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Social Perceptions of Biodiversity and Ecosystem Services in the Ecuadorian Amazon

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Abstract The Amazon basin is widely recognized for its high biological and cultural diversity, enabling the provision of many ecosystem services. This study explores social perceptions of some of the features of biodiversity and ecosystem services in a tropical forest in Sangay Parish, Ecuador. Following a survey of residents, we identified three groups whose perceptions vary in relation to socioeconomic characteristics, cultural backgrounds, lifestyles, and the benefits obtained from the Sangay forest. Mestizo professionals, with a better socioeconomic situation, identify more regulation and cultural services; Shuar farmers have a comprehensive knowledge of biodiversity features and rely on provisioning services; and Shuar gatherers consume more forest products but are the least likely to formally recognize ecosystem services. We emphasize the importance of identifying social groups within a population and understanding their particular characteristics and perspectives before developing conservation and land use planning policies.

Keywords Ecosystem services · Conservation policy · Decision-making · Stakeholders · Social-ecological systems · Amazon · Ecuador

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Introduction

The benefits obtained directly or indirectly from ecosystem functions are described as ecosystem services (ES) (de Groot *et al.* 2002) that societies can manage according to their needs and choices (Aretano *et al.* 2013). Resource management concerned largely with human well-being have resulted in drastic transformations of the planet's ecosystems over the last 50 years, more than in any other period of history (MEA 2005). An ES research and management framework can provide essential information about the relationship between biodiversity and human well-being, in order to design and implement holistic conservation strategies (Vihervaara *et al.* 2010).

One of the main contributions of ES research is its multidisciplinary approach to decision-making processes (Daily *et al*. 2009) that integrates ecological, economic, and socio-cultural perspectives (Burkhard *et al.* 2010). Ideally, decision-making is aimed at ensuring biodiversity conservation, sustained provision of ES, and human development (Vihervaara *et al.* 2010; Balvanera *et al.* 2012). ES assessment has focused mainly on biophysical (e.g., Ghillardi *et al.* 2007; Guariguata and Balvanera 2009) and economic indicators (e.g., Asquith *et al.* 2008; Quintero *et al.* 2009; Estrada-Carmona and DeClerck 2011), while socio-cultural indicators have been less frequently incorporated (Vihervaara *et al.* 2010; Martín-López *et al*. 2012; Scholte *et al*. 2015). However, there is a growing interest in incorporating socio-cultural elements into the ES framework via policy and environmental management strategies. To consider socio-cultural dimensions is crucial, because the way a society modifies an ecosystem is a function of perceptions, interest, and values associated with it.

The socio-cultural value of an ES is defined as the importance that people assign to it at an individual or group level (Scholte *et al.* 2015). Several studies have shown how socio-cultural factors can influence the perception of ES (Martín-López *et al*. 2012; Casado-Arzuaga *et al.* 2013), and because not all beneficiaries obtain the same ES from the same ecosystems (Felipe-Lucia *et al.* 2015), social perception studies can elucidate the relationships between populations and the ecosystems they inhabit (Castillo *et al.* 2005). The study of social perceptions at local levels is crucial because decisions that local people make or accept regarding natural resources are related to ensuring continued access to ES they value (Díaz *et al.* 2011). They also help to reveal synergies and trade-offs people make among ES (Martín-López *et al*. 2012). In particular, *a priori* identification of user groups allows managers to predict how their impact on ES is influenced by changing economic, cultural, and social conditions (Byron and Arnold 1999).

Amazonian tropical forests are known for their exceptional wealth of biodiversity (Mittermeier *et al.* 2003) and wide range of ecosystem goods and services at local and larger scales (Foley *et al.* 2007). Their ability to provide ES is influenced not only by the structure and characteristics of their landscapes, but also by historical land uses (Ferraz *et al.* 2014). Generally, tropical forests are inhabited by indigenous people who depend directly on forest resources for their subsistence and market-oriented activities (Gray *et al.* 2008). Ecuador is a megadiverse country (Mittermeier *et al.* 2004), in which indigenous territories overlap with areas of high biodiversity where both ecological and cultural diversity are threatened, as in other tropical areas (Toledo 2001). In the Ecuadorian Amazon region one of the main threats is tropical deforestation for agricultural expansion (Gibbs *et al.* 2010) causing a substantial loss of biodiversity (Bilsborrow *et al.* 2004), often with an increase in provisioning ES but with considerable declines in other ES (Gordon *et al.* 2010). Increased soil erosion and ultimately a decline in agricultural productivity have affected the livelihoods of many people previously dependent on cleared areas of the Amazonian forest (Chomitz and Kumari 1998). Using an example from the Ecuadorian Amazon, we aim to describe social perceptions of biodiversity features (local flora and fauna; Cárcamo *et al.* 2014) and ES in order to facilitate the design and implementation of effective conservation strategies.

We report on socio-cultural aspects of the indigenous (*Shuar*) and *mestizo* populations of Sangay Parish in Morona Santiago province of Ecuador. We interviewed residents (i) to identify ES users groups within the Sangay Parish population, (ii) to describe their range of perceptions about ES and biodiversity features of their forest, and (iii) to define the socioeconomic factors that contribute to perceptions. Using recent literature on payment models for ES (e.g., Bennett and Balvanera 2007), combined with older literature on valuation of ES (e.g., de Groot *et al.* 2002), we hypothesized (i) that user groups perceive ES and biodiversity features according to their socioeconomic characteristics and the benefits they obtain from ecosystems; and (ii) that different perceptions about ES and biodiversity features are influenced by different interpretations of the common environmental history experienced by forest users (Castillo *et al.* 2005).

Study Area

The research was carried out in Sangay Parish (78°0′-77°55′W, 1°43′-1°48′S) in Palora municipality of the northern part of Morona Santiago province in the Ecuadorian Amazon. Palora is divided into four parishes, the smallest administrative unit in Ecuador (Fig. 1). Sangay Parish has an area of 201 km^2, and in 2010 a population of 1172, including five ethnic groups, predominantly Shuar indigenous people (65%) and mestizos (32%; INEC 2011). Administratively, Sangay is shaped by a parish centre (*cabecera parroquial*) and its surrounding communities. The parish centre serves as the administrative centre where the local government is established. Unlike the surrounding

