66 Ecological and social bases for the restoration of a High Andean cloud forest: preliminary results and lessons from a case study in northern Ecuador

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ABSTRACT

The High Andean cloud forests of northern Ecuador have been exploited by humans for centuries. Presently, ecological restoration is urgently needed to enhance biodiversity conservation, and ecosystem processes and services. This chapter presents the basis for a strategy that integrates ecological knowledge and local people's perspectives on the utilization of biodiversity for the restoration and management of a High Andean landscape. The objectives were: (i) to evaluate the restoration needs of the landscape, (ii) to identify groups within society that are interested in forest restoration, (iii) to select the species of plants with potential for forest restoration, and species of mammals for managed production, and (iv) to provide recommendations for integrating groups within society to achieve participative restoration. It was found that: (i) upper montane cloud forests (2900–3400 m.a.s.l.) are most in need of restoration, (ii) more affluent groups within the society are more willing to use biodiversity, with gender and ethno-biological knowledge influencing these trends, and (iii) seven species of plants and five species of mammals have the highest potential for restoration and management. Thus, an initial phase for a restoration project should encourage and guide the more affluent parts of society to restore their lands first. Less affluent people are likely to become interested in restoration once they can explore concrete examples of the uses they can make of local biodiversity, and if support for these activities is available through participatory learning. This case study shows how ecological, social, and ethno-biologic knowledge can be combined to design a participative forest restoration strategy for a human-dominated landscape.

INTRODUCTION

The High Andean cloud forest belt, corresponding to the upper montane rain forest formation of Grubb (1977), constitutes one of the most important centers of biodiversity in the world (Dinerstein *et al*., 1995; Barthlott *et al*., 2005; Beck *et al*., 2007). However, the conservation status of these forests is extremely poor due to the intense exploitation that has taken place especially during the last century (Mosandl *et al*., 2008). Currently, less than 10% of the original forest cover remains in scattered fragments distributed between Venezuela and Bolivia (Laegaard, 1992; Kessler, 1995; Wille *et al*., 2002; Mulligan, this volume). Over large areas of the High Andes, the expansion of urban settlements and agricultural lands, and inappropriate timber exploitation is reflected in the loss of biodiversity (Pitman *et al*., 2002; Mosandl *et al*., 2008; Pohle and Gerique, 2008), and altered hydrologic regulation (Buytaert *et al*., 2006; Molina *et al*., 2007; cf. Bruijnzeel, 2004). From a socio-economic perspective, the poor land-management practices that lead to the loss of these ecosystems contribute to poverty, malnutrition, and migration (Anand, 2002).

During the last decade, ecological restoration has emerged as an option to increase the cover of terrestrial ecosystems that are highly impacted by human activities (Hobbs and Harris, 2001;

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Günter *et al*., 2009; Williams-Linera *et al*., this volume). In northern Ecuador, the conversion of degraded lands into natural forest could contribute to the conservation of the area's unique flora and fauna. Increased forest cover could also diminish the risk of extinction of endangered species, and improve habitat conditions for wildlife (cf. Jordan *et al*., 1987; Cavelier *et al*., this volume; Hofstede *et al*., this volume). At the same time, higher forest cover may enhance the provision of ecological services that contribute to the stabilization of agricultural production, including more dependable streamflow during the dry season and lower stream sediment loads; see Bruijnzeel (2004), Scott *et al*. (2005), and Malmer *et al*. (2009) for a fuller discussion of the circumstances under which reforestation may be expected to improve streamflow regulation. In particular, a higher availability of forest resources would provide local communities with a variety of timber and non-timber forest products that could both diminish expenses and raise their income (see also Pohle and Gerique, 2008). Thus, from a holistic perspective, restoring degraded areas in human-dominated landscapes could contribute to the alleviation of local ecological and socio-economic problems.

In landscapes that are highly populated and where most of the land is privately owned, restoration efforts must be tailored on the basis of people's perceptions, resource dependence, and need of biodiversity and ecological services (Cook *et al*., 2004; Armitage, 2005). Because different groups in society – including men and women, wealthy and poor – tend to have different perceptions and attitudes toward the utilization of forest resources (Phillips and Gentry, 1993; Phillips *et al*., 1994; Byg and Balslev, 2001), their reasons for supporting forest restoration will vary accordingly. Thus, the connection between people and nature needs to be evaluated carefully in order to develop effective strategies for ecosystem restoration. In addition, it is critical to assess the possibilities of forest restoration in the context set by the prevailing local production systems.

This study aimed at developing a holistic strategy for the restoration of High Andean forests in a human-dominated landscape in northern Ecuador. Livelihoods in the study area are based on the production of potatoes and extensive cattle ranching; both activities promote deforestation and require high human and agrochemical inputs, including excessive use of health-threatening pesticides (Yanggen *et al*., 2004; Hofstede *et al*., this volume). The present study integrated the needs of restoration of native forests with local peoples' perspectives on restoration, and made specific suggestions about ways in which each group of society could contribute (Engel, 1997; FAO, 1999; Leeuwis and Rhiannon, 2002). An ethno-biologic approach was taken to evaluate people's interest in forest restoration in relation to their socio-economic status, gender, knowledge, and dependence on forest resources. Given the dependence of the local population on agricultural production, the possibilities for using agricultural experimentation to improve the use of local biodiversity and promote forest restoration were explored as well (see also Pohle and Gerique, 2008 for an example from southern Ecuador). Hence, the objectives of the project were: (i) to evaluate the restoration needs of the local forests, (ii) to identify groups of society interested in forest restoration, (iii) to select the species of plants with potential for forest restoration, and of mammals for managed production, and (iv) to provide specific recommendations for integrating groups of society to achieve participative restoration. The investigation was carried out as part of the Biodiversity-Based Livelihoods in High Andean Cloud Forests project investigating ways in which local biodiversity can contribute to sustainable livelihoods, including agricultural diversity and ecological restoration.

