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1.3 Improvement of forest management key strategies: a contribution to conservation and sustainable land use

ABSTRACT

Reforestation is a key strategy for restoration and rehabilitation of degraded lands in the tropical mountain forest ecosystem.

The experiences with ***Alnus acuminata*** are promising and further research about reforestation with native tree species in mountain regions is desirable; highly relevant topics like the selection of suitable sites and reproductive material, efficient seedling production, and silvicultural management in the field should be addressed in order to ensure successful reforestation projects.

Plantations of native ***Alnus acuminata*** or exotic ***Pinus patula*** can also serve as nurse trees for enrichment planting with native tree species.

1.3.1 Introduction

The sustainable management of natural resources has been declared an objective of national policy by the Ecuadorian government (see chapter 1.1). This includes the control of agricultural expansion, the conservation of intact vegetation as well as the restoration of degraded ecosystems (SENPLADES 2014). Restoration is thus considered a key-strategy for sustainable land use. The objectives of restoration activities comprise the reforestation of 300,000 ha of degraded areas until the end of 2017 (MAE 2014): 180,000 ha are part of the national program for reforestation for environmental conservation (MAE 2014), encompassing enrichment planting with native species as well as assisted natural regeneration on degraded sites and fragmented ecosystems. Additional 120,000 ha are part of the incentive program for reforestation with commercial purposes (MAGAP 2015) which is focused on timber production with both native and exotic species. The ambitious objectives require well developed strategies and procedures in order to promote a successful implementation. Nevertheless, detailed information about several silvicultural topics like seedling production or suitable management concepts is still scarce especially for native tree species. In the following chapter we provide a condensed summary about research on reforestation in the tropical mountain forest ecosystem and emphasize the most relevant knowledge gaps. A special focus is on the selection of tree species, reproductive material and seedling production; in addition we address the financial aspects of commercial reforestation.

1.3.2 Species and site selection as basis for reforestation

The suitability of reforestation options for specific sites has to be assessed in the landscape context considering topography, soil characteristics, local climate, surrounding vegetation, and the demand for ecosystem services (see chapter 1.1). According to the dominant vegetation, three main successional stages can be distinguished on degraded sites in the Andean tropical mountain forest ecosystem: degraded but still extensively used pasture sites, bracken sites and shrub sites. We observed the natural succession in terms of abundance and species richness of woody species during four years in all three vegetation types: According to our studies, natural succession was considerably limited on the pasture site due to the competitive impact of the exotic grasses on woody species recruitment. In general, bracken and shrub vegetation seem to facilitate the establishment of woody vegetation (Palomeque et al. 2017a), with higher chances of late-successional species to establish on the shrub sites. Natural succession resulted most dynamic on shrub sites, with the highest

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abundance and species richness of woody species. Manual weeding (by cutting back the competitive vegetation every four months during the first two years of the experiment) did not improve the recruitment of woody species on any site.

In consequence, several conditions require active reforestation measures, including direct seeding or planting of tree species: In any case the selection of suitable tree species is the basic step, depending among other criteria on the motivation for the reforestation (ranging from rehabilitation for productive purposes and/or carbon sequestration to restoration aiming at re-establishing a natural vegetation cover), the site adaptation, and the availability of reproductive material. Taking into account the high number of native tree species, they are still underrepresented in many reforestation activities. Reforestation for commercial purposes as well as for protection and conservation is supported by incentive payments from the Ecuadorian government. Nevertheless, because the experiences about the performance and suitable silvicultural concepts for reforestation with native species are still limited, for mountain regions *Alnus acuminata* is the only native species supported by the incentive program for reforestation with commercial purposes (MAGAP 2015) besides the exotics *Pinus patula*, *P. radiata*, *Eucalyptus globulus* and *Cupressus macrocarpa*. For the costal and oriental region more native species are promoted by incentive payments, disclosing a special need for additional studies on reforestation with native species in mountain regions. Our reforestation trials on pasture, bracken, and shrub sites in the San Francisco valley generally confirmed the competitiveness of *A. acuminata* in comparison to the growth rates of *P. patula* and *E. saligna* during the first three years after planting (Günter et al. 2009). In addition, some native species like *Handroanthus chrysanthus* (syn. *Tabebuia chrysantha*) showed convincing survival rates and might accelerate their growth rates after a phase of root establishment and site adaptation. General conclusions on the impact of the dominating vegetation are complicated due to the heterogeneous soil conditions on all sites, but *H. chrysanthus* performed best on shrub sites whereas *A. acuminata* and *P. patula* showed highest growth rates on pasture sites. Bracken vegetation seems to have a negative impact on the increment of *P. patula* and *E. saligna*, but not on the growth of *Heliocarpus americanus* and *Juglans neotropica*. Soil conditions affected especially the growth of *A. acuminata* and *E. saligna*, which was not the case for *P. patula*, *J. neotropica* and *H. americanus*. In general terms, early successional species seem to be a better option for reforestation on pasture sites, while mid successional species perform better on more shaded sites. These results have been confirmed during the following periods, like e.g. the highest increment for *A. acuminata* on pasture sites (**Fig. 1**; Palomeque 2012).