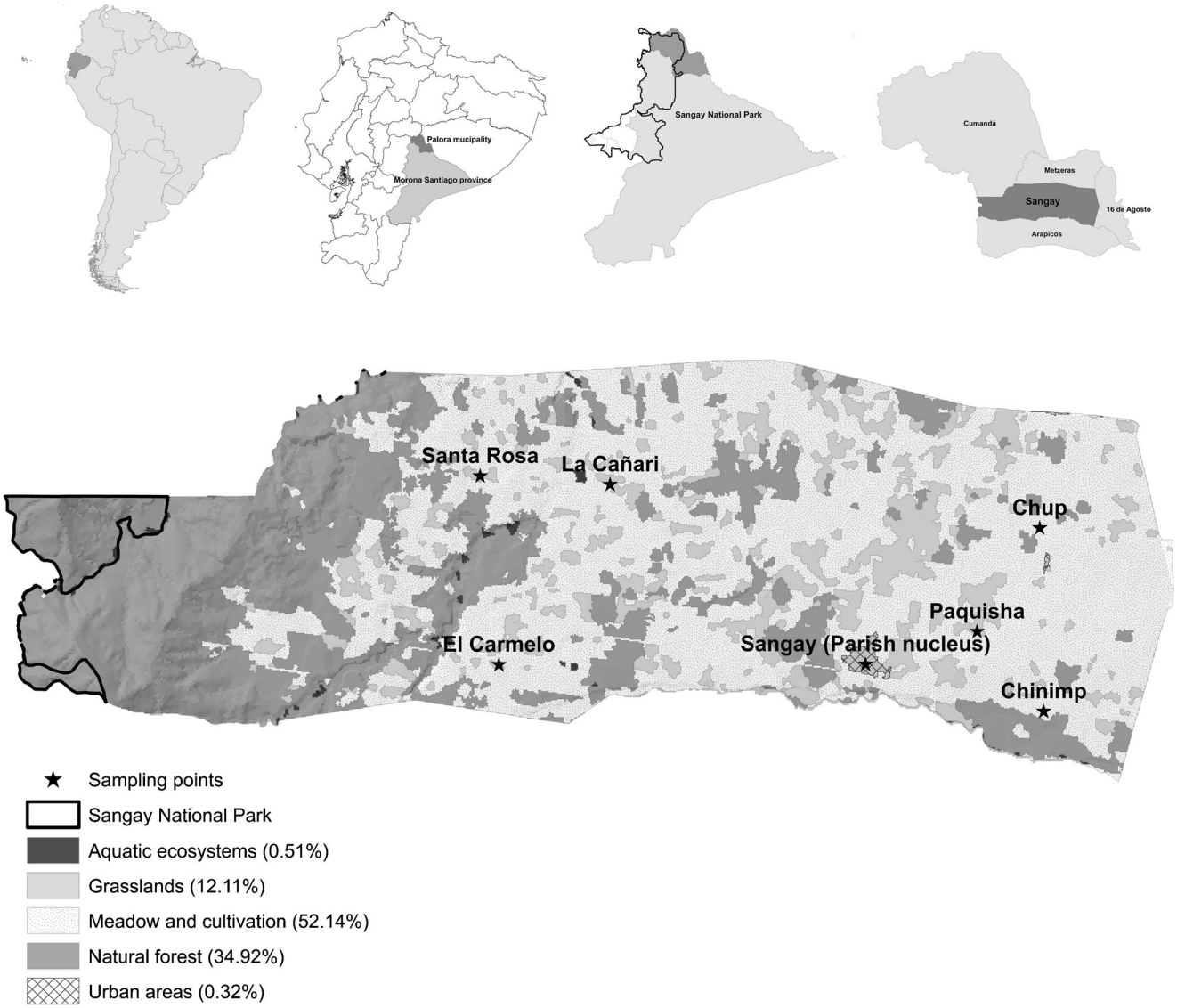

Fig. 1 Location of the study area, land uses and sampling points. **Source**: Vegetation cover map of Ecuador (2008). Ministry of Environment of Ecuador (MAE). UTM WGS 84, 17S

communities, the parish centre has potable water, sewage, wastewater treatment, and a secondary school. Only the parish centre and a few other communities have garbage collection, so residents of most communities must treat their own waste.

Sangay Parish has a tropical humid climate with an annual average temperature around 22 °C, relative humidity of 85%, and rainfall of 3000–4000 mm (INAMHI 2014). Land use includes pasture and cultivated areas (52%), natural forest (35%), grasslands (12%), and a small proportion in urban areas (0.3%; Fig. 1). According to the classification system of ecosystems of continental Ecuador (MAE 2013a), there are two types of evergreen forests: foothill and lower montane. The main agricultural crops are pitaya (*Hylocereus* sp.) (54% of total production), sugar cane (*Saccharum officinarum* L.) (42%), and cocoa (*Theobroma cacao* L.) (4%) (MAGAP 2010). Currently, the main economic activities of the parish are agriculture and livestock ranching (70% of the population) (INEC 2011). A small extension (6.36 km^2) of the Sangay National Park (SNP) is within the parish limits, equivalent to 3.16% of the total parish area. The SNP is one of the most important protected natural areas in Ecuador owing to its richness and diversity of ecosystems and species; in 1983 it was declared a World Heritage Site. Because of the large extent of the SNP and the lack of law enforcement, some locals have settled in some areas of the park to extract its resources for their livelihoods.

Environmental History: Land Use Changes

We reconstructed the environmental history of the study area based on the testimony of elderly inhabitants of Palora as well as published sources. The forest remained relatively intact

until 1950, when oil exploration began in the region. The Shuar were among the first inhabitants of the Ecuadorian Amazon, and probably came from the east, crossing the Andean cordillera (Uquillas 1984). Around 1956, there were few Shuar established in the territory corresponding to Palora (Harner 1994), but in 1967, an oil discovery prompted an intense colonization period of mestizos, mainly from the Andes, and the opening of roads that allowed exploitation of a variety of Amazonian forest resources (UNAE 1985). Agrarian Reform policies implemented in 1964 and 1973 considered the Amazonian forest "barren," and promoted deforestation as a form of land tenure or alternative economic development to reduce poverty. However, local Amazonian people take the view that colonization led to the extraction of natural resources as an economic benefit for private enterprise rather than as a poverty alleviation strategy (UNAE 1985).

Agricultural colonization of the Amazon caused high rates of deforestation and biodiversity loss (Bilsborrow *et al.* 2004). To claim possession of land colonists cleared the forest and registered new pastures in accordance with the laws of land tenure (Hicks *et al*. 1990). With the invasion of their lands, the Shuar were relocated into organized in communities in the forest ("*centros*"; Gray *et al.* 2008). Most were forced to become livestock ranchers to ensure their claim of ownership of their ancestral lands (Rudel *et al.* 2002). In 1964, the Sangay Tea Estate was founded in Palora, and 5000 ha of forest was converted to create tea (*Camellia sinensis* (L.) Kuntze) plantations. New colonists were attracted and settlements were consolidated. Because the Amazon soils are extremely fragile and very susceptible to erosion (Hicks *et al.* 1990), by 1970 a significant decrease in soil productivity and erosion was observed. However, agricultural production was intensified with increased use of chemical inputs used mainly by mestizos (Rudel *et al.* 2002). By 1980, most mestizos had individual titles to their properties, while Shuar possessed global titles held by their communities.