STUDY AREA

The study was carried out in a remnant of the humid montane Andean forest known locally as *bosque de Ceja Andina* or *bosque siempreverde montano alto* (Sierra *et al*., 1999; Balslev and Ølgard, 2002). The study area is located on the western flanks of the volcanic Eastern Andean Cordillera in the Carchi Province of northern Ecuador (Figure 66.1). The investigated forest remnant stretched for approximately 30 km from north to south and covered an altitudinal range between 2800 and 3700 m.a.s.l. (Sierra *et al*., 1999). Details on the respective forest types found in the area are given in the Results section below. The region has a steep topography, with slopes up to 40°, as well as numerous ravines, rivers, and valleys. The area has a mean annual precipitation of approximately 2000 mm, with two wetter seasons occurring from February to May, and from October to December; the most pronounced dry season is from June to August. The annual mean daily temperature is about 12°C, and daily variations in temperature exceed seasonal variations. Insolation ranges between 1000 and 2000 hours of sunshine per year (Hofstede *et al*., 1998).

The population is composed mainly of *mestizo* people that during the last 40 years have moved to the area from neighboring Ecuadorian and Colombian highlands. This study was carried out in the localities of Mariscal Sucre and Jesús del Gran Poder, which had 1750 and 400 inhabitants in 2004, respectively.

METHODS

Classification and restoration of forest cover

To define the restoration needs of the natural forest of the area, the various forest types were classified, and their conservation status evaluated. To classify and estimate the extent of the

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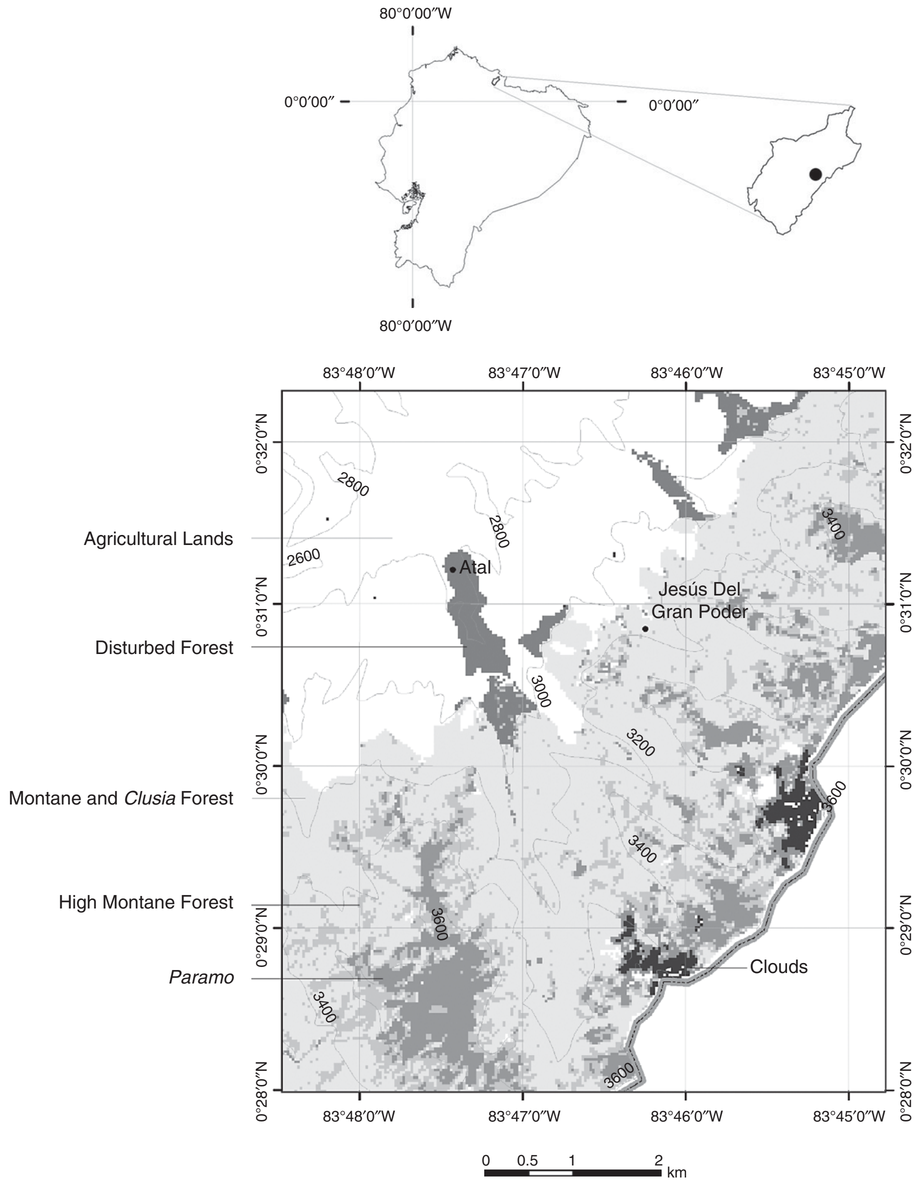

Figure 66.1. Map of a section of the study area in northern Ecuador indicating the distribution of different vegetation types and agricultural lands.

different vegetation types a Landsat TM image was used from November 1999 (scene P10 R60, complete, bands 2, 4, and 5, re-sampled at 30 × 30 m). The image was corrected using coordinate points, so distortion was less than 30 m. The vegetation types present in the image were classified using the method of supervised digital classification Maxlike (IDRISI 2.0, 1997).

To evaluate differences in the floristic composition of the respective forest types, 20 plots of 10 × 20 m were established along an altitudinal gradient between 2900 and 3600 m.a.s.l. at 50–80-m intervals. Plots were set up within each of the major vegetation types distinguished, choosing stands that showed little or no human alteration. For each plot, altitude and coordinates were recorded and each tree >10 cm DBH (diameter at breast height) was measured and identified. For the vegetation classification analysis floristic data were included from previous studies in the study area by Van Geloof (2003) (20 plots of 10 ×10 m), and by Mora (1996) (four plots of 50 × 50 m).

