Chapter 13
Conservation, Management of Natural Forests and Reforestation of Pastures to Retain and Restore Current Provisioning Services

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13.1 Introduction

In 2010, forests covered 36 % (9.87 million ha) of the Ecuadorian land area (FAO 2010). 4.5 million ha are estimated to be potentially used as production forest, but only about 2 million ha are considered as permanent productive forest estate (Blaser et al. 2011). Despite the fact that the forest sector contributes only about 2 % to the gross domestic product (GDP) and 1–2 % to the total exports of Ecuador (FAO 2011), provisioning services of forests can be considered to be of high importance, especially for the rural population. As more than 50 % of the forests are under community or indigenous ownership, many products from forests are consumed by

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the forest owners or sold locally and thus not registered by market statistics. Consequently, reliable data on forest production are very rare. The Government of Ecuador (2009; cited in Blaser et al. 2011) estimated that about 75 % of the total forest area is used directly or indirectly by indigenous communities to contribute to their livelihoods, while 850,000 people depend directly on forest resources.

As revealed in several studies (Gerique 2010; Pohle and Gerique 2008), the importance of the provisioning services of forest ecosystems depends highly on the ethnic-cultural affiliation of the population and their socio-economic setting. In the study area of our Research Unit (see Chap. 1), three different ethnic groups have to be distinguished (Pohle 2008): The Shuar, Amazonian Indians, settling in the lower area (<1,400 m a.s.l.) of the tropical mountain rainforest range, who are typical forest dwellers practicing shifting cultivation in a subsistence economy. The Saraguros are highland Indians who live as agropastoralists in the mid-altitudes (1,700–2,800 m a.s.l.), and the Mestizos, a heterogeneous group of mixed Spanish and indigenous descents, who immigrated to the area since 1960s. They live in rural communities or scattered farms as cattle farmers and agriculturalists. The farmers of all groups highly value the provisioning services of the forests as they strengthen their livelihoods and overall economic situation (Pohle et al. 2010; Gerique 2010). A study in two northeastern provinces of Ecuador revealed that forest uses contributed 10–30 % to the family income.

The various forest goods and its consideration in official statistics are also closely linked to the type of forest they are originating from. While plantations are preferably established or managed for industrial roundwood production, products from natural forest are predominantly used to satisfy the various demands of the local population. Furthermore, the forest type also affects the sustainable yield that can be expected: that of the natural forests is estimated on 0.9 cbm ha^{-1} $year^{-1}$ while that of plantations is 10 cbm ha^{-1} $year^{-1}$ (FAO 2006).

The provisioning services comprise a multifaceted bundle of goods and services that are already or can be influenced and governed by human interventions and management. The following paragraphs provide an overview on corresponding aspects of conservation, management of natural forests and reforestation in the greater study area of the Reserva Biológica San Francisco (RBSF, see Fig. 1.1).

13.2 Material and Methods

The results of this chapter are based upon comprehensive studies conducted within the research unit RU 816 comprising ethnobotanical inventory, livelihood analyses, field monitoring as well as experiments. The details on material and methods for the several issues can be found in Pohle et al. (2010) and Gerique (2010) (ethnobotanical inventory and livelihood analyses), Günter et al. (2008) (natural forest management), Aguirre (2007) (reforestation of abandoned pastures) and Stimm et al. (2008) (forest reproductive material).

13.3 Results and Discussion

13.3.1 Conservation

People depend on trees as raw material for the production of, e.g. furniture, buildings, boats, handicrafts, fence posts or fuel. Consequently, conservation measures must be organised in a way that does not completely exclude people from the use of the forest resources. In Ecuador, a major state strategy for in situ conservation of biodiversity, ecosystems functions and services has been the protected area (PA) model. In 1976, the government established the National System of Protected Areas (*Sistema Nacional de Áreas Protegidas*-SNAP) under the notions of "protection from use" and command and control mechanisms (Gerique 2010).

