruiting. Some species of ficus are used for construction. Many species of ficus are good for vegetative propagation. Cuttings can be planted in the nursery and big branches can be planted directly in secondary forest or grassland. Seeds should be collected from fruits or faeces.

Extract seeds from fruit by washing through a sieve. In Los-Cedros the large fig trees near the house were planted as branches a few years ago.

Add your observations _____

***Garcinia madruno*: madruno-** Family Gutiferae. Fruit is fleshy and sweet, and is eaten by people and animals. It is one of the main food components of spider monkeys diets. Fruiting occurs between August and December. The species is easily propagated from seed. It can be used for enrichment planting of secondary forests by direct seeding or planting seedlings. High germination in the wild and in the nursery was observed in Los Cedros. Slow germination in direct seeding plots but probably because of the dry weather conditions at the time. Important tree to plant for wildlife and people.

Add your observations _____

***Guadua angustifolia*: bamboo, guadua-** Family Graminae. Bamboo can be a very important component for improving local livelihood. The species grows very fast and can be planted as watershed protection or on degraded land. It is very strong and can be used for furniture and light construction. It is very easy to work with and therefore local communities can be trained to propagate and produce handicraft and carpentry with it. Because of rapid growth its use is much less destructive than the use of timber. Propagation can be vegetative through culm or stem segments; culm segments of bamboos of 2-3 nodes bearing healthy buds or branches, have been used for propagation. The branches on each culm segment are generally pruned to a length of less than 25cm and no foliage is retained. Such cuttings are usually set upright or at a slight angle, with at least one node well covered. Another method is to plant 40-50cm long rhizome cuttings, 10cm deep in the ground. Seed propagation can be used but seeds are hard to collect. Wildlings can also be collected.

Add your observations _____

***Inga edulis*: guabo, ice cream bean-** Family Leguminosae. Grows at elevation of 1000-2500. It is used as fire wood and the fruits are eaten by people and by many species of wildlife. Spider monkeys are major dispersers of the species. It is a nitrogen fixer and therefore good for degraded forest rehabilitation, coffee shading and pasture improvement. Inga is a fast growing tree. Propagation is mainly from seed which have very high germination rates. The seeds cannot be preserved for more than a few days. In Los-Cedros vegetative propagation failed, probably because of very dry weather conditions at the time.

Add your observations _____

Otoba gordonifolia : Sngre de gallina- Family Myristicaceae. Found from sea level up to 1700m. Wood used in carpentry and to make soap, candles and perfume. It is used as medicine and by Indian tribes as an hallucinogenic. Howler and spider monkeys are often seen on these trees in the reserve. Fruiting is irregular but lasts for long periods producing high quantities. Store in wet sand. Used a lot for reforestation. In Los-Cedros; none of the seeds in the forest or in the experiments were observed to germinate, probably because it was the wrong season (June, July). This species is known to have good germination rates so it should be tried in different seasons, with different seed collection or germination techniques. Try to soak seeds in water for a day or two before sowing.

Add your observations _____

Poutaria: sapote- Family sapotaceae. Primary forest tree with large seeds. Fruits between April to May. Fruits eaten raw and used for jams, drinks, ice-cream. Oil from the seeds is good for hair problems. Wood used for construction. All three monkey species in the area eat the fruits. The Tree is easy to grow from seed. Remove hard seed coat before sowing to shorten germination time. In Los Ceros: Slow to germinate, but has good growth rates.

Add your observations _____

Rollinia mucosa: anonna, cherimoya- Family Annonaceae. The wood of the tree is hard, heavy, and strong. It is used as canoes ribs, boat masts, boards and boxes. Fruits are eaten fresh or used for juice, ice cream and wine. It is fast growing; starts fruiting after 3-4 years. Propagate from seed. Keep seeds for a short time only, in wet sand.

Add your observations _____

Virola: chalvinde- family Myristicaceae. 0-1200m. Used mainly for plywood and for Indian hallucinogenic rituals. Fruits every two years in February/March. Has 80-85% germination rate when fresh. Viable for 1-12 days at room temperature. Can be preserved for up to a month in wet sand.

Add your observations _____

Lauraceae species such as: **Nectandra: aguacatillo, Ocotea: canelo, hueso and valte, Belismedia: patche and Miquartia: guayacan, Aniba: rosa** – These species are characteristic to primary forests in the area. They comprise a major part of the brown headed spider monkey. Wood has excellent durability. Usually fruiting is irregular and rare. Preserve in wet sand. Good germination but seedlings grow slowly. Can be propagates from seed or seedlings. Add your observations _____

Appendix 4: Map of direct seeding experimental plots

Experimental Plots: Direct Seeding