A multivariate method was used to evaluate the similarity of species composition between vegetation plots to distinguish different vegetation types. The Euclidean distance (*ED*) method calculates the absolute distance between points in one or many dimensions and is a measure of the magnitude of difference between samples of interest (Gasgrain and Legendre, 2000). Individuals of unclear taxonomy at the species level were grouped within their corresponding genus (e.g. *Shefflera*, *Oreopanax*). The calculated *ED*-values between plots were used to construct a cluster diagram illustrating similarities of species composition between plots. The conservation status of the

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Table 66.1 *Indices of types of ethno-biologic information*

Measure	Calculation	Description
Use value (UV_s)	$UV_s = \sum VU_{i,s}/n$; UV is the number of uses that the informant *i* knows for the species *s*; *n* = total number of informants	Indicates the average number of uses that the informants know for a species
Use value per category (UV_c)	$VU_s = \sum UV_{i,s,c}/n$; UV is the number of uses that the informant *i* knows for the species *s* in the use category *c*; *n* = total number of informants	Indicates the average number of uses in one use category that the informants know for a species in a category of use
Index of diversity of use (DU_s)	$DU_s = 1/\sum P_c^2$; P_c = contribution of the use categories *c* to the total utility of a species *s* (= number of times a species *s* was mentioned within a category of use, divided by the total number of reports of use of the species s among all the categories)	Indicates the number of categories of use a species is used, and how homogeneously this contributes to their use; values range from 0 to the total number of categories a plant is used for
Use frequency (UF_i)	$UF_i = \sum UF_{i,s}/n$; UF is the number of times an informant *i* uses a species *s* in a year; *n* = total number of species	Indicates the average number of times an informant uses a species in a 1-year period

respective forest types was mapped using a GIS (IDRISI 2.0). The present distribution of a given forest type was compared with its potential altitudinal distribution, but excluding areas occupied by other types of natural vegetation.

Peoples' interest in forest restoration and their relationship with biodiversity

In total, 155 people (93 men, 62 women) were interviewed to obtain information on their socio-economic status (notably education, land tenure, and income), their knowledge of the use of local plants and mammals, and their interest in restoring and managing wildlife species on their lands. The informants were randomly chosen during visits to their homes, but care was taken to have a representative sample in terms of gender, age, and socio-economic status. The interviews had a fixed format and used a color picture of each tree or mammal species considered in the study (Tirira, 1999). The informants answered questions related to the use of 17 species of timber trees that are naturally abundant in the local forest and considered to have high potential for reforestation projects (Fehse *et al*., 1998; Loján, 2003). The pictures of the plants and mammals did not include their local names to avoid obtaining information belonging to other species that share a local name. The first question referred to each person's knowledge of the particular plant/animal indicated in the picture. If positively answered, the following questions were related to the species' use, the frequency of use, and its potential to be used for forest restoration. A partly different set of informants provided information about the use of 18 species of mammals native to the High Andean forests of the area. The questions inquired about the use of the animal, the frequency of use, and people's personal interest in managing the species. The interviews also included casual questions related to personal perspectives on restoring and managing species.

The data analysis was designed to identify the socio-economic groups and gender that had an interest in restoring local forests and managing wildlife. It was considered particularly important to know how peoples' interest in restoration related to their ethno-biologic knowledge and to what degree they used local biodiversity. Various indices were calculated to standardize this information (Table 66.1). The socio-economic status of the informants was evaluated using an index ranging from 0 to 1, calculated by weighing values of degree of education (ranging from 0 = no education, 1 = primary school, 2 = secondary school, and 3 = college education); land tenure (0 = no land owned, 1 = renting land, 2 = land owned by relatives, and 3 = land owned by the family); and total monthly income in cash (weighting values relative to the observed minimum (0) and maximum (1) values. The ethno-biologic information was used to calculate indices that evaluated different aspects of people's knowledge, and frequency of use of the species. These were log-transformed to achieve normality and homogeneity of variance; those that did not meet these conditions after the transformations were not used in the statistical analyses. One-way ANOVAs were used to identify gender-related differences.

The ethno-botanic and ethno-zoologic data were analyzed separately. For the ethno-botanic data, a multiple regression approach with backward selection of variables was used to evaluate the relationship between an informant's socio-economic status (independent variable) and the Use Value, Use Diversity, and Use Frequency, reported for all the plant species (dependent variables). The same analysis was carried out for the ethno-zoologic data, but the Use Frequency variable was not included, given the reluctance of informants to answer this question. Finally, a two-way ANOVA was used to search for relationships between socio-economic status of the informants, gender, and interest in restoring one's land with timber species or to manage native species of mammals. The index of Use Value (Table 66.1)

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was used to evaluate the plant species' potential to be used in restoration activities, and the animal species' potential to be used in projects of wildlife management.

RESULTS

Classification and conservation status of forest cover

The GIS and field classification gave complementary results that indicated the existence of three types of forest that had remained largely unaltered by human activity, plus disturbed forests that were lumped into a single category (Figures 66.1 and 66.2).

The 44 plots used in the vegetation analysis together covered an area of 16 040 m^2 and had 71 species of trees with DBH > 10 cm (Appendix 66.1). The plots were classified into three main vegetation types corresponding to: (i) (upper) montane cloud forest – locally known as *bosque de encinos*, (ii) upper montane *Clusia* forest – locally known as *guandera* forest, and (iii) High Andean forest (sub-alpine cloud forest) – with no local name registered. Figure 66.1 shows the distribution of the respective forest types whereas Table 66.2 lists their areal extent. The upper montane cloud forest tended to occur at somewhat lower altitudes (2900–3400 m.a.s.l.), while *Clusia* forest was typically found at slightly higher elevations (3220–3633 m.a.s.l.) although there was considerable altitudinal overlap between the two forest types (Figures 66.1 and 66.2). The High Andean forest was distributed along the upper boundaries of the forest belt (3540–3675 m.a.s.l.).