Nowadays, the Ecuadorian reserve network SNAP has modified its structure, aiming to incorporate more participative management concepts. The SNAP has currently four subsystems:

(a) The State Patrimony of Natural Areas (*Patrimonio de Áreas Naturales del Estado-PANE*)
(b) The decentralised areas under administration of subnational governments, mainly municipalities (*Áreas de Gobiernos Autónomos Decentralizados*)
(c) The communal protected areas (*Áreas Protegidas Comunitarias*)
(d) The private protected areas (*Áreas Protegidas Privadas*)

Biosphere reserves are considered conservation tools (*herramientas de conservación*). The PANE has currently 45 protected areas, which cover around 19 % of Ecuador's total surface (MAE 2013). The protected areas inside this subsystem are managed and administered by the state through the Ministry of Environment, except for few decentralised experiences such as the Cajas National Park. Only the protected areas inside the PANE have officially a correspondent to the IUCN categories, e.g. the biological and ecological reserves to category I, the national parks to category II, representing the highest degree of protection. The Forestry Law of Silvestre Life regulates the legislation over protected areas since 1992 (Ulloa et al. 2007).

Particularly in the protected areas in the Andean region, a main goal of the SNAP is the conservation of water resources as a main provisioning service for civil society; four national parks are located in the eastern Cordillera and three of them serve as water reserves for important urban centres. A detailed analysis of water resources as a provisioning service and the impacts of forest conversion on water regulation and quality are provided in Sect. 9.1. The Ministry of Environment has overall responsibility for the protection of these areas, although it is beginning to share management responsibilities with municipalities and private organisations (Gerique 2010). Multistakeholder initiatives, such as "water protection funds", are implemented as finance mechanisms to support conservation by linking consumers and protected areas through trust funds to compensate for water provision

Table 13.1 Main state protected areas (IUCN categories I and II) and protective forest in the Biosphere Reserve Podocarpus-El Cóndor

Protected area	Extension (ha)	Year of establishment
Podocarpus National Park	144,993	1982
Colambo–Yacuri National Park	43,000	2010
Cerro Plateado biological reserve[a]	26,114	2010
Alto Nangaritza protective forest	128,866	2002
Corazón de Oro protective forest	54,000	2000
Podocarpus–El Cóndor biosphere reserve	1,140,080	2007

Sources: [a]Registro oficial No. 318. Quito; Gerique (2010), Com. López Sandoval, 2011

(Echavarria 2002). The *Fondo Regional del Agua* (FORAGUA) supports, among others, conservation in and around the Podocarpus National Park, PNP (FORAGUA 2009). As an example, water management by the municipality of Loja is accomplished with money raised through a city water tax, created for the protection of watersheds and other priority conservation areas (NCI 2012).

To preserve biodiversity and water resources around PNP has been the goal of the establishment of other protected areas in the region (Table 13.1). The declaration of the Biosphere Reserve Podocarpus-El Cóndor by the UNESCO in October 2007 was a major strategy to improve governance of natural resource management and provision of ecosystem services. This was supported by local institutions, universities, NGOs and the subnational governments of the provinces of Loja and Zamora Chinchipe (NCI 2009). Besides state protected areas, several private reserves under different management initiatives are being established in the region, i.e. the San Francisco Research Station (ECSF) or the Angashcola Communal Forest Reserve.

The effectiveness of protected areas as a strategy for the conservation of ecosystem services is still under discussion. In Ecuador, not only the reforms of the legal framework for land colonisation (Pohle et al. 2010 and Chap. 16) but also the establishment of protected areas have influenced deforestation rates in and around them (Mena et al. 2006). However, illegal actions, such as logging, mining (Naughton-Treves et al. 2006) or increasing hunting and fishing (Castro 2008), are ongoing facts in the region. Furthermore, direct conflicts of “local populations vs. protected areas” in the study area (Burbano 2008; Cabrera and Dumas 2008) clearly show that community-based strategies shall consider the specific cultural and social demands of local populations and reinforce protected area management. The establishment of the Biosphere Reserve offers concrete opportunities to intensify and facilitate partnerships among different stakeholders, i.e. resource users, managers, administrators and local communities at different scales of governance (Gerique 2010).