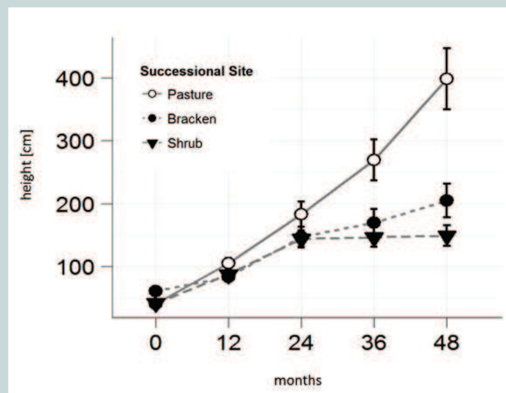

Fig. 1 Development of the mean height of *A. acuminata* on pasture, bracken, and shrub sites from 0 to 48 months (error bars = standard error; Palomeque 2012).

A comparison of growth rates among seven common native species and 12 montane forest sites across the northern Andes (Bare and Ashton 2015) also confirmed the fast growth of *A. acuminata* but also its sensitivity regarding soil conditions. Additional studies on growth performance of native and exotic tree species on degraded sites in the Ecuadorian Andes are sparse: Hofstede et al. (1998) provided a summary of information about plantations of *A. acuminata* and *P. patula* above 3000m asl in

Colombia. Further reliable data is desirable in order to facilitate the process of tree species selection for reforestation and to increase the share of native tree species. Studies on the contribution of topographic variables for the distribution of trees species within their natural habitat as conducted by Kübler et al. (2016) provide additional helpful information, notwithstanding the fact that the distribution in the natural forest is also influenced by biotic factors, like competition. For instance, these authors confirmed the qualification of certain species for growth on ridges and upper slopes due to their belowground competiveness on nutrient-poor soils, which should be a useful property for reforestation on degraded sites. Another aspect of species selection for reforestation activities is their susceptibility to climate change effects. We used species distribution models to explore the potential effects of climate change (RCP 8.5 future scenario; global circulation model HadGEM2-ES; year 2070) on the local distribution of selected native species in Ecuador. Most commercially-valuable species showed a decrease in the projected areas (which represent suitable climatic niches) and as expected shift towards higher elevations (**Fig. 2**). This effect appears to be higher for lowland species, such as *Bursera graveolens*, *Cedrelinga cateniformis*, *Cordia alliodora*, *Jacaranda copaia*, *Parkia multijuga* and *Handroanthus chrysanthus*. Mountain tree species such as *Alnus acuminata*, *Cinchona officinalis*, *Juglans neotropica* and *Podocarpus oleifolius* showed consistently the least effect in eventual area reduction. If tree species indeed will response with shifts in distribution ranges and thus potential effects on species or community resilience requires further research.