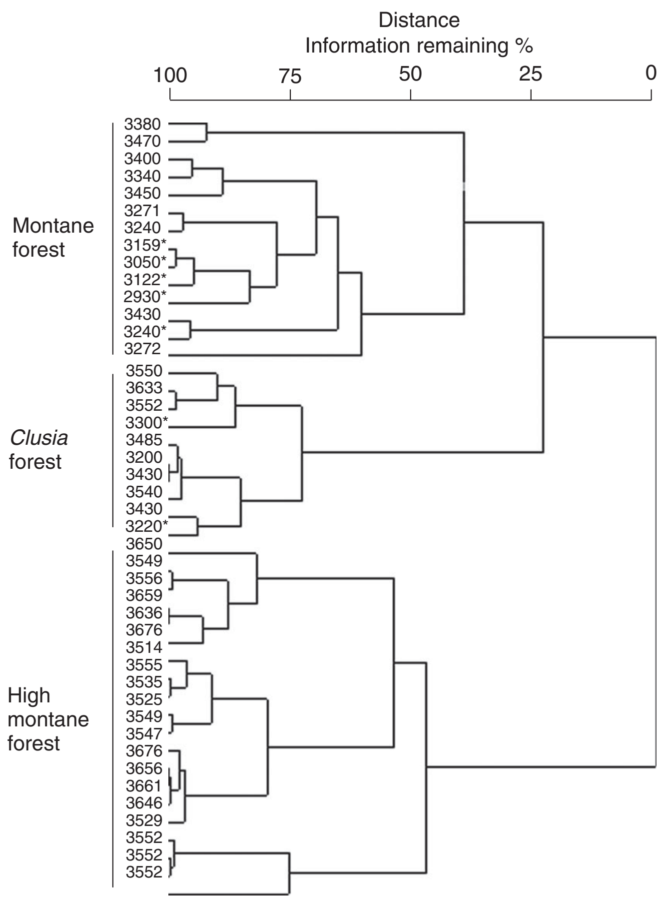

Figure 66.2. Classification analysis based on Euclidean Distance of 44 vegetation plots within the upper montane and sub-alpine forest zones in Northern Ecuador. * indicates plots established in the area of Jesús del Gran Poder.

UPPER MONTANE CLOUD FOREST

This forest (2900–3400 m.a.s.l.) is dominated by various species of the genus *Weinmannia* (Cunnoniaceae), locally known as *encinos*. Trees in the *Weinmannia* genus have straight boles that reach 20–25 m height. The understory is dense, and covered with shrubs and herbs. The lowest altitudes with this forest type (e.g. the plot at 2930 m.a.s.l.) included species not found at higher elevations (e.g. *Clethra crispa, Freziera, Hesperomeles, Miconia, Saurauia, Myrciantes rophaloides, Myrsine, Prunus, Symploccos quitensis, Oreopanax* spp., *Schefflera* spp.).

CLUSIA FOREST

This forest (3220–3630 m.a.s.l.) is characterized by the dominance of large *Clusia flaviflora* and *C. multiflora* (Clusiaceae) trees and is perhaps the most impressive and unique forest formation in the area, with trees reaching up to 25 m and crown areas of up to 70 m^2. In addition, abundant aerial roots extend from the large branches to the ground. The understory is open and largely dominated by the clonal rosette *Guzmania* spp. (Bromeliaceae) carpeting the soil surface and tree trunks.

HIGH MONTANE FOREST

This sub-alpine cloud forest (3540–3675 m.a.s.l.) forms the treeline and its border with the *páramo*. Its thick and twisted trunks are covered with mosses and reach a height of 6–10 m, becoming more stunted and elfin-forest-like in appearance at the highest elevations. The most common species are *Gaiadendron punctatum, Ilex* spp., and *Ocotea infrafoveolata*.

It was not possible to evaluate the conservation status of the upper montane and *Clusia* forests separately because they were not distinguishable from each other in the satellite image. Also, their altitude-overlapping distribution prohibited separate evaluation. Taken together, upper montane and *Clusia* forest made up 71.7% of the total forested area in the study area, whereas High Andean forest contributed 21.9%, and disturbed forest the remaining 6.3% (Table 66.2). Old-growth upper montane and *Clusia* forests occupied only 8.7% of their potential distribution (below 3450 m.a.s.l.) and most of their potential distribution is presently covered by agricultural lands and human settlements (89%); disturbed montane forest represented only a very small

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Table 66.2 *Extents of different types of forest in the study area*

Altitudinal range (m.a.s.l.)	Montane forest (km^2)	High montane forest (km^2)	Disturbed forest (km^2)	Agricultural land and towns (km^2)	Area total (km^2)
<3450	24.58 (8.7)	2.99 (1.0)	3.61 (1.3)	255.01 (89.1)	286.2
3450–3700	15.96 (62.7)	9.37 (98.5)	0 (0)	0.14 (0.6)	25.4
Total	40.5	12.4	3.6	255.2	311.7

Table 66.3 *Ethno-biologic knowledge of men and women of the High Andean forests in northern Ecuador. Differences between men's and women's knowledge were calculated using one-way ANOVA*[a]