A valuable contribution to provisioning services that can be provided by protected areas may be ecotourism. Ecotourism is widely considered as a provisioning service, which can help to conserve natural resources while improving the livelihoods of local people (Kiss 2004; Page and Dowling 2001). However, to be able to substitute non-sustainable or degrading practices of forest users, they must receive significant economic benefits from the ecotourism activities. According to Moran-Cahusac (2009), 66 % of the 22,707 foreign visitors of the south of Ecuador are visiting the province of Loja. As for example birders are considered to stay for periods of up to 15 days and spending up to USD 100 per day (Moran-Cahusac 2009), the annual financial contribution to the local economies can be estimated to be in the order of about 10 million USD.

13.3.2 Management of Natural Forests

In the San Francisco valley, natural forest is still the dominating land-cover type in altitudes >2,200 m a.s.l. with a share of 85.4 % (Göttlicher et al. 2009). However, below this altitude, forest cover is only 45.2 %, while forests have been converted into anthropogenic replacement systems (predominantly pastures), which were considered to be more profitable than forest. Homeier et al. (Sect. 8.3.6) estimate that the anthropogenic transformation of natural forests in the study area reduces the average value of the ecosystem services by 10.9 million $ annually!

Most of the 120 timber species that can be found on the Ecuadorian market (Blaser et al. 2011) come from natural forests. About 80 % of the wood species utilised in the city of Loja are harvested in natural forests of the Province of Zamora-Chinchipe, with most species coming from the lowland rainforest, i.e. Almendro (*Swietenia macrophylla*), Yumbingue (*Terminalia amazonia*) and Seique (*Cedrelinga catenaeformis*) (Leischner 2000). The remaining 20 % come from Eucalypt and Pine plantations as well as from dry forests of the Province of Loja, particularly Guayacán (*Tabebuia chrysantha*) and Gualtaco (*Loxopterigum huasango*). In her study of the local wood market in the city of Loja, Leischner (2000) identified the following highly valued woods from the natural forest: Cedro (*Cedrela odorata*, *Cedrela montana* and *Cedrela lilloi*), Forastero (*Ocotea* spec., *Nectandra* spec.), Romerillo (*Podocarpus oleifolius*, *Podocarpus sprucei* and *Prumnopitys montana*). Nogal (*Juglans neotropica*) is also present in the Province of Loja. Consequently, natural forests have an important provisioning function for the local wood industry. Despite this fact there are no coordinated efforts towards a real "management" of natural forests. The normative framework of the "Sustainable Forest Management Programme" (PAFSU) for mechanised logging and the "Simplified Management Programme" (PAFSI) for non-mechanised extraction, introduced in the year 2000, are well adapted to the local reality and are a valuable tool to prevent forest destruction, but they are based on the fact that forests are not managed but harvested (FAO/World Bank 2006). The measurable criteria and indicators defined in these norms are predominantly intended to limit harvesting operations to an ecologically compatible level.

However, silvicultural management techniques, which enhance the economic value of natural forests, such as, e.g. improvement thinning or enrichment planting, are not yet scientifically investigated enough. This was the reason for the establishment of a natural forest experiment within our Research Unit in the forest of the

