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ORIGINAL PAPER

Participatory rural appraisal of ecosystem services of wetlands in the Amazonian Piedmont of Colombia: elements for a sustainable management concept

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Abstract Considering the rapid changes in land use in tropical countries and the difficulties of law enforcement in remote areas, management of ecosystems benefits from the landscape approach. Within the landscape approach it is important to assess the different livelihoods of the local populations, as well as the vulnerability of the ecosystems that are supporting these livelihoods. Specifically for wetlands in rural tropical areas that face fast developing agro-industrial land use change, there is little information available on the attitude of stakeholders considering the ecosystems they manage. We used a combination of participatory rural appraisal and participatory mapping methods on rural wetlands in the Amazonian Piedmont region in Colombia, an area that has hardly ever been studied. We found that 77.7 % of the current livelihoods depend directly on the provisioning ecosystem services delivered by the wetlands, where fishing and hunting are the most important services that contribute to the household income. Ecotourism, which is emerging as a promising source of income, was also pointed as one key ecosystem service. However, our results revealed that the wetlands in our study area are very vulnerable (up to 41 % endangered). The main causes for wetland deterioration were cattle ranching, invasive grasses, deforestation, drainage, and burning. We conclude with a brief overview on the pros and cons of reconciling wetland conservation and human development in sensitive regions such as the Amazonian Piedmont in Colombia and other similar regions in the Tropics.

Keywords Agricultural landscapes · Biodiversity · Drivers of change · Livelihoods · Small-sized wetlands · Landscape approach

Introduction

Use of wetlands, including all types of aquatic ecosystems, constitutes an inherent part of human history. Since early history people obtain essential

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protein, water, wood and other plant parts for various uses from wetlands. Not surprisingly, wetlands are defined as "multiple-value systems" (Mitsch and Gosselink 2000). More recently, the benefit that ecosystems provide to society has been defined as "ecosystem services" (MEA 2003). The Millennium Ecosystem Assessment and TEEB (Russi et al. 2013) provided the framework to develop a comprehensive analysis of the dependence of human well-being on the provisioning, regulating, supporting and cultural services provided by inland and coastal wetlands worldwide (Finlayson et al. 2005). Wetlands provide ecosystem services that are disproportionately important compared to the area they cover, e.g. they store 830 Tg of carbon per year while covering only 2–8 % of the land surface of our planet (Mitsch et al. 2013). Especially small wetlands in agriculture landscapes deliver high-value services (Blackwell and Pilgrim 2011).

However, wetlands have been degraded or destroyed over the past decades so that their ecosystem services have significantly reduced. Wetlands have been converted to urban and agricultural use as well as contaminated by industrial, urban and agricultural waste. As a result, the wetland area has diminished up to 50 % especially in the developed countries and since 1950s the losses have rapidly increased in the tropical (Junk 2002) and subtropical countries (Zedler and Kercher 2005). A recent study by Prigent et al. (2012) found that the global wetland area drastically declined between 1993 and 2007, especially in the tropical regions of South America and South Asia. The areas with the highest losses are those with the fastest population and economic growth (WTO 2012). Wetland losses go hand in hand with a dramatic shift in the supply of water and freshwater biodiversity, making the scope of global common aims such as nature conservation, food security and poverty alleviation more difficult (Dudgeon et al. 2006).