	Men (mean (min, max)/standard deviation)	Women (mean (min, max) /standard deviation)	*p*
17 species of			
Number of informants/reports	53/898	35/589	
Index of socio-economic status	0.68 (0, 1)/0.220	0.58 (0.2, 93)/0.200	***
Use value (UV)	0.10 (0, 1)/0.229	0.05 (0, 1)/0.169	*
Index of diversity of use (DU)	0.11 (0, 1)/0.229	0.05 (0, 1)/0.169	ns
UV medicinal	0.05 (0, 1.4)/0.095	0.14 (0, 1)/0.234	*
UV edible	0.10 (0, 0.5)/0.154	0.10 (0, 0.5)/0.173	ns
UV timber	0.35 (0, 1)/0.249	0.19 (0, 1)/0.170	ns
UV firewood	0.37 (0, 1)/0.227	0.33 (0, 1)/0.307	ns
UV crafts	0.09 (0, 0.4)/0.118	0.15 (0, 1)/0.231	ns
UV ritual	0.001 (0, 0.02)/0.003	0.01 (0, 0.5)/0.085	nc
12 species of mammals			
Number of informants/reports	46/585	28/377	
Index of socio-economic status	0.57 (0.06, 1)/0.19	0.57 (0.2, 0.9)/0.2	***
Use value (UV)	0.19 (0, 2)/0.45	0.23 (0, 3)/0.5	*
Index of diversity of use (DU)	0.003(0, 1)/0.03	0.006 (0, 0.1)/0.005	ns
UV medicinal	0.09 (0, 1)/0.288	0.009 (0, 1)/0.28	ns
UV edible	0.07 (0, 1)/0.26	0.100 (0, 0.5)/0.31	*
UV pets	0.004 (0, 1)/0.06	0.006 (0, 1)/0.09	nc
UV decoration	0.001 (0, 1)/0.003	0.0 (0,0)/0.0	nc

[a]Statistical significance indicated as *, $p \leq 0.05$; ***, $p \leq 0.001$; ns, not significant; nc, not calculated due to lack of normal distribution or homogeneity of variance.

portion (1.2%). Conversely, the high montane forest still occupied most of its potential distribution (98.5%), with agricultural land and human settlements representing the remaining 1.5% (Table 66.2).

PEOPLE'S RELATIONS WITH BIODIVERSITY AND THEIR INTEREST IN FOREST RESTORATION

The informants provided socio-economic information that resulted in a total of 2854 records of use for 17 species of trees and 18 species of mammals. The data were used to calculate socio-economic and ethno-biologic indices (Table 66.3). Four species of mammals were not used in the statistical analyses, as no ethno-biologic information was recorded for them: puma (*Puma concolor*), pampas cat (*Lynchailurus pajeros*), pudu deer (*Pudu mephistophiles*), and southern river otter (*Lutra longicaulis*).

Examination of the variation in socio-economic standards and ethno-biologic knowledge between men and women indicated that men always had significantly higher socio-economic standards than women (Table 66.3). Also, men reported higher general ethno-botanic knowledge (in terms of use value, UV) than did women, but women had a higher knowledge of the medicinal uses of plants (UV medicinal). The analysis did not detect any differences in the diversity of use (DU), nor within other categories of use of plants. Use frequency (UF) was markedly higher for women although this could not be tested statistically because the data did not meet the statistical requirements.

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The ethno-zoologic data showed that women had a significantly higher knowledge of the use value, and uses for edible mammals (category UV edible) (ANOVA, $p < 0.05$, $n = 74$) indicating that women know more total uses per species, and more species used for food. The other aspects of ethno-biologic knowledge were not significantly different between genders or could not be tested because the data-set did not meet the statistical requirements. In addition, the UF of species was significantly higher for women than for men (Table 66.3).

In the ethno-botanic section, there was a significant relation between people's socio-economic status, and their UV, DU, and UF indices, but the explanatory power of the relationship was very low (multiple regression, $r^2 = 0.09$, $p < 0001$, $n = 81$). However, there was a strong positive relationship between socio-economic status and interest in reforestation and forest restoration, regardless of gender (two-way ANOVA, $p < 0.001$, $n = 88$). In total, 85% of the people interviewed had some interest in reforesting their land, but the inclination was more marked among people with better socio-economic conditions. People's motivations for restoring their land were related to species utility, and need of environmental goods and services such as water, soil conservation, wind protection, and landscape preservation. On the other hand, only 5% of the people that had no interest in restoration expressed a clear reason for their lack of interest, such as inaccessibility to land, slow growth of the species, or little time to dedicate to restoration activities.

In the ethno-zoologic section, there was no significant relation between people's socio-economic status and use value or use diversity (multiple regression, $r^2 = 0.06$, $p > 0.05$, $n = 74$). However, when investigating the relationships between socio-economic status, gender, and interest in managing species of mammals, a positive interaction term was found that linked the relationship between gender and interest in management of mammals (two-way ANOVA, $p < 0.001$, $n = 74$). This interest in managing wildlife species was restricted to 24 men with high socio-economic status (30% of the sample). An additional trend indicated that people reporting a higher use value tended to be interested in managing mammals (simple correlation 12%, $p < 0.001$, $n = 74$.)

Species with potential to restore forest cover and for wildlife management

Differences were found in the use values (UV) for species of plants and mammals (Table 66.4). Plant species with a high UV included: *Prunus huantensis, Weinmannia pinnata, W. cochensis, Freziera canescens, Myrica rophaloides*, and to a lesser degree *W. rollonii* and *Vallea stipularis*. The animal species that recorded high UV values were agouti (*Nasuella* sp.), armadillo (*Dasypus novemcinctus*), striped hog-nosed skunk (*Conepatus semistriatus*), Andean tapir (*Tapirus pinchaque*; cf. Cavelier *et al*., this volume), and white-eared Andean opossum (*Didelphis pernigra*). Most of the plant species recognized as useful were abundant in the upper montane forest. In general, no specific mammals were associated with a given forest type.

DISCUSSION

Restoration of forest cover

Restoration needs for the respective forest types vary greatly. Upper montane and *Clusia* forests in the study area are very poorly preserved because agricultural lands and human settlements already occupy 89% of the potential distribution for these forests. On the other hand, the High Andean montane forests enjoy relatively good conservation status (Table 66.2). Agricultural land in the distribution range of this forest type is still very limited (<1.5%), presumably due to the lack of roads entering these areas, and perhaps due to increased public awareness of the importance of protecting the adjacent *páramo* grasslands and High Andean montane forests from intentional fire (cf. Sarmiento, 2002; Buytaert *et al*., 2006). Thus, restoration efforts should focus on the upper montane and *Clusia* forests rather than on the high montane forest. Interestingly, the fact that the tree species with the highest UV values all occurred in the upper montane forest may facilitate the use of these species in restoration activities (*P. huantensis, W. pinnata, W. cochensis, F. canescens, M. rophaloides, W. rollonii*, and *V. stipularis*).