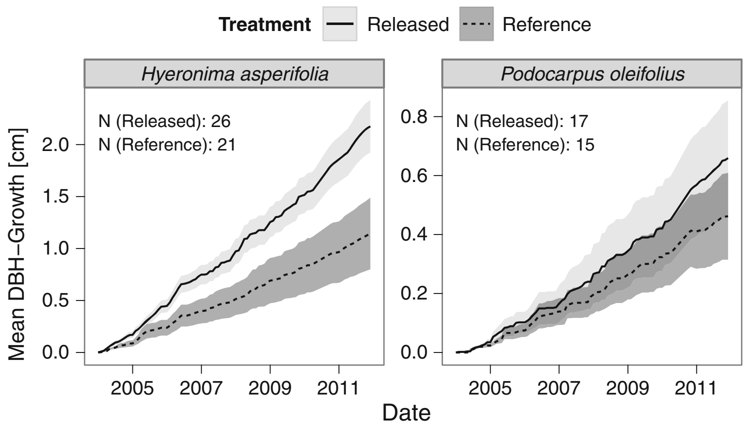

Fig. 13.1 Growth reaction (measured: diameter at breast height, DBH) of individuals of the valuable tree species *Hyeronima asperifolia* and *Podocarpus oleifolius* to an improvement thinning experiment at the RBSF ("released") compared to not treated references. Shown are means $\pm$ standard deviations

RBSF (Günter et al. 2008). First results show that improvement felling can slightly increase the number and growth of individuals of valuable timber species at the expense of very frequent but low-value species (Fig. 13.1) (Günter et al. 2004, 2008; Mosandl and Günter 2008; Weber et al. 2008).

An inventory of all trees within the area (13 ha) of the natural forest experiment (Günter et al. 2008) also allowed to calculate the sustainable utilisation potential in the natural forest (Knoke et al. 2009). In the research area, about 140 different tree species with a diameter at breast height (dbh) above 40 cm could be distinguished with mean densities of 42.9 trees per ha. Under consideration of the net mortality and the mean annual diameter increment, 1.5 trees per ha could be harvested annually without changing the actual forest structure. The harvestable trees represented an average bole volume of 1.482 m^3, of which 50 % (0.741 m^3) were considered merchantable (Leischner 2000). Based on these facts, Knoke et al. (2009) calculated yearly sustainable net revenues of US$ 31.4 per ha with an SD of $\pm$21.80 [considering uncertainty of timber biophysical yield (30 %), timber price volatility (10 %) and logging costs (10 %)].

However, as Ecuador's forests are predominantly under the ownership of local communities and indigenous groups, non-timber forest products (NTFPs) may be of similar or even higher importance as timber. According to Blaser et al. (2011), at least 589 species are used for NTFPs in Ecuadorian forests. Although a substantial part of the products may be home consumption to cover the basic needs for food, fuel, constructive material, medicinal purposes or ornamentals and are therefore not captured by the official market statistics, the exports of NTFPs amounted to 13 million USD per year between 2006 and 2008 (Blaser et al. 2011).

From an ethnobotanical survey in the research area, it can be concluded that NTFPs play a substantial role in the livelihoods of all communities. However, the extent differs among the different ethnic groups. In their study Pohle et al. (2010) investigated the use of NTFPs in communities of the Shuar, Saraguros and Mestizos. As typical rainforest dwellers, the Shuar have the highest number of plant uses. They use 204 forest plants (43.5 % of all species used) and most of them are collected in the forest (Table 13.2). For them, the forest is not only an elementary part of their livelihoods but has also a deep cultural and spiritual meaning and provides them with their cultural identity. In fact, timber extraction has been the most profitable income activity for the Shuar over recent decades (Gerique 2010).

In the Saraguro and Mestizo communities, the use of forest plants is noticeable lower (Table 13.2). However, the forest basically supplies them with timber for their own use or to sell occasionally outside the community.

For instance, the Saraguros use 37 tree species for wood products (posts for fences, furniture, house walls and floors) from which 16 are considered wild forest species. Among them, the most important are *Podocarpus oleifolius*, *Prumnopitys montana*, *Tabebuia chrysantha* and *Cedrela* spp. Only six timber species are cultivated (*Cupressus lusitanica*, *Pinus patula*, *Eucalyptus globulus*, *Persea americana*, *Pouteria lucuma* and *Juglans neotropica*). In the Mestizo communities, the use of cultivated species is more dominant. Nevertheless, they also harvest timber from 29 non-cultivated forest species. Furthermore, the forest is used to collect Bromelia and Orchids and to transplant them to their home gardens.