1.3.3 Selection of reproductive material

The access to and the selection of reproductive material (seeds, cuttings or planting stocks) is

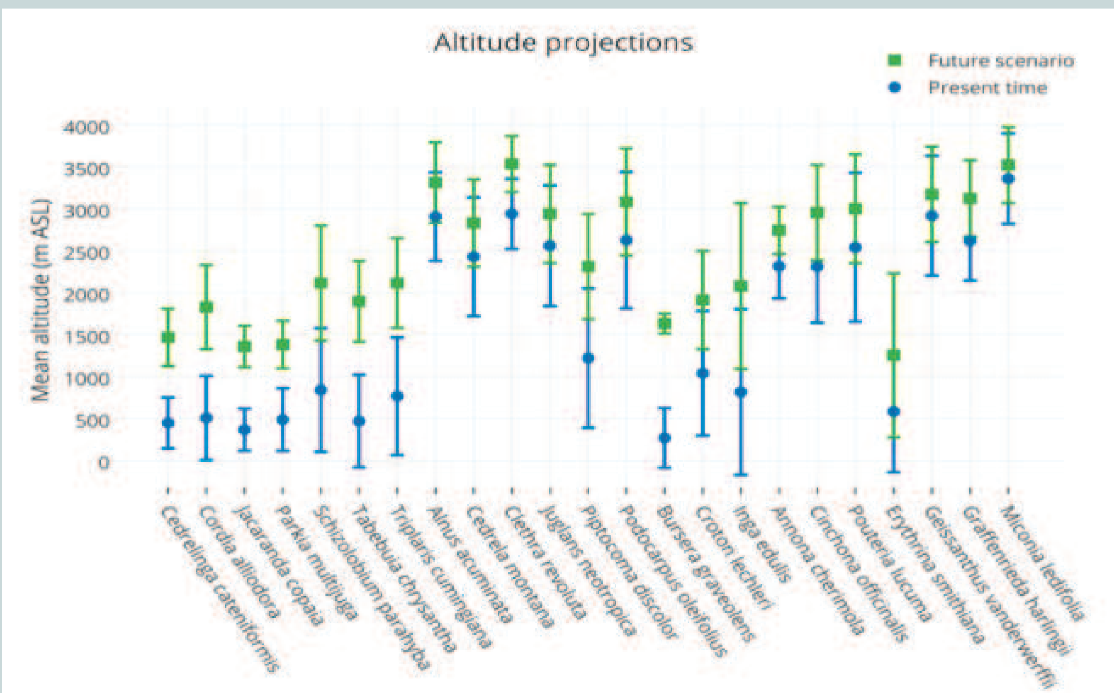

Fig. 2 Projections of the altitudinal range of occurrence of selected tree species under present and future (2070) climate according to Wordclim's uncorrelated bioclimatic variables (Error bars represent SD, Manchego et al. 2015).

another important step for successful reforestation, which is essential for ensuring the genetic suitability from different tree provenances and a high timber quality. A comprehensive overview with reference to local conditions has been presented by Ordoñez et al. (2004) and Stimm et al. (2008); detailed information about the handling of tropical forest seeds in general is provided by e.g. Salazar (2000), Schmid (2007) and Vozzo (2002). The regulations for forest seeds (MAE 2004) build the normative framework for public and private reforestation activities related to the production, trade, and quality control of tree seeds. Among other things, the regulations define standards and registration of seed provenances, producers and traders, seed collection and documentation. In order to improve the production of seeds with high quality and documented origin for commercial plantations, the Ecuadorian Ministry of Agriculture, Livestock and Fisheries (MAGAP) has recently published a description of the methodology for the identification of seed provenances and mother trees (MAGAP 2016). Beyond commercial plantations, these guidelines are also useful for any other objective of reforestation and have to be applied by registered seed producers. They define criteria for suitable sites, regulations for inventories in planted and natural forests, and criteria for the evaluation of single trees, with the objective of categorizing seed sources and selecting individual seed trees. This is a valuable progress for coordinated and documented collection of information on seed sources and a basic contribution to the program of reforestation.
Several institutions already identified seed sources for native species (Grijalva et al. 2012): EcoPar (20 sites for 8 species from the mountain forest), Asosación de Agrónomos Indígenas de Cañar, AAIC (13 sites for 12 species from the mountain forest), Fundación Ecológica Arcoiris (14 sites for 10 species in the province of Loja); 63 seed sources for 20 native species have been established since 2000 in the scope of the program FOSEFOR (Fomento de Semillas Forestales) in the Andes region of south Ecuador (Prado et al. 2010).
Further information about seed provenances of selected native tree species from the mountain region in Southern Ecuador has been published by e.g. Ordoñez et al. (2001), Samaniego et al. (2005), Raurau (2012) and Palomeque et al. (2017b). Studies on the identification of seed trees of selected native tree species are also provided by e.g. Armijos (2008), Raurau (2012) and Maldonado and Doris (2015).
Suitable periods for seed collection depend on the tree species, the regional climate, and the climate variability. Even under perhumid conditions in mountain forests, many tree species tend to adapt the reproductive cycle to climate factors (Cueva et al. 2006; Bendix et al. 2006) which is even more pronounced on seasonal sites (Günter et al. 2008). Consequently, phenological calendars are an indispensable tool for efficient seed collection. Species specific information for 46 native tree and shrub species from the Andes of Bolivia and Ecuador has been presented by Prado and Valdebenito (2000). Long term phenological studies have been conducted for selected tree species in the RBSF (**Fig. 3**), and additional studies are listed in **Table 1**.