The Orteguaza river catchment at the Amazonian Piedmont in the Caquetá Department of Colombia represents one of the most active fronts of colonization within the Amazon basin (Gutierrez et al. 2003). The occupation of the region began in the late 1800's by the exploitation of cocoa, quinine, rubber, ivory palm, skins of wild animals, fishing and timber from the yet largely maintained forests. Since 1950s, however, cattle ranching, oil palm plantations, mining and agriculture, including cultivation of coca (*Erythroxylum coca*), have transformed the natural land cover (Arcila et al. 2000). This trend has become increasingly intensive in the last two decades. Etter et al. (2006) determined that the colonization front advances eastward within the Amazon basin along the large rivers, with a speed of 0.84 km year^{-1} leading to an annual deforestation rate of up to 4 %. A recent result of this land conversion is the ongoing transformation of remnant patches of wetlands into pasture lands. In a previous study (Ricaurte et al. 2012) we estimated that small and middle-sized wetlands currently cover about 11 % of the basin today. But, the same study found that up to 77 % of the flooded active floodplain area has already been converted to pastures and crops, which means that the original wetland area accounted for up to 30 % of the area. The remaining wetlands have prevailed through their geographic location along the rivers and streams and in topographic depressions at the interfluves. Remnant patches of wetlands within agricultural landscapes in geographic areas of high biodiversity such as the Amazonian Piedmont (Myers et al. 2000; Abell et al. 2008) form a functional systems of corridors and stepping stones that harbor important flora and fauna communities that support overall ecosystem functioning (Ricaurte et al. 2012). However, at the same time, such wetlands are most vulnerable to environmental changes as agricultural impacts likely reduce their resilience and ecosystem functions (Finlayson et al. 2005; Wantzen et al. 2012).

In the light of the current land use change, the effects of the anthropogenic climate change and the increasing demand of water (Vörösmarty et al. 2010), the need for a landscape approach (Sayer et al. 2013) for ecosystem management is increasingly being recognized, especially for rural landscapes, where concerns of society regarding livelihoods are of utmost importance. The landscape approach includes "continual learning and adaptive management, common concern entry point, multiple scales, multifunctionality, multiple stakeholders, negotiated and transparent change logic, clarification of rights and responsibilities, participatory and user-friendly monitoring, resilience and strengthened stakeholder capacity" (Sayer et al. 2013). In agricultural landscapes as the Amazonian Piedmont in Colombia, wetlands may serve as strategic regional elements in sustainable management concepts, as they integrate aspects of nature conservation and economic development, but there is still little information available on the stakeholders' attitude, considering the wetlands which they manage. The process of decision-making is a societal issue (Reichert et al. 2007), into which stakeholders have to be involved as early as possible in order to avoid skepticism and resistance (Palomo et al. 2011). Cox and Searle (2009) argue that the link between ecosystem services and human well-being is the most powerful argument to achieve any conservation initiative at a given region, because it is the only one way of getting local stakeholders actively interested in it.

In a previous study (Ricaurte et al. 2012) demonstrated the importance of wetlands for the ecological integrity of the region through the analysis of the spatial arrangement and the diversity of remnant wetland patches. However, scientific arguments are rarely used for local decision taking. Therefore, we studied the local livelihood strategies obtained from the wetland ecosystem services and the conflicts related to wetlands from the viewpoint of local stakeholders.