Due to the clearing and overexploitation of the forest resources, timber is progressively becoming scarce. Hence, the Saraguros started to grow transplanted *Cedrela* spp., *Prumnopitys montana* and *Tabebuia chrsysantha* in home gardens or protected pastures to meet their future demand for timber. The Mestizos substitute high-quality timber by low-quality species for the same purpose.

Figure 13.2 provides a summarised overview on the importance for the resource "forest" for the different ethnic groups.

Another very important but still neglected service of natural forests which is closely linked with sustainable forest management is its relevance as a resource for reproductive material (Stimm et al. 2008). The continuous supply with tree reproductive material of desired species, i.e. seed, seedlings and/or material from vegetative propagation, builds the basis for the reestablishment of native species and their extension. Consequently, in many countries of the world the conceptual development and implementation of national tree seed management programmes are a widely accepted and recognised measure of sustainable forestry.

A conservative management of tree genetic resources should focus on the conservation of natural forests with their furnishing of sets of diverse species and—within the species level—diverse populations of trees that are well adapted to the conditions in their natural habitat. Because of exploitation or changes to agricultural land use, Ecuadorian forests have not only declined drastically in area but their diversity has also been depleted, the latter often indicating "genetic degradation" as well.

Reforestation or restoration of course needs an infrastructural network of productive nurseries, whether public or private, to provide the urgently needed reproductive material (Kindt et al. 2006).

Table 13.2 Number of different applications of forest plants used by the Shuar (Shaime, Chumpias, Napints), the Saraguros (El Tibio, El Cristal) and the Mestizos (Los Guabos, Sabanilla, El Retorno, La Fragancia)

	Number of uses of forest plants										
Group	Medicine	Food	Construction	Tools	Fodder	Fuel	Ornamentals	Ritual	Veterinary	Other	Total
Shuar	37	34	43	9	21	18	4	6	9	23	204
Saraguro	1	9	16	9	0	4	1	2	0	1	43
Mestizo	2	10	14	4	0	4	10	1	0	6	51

Note: One plant species can be found in more than one use category (compiled after Gerique 2010)

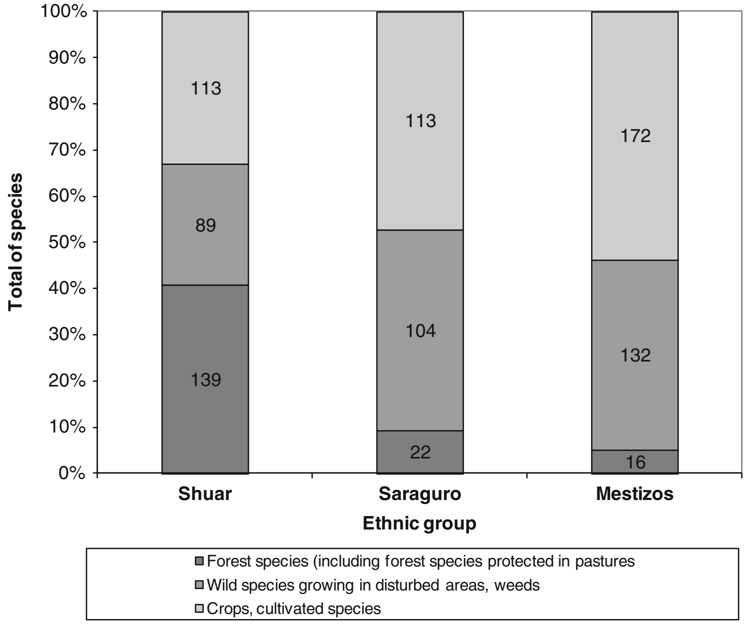

Fig. 13.2 Plant species used by Shuar, Saraguros and Mestizos according to their gathering places. *Note*: The numbers inside the *columns* indicate total values and not percentages (Source: Gerique 2010)

The monitoring, documentation and conservation of seed sources with broad genetic variability is of high importance. Appropriate seed collection for plant propagation is an opportunity to reverse the trends of genetic degradation and species loss, where nurseries play a key role in conserving the gene pool of native trees (Luna and Wilkinson 2009).