1.3.4 Seedling cultivation

Ruano Martinez (2003) provided comprehensive instructions for cultivation of seedlings in nurseries. The process of an economic production of high amounts of seedlings with good qualities is subject to several requirements which are species specific in many cases and still unknown or at least not well documented for many tree species from the tropical mountain forest. Germination rates are generally influenced by seed quality (germination capacity), dormancy and pretreatment, and germination conditions (e.g. water, temperature, substrate, Schmid 2007). Several experiments have been conducted by our research group (the results of most studies have been summarized by Stimm et al. 2008) or have been published by other institutions (**Tab. 1**). The variety of species, variables and results within a relatively small geographical area underlines the importance of structured regional seed management programs as already stated by

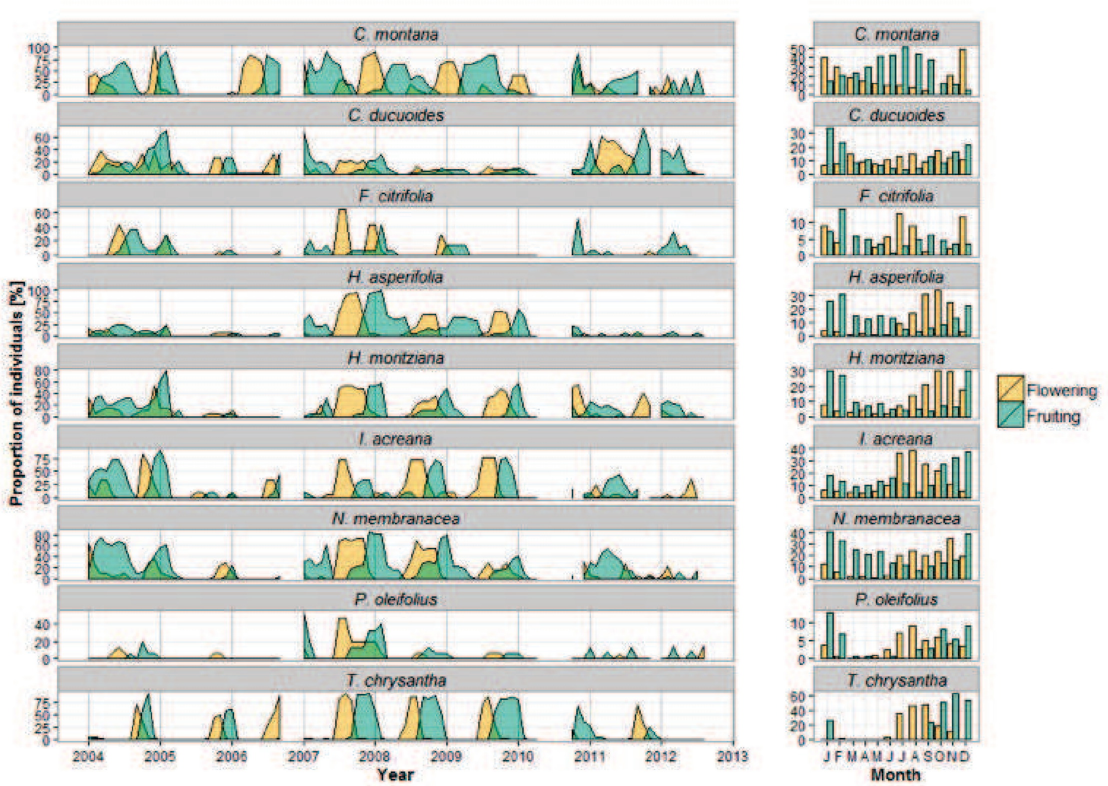

Fig. 3 Flowering and fruiting of 9 selected species; the monitoring period comprised almost nine years in order to detect annual variation (left) and to enable the estimation of consolidated probabilities of flowering and fruiting (right) (Hildebrandt et al. 2013).

Stimm et al. (2008) or Prado et al. (2010). Hertel (2012) evaluated the current practices of seed management in the Province of Loja based on questionnaire surveys among local nurseries and developed a concept for a regional seed program. Among other topics, drawbacks regarding infrastructure and education of workforce but also seed handling (e.g. documentation, seed zoning, quality control, distribution) have been identified for potential improvement.

Finally, additional aspects of plant breeding have to be involved in order to facilitate seedling production for reforestation: A clonal orchard of *P. oleifolius* and *P. sprucei* for the provision of cuttings was successfully established by one of the authors (N. Aguirre) in the vicinity of El Jardín Botánico "Reinaldo Espinosa" in Loja. Significant improvement may be achieved by selection of suitable substrate, pest control, fertilization, and inoculation with arbuscular mycorrhizal fungi (AMF). For instance, Schüßler et al. (2016) and Urgiles et al. (2016) pointed out the positive effect of using specific mycorrhizal fungi inocula for seedling production in the nursery, which can also reduce mortality rates in the field (Krüger 2013).

1.3.5 Establishment and management in the field