During 1980–2000, the Arboriente Logging Company eliminated large tracts of forest through unsustainable forms of extraction. Subsequently, local people continued logging at smaller scales. By 1990, the 52% of the parish territory had been converted to agricultural uses, and between 1990 and 2008, an additional 15% of Sangay Parish territory was deforested (MAE 2013b). Logging activity then decreased, because some overexploited species had become extirpated from the area, and also because government now regulated logging through the "Forestry and Natural Areas and Wildlife Conservation Law" (*Ley Forestal y de Conservación de Areas Naturales y Vida Silvestre*). Today, 64% of parish territory supports agriculture.

Survey Methodology and Data Sampling

Seven sample points were selected to conduct questionnaires; these included the parish centre, referred to as Sangay, and six other communities: Chinimp, Paquisha, Santa Rosa, El Carmelo, La Cañari, and Chup (Fig. 1). They were selected to capture a range of community size and ethnicity. Sangay, El Carmelo, and La Cañari have a majority of mestizos, while Chinimp, Paquisha, Santa Rosa, and Chup are Shuar.

We used a random survey based on similar work on social perception of biodiversity features and ecosystem services in Latin America (e.g., Higuera *et al.* 2013; Cárcamo *et al.* 2014). We asked local people about their perception of flora and fauna and ES and their contribution to human welfare. A face-to-face questionnaire was conducted with parishioners and municipal decision-makers, farmers, homemakers, educators, and local people in general. In each case, the household head was interviewed, if she/he was not present in the household, the person in charge of the home at that time was interviewed if she/he was 18 years old. In each interview, we first explained our research objectives and defined ES as the benefits that people obtain from ecosystems. Data were collected from a written questionnaire between February and June 2012, following a pre-survey completed in January of the same year that was used to verify that questions were clear and easy to understand. Although we received 160 responses to our questionnaires, we used only 142 in our analysis, eliminating data from respondents who had not fully answered all questions. The sample size is comparable to other surveys of social perception of ES (e.g., Castillo *et al.* 2005).

Questionnaire

Twelve of the questions were closed-ended, in which respondents chose among listed answers; seven open questions required respondents to complete answers according to their knowledge, and six questions were included with options to choose answers and to add further information. The resulting 25 items were then grouped into four sections (Table S1):

1. S*ocial and demographic characteristics:* age, monthly household cash income (in USD, the local currency), number of family members, education level, gender, occupation, ethnicity, and place of residence.
2. *Knowledge about the natural environment and the study area:* knowledge about populations of flora and fauna that have been extirpated or whose populations have declined in the study area, local environmental problems, and the location and importance of the SNP. Respondents were also asked about the local medicinal plants they used drawn from a list of 39 common species compiled with the prior help of two local healers. Medicinal plants play a crucial role in human well-being, especially in developing countries, where around 80% of population use them as their primary source of health care (WHO 2013). Among the plant species used by Shuar, medicinal plants are the

most diverse, with 211 species (Bennett *et al.* 2002). Indeed, medicinal plants were widely cultivated in home gardens in Sangay Parish by both Shuar and mestizos (Caballero-Serrano *et al.* 2016).

3. *Environmental behaviour and use of natural resources:* extractive activities (hunting, fishing, logging, and collecting fruit and fibres from palms), household waste management, and animals used for food.
4. *Perceptions about ecosystem services and biodiversity features:* causes of ES degradation, local flora and fauna, particularly ES that people obtain locally. ES identified at least once by a respondent during the pre-survey were listed in the definitive survey. ES mentioned by respondents were subsequently classified according to the Millennium Ecosystem Assessment (MEA 2005) into three categories: provisioning (food, water, raw materials, wood, hunting, fishing, medicinal plants, palms, and fruits from the forest), regulatory (climate regulation, water regulation, soil fertility, and air purification), and cultural services (ecological knowledge of medicinal plants, ecotourism, and recreational activities). Supporting services were never recognized by respondents; therefore this category was not included in our analysis. In the survey, ES were discussed as benefits provided by local ecosystems. Hunting and fishing were considered activities in the survey, but in the analysis they were also considered as provisioning ES. Some ES can simultaneously provide material and non-material benefits, presenting a challenge in analysis (Satz *et al*. 2013). In this case, we considered such services only as provisioning, counting the activities as providing mostly short-term benefits from consumption, in order to avoid double-counting (Fu *et al.* 2011).

Data Analysis

Data were analysed using two statistical programmes: XlStat (Version 2015) for Hierarchical Ascendant Correspondence Analysis (HAC) and analysis of variance (ANOVA), and the R Statistical Package (Version 3.2.3; R Core Team 2015) for Kruskal-Wallis tests, Chi-square tests and the Correspondence Analysis.

First, to classify respondents into relatively homogeneous user groups, we standardized the socioeconomic variables (age, education level, monthly household income, and number of family members) and then used HAC with the Euclidean distance and Ward's method to calculate a dissimilarity coefficient (García-Llorente *et al.* 2008). Other socioeconomic variables (occupation, ethnicity, gender, place of residence, ability to identify environmental problems, ability to identify depleted and diminished populations of flora and fauna, most commonly practiced extractive activities, and types of waste management) were allowed to intervene in characterizing user groups (Table S2). To characterize user groups further, we applied ANOVA for continuous variables, Kruskal-Wallis tests for discrete variables and Chi-square tests for nominal, ordinal, and dichotomous socioeconomic variables.

We also used the Chi-square test to match user groups with particular services to identify the probability that group members recognized ES, and to compare the values assigned by group members to biodiversity features and to two critical services: ecological knowledge of medicinal plants and food provisioning by agricultural activity. This valuation consisted of responses to questions on these themes on a scale of 1 to 5, where 1 = low importance and 5 = maximum importance. We applied Correspondence Analysis to relate the user groups to biodiversity features, ES, and socioeconomic characteristics (e.g., gender, education level, occupation, and monthly household income).

Results

Respondents to the survey were all adults (>18 years) whose average age was 40 years; 77% were male and 23% female, an imbalance resulting from the fact that men are more involved than women in some community activities. The most common occupations of respondents were in agriculture (72%); other occupations were homemaker (10%), public employee (6%), student (5%), professor (4%), merchant (1%), mechanic (1%), and carpenter (1%). The maximum level of education ranged from primary (56%) to secondary (32%) and university level (12%). Average monthly household cash income was $50 for 13% of respondents, $100–200 for 58%, $200–300 for 18%, and >$300 for 11%. The average number of family members was five. Fifty-six of the respondents (39%) identified as mestizo and 86 (61%) as belonging to the Shuar ethnic group.