People's relations with biodiversity and their interest in forest restoration

The present results suggest that decisions made by men on land use and restoration will be critical in defining whether and how families are to be involved in forest restoration activities. Gender proved to be an important factor in defining socio-economic status and to some extent ethno-biologic knowledge, and as a result, decision-making on land use is likely to be influenced mostly by the men's perspectives. Men had more access to secondary education, managed the production and commercialization of crops and cattle produced on their farms, and usually had the family property registered under their names. Female roles were more restricted to the maintenance of homes, small gardens, domestic mammals, and cattle.

The fact that people's interest in forest restoration was positively related to ethno-biologic knowledge and socio-economic status indicates that more affluent groups of society could be involved in restoration activities more readily than disadvantaged groups. A positive relationship between people's socio-economic status and their ethno-botanic knowledge (in terms of use value, diversity of use, and use frequency) has also been found in other ethno-botanic studies (Byg and Balslev, 2001) and

Table 66.4 *Differences in the use values for species of plants and animals*

Plant species	Common name	Uses	Use value	UV medical	UV edible	UV wood	UV fuel	UV crafts	UV ritual
Cedrela montana	cedro	F W	0.281	0.000	0.025	0.514	0.088	0.373	0.000
Clethra crispa	palo de león cuguaca	F M W	0.100	0.125	0.208	0.125	0.458	0.0083	0.000
Freziera canescens	pisique guayusa	C E F M W	1.138	0.007	0.366	0.188	0.430	0.009	0.000
Freziera reticulata	palo de rosa, yalte	C F M R W	0.420	0.000	0.171	0.267	0.471	0.092	0.000
Gaiadendron punctatum	popa	C F W	0.115	0.350	0.025	0.150	0.150	0.025	0.000
Myrsine coriacea	yalte, hojarasca	C F	0.113	0.147	0.125	0.125	0.333	0.167	0.000
Myrcianthes rhopaloides	arrayán	C E F M R W	2.039	0.168	0.377	0.115	0.221	0.120	0.000
Nectandra laurel	pandala rojo	C, F, W	0.323	0.000	0.273	0.179	0.547	0.000	0.000
Ocotea heterochroma	yalte	W	0.392	0.063	0.120	0.341	0.400	0.077	0.000
Ocotea infrafoveolata	yalte negro	C M W	0.362	0.050	0.036	0.450	0.428	0.036	0.000
Prunus huantensis	aguacatillo, pandala, canelo	C E F M W	1.141	0.011	0.000	0.434	0.163	0.392	0.000
Ruagea hirsuta	cedrillo	F W	0.051	0.000	0.000	0.375	0.000	0.000	0.125
Valea stipularis	sacha rosa, rosa de monte	E, M, R, W	0.962	0.211	0.000	0.082	0.281	0.421	0.006
Weinmannia cochensis	encino rosado o colorado	F, C, M, W	0.619	0.118	0.000	0.313	0.468	0.102	0.000
Weinmannia fagaroides	encino blanco	C W	0.583	0.104	0.008	0.448	0.088	0.000	0.000
Weinmannia pinnata	encino	F C W	0.950	0.114	0.000	0.336	0.472	0.078	0.000
Weinmannia rollonii	encino común o amarillo	F C M W	0.380	0.167	0.000	0.264	0.569	0.000	0.000
Animal species	**Common name in Spanish (English)**	**Uses**	**Use value**	**UV medical**	**UV edible**	**UV tools**	**UV ritual**	**UV pets**	**UV decorative**
Coendou quichua	irizo (porcupine)	E M	0.380	0.675	0.300	0.000	0.000	0.025	0.000
Conepatus semistriatus	zorro (striped long-nosed skunk)	M	0.511	0.960	0.019	0.021	0.000	0.000	0.000
Cuniculus taczanowskii	sacha cuy (mountain paca)	E	0.090	0.000	0.333	0.000	0.000	0.000	0.000
Dasypus novemcinctus	armadillo cachicambo (armadillo)	E M C O	0.395	0.120	0.742	0.138	0.000	0.000	0.000
Didelphis pernigra	zariguella raposa (white-eared opossum)	E C M	0.752	0.802	0.135	0.063	0.000	0.000	0.000
Mazama rufina	venado soche (red brocket)	E C M O	0.230	0.042	0.596	0.042	0.000	0.071	0.000
Mustela frenata	chucuri (long-tailed weasel)	R	0.010	0.000	0.000	0.000	0.250	0.000	0.000
Nasuella sp.	cusumbe (coati)	E M P	0.326	0.378	0.567	0.056	0.000	0.000	0.000
Odocoileus peruvianus	venado de paramo (deer)	E O	0.227	0.000	0.381	0.119	0.000	0.000	0.000
Pseudalopex culpaeus	lobo de monte (colored fox)	R F	0.266	0.031	0.000	0.156	0.781	0.031	0.000
Sciurus granatensis	ardilla (squirrel)	E O	0.160	0.792	0.042	0.000	0.167	0.000	0.000
Sylvilagus brasiliensis	conejo (tapeti)	E	0.230	0.125	0.583	0.000	0.000	0.042	0.000
Tapirus pinchaque	tapir andino (Andean tapir)	E M O	0.483	0.172	0.772	0.015	0.000	0.000	0.042
Tremarctos ornatus	oso de anteojos (spectacled bear)	E C M O	0.284	0.483	0.258	0.167	0.050	0.000	0.000

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contradicts the general belief that poorer people are more dependent on natural products, and therefore know more about them. Rather, the observed trend can be understood in terms of individual attitudes toward exploiting the natural environment, which may result in marked entrepreneurial behavior and higher living standards. In addition, it is also possible that higher exploitation of agro-biodiversity improves the socio-economic standards of families in rural areas (Byg and Balslev, 2001). Higher diversity of agricultural and forest crops is certainly a valid strategy to stabilize the economy of the local families in this area because the market for potatoes, the main agricultural product, suffers from drastic fluctuations in price. This reasoning is supported further by the fact that people of higher socio-economic status showed higher UF of plants.