Establishment (tree densities, weeding) and management (e.g. fertilization, pest control, thinning, pruning) depend on species and sites, but available information about native species is scarce. Some concepts for reforestation with *A. acuminata* and exotic *P. patula* are summarized in the following [*Further information about the establishment and management of pine and alder plantations is available in e.g. Dunn et al. (1990), Ospina et al. (2005), Ospina et al. (2011), Reynel and Marcelo (2009)*]: MAGAP (2015) provides regulations and recommendations for all species included in the incentive program for reforestation with commercial purposes. Plantations of *A. acuminata* for instance should be established with a tree density of 1111 ind./ha (3 x 3 m) and weeding should be applied during the first two years. Fertilization is not recommended as no information about the necessity is available and *A. acuminata* is able to fix nitrogen (Russo 1989) and to improve soil fertility. Hofstede et al. (1998) also recommended the same density for plantations with the purpose of watershed protection, Añazco Romero (1996) reported tree densities from 100-600 for silvopastoral plantations and recommended a maximum of 1111 ind./ha for timber production. Fertilization with boron and phosphor is recommended by MAGAP (2015) at the moment of plantation and 2 years later in the case of *P. patula*.

In our field experiment management of aboveground competition by manual weeding every 6 months during the first 2 years after planting resulted in species specific and site specific effects at the age of 3 years after planting according to Günter et al. (2009): *H. americanus* and *H. chrysanthus* reacted positively on the removal of competing vegetation, whereas *C. montana* showed reduced height increment rates on pasture and bracken sites. Manual weeding on the shrub site had no effect for any species. Palomeque (2012) confirmed these results for the age of 5 years after planting, but the positive effect on height increment of *H. americanus* was no longer significant.

Additional analysis of insect herbivory of *H. americanus*, *H. chrysanthus* and *C. montana* on the pasture and shrub sites did not reveal major concerns. Merely *H. chrysanthus* has been affected by leaf-cutter ants on the shrub site (53% of all sampled trees have been affected at least once during the monitoring period between October 2010 and May 2011) and the pasture site (39%) (Adams & Fiedler 2016). For commercial plantations of *P. patula* MAGAP (2015) recommends the control of Dothistroma pini by fungicide and *Diplodia pinea* by pruning and thinning. In some cases chemical control is also necessary against insects and fungi affecting *A. acuminata* (MAGAP 2015).