Natural forests are usually the major sources for the collection of seeds. In an attempt to evaluate seed sources for seed collection in Loja Province, Samaniego et al. (2005) identified 17 seed sources for *Clethra fimbriata*, *Cedrela montana*, *Myrica pubescens*, *Tecoma stans*, *Eugenia* sp., *Ilex* sp., *Juglans neotropica*, *Ocotea* sp., *Hyeronima macrocarpa*, *Clusia* sp., *Clethra revoluta* and *Lafoensia acuminata*.

Loja Province has an area of 11,000 km^2 and shows an altitudinal variation from 450 m a.s.l. (Macará) to 2,850 m a.s.l. (El Tiro). The larger part of the province is covered with deciduous dry forest (*bosque semideciduo y deciduo piemontano*) characterised by drought tolerant tree species like *Acacia pelyacantha*. Along the western cordillera in an elevation between 1,100 and 1,500 m a.s.l., there is a transition zone between dry to humid forests, so-called sub-montane semideciduous forest (*bosque semideciduo montano bajo*), characterised by the presence of *Tabebuia chrysantha*, *Cecropia litoralis*, *Pleurothyrium obovatum* and *Miconia denticulate* (Leischner 2000), which is followed in elevations up to 2,400 m a.s.l., particularly in the eastern part of the province by sub-montane humid rainforest zone (*bosque húmedo montano bajo*) and subsequently by the montane rainforest ecotone (*bosque húmedo montano*). As a consequence of this variation, Günter et al. (2004) revealed a total of 134 potential gene-ecological zones for the Loja Province, which need to be considered in reforestation planning. Furthermore, because of high interzonal variability, seed collection calendars must be elaborated for each species and separately for different eco-zones of the province. To receive sufficient genetic variety for large-scale reforestation, it is suggested to harvest a minimum of 50 seed trees of one provenance and species (Stimm et al. 2008).

13.3.3 Reforestation

The actual area of planted forest in Ecuador is estimated at 175,000 ha (Blaser et al. 2011). Between 2005 and 2010, the increase of planted forests for production was 11,000 ha, which corresponds to an annual afforestation rate of 2,200 ha. This has to be seen alongside the average annual loss of forest cover of 198,000 ha in the same period. Furthermore, there exists an area of degraded forest land of 3.8 million ha (Blaser et al. 2011). As abandoned and degraded land is barely used and thus contributes only little to the livelihoods of the people, it is important to put it back into production as fast as possible. For instance, for our study area Göttlicher et al. (2009) revealed that pasture management is obviously not be applied in a sustainable manner as only 15.4 % of the converted land is still in use. 32.3 % of the land resource consists of areas that are already abandoned and does neither contribute to the livelihoods of the local people nor to the conservation of biodiversity.

Many studies have shown that the establishment of plantations is an adequate means to restore forest cover on abandoned and degraded lands and to rehabilitate its provisioning functions in a reasonable time (Lamb 1998; Parrotta 1992). Mostly, exotic tree species are used for this purpose because they usually grow well, seedlings are easily accessible, and sufficient knowledge exists on their biological and silvicultural characteristics (Weber et al. 2008, 2011; Aguirre et al. 2011). Correspondingly, 80 % of the above-mentioned afforestations are Eucalypt and Pine plantations in the Andes.

However, our reforestation trials at the RBSF revealed that the growth of the native species *Alnus acuminata* is competitive to that of the exotics *Eucalyptus saligna* and *Pinus patula* (Table 13.3). Moreover, the native *Tabebuia chrysantha* showed excellent survival although the growth was very slow during the first 5 years after establishment. But as Weber et al. (2008) stated, in the initial phase of growth this species invests especially into the development of the root system. Thus, on the long run, the initial inferiority may be compensated by improved growth, superior wood quality and higher timber price at the market.