General Perceptions about Biodiversity Features and Ecosystem Services

For 81% of respondents, ecosystems provide many services, and 96% stated that ES contributed to their well-being. Flora and fauna were considered the most important benefits (87%). Regarding animal and plant populations that have been extirpated or have declined in their sectors, respondents mentioned several large mammals, birds, and other wild animals used for food, as well as several commercial tree species (Table S3); on average, respondents mentioned three species that have declined (range 0–14) and two species that have been extirpated from the study area (range 0–11).

Most of the ES identified were in the provisioning category (65%), followed by regulation (20%) and cultural services (15%). Water provision was an ES recognized by 85% of

respondents, wood (78%), fruits from the forest (78%), medicinal plants (76%), and knowledge of medicinal plants (70%); other services frequently identified were ecotourism and recreational activities (66%), soil fertility (64%), and food provision (62%). Air purification was the service least often identified by respondents (7%).

Ninety-two percent of respondents agreed that ES have deteriorated significantly in recent years. Deforestation was also considered among the major environmental problems (74%), along with water pollution (82%), and biodiversity loss (71%). Eighty percent of respondents knew that a portion of the SNP is within the parish boundaries; for 99% of respondents, the conservation of this protected area is important.

The ES most valued by the population was food provision by agriculture systems (4.09 on the five-point scale), followed by biodiversity features (4.04); the least valued was the cultural service of traditional knowledge of medicinal plants (3.24). At the same time, respondents identified on average 21 medicinal plants (range 0–39).

Identification of User Groups, their Environmental Knowledge and use of Resources

Three user groups were identified by cluster analysis: 38% (54 respondents) belong to a first group, 41% (58) to a second, and 21% (30) to a third. The dissimilarity coefficient among the groups was 61%. Based on their most relevant characteristics an identifying name was assigned to each group:

Group 1: Mestizo professionals (38%). This group mainly comprises mestizos from the localities of El Carmelo, Sangay, and La Cañari. Members have an average age of 34 years, a high education level (secondary and university) and a relatively high monthly household income ($200–300 and >$300). Most women we interviewed fall into this group (18 respondents). One third are farmers; however, the remaining group members hold more diverse occupations than in other groups, including professors, carpenters, mechanics, and public employees. A higher number of respondents (43%) know that the SNP is inside the parish boundaries, and members of this group perceive more environmental problems than members of the other groups (median = 4.5). Burning garbage is practiced less than average by members of this group (Table S2).

Group 2: *Shuar farmers* (41%). Members of this group are of Shuar ethnicity, mainly from the localities of Paquisha, Chinimp, and Santa Rosa (Table S2). They are largely men (46% of respondents), and older (median = 48 years) than the other groups. Education is mostly limited to primary. The declared occupation of most members is farmer or homemaker. Members recognize more medicinal plants (median = 24 plants) and diminished populations of flora and fauna (median = 1.50) than the other groups; they also practice more logging than expected based on their representation in the parish population.

Group 3: Shuar gatherers (21%). This group mainly comprised Shuar from the localities of Chup and Chinimp. They are younger (median = 24 years) than other groups, with primary or secondary education and an average monthly income lower than in other groups. Their main occupations include farmer, merchant, student, and homemaker. Fewer members know that the SNP is inside the parish boundaries (20%). They practice hunting (54%), fishing (49%), and collecting fruits (42%) in higher proportions than in the other groups. They identify more animals used for food than members of the other groups, but fewer medicinal plants (median = 13 plants). A higher percentage of them burn garbage than the other groups (38%; Table S2).

Perceptions of Biodiversity Features and Ecosystem Services Among User Groups

An association between biodiversity features (flora and fauna) and personal well-being was recognized to different degrees among user groups (χ^2 = 26.0, df = 2, $p < 0.001$). Shuar farmers made this association more often (Fig. 2), and more than other groups identified the flora and fauna that have declined in the last few years (Table S2).

The valuation of biodiversity features was also different among user groups (χ^2 = 21.2, df = 10, p = 0.02): Shuar farmers provided scores of 5 in a higher proportion (44%) than members of other groups (Table S2). Mestizo professionals and Shuar farmers recognized many ES (42 and 43%, respectively), while a higher percentage of Shuar gatherers recognized few ES (50%). The perspective on the number of ES provided by ecosystems differed too: mestizo professionals identified more services overall (Kruskal-Wallis, median = 10, p = 0.002). Shuar farmers identified more provisioning services, while mestizo professionals recognized a relatively larger number of regulatory and cultural services (Table S2; Fig. 2). However, a lower proportion (15%) of Shuar gatherers associated biodiversity features with well-being, and generally identified a lower proportion of ES than the other groups. The ES most frequently identified by mestizo professionals were air purification, climate regulation, and soil fertility, while Shuar farmers identified provisioning of palms, medicinal plants, wood, fruits from the forest, water, and food. Shuar gatherers most frequently identified hunting and fishing (Table 1). On the other hand, the assessment of the value of the food supply (average of 4.09) and local ecological