Thinning with subsequent pruning is recommended for commercial plantations of *A. acuminata* at ages of 6 (intensity 50%) and 13 years (40%), in case of *P. patula* at the age of 6 years (40%) and 12 years (40%). The rotation periods are indicated with almost 20 years for both species (MAGAP 2015).

Knoke et al. (2014) modeled the growth of *A. acuminata* and *P. patula* based on data from the experimental plots mentioned above: Considering thinning campaigns at years 12 and 16 as well as rotation periods of 20 years for both species resulted in a mean dbh of 28.44 cm (mean height 14.63 m) for *A. acuminata* and a mean dbh of 26.87 cm (mean height 17.34 m) for *P. patula*. Taking into account the costs and revenues for plantation establishment, maintenance and production (**Fig. 4**) resulted in net present values (5% discount rate) of US$ 1435 (*A. acuminata*) and US$ 1322 (*P. patula*), and payback periods of 16 years for both species. Both options are thus attractive from an economic perspective, but less favorable than the common practice of forest clearing followed by pasture establishment (net present value US$ 1765 at 5% discount rate) (Knoke et al. 2014). The incentive program for reforestation (MAGAP 2015) is therefore also a valuable tool for reducing the pressure on natural forests in the region.

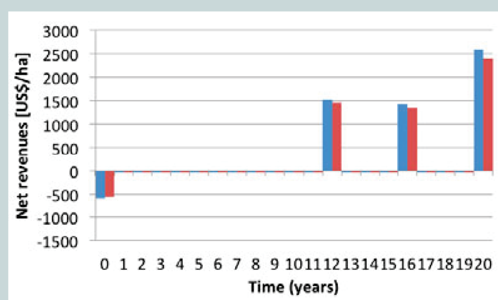

Fig. 4 Net revenues of *A. acuminata* (blue) and *P. patula* (red) plantations with rotation periods of 20 years.

A. acuminata and *P. patula* can also serve as nurse trees for enrichment planting with native tree species. Studies in a pine plantation on our research site (Aguirre et al. 2006; Weber et al.

2013) have confirmed the feasibility of this concept which is currently tested with nine native species (*A. acuminata*, *C. montana*, *Cordia alliodora*, *H. chrysanthus*, *Jacaranda mimosifolia*, *Lafoensia acuminata*, *Podocarpus oleifolius*, *Podocarpus sprucei*, *Triplaris cumingiana*) and different intensities of silvicultural treatments (control = without intervention, slight treatment = 25% basal area removed, strong treatment = 50% basal area removed) in alder and pine stands on additional sites in the province of Loja. Six months after planting, early successional species showed the best height increment and almost all species reacted positively on treatment intensity (**Fig. 5**).

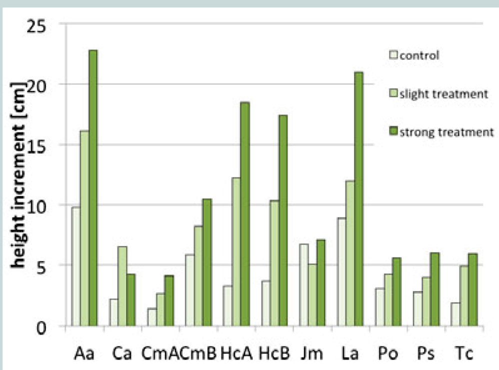

Fig. 5 Means of height increment of native tree seedlings (Aa= *A. acuminata*, Ca= *Cordia alliodora*, CmA= *C. montana* provenance A, CmB= *C. montana* provenance B, HcA= *H. chrysanthus* provenance A, HcB= H. *chrysanthus provenance* B, Jm= *Jacaranda mimosifolia*, La= *Lafoensia acuminata*, Po= *Podocarpus oleifolius*, Ps= *Podocarpus sprucei*, Tc= *Triplaris cumingiana*) in pine plantations six months after planting.