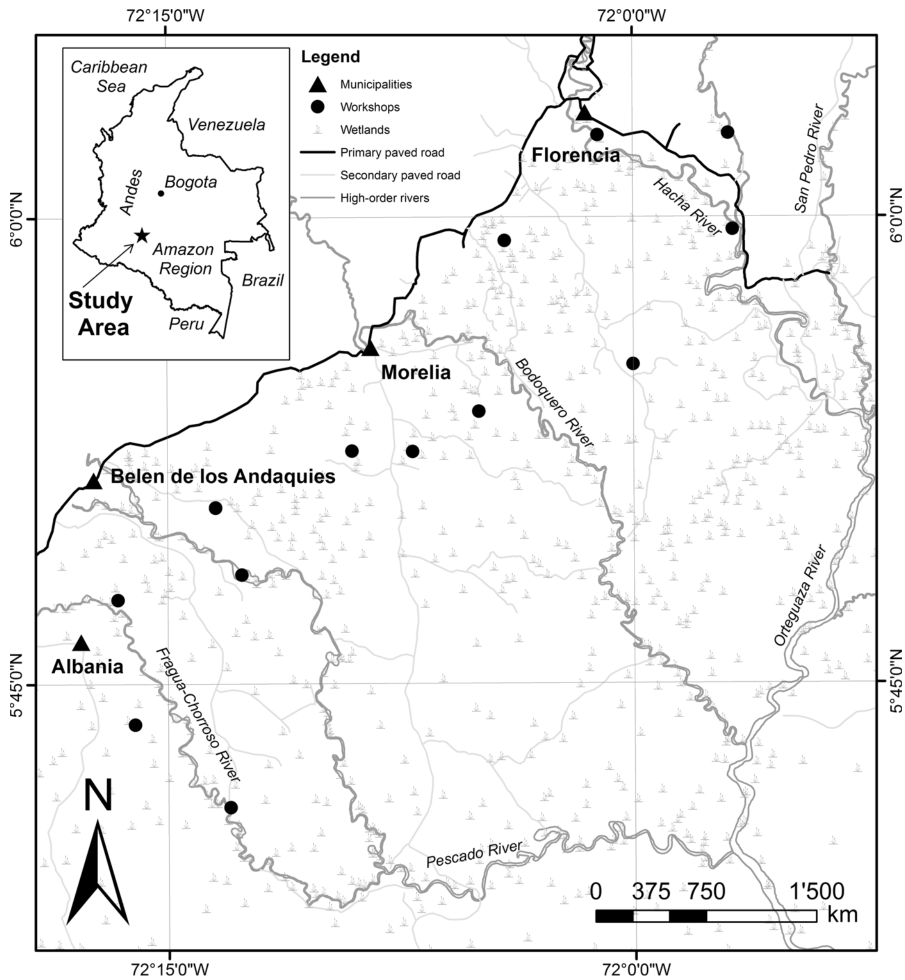
With this study we attempt to deliver elements for a sustainable management of the Amazonian Piedmont in Colombia by identifying the ecosystem services that are supporting the livelihood strategies of local people and by analyzing the environmental conflicts related to wetlands from the viewpoint of local stakeholders. As a research method we used different participatory methods (Chambers 1994, 2010), consisting in participatory rural appraisal (PRA) and participative mapping (PM), which have been widely used for stakeholder's analysis and wetland assessments valuations (De Groot et al. 2006). We chose a participatory approach due to the close dependence of livelihoods from ecosystem services and because it enables people to share and analyze their own information (Bhandari 2003). Studies that have followed a similar approach have been carried out for the management of the Stoeng Treng Ramsar Site in Cambodia (Chong 2005), for wetlands and livelihoods at the Bahi Wetlands in Manyoni District in Tanzania (Mwakaje 2009), for ecosystem services and livelihoods in Cambodia (Persson et al. 2010), for community-based wetland management in Northern Thailand (Trisurat 2006), for wetland livelihoods at the lower basin of the River Paz in Guatemala (Gallo and Rodriguez 2010), and for the management of Doñana Ramsar site in Spain (Palomo et al. 2011). We performed our analysis on the basis of the wetland ecosystem services classification provided by Finlayson et al. (2005), with focal point on provisioning ecosystem services. Specifically, we identified the main wetland plants and animals that people know and use, the principal livelihoods that people benefit from, and the main drivers of change that people consider as a major threat to wetlands. Finally, we discuss the pros and cons of reconciling wetland conservation and human development in sensitive regions such as the agricultural landscapes of the Amazonian Piedmont in Colombia.

Methods

Study area

The study area extends between the Municipalities of Albania (417 km^2), Belen de los Andaquíes (1,095 km^2), Morelia (440 km^2) and Florencia (2,292 km^2) with a total area of 4,244 km^2 (Gutierrez et al. 2003), in the Caquetá Department, which is located in the upper basin of the Orteguaza River, at the Amazonian Piedmont to the Northwest of the Amazon Basin in Colombia (Fig. 1). The prevailing climate is warm-humid, with an average annual temperature of 25.3 °C, an average humidity of 85 %, and an average annual rainfall of 3,900 mm (IDEAM 2011). A detailed description of the site is given in Ricaurte et al. (2012). In 2005, the Caquetá Department concentrated 337 932 inhabitants corresponding to 40.75 % of the entire population of the Colombian Amazon region (