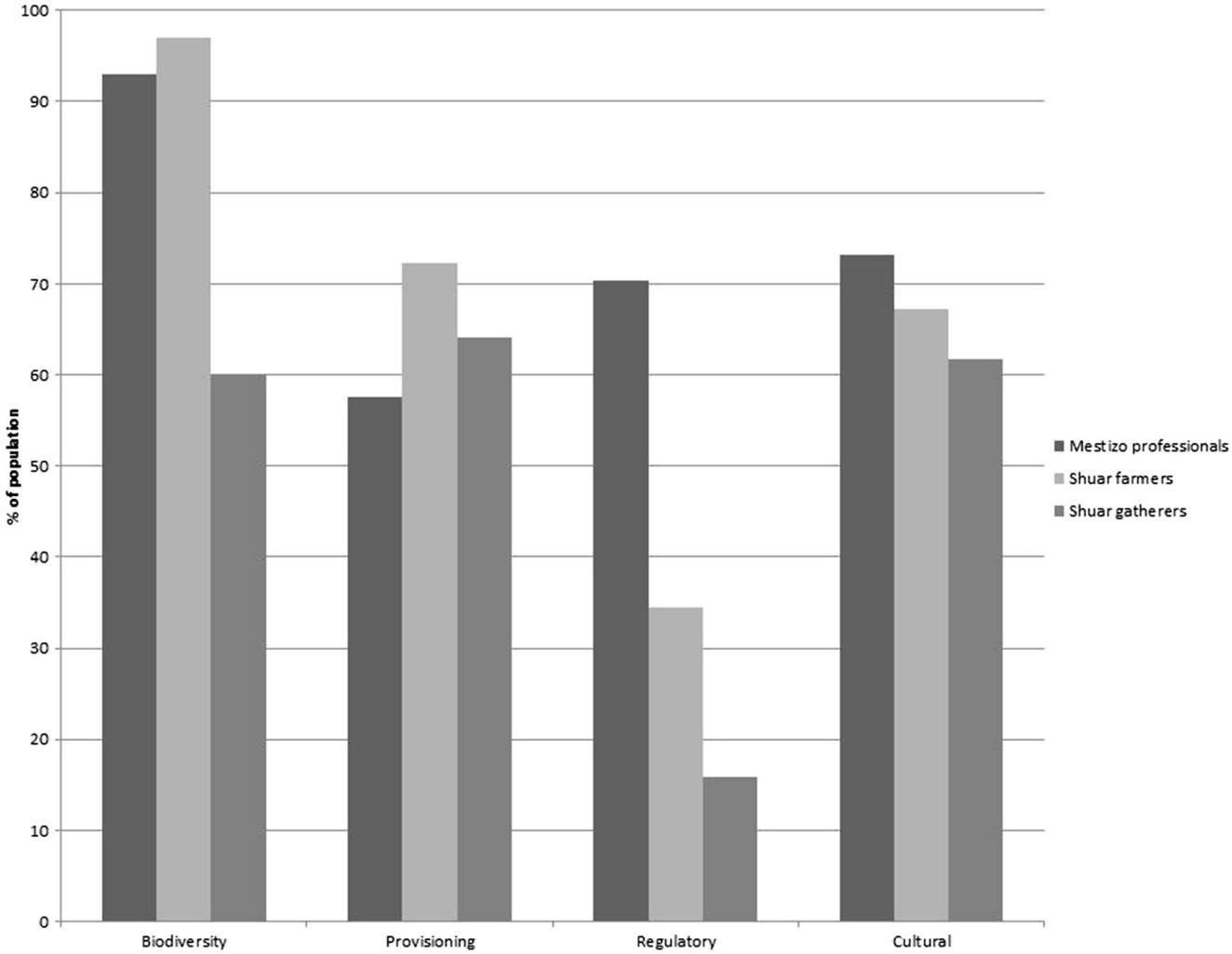

Fig. 2 Biodiversity features and ecosystem services identification by user groups

knowledge of medicinal plants (3.25) were similar among the three groups (Table S2).

The extent of a perception of deterioration of ES over the last few years varied among user groups (χ^2 = 6.03, df = 2, p = 0.05). Mestizo professionals (40%) and Shuar farmers (40%) more frequently sensed ES degradation than Shuar gatherers (20%). In an open question, pollution, deforestation, inadequate management, global warming, and human pressure were all identified as reasons for ES degradation. Mestizo professionals identified a higher number of such causes (χ^2 = 33.3, df = 6, p < 0.001), but all groups agreed on the need for recovery of degraded services (Table S2).

The first two axes of the Correspondence Analysis explained 24% of total variance (axis 1, 14%; axis 2, 10%) in the relationship among biodiversity features, ES, and socioeconomic characteristics. The first axis was positively correlated with responses typical of mestizo professionals, strongly associated with the identification of biodiversity features and ES, especially regulation services (air purification, soil fertility, water regulation, and climate regulation); respondents associated with this first axis had \$200–300 and >\$300 monthly incomes and secondary or university education (Fig. 3). This axis was also correlated with the identification of ES including food, raw materials, knowledge of medicinal plants, ecotourism, and recreational activities; it was more associated with female respondents and with occupations such as professor, public employee, carpenter, and homemaker. The axis was not associated with any practice of hunting and fishing. The second axis was correlated with responses characteristic of Shuar farmers and with the highest level of association between biodiversity features and personal well-being. It was also associated with provisioning services, such as water, palms, fruits from the forest, wood, and medicinal plants; respondents associated with this second axis were more likely male, with a primary level of education and monthly income of \$100–200. This axis was also associated with farmers, but not with hunting and fishing. The Shuar gatherers group was not associated either with biodiversity features as a factor of well-being or with ES in

Table 1 Percentage by user group of respondents identifying ecosystem services. Differences from expected values from the number of survey respondents by user group are based on Chi-squared tests

Ecosystem services	GROUPS			χ^2
	Mestizo professionals	Shuar farmers	Shuar gatherers	
Provisioning services				
Food provision	42	45	13	20.68***
Water provision	37	47	16	14.10***
Raw material	46	36	18	6.18*
Fishing	24	32	44	32.42***
Wood	32	49	19	12.94***
Hunting	10	31	59	48.70***
Medicinal plants	30	52	19	23.20***
Palms	32	53	15	14.04***
Fruits from the forest	35	49	16	14.50***
Regulatory services				
Soil fertility	59	31	10	51.70***
Water regulation	55	39	6	26.87***
Air purification	80	20	0	8.40**
Climate regulation	67	29	4	64.86***
Cultural services				
Ecological knowledge medicinal plants	44	41	14	11.12***
Ecotourism and recreational activities	37	39	23	0.88

df = 2 *Significance level at 5%, **Significance level at 1%, *** Significance level at >1%