1.3.6 Knowledge transfer

The results of our studies have been presented and discussed during the annual Status Symposia of the German-Ecuadorian platform in Loja and Cuenca; in addition, we presented our experiences on reforestation of abandoned pastures during the knowledge transfer workshop in October 2015 and during the first Ecuadorian Congress of Landscape Restoration (CERP; April 2016). Both events have been complemented with a guided field trip on afforestation sites of the associated knowledge transfer project “Facilitation of biodiversity in montane ecosystems by large-scale conversion of monocultures into mixed forests” or our study sites in the RBSF respectively (**Fig. 6**). In cooperation with our colleague Julia Adams we have conducted guided field trips with representatives of the Junta Parroquial de Sabanilla (see chapter 1.2) and shared our experiences on reforestation as well as reproductive material of native tree species. The collection of high quality seeds requires also suitable techniques (see Anderson et al. 2015 for a review and safety assessment of different tree climbing methods), adequate equipment and educated staff. Several training courses in tree climbing (**Fig. 7**) have been realized during the last years in cooperation with MAE, MAGAP, NCI, UNL, and UTPL (see DFG Research Unit 816, 2012) in the scope of the knowledge transfer project “Facilitation of biodiversity in montane ecosystems by large-scale conversion of monocultures into mixed forests”.

1.3.7 Acknowledgements

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Fig. 6 Felipe Serrano (NCI) introducing the study sites during the guided field trip with participants of the first Ecuadorian Congress of Landscape Restoration (CERP 2016).

Fig. 7 Training course in tree climbing on our study site in San Francisco.

Tab. 1 Seed ecology data of selected native South Ecuadorian mountain rainforest tree species, adopted from Stimm et al. (2008) and supplemented with additional results. Prov: Provenance, Disp: seed dispersal mode, M.C.: moisture content of seeds.
Data compiled from: Beck (personal communication), Briceño (2005), Cabrera and Ordoñez (2004), Cueva (personal communication), Diaz and Lojan (2004), Homeier (personal communication), Jara and Romero (2005), Leischner (2005), Merkl (2000), Jumbo (2005), Armijos (2008), Alvarado and Encalada (2010), Aponte and Sanmartin (2011), Gonzaga and Moncayo (2012), Raurau (2012), Calle Cueva (2016)