Aguirre et al. (2006) revealed that many native species can better establish under the shelter or in gaps of *Pinus patula* than at a neighbouring pasture site without any tree cover (Fig. 13.3). This offers the opportunity to use exotic species as pioneer crop to achieve a fast forest cover and to subsequently convert them into more

Table 13.3 Mean height, basal diameter and survival of three native and two exotic species 60 months (*Alnus* 48 months) after planting on three different sites: pasture, bracken and shrub, respectively

	Native species			Exotic species	
	Aa	Mp	Tc	Es	Pp
Height [cm ±SD]					
Pasture	409.1 (±245.4)	146.2 (±72.2)	25.8 (±10.2)	313.8 (±244.8)	612.4 (±140.9)
Bracken	191.8 (±104.7)	224.2 (±70.9)	44.1 (±35.9)	169.6 (±131.2)	425.9 (±124.1)
Shrub	161.0 (±82.0)	100.1 (±68.9)	48.4 (±26.4)	221.9 (±105.2)	401.8 (±132.4)
Basal diameter [cm ± SD]					
Pasture	7.1 (±4.7)	2.5 (±1.5)	1.2 (±0.2)	5.2 (±4.9)	14.8 (±4.3)
Bracken	4.5 (±2.1)	6.7 (±2.2)	1.6 (±0.8)	2.5 (±2.2)	10.8 (±3.7)
Shrub	3.0 (±1.2)	3.8 (±1.9)	1.8 (±0.6)	2.5 (±1.7)	7.5 (±3.2)
Survival [% ± SD]					
Pasture	49 (±14.9)	44 (±24.0)	80 (±13.8)	82 (±11.1)	95 (±5.8)
Bracken	38 (±24.3)	79 (±10.9)	82 (±13.2)	88 (±16.7)	88 (±12.8)
Shrub	39 (±37.7)	37 (±14.6)	97 (± 7.0)	76 (±27.0)	92 (±7.3)

Aa, *Alnus acuminata*; Mp, *Morella pubescens*; Tc, *Tabebuia chrysantha*; Es, *Eucalyptus saligna*; Pp, *Pinus patula*. $N = 25$ per species (*SD* standard deviation)