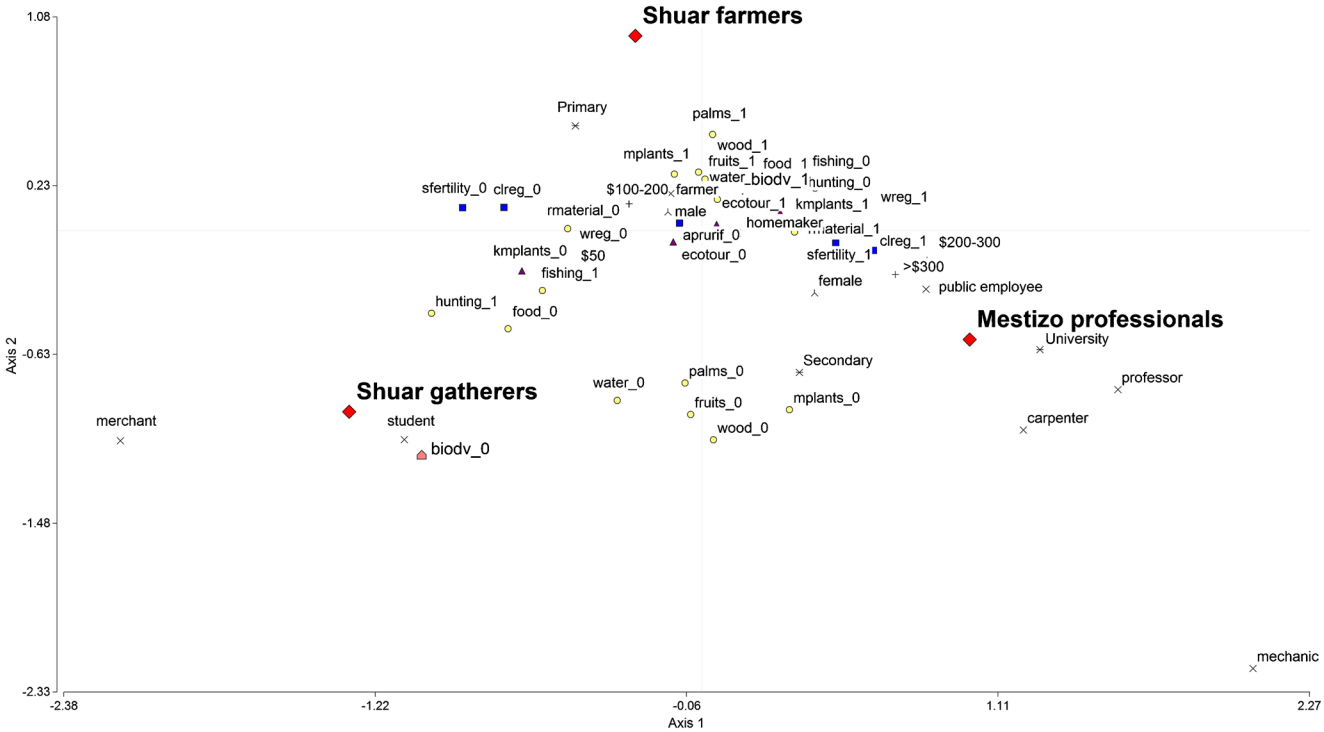

Fig. 3 Correspondence analysis diagram depicting relationship between the user groups identified, socioeconomic characteristics and ecosystem services in Sangay Parish. _1: identification of ES
_0: no identification of ES

general; the group was associated with the practices of hunting and fishing and a relatively low monthly income.

Discussion

Perception of Biodiversity Features and Ecosystem Services Varies by User Group

The importance of ES and biodiversity features of the local ecosystems was recognized by all populations of the Sangay Parish. The state of biodiversity and degradation of ES were concerns to all respondents and all mentioned the importance of recovering ES. Local flora and fauna were frequently associated with personal well-being and provisioning services. However, as hypothesized, user groups had different perceptions of ES and biodiversity features, and these varied according to their socioeconomic status and depending on which benefits they obtained from the local ES. Shuar farmers and Shuar gatherers especially recognized provisioning services. In a subsistence economy, provisioning services become the most important (Iftekhar and Takama 2008). In contrast, cultural services are usually perceived as most important in industrialized areas (Martín-López *et al*. 2012; Casado-Arzuaga *et al.* 2013); here, the cultural salience of ecological knowledge of medicinal plants were appreciated similarly by mestizo professionals and Shuar farmers, the two groups with generally older members. Shuar farmers also recognized more medicinal plants and their properties. As established in previous studies, people who live longer in a place know more about local plants and make greater use of them (Byg and Balslev 2006).

It has been recognized elsewhere that perceptions of local stakeholders on biodiversity features and ES vary depending on their access to resources (Castillo *et al.* 2005; Díaz *et al.* 2011). Water provision was the most recognised service by respondents, as in other areas of tropical forest (Higuera *et al.* 2013). Traditionally, the Shuar built their homes near streams, next to trees, and used palm fibre as their basic construction material (Harner 1994); today a great proportion of Shuar houses are built with wood. Also medicinal plants and fruits from the forest are more recognised by Shuar farmers, while fishing and hunting are more valued by Shuar gatherers. Regulation services are most recognized by mestizo professionals, despite the intangibility of this category, and probably as a result of their higher levels of education. Frequently, higher education is related with pro-environmental behaviour (Lu *et al.* 2010); in the case of the Sangay Parish, mestizo professionals undertake fewer extractive activities and they manage their household waste in a more environmentally sensitive way than members of the other groups. The group includes relatively more women, who are generally associated with a more positive attitude toward the environment (Martín-López *et al.* 2012) and a more frequent identification of regulation services (Castillo *et al.* 2005).

Environmental Background

Our second hypothesis is also supported by this research, as the user groups are distinctly linked to environmental history and members' interpretations of their environment, which are reflected in their current relationships with the ecosystem. Both mestizos and Shuar moved to the Palora municipality for economic survival. These two groups, with different cultural and social characteristics, converged in perspective because they live in the same environment, but they also relate in different ways with the tropical forest. Mestizos seem today to be closer to the history of colonists who came to the Amazon region to develop agricultural activities without knowledge of the tropical environment and its natural resources; they did not adapt to the environment but transformed it. To this day they make less use of forest resources, probably because they live in better socioeconomic conditions and they are less directly dependent on forests. Shuar farmers seem to be closer to the indigenous Shuar culture, considered an outcome of countless adaptations of various kinds to Amazonian ecosystems, and intimately linked with their environment and the services provided by forests.

The Shuar tradition is embedded in social interpretations of ES, as has been explained for other ethnicities (Hartter 2010). Shuar farmers display a much wider knowledge of biodiversity features and provisioning services. Indigenous traditional knowledge can provide essential insights into understanding historical values assigned to landscapes (Tengberg *et al.* 2012). Indigenous communities use local resources and possess a broad knowledge of ecological systems and local biodiversity (Gadgil *et al.* 1993), two characteristics usually linked (Byron and Arnold 1999).

Commonly, humans are considered a threat to biodiversity (Castillo *et al.* 2005; Maffi 2007), but it is increasingly recognized that loss of culture may have negative consequences for biodiversity conservation, as traditional practices can enhance biodiversity (Gadgil *et al.* 1993). In our case, Shuar farmers, as for other indigenous groups, were conscious of the importance of biodiversity and its role in the generation of ES. Shuar gatherers, for whom this relationship was less clear, and who seemed less aware of larger-scale loss of biodiversity, probably suffer loss of traditional knowledge. User groups still related closely to the indigenous culture may nevertheless be causing deterioration to the environment, with the aggravating circumstance that traditional knowledge seems to be declining. Hunting, for example, important to the Shuar for cultural and economic survival, is not a sustainable practice in Ecuador (Zapata-Ríos *et al.* 2009). In the past, small populations and traditional hunting techniques had a minor impact on

wildlife (Harner 1994). Younger Shuars gatherers practice more hunting, and more commonly use firearms.

Recommendations for Sangay Parish

The recovery of traditional knowledge and the recognition of positive links between culture and biodiversity should be considered as an initial strategy for management and conservation planning. The establishment of permanent programs in environmental education would be desirable in promoting pro-environmental behaviour. In this case, environmental education (including transmission of traditional knowledge) could play an important role in implementing conservation strategies. In the Ecuadorian Amazon, the dynamic interaction between social and natural systems has been not well understood; hence, the failure of political and sustainable management of resources in the region (Neira 2006). In Sangay Parish, agrarian reforms promoted by government were perceived by our survey respondents as one of the main causes of degradation. It is increasingly recognized that Sangay Parish is better suited to a forest-based economy, due to many limitations associated with agricultural efforts (MAGAP 2012). Nevertheless, the area has been continually transformed for agricultural use, although the consequent ecosystem degradation can still be changed through effective agricultural policies (Castillo *et al.* 2005). Moreover, alternative and complementary activities to agriculture, such as ecotourism, might be undertaken in order to achieve forest conservation and recovery (Sodhi *et al.* 2010).