The influence of gender on ethno-botanic knowledge revealed different patterns in the use of biodiversity by the local population. Such patterns provide an opportunity to exploit a broader variety of resources of the forest. Although men and women had similar knowledge on the diversity of uses per species of plant (DU), women knew more about medicinal uses (UV medicinal), and tended to use them more frequently (UF). Nonetheless, men knew significantly more uses per species (UV). These results show that men and women depended equally on biodiversity, but that gender influenced the specialization of their knowledge about the use of plants (Phillips and Gentry, 1993). The women's greater knowledge and frequency of use of medicinal plants reflect their expertise with respect to meeting the day-to-day health care needs of family members. On the other hand, the men's higher UV may be related to the higher number of ecosystems they are exploiting (e.g. forests, pastures, *páramo*), and the broader spectrum of needs that they have to cover for their families, including wood exploitation for construction of houses, fences, and tools. As a consequence, restoration through the use of biodiversity by men and women could be achieved if men would focus on species that are more broadly distributed in the forest and have a broad variety of uses. Similarly, women may be more interested in species that are useful to their households.

Bias in the present data prevented a characterization of how ethno-zoologic knowledge varied with gender and socio-economic status, or with the opportunities to use wildlife resources to promote the restoration of the Andean forest. The fact that women had significantly higher knowledge (UV) and knew more species of mammals used for food (UV edible) implied that men did not hunt the mammals, or only participated in their consumption and use when prepared. This must be regarded as an anomaly in the data because men are traditionally charged with hunting and fishing activities whilst women cook the hunted animals, prepare medicines extracted from them, and help the men to prepare decorations or tools (e.g. dried skins, leather, dried claws to comb domestic mammals). This bias in the data was likely due to the male informants' reluctance to provide information related to their hunting activities to people involved in local conservation activities, as men and women never responded to questions related to frequency of hunting activities or observation of mammals.

Nonetheless, the present information still reveals general trends in the use of species, the diversity of uses they have, and their potential for production in local farms or to be considered in silvo-pastoral systems. It was found that the interest to use wild mammals was related to gender and socio-economic status. Wealthier men were more eager to try and breed certain species of native mammals on their land. In fact, a few persons in this group mentioned attempts to farm various species of native animals. The mammals with the highest UV (cuchucho, armadillo, striped hog-nosed skunk, Andean tapir, and white-eared opossum) could be farmed locally for the commercialization of meat and possibly contribute to a reduction of hunting pressure on the wild populations (Medellín *et al*., 2005). Some of these species share their genus with species used by native communities elsewhere in the Neotropics (Orejuela, 1992; Stearman, 1992; Medeiros Costa-Neto, 1999; Cavelier *et al*., this volume). This consistency in regional trends of use of these species may facilitate the development of management techniques, and of strategies for their conservation in the wild. Nonetheless, it is interesting to note that people were not interested in managing large mammals, such as deer or Andean tapir, which may yield relatively larger benefits, but also require a higher investment of time and energy for their management. On the other hand, people's interest to manage small mammals may be related to their need to fulfill their requirements in the short term.

Recommendations for participative restoration of forest cover

A locally designed and implemented restoration plan should contribute to the fulfillment of needs and interests of the men and women in the various socio-economic strata present in this society (Conway *et al*., 1998). During the course of this study local farmers expressed a favorable view toward forest restoration to improve water regulation, stream protection, soil recovery, and scenic beauty; and as a means to recover timber and non-timber forest resources. However, people were only interested in restoring areas that were not currently used for agricultural production, including riparian areas and fence lines. They often mentioned that converting their agricultural lands into forest was not feasible due to their need to continue with their potato crops and cattle ranching. Therefore, large-scale restoration of the area is unlikely to happen in the short term unless substantial economic benefits (e.g. tax deductions or payments for forest restoration) are provided to compensate the loss of the higher revenues from the agricultural land. Such a system has proved to be effective in a nearby county where a payment scheme for water regulation (ecosystem services) was introduced, and therefore the protection of montane cloud forests was secured (Yaguache and Carrion, 2004; cf. Muñoz-Piña *et al*., 2008; Calvo-Alvarado *et al*., this volume; Tognetti *et al*., this volume).

Clearly, the main cause of forest destruction in the study area is agricultural expansion, which is also the main impediment for the restoration of forest cover. Therefore, promoting the restoration of the original forest cover has to be connected with modifications of agricultural practices. These must help to reduce the need for more agricultural land, and improve opportunities to increase the amount of land available for the recovery of cloud forests (Pohle and Gerique, 2008; Grau *et al*., this volume; Hofstede *et al*., this volume). Because both men and women are familiar with and make use of local biodiversity, a viable strategy for forest restoration would be to increase the awareness of their dependence on forest products (plants and mammals) and to integrate useful species into their agricultural practices. It is thought that such a strategy would diversify people's crops, thereby reducing their dependence on the external market and rendering their livelihoods less vulnerable to economic fluctuation.

The inclination of the better-off part of society to become involved in restoration activities, and the fact that this stratum has more knowledge of the use of plant species (UV), provides important insights into understanding people's perceptions regarding which resources have positive probabilities of successful exploitation and management. It is suggested that an initial phase for the successful restoration of this area should encourage and guide the more affluent parts of society to restore their lands using species with high use value that will provide them with services they are familiar with. People in the lower strata of society are then likely to become gradually interested in restoring their lands and managing wildlife species once they witness concrete examples of the direct uses they can obtain from local biodiversity, particularly if support for such activities is made available through participatory research and learning systems. Presently, Farmers, Field Schools (FFS) and Local Agricultural Research Committees (CIALs) are being established in the study area to promote learning processes that enhance the use of local biodiversity in livelihoods through participatory research and experimentation (Hofstede *et al*., this volume). These local learning centers attract young people of many different socio-economic backgrounds and give them the opportunity to learn alternative ways of agricultural production, including species that could be used in agro-forestry or silvo-pastoral systems. It is expected that these activities may change poorer peoples' perceptions and benefits of forest biodiversity and forest restoration.