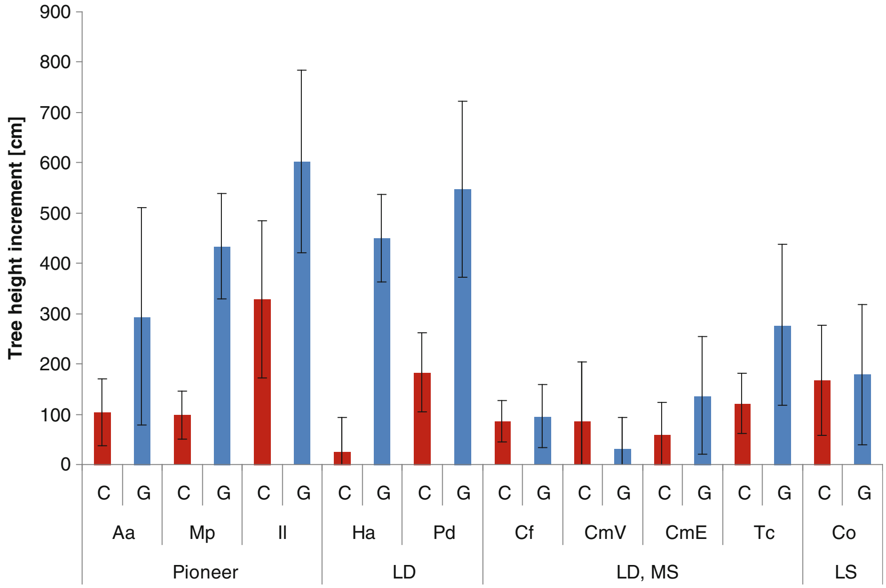

Fig. 13.3 Growth of individuals of ten native species planted in an enrichment planting experiment under the shelter and in gaps of a Pine plantation: shown are means and standard deviations of tree height increments after 85 months; Aa, *Alnus acuminata*; Mp, *Morella pubescens*; Il, *Isertia laevis*; Ha, *Heliocarpus americanus*; Pd, *Piptocoma discolor*; Cf, *Cupania* sp.; CmV, *Cedrela montana* (seed source Vilcabamba); CmE, *Cedrela montana* (seed source RBSF); Tc, *Tabebuia chrysantha*; Co, *Cinchona officinalis*. *C* canopy, *G* gaps, *LD* light demanding, *MS* mid successional, *LS* late successional

natural stands via underplanting. Consequently, the reforestation of unproductive land is an important element of the efforts to reduce the pressure on natural forests and to rehabilitate the provisioning services of forests.

In 2006, the Ecuadorian government approved a National forest and reforestation programme in order to restore a higher forest cover and to increase forest production. According to this programme, 750,000 ha of industrial forest plantations, 150,000 ha of agroforestry practices and 100,000 ha of protective plantations shall be established in Ecuador within 20 years. To fulfil the demand for the establishment of those plantations, about 56 million seedlings are needed on an annual basis. Based on information provided by UNDP/ILO (1989) on work organisation in nurseries, a permanent workforce of 7–8 workers (incl. foreman and watchman) is needed for the operation of a nursery producing about 100,000 containerised seedlings with only one planting season (begin of rainy season) per year. For producing annually 56 million seedlings this means a need of 560 nurseries with a total of nearly 4,500 permanent jobs and a high number of additional temporary workforces. Annual sales volume of 56 million seedlings may be calculated with 28 million US$ (average of 0.5 US$ per seedling).

Under the assumption that the Province of Loja is planning to reforest 40,000 ha of abandoned land in the next 20 years, this would result in an average annual establishment of 2,000 ha and a calculated number of 2.2 million tree seedlings per year. If 80 % of the area (1,600 ha) should be established with native tree seedlings, about 1.8 million of native seedlings have to be produced yearly. Let us further assume that 10 % of the seedlings (180,000) should be from *Cedrela*, another 10 % of *Tabebuia*, 10 % from *Alnus* and another 10 % of *Juglans* the required seed mass is 4.3 kg for *Cedrela*, 4.13 kg for *Tabebuia*, 0.23 kg for *Alnus* and 7,650 kg for *Juglans*. Our studies of *Cedrela montana* fruiting phenology showed that in a good seed year, one individual tree is producing up to 11,000 seeds (Stimm et al. 2008), which means a population of 32 seed trees will be needed to produce the required amount.

Of course such an estimate is theoretical because it does for instance not take into account the necessity of seed stands from different gene-ecological zones. However, it makes clear that the establishment of competent national and regional tree seed centres in Ecuador is a prerequisite to meet the ambitious goals of the national reforestation programme. The seed centres task is the appropriate management of a network of seed production stands, which is a prerequisite of sustainable seed and seedling production.

13.4 Conclusions

Forests do still have an important provisioning function for the people in the study region. As many of the products taken from the forests are used for home consumption, it is very difficult to quantify their total amount and market value exactly. However, there is no doubt that there exists a high potential to enhance respectively rehabilitate their role in the provision of goods and services for the local communities. Sustainable management of natural forest considering low impact harvesting, improvement thinning and enrichment planting is considered as one important option. The most important need is to reintegrate the increasing amount of unproductive and degraded land into the production area. Plantations either with native or exotic species are an adequate tool for this. To meet the goals of the national afforestation programme, the establishment of national and regional tree seed centres is seen as an indispensable prerequisite. However, this would provide thousands of job opportunities and generate a huge market for forest reproductive material. Finally, agricultural and forestry activities must be integrated to come to more sustainable land use. Knoke et al. (2009) have already presented a model, which combines agriculture, plantations and selective management of natural forests leading to more stable and higher income while halting deforestation. Further examples are presented by Knoke et al. in Chap. 25.

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