Species	Prov[a]	Disp[b]	Flower[c] (months)	Fruiting (months)	Ave. purity (%)	M.C. (%)	Weight[d] (g)	No. seeds/kg[e] (×1000)	No. seeds/fruit	No. fruits/tree (×1000)	No. seeds/tree (×1000)	Ave. germination[f] (%)
Alnus acuminata Kunth	EB	w	VII--III	IX--V	91	--	0.29--0.31	3400	180--210	--	--	35 (*39*)
Alnus acuminata Kunth	A	w	--	--	--	--	0.19	5263	--	--	--	58 (*38*)
Alnus acuminata Kunth	LA	w	--	--	87	12	0.2--0.5	2921	152	--	--	10--62
Alnus acuminata Kunth	SH	w	--	--	52--87	--	--	--	--	--	--	5
Alnus acuminata Kunth	RS	w	--	--	70	17.2	0.2--0.4	2898	155	--	--	13
Cedrela lilloi C.DC.	SF	w	--	--	--	--	11.9--15.0	83.9--66.0	21--24	0.01--0.5	0.23--11.5	62
Cedrela montana Moritz ex Turcz.	SF	w	X--III	II--IX	87--90	12--13.3	12.4-15.6	81.6	--	0.15	2.8	86--96 (*80*)
Cedrela montana Moritz ex Turcz.	EB	w	VII--III	VIII--V	90	--	42.5	23.5	27	--	--	86 (*69*)
Cinchona officinalis L.	EB	w	ay	ay	77--83	16.1	0.58--0.97	1310	39--42	--	--	80 (*90*)
Clethra revoluta Ruiz & Pav.	SF	w	III--VII	IV--X	63--66	6.5	0.05	19 417	--	--	--	54--69 (71)
Clethra revoluta Ruiz & Pav.	EB	w	X--III	XI--IV	93	12.6	0.05--0.078	13 260	40--46	--	--	48 (*8*)
Croton lechleri Müll.Arg.	JA	a/w	--	--	85	--	69.5	14388	--	--	--	--
Cupania sp.	EB	a/g	I--VIII	VI--I	93	--	445--580	--	3	--	--	-40
Cupania americana	EB	a/g	X--V	IV--IX	81	47	1816	--	--	--	--	80
Heliocarpus americanus L.	SF	w	II--VIII	V--X	93	10.4	1.39	732.3	1--3	21.9--125.0	42.5--250.0	27 (59)
Hyeronima asperifolia Pax & K. Hoffm.	SF	a/g	VI--XII	I--VI	95	36.3	352.6	--	--	0.24	0.24	--
Inga acreana Harms	SF	a/g	VI-I	XI--V	98	3.6	400.8--550.1	1.8	--	0.3	2.2	84
Isertia laevis (Triana) B. M. Boom	SF	a	I--IX	VI--III	62	14	0.15--0.23	5530	200--300	1.0--2.4	200--720	89
Juglans neotropica Diels	L	a/g	VII--II	IX--VI	--	--	18 200--21 400	0.05	1	0.5--1.0	--	-72
Juglans neotropica Diels	EB	a/g	VIII--XII	XI--XII	--	--	--	--	--	--	--	--
Juglans neotropica Diels	JA	a/g	--	--	88	--	15000	0.066	--	--	--	3.75
Juglans neotropica Diels	LA	a/g	--	--	88	--	13870	0.072	--	--	--	6.75
Lafoensia acuminata (Ruiz & Pav.) DC.	CC	w	--	--	96	--	52.4	19083	--	--	--	64.25
Lafoensia acuminata (Ruiz & Pav.) DC.	GZ	w	--	--	96	--	49.6	20161	--	--	--	48.25
Myrica pubescens Humb. & Bonpl. ex Willd.	SF	a	V--VI ♀ ay ♂	II--III ♀ ay ♂	98	11.9--15.8	12.3	85.7	1	30.8	30.8	76 (34)
Myrica pubescens Humb. & Bonpl. ex Willd.	EB	a	ay ♂	ay ♂	83--96	33.3	3.45	290	1	--	--	5--23 (15)
Myrsine sodiroana (Mez) Pipoly.	EB		VII--I	VIII--II	96	26	28	--	--	--	--	12
Nectandra membranacea (Sw.) Griseb.	SF	a	VIII--XII	I--V	--	--	--	--	--	--	--	
Piptocoma discolor (Kunth) Pruski	SF	w/(a)	VII--X	VIII--II	93	8.6	0.29	3434.4	--	254.7	509	23 (33)
Prumnopitys montana (Humb. & Bonpl. ex Willd.) de Laub.	SF	a/g	XI--II	II--V	--	--	--	--	--	--	--	--
Prumnopitys montana (Humb. & Bonpl. ex Willd.) de Laub.	EB	a/g	IX--IV	XII--VI	--	--	74	13.5	1	--	--	--
Tabebuia chrysantha (Jacq.) G. Nicholson	SF	w	VI--XI	VIII--II	76	13.1	9-23.1	111	--	0.01-0.21	--	86 (*59*)
Tabebuia chrysantha (Jacq.) G. Nicholson	J	w	--	--	--	10	13--27.4	49.21	41--157	--	--	11
Tabebuia chrysantha (Jacq.) G. Nicholson	VP	w	--	--	--	11	22.1--74.3	22.68	40--238	--	--	12
Vismia tomentosa Ruiz & Pav.	SF	a	IX--V	I--VIII	85	11	0.59	1724	60	9	540	15 (25)
Weinmannia glabra L.f.	EB	w	V--VIII	XI--II	98	17.8	0.09	--	--	--	--	82

a Provenance: A = Alisal, CC = Catacocha, EB = El Bosque, GZ = Gonzanama, J = Jipiro, JA = Jipiro Alto, L = Loja, LA = La Argelia, RS = Rumishitana, SF = San Francisco, SH = Shucos, VP = Virgenpamba**;** **b** Seed dispersal mode: a = animal, g = gravity, w = wind**;** **c** Flowering period (in calendar months): ay = all year**;** **d** Weight of 1000 seeds.
e Number of seeds per kilogram of seeds; **f** Average germination on wet filter paper or wet sand under laboratory conditions; in italics: max. germination (%) in greenhouse tests.

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1.3.8 References

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