Conclusion

The identification of user groups allowed us to distinguish differences among residents of Sangay Parish, not only by their socioeconomic characteristics and use of resources, but also in their perceptions about biodiversity features, ES, and environmental history. The integration of social, biophysical, and economic facets of sustainability could guide holistic policies and not only focus on the more tangible and direct ES, such as provisioning services, but also on others less frequently identified but essential to ecosystem balance and cultural survival. It is essential that local authorities generate spaces where the population is directly involved in the proposal, design, and implementation of government policies related to conservation. Conservation of ecosystems and their services depends on integration of the needs of a variety of user groups, including the development of viable economic alternatives for local people, and is best complemented by environmental education programs.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

References

Aretano R., Petrosillo I., Zaccarelli N., Semeraro T., and Zurlini G. (2013). People Perception of Landscape Change Effects on Ecosystem Services in Small Mediterranean Islands: A Combination of Subjective and Objective Assessments. Landscape and Urban Planning 112: 63–73.

Asquith N. M., Vargas M. T., and Wunder S. (2008). Selling two Environmental Services: In-Kind Payments for Bird Habitat and Watershed Protection in Los Negros, Bolivia. Ecological Economics 65: 675–684.

Balvanera P., Uriarte M., Almeida-Leñero L., Altesor A., DeClerck F., Gardner T., Hall J., Lara A., Laterra P., et al (2012). Ecosystem services research in Latin America: The state of the art. Ecosystem Services 2: 56–70.

Bennett B. C., Baker M. A., and Gómez-Andrade P. (2002). Ethnobotany of the *Shuar* of Eastern Ecuador. Advances in Economic Botany 14: 1–299.

Bennett E., and Balvanera P. (2007). The future of production systems in a globalized world. Frontiers in Ecology and the Environment 5: 191–198.

Bilsborrow R. E., Barbieri A., and Pan W. (2004). Changes in population and land use over time in the Ecuadorian Amazon. Acta Amazonica 34: 635–647.

Byg A., and Balslev H. (2006). Palms in indigenous and settler communities in southeastern Ecuador: Farmers' perceptions and cultivation practices. Agroforestry Systems 67: 147–158.

Byron N., and Arnold M. (1999). What futures for the people of the tropical forests? World Development 27: 789–805.

Burkhard B., Petrosillo I., and Costanza R. (2010). Ecosystem services: bridging ecology, economy and social sciences. Ecological Complexity 7(3): 257–259.

Caballero-Serrano V., Onaindia M., Alday J. G., Caballero D., Carrasco J. C., McLaren B., and Amigo J. (2016). Plant diversity and ecosystem services in Amazonian homegardens of Ecuador. Agric. Ecosystem Environ. 225: 116–125.

Cárcamo P. F., Garay-Flühmann R., Squeo F. A., and Gaymer C. F. (2014). Using stakeholders' perspective of ecosystem services and biodiversity features to plan a marine protected area. Environmental Science & Policy 40: 116–131.

Casado-Arzuaga I., Madariaga I., and Onaindia M. (2013). Perception, demand and user contribution to ecosystem services in the Bilbao Metropolitan Greenbelt. Journal of Environmental Management 129: 33–43.

Castillo A., Magaña A., Pujadas A., Martínez L., and Godínez C. (2005). Understanding the interaction of rural people with ecosystems: A case study in a tropical dry forest of Mexico. Ecosystems 8: 630–643.

Chomitz K. M., and Kumari K. (1998). The domestic benefits of tropical forests: A critical review. World Bank Research Observer 13(1): 13.

Daily G. C., Polasky S., Goldstein J., Kareiva P. M., Mooney H. A., Pejchar L., Ricketts T. H., Salzman J., and Shallenberger R. (2009). Ecosystem services in decision making: Time to deliver. Frontiers in Ecology and the Environment 7: 21–28.

De Groot R. S., Wilson M. A., and Bouman R. M. J. (2002). A typology for the classification, description and valuation of ecosystem services, goods and services. Ecological Economics 41: 393–408.

Díaz S., Quétier F., Cáceres D. M., Trainor S. F., Pérez-Harguindeguy N., Bret-Harte M. S., Finegan B., Peña-Claros M., and Poorter L. (2011). Linking functional diversity and social actor strategies in a framework for interdisciplinary analysis of nature's benefits to society. Proceedings of the National Academy of Sciences 108: 895–902.

Estrada-Carmona N., and DeClerck F. (2011). Payment for ecosystem services for energy, biodiversity conservation and poverty reduction in Costa Rica. In Ingram J. I., DeClerck F., and Rumbaitis del Rio C. (eds.), Integrating Ecology and Poverty Reduction: The Application of Ecology in Development Solutions, Springer, New York, pp. 191–210.

Felipe-Lucia M. R., Martín-López B., Lavorel S., Berraquero-Díaz L., Escalera-Reyes J., and Comín F. A. (2015). Ecosystem services flows: why stakeholders' power relationships matter. PLoS One 10: e0132232.

Ferraz S. F. B., Ferraz K. M. P. M. B., Cassiano C. C., Brancalion P. H. S., Luz D., Azevedo T. N., Tambosi L., and Metzger J. P. (2014). How good are tropical forest patches for ecosystem services provisioning? Landscape Ecology 29: 187–200.

Foley J. A., Asner G. P., Costa M. H., Coe M. T., DeFries R., Gibbs H. K., Howard E. A., Olson S., Patz J., Ramankutty N., and Snyder P. (2007). Amazonia revealed: forest degradation and loss of ecosystem goods and services in the Amazon Basin. Frontiers in Ecology and the Environment 5: 25–32.

Fu B. J., Su C. H., Wei Y. P., Willett I. R., Lü Y. H., and Liu G. H. (2011). Double counting in ecosystem services valuation: Causes and countermeasures. Ecological Research 26: 1–14.

Gadgil M., Berkes F., and Folke C. (1993). Indigenous knowledge for biodiversity conservation. Ambio 22: 151–156.

García-Llorente M., Martín-López B., González J. A., Alcorlo P., and Montes C. (2008). Social perceptions of the impacts and benefits of invasive alien species: implications for management. Biological Conservation 141: 2969–2983.

Gibbs H. K., Ruesch A. S., Achard F., Clayton M. K., Holmgren P., Ramankutty N., and Foley J. A. (2010). Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. Proceedings of the National Academy of Sciences 107: 16732–16737.

Gordon L., Finlayson C. M., and Falkenmark M. (2010). Managing water in agriculture for food production and other ecosystem services. Agricultural Water Management 97: 512–519.

Gray C. L., Bilsborrow R. E., Bremner J. L., and Lu F. (2008). Indigenous land use in the Ecuadorian Amazon: a cross-cultural and multilevel analysis. Human Ecology 36: 97–109.