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Appendix 66.1

Species	Altitudinal location of the plots (meters above sea level)																																									
	2930	3050	3122	3159	3200	3220	3240	3240	3271	3272	3300	3340	3380	3400	3430	3430	3430	3450	3470	3485	3514	3525	3529	3535	3540	3547	3549	3549	3550	3552	3552	3552	3552	3555	3556	3633	3636	3646	3650	3656	3659	3661	3676
Aequatorium asterotrichum B. Nord.										x		x						x																									
Aristeguietia budleaefolia (Benth) R.M. King & Rob.												x																															
Aequatorium campii B. Nord.												x																															
Ardisia colombiana Lundell.												x																															
Blechnum aureatum						x														x																x			x				
Brunellia pauciflora Cuatrec. & C.I. Orozco					x							x					x																										
Blechnum schomburgkii (Klotzch) C. Chr.																	x																										
Brunellia tomentosa Bompl.				x	x																																						
Clethra crispa C. Gust.	x				x	x											x								x																		
Clusia flaviflora Engl.					x	x					x	x		x	x		x		x	x	x	x	x	x	x	x	x	x	x	x				x	x	x		x			x	x	
Clethra ovaliforia (R. & P.) Dom.					x												x								x	x																	
Cyathea caracasana (Klotzch) Dom.		x	x	x	x		x	x	x	x		x	x																x														
Dicksonia sellowiana Hook.					x																																						
Disterigma alaternoides (Kunth) Nied.					x																																						
Diplostephium floribundum (Benth) Wedd.					x																																						

Escallonia myrtilloides L.f.					x																																	x						
Escallonia paniculata (Ruiz & Pav.) Roem. & Schult.																	x																											
Freziera canescens Bonpl.	x																																											
Freziera microphylla Sandwith								x																																				
Gaiadendron punctatum (R. & P.) G. Don.		x	x	x					x												x	x	x	x			x			x	x	x	x	x			x	x		x	x	x	x	x
Geissanthus spp.	x	x	x	x																																								
Grosvenoria rimbachii (B.L. Rob.) R.M. King. & H. Rob.												x																																
Hedyosmum cuatrecasanum	x	x		x								x																																
Hedyosmum cumbalense Swartz					x												x					x		x	x	x	x	x																
Hedyosmum translucidum														x				x																										
Hesperomeles ferruginea (Pers.) Benth.																		x																										
Ilex colombiana Cuatrec.						x															x	x	x		x	x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	X
Indet. 1															x																													
Indet. 2	x																																											
Indet. 3										x																																		
Lauraceae sp. 1													x																															
Lauraceae sp. 2			x	x									x																															
Lauraceae sp. 3													x																															
Macleania rupestris (Kunth) AC. Sm.					x												x																											
Melastomataceae sp. 1													x																															
Melastomataceae sp. 2		x	x																																									

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Appendix 66.1 (*cont.*)

Species	Altitudinal location of the plots (meters above sea level)																																									
	2930	3050	3122	3159	3200	3220	3240	3240	3271	3272	3300	3340	3380	3400	3430	3430	3430	3450	3470	3485	3514	3525	3529	3535	3540	3547	3549	3549	3550	3552	3552	3552	3552	3555	3556	3633	3636	3646	3650	3656	3659	3661	3676
Miconia bracteolata (Bompl.) DC.					x				x	x	x	x		x	x	x		x																									
Miconia chlorocarpa Cogn.															x			x																									
Miconia coriacea (Sw.) DC.							x		x																																		
Miconia nodosa Cogn.																		x																									
Miconia ochracea Triana					x							x																															
Miconia ochreotoma Naudin					x							x					x								x																		
Miconia theazans (Bompl.) Cogn.	x		x	x				x				x	x																														
Miconia tinifolia Naudin					x							x					x				x	x	x	x	x	x	x	x		x		x	x	x	x			x		x	x	x	x
Myrica pubescens Humb. & Bonpl. ex Willd.		x																																									
Myrsine andina (Mez.) Pipoly															x																												
Myrsine coriacea (Sw.) R. Br. ex Roem. & Schult.		x																																									
Myrsine dependens (R. & P.) Spreng.		x		x		x		x										x																									
Ocotea infrafoveolata Van der Welf.					x							x		x			x								x																		
Ocotea cf. *serisea*		x																																									
Oreopanax spp.			x		x							x	x		x	x	x					x			x						x											x	x
Palicourea amethystina (R. & P.) DC.					x							x																															
					x																																						

Pentacalia campii (Cuatrec.) Cuatrec.																																												
Pernettia prostrata spp.																									x																			
Piper barbatum Kunth												x																																
Prunus huantensis Pilg.		x	x	x								x		x																														
Prunus rugosa Koehne.					x																																							
Saurauia bullosa Wawra					x				x																																			
Shefflera spp.			x	x	x		x		x	x							x																											
Solanum asperolanatum R. & P.					x																																							
Solanum hypalaurotricum Bitter												x																																
Symplocos quitensis Brand				x	x							x		x		x		x																										
Turnefortia fuliginosa Kunt												x																																
Turnefortia cf. *scabrida*															x																													
Weinmannia brachystachia L.																					x	x	x	x		x	x	x		x	x	x	x	x	x		x	x		x	x	x	x	X
Weinmannia cochensis Hieron					x												x			x					x														x					
Weinmannia glabra L.f.	x					x	x	x	x				x		x			x	x																									
Weinmannia pinnata L.					x							x					x			x					x				x							x			x					
Weinmannia rollotti Killip.		x	x	x			x	x	x	x		x		x		x	x	x																										

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