Ghillardi A., Gabriela G., and Masera O. (2007). Spatial analysis of residential fuelwood supply and demand patterns in Mexico using the WISDOM approach. Biomass and Bioenergy 31: 475–491.

Guariguata M. R., and Balvanera P. (2009). Quantifying the flow of tropical forest ecosystem services. Forest Ecology and Management 258: 1825–1895.

Harner M. (1994). Shuar, pueblo de las cascadas sagradas, Abya Yala, Quito.

Hartter J. (2010). Resource use and ecosystem services in a forest park landscape. Society and Natural Resources 23: 207–223.

Hicks J. F., Daly H. E., Davis S. H., and de Freitas M. L. (1990). Ecuador's Amazon Region Development Issues and Options, World Bank, Washington D.C., p. 41.

Higuera D., Martín-López B., and Sánchez-Jabba A. (2013). Social preferences towards ecosystem services provided by cloud forests in the neotropics: implications for conservation strategies. Regional Environmental Change 13: 861–872.

Iftekhar M. S., and Takama T. (2008). Perceptions of biodiversity, environmental services, and conservation of planted mangroves: a case study on Nijhum Dwip Island, Bangladesh. Wetlands Ecology and Management 16: 119–137.

INAMHI (Instituto Nacional de Meteorología e Hidrología). (2014). Registros meteorológicos Estación Meteorológica Té Sangay.

INEC (Instituto Nacional de Estadística y Censos). (2011). VII Censo de Población y VI de Vivienda 2010.

Lu F., Gray C., Bilsborrow R. E., Mena C. F., Erlien C. M., Bremner J., Barbieri A., and Walsh S. J. (2010). Contrasting colonist and indigenous impacts on Amazonian forests. Conservation Biology 24(3): 881–885.

MAE (Ministerio de Ambiente del Ecuador). (2013a). Sistema de Clasificación de los Ecosistemas del Ecuador Continental. Subsecretaría de Patrimonio Natural. Quito- Ecuador. Escala 1: 50000. WGS 84, 17S.

MAE (Ministerio de Ambiente del Ecuador). (2013b). Mapa de Deforestación del Ecuador (1990–2000; 2000–2008). Proyecto Mapa Histórico de Deforestación del Ecuador. Escala 1:100000. WGS 84, 17S.

Maffi L. (2007). Biocultural Diversity and Sustainability. In Pretty J., Ball A., Benton T., Guivant J., Lee D. R., Orr D., Pfeffer M., and Ward H. (eds.), The Sage Handbook of Environment and Society, Cromwell Press, Great Britain, pp. 267–277.

MAGAP (Ministerio de Agricultura, Ganadería, Acuacultura y Pesca). (2010). Registros de talleres participativos.

MAGAP (Ministerio de Agricultura, Ganadería, Acuacultura y Pesca). (2012). Mapa de aptitudes agrícolas de la provincial de Morona Santiago. Escala 1:250000. WGS 84, 17S.

Martín-López B., Iniesta-Arandia I., García-Llorente M., Palomo I., Casado-Arzuaga I., García Del Amo D., Gómez-Baggethun E., Oteros-Rozas E., Palacios-Agundez I., Willaarts B., González J. A., Santos-Martín F., Onaindia M., López-Santiago C., and Montes C. (2012). Uncovering ecosystem service bundles through social preferences. PLoS ONE 7(6): e38970.

MEA (Millennium Ecosystem Assessment) (2005). Ecosystems and Human Wellbeing: Current State and Trends, Island Press, Washington DC.

Mittermeier R., Mittermeier C., Brooks T., Pilgrim J., Konstant W., da Fonseca G., and Kormos C. (2003). Wilderness and Biodiversity Conservation. Proceedings of the National Academy of Sciences 100(18): 10309–10313.

Mittermeier R. A., Robles G. P., and Mittermeier C. G. (2004). Megadiversity: Earth's Biologically Wealthiest Nations, Cemex, USA, p. 501.

Neira F. (2006). Representaciones de la naturaleza en la Amazonía ecuatoriana: ¿Subsistencia local o conservación global? Iconos 25: 57–65.

Quintero M., Wunder S., and Estrada R. D. (2009). For services rendered? Modeling hydrology and livelihoods in Andean payments for environmental services schemes. Forest Ecology and Management 258: 1871–1880.

R Core Team. (2015). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL (http://www.Rproject.org/).

Rudel T. K., Bates D., and Machinguiashi R. (2002). Ecologically noble Amerindians? Cattle ranching and cash cropping among *Shuar* and colonists in Ecuador. Latin American Research Review 37: 144–159.

Satz D., Gould R. K., Chan K. M. A., Guerry A., Norton B., Satterfield T., Halpern B. S., Levine J., Woodside U., Hannahsm N., Basurto X.,

and Klain S. (2013). The challenges of incorporating cultural ecosystem services into environmental assessment. Ambio 6: 675–684.

Sodhi N. S., Lee T. M., Sekercioglu C. H., Webb E. L., Prawiradilaga D. M., Lohman D. J., Pierce N. E., Diesmos A. C., Rao M., and Ehrlich R. (2010). Local people value environmental services provided by forested parks. Biodiversity and Conservation 19: 1175–1188.

Scholte S. S., van Teeffelen A. J., and Verburg P. H. (2015). Integrating sociocultural perspectives into ecosystem service valuation: A review of concepts and methods. Ecological Economics 114: 67–78.

Tengberg A., Fredholm S., Eliasson I., Knez I., Saltzman K., and Wetterberg O. (2012). Cultural ecosystem services provided by landscapes: Assessment of heritage values and identity. Ecosystem Services 2: 14–26.

Toledo V. M. (2001). Biodiversity and indigenous peoples. Encyclopedia of Biodiversity, Academic Press, San Diego, pp. 330–340.

UNAE (Unión de Nativos de la Amazonía Ecuatoriana). (1985). Problemática Social y Agraria en el Oriente Ecuatoriano. Reflexiones Nacidas al interior de la Unión de Nativos de la Amazonía Ecuatoriana. Working document.

Uquillas J. (1984). Colonization and spontaneous settlement in the Ecuadorian Amazon. In Schmink M., and Wood C. H. (eds.), Frontier expansion in Amazonia, University of Florida Press, Gainesville, pp. 261–284.

Vihervaara P., Rönkä M., and Walls M. (2010). Trends in ecosystem service research: early steps and current drivers. Ambio 39: 314–324.

WHO (World Health Organization) (2013). Traditional Medicine Strategy 2014–2025, World Health Organization, Geneva.

Zapata-Ríos G., Urgilés C., and Suárez E. (2009). Mammal hunting by the *Shuar* of the Ecuadorian Amazon: is it sustainable? Oryx 43: 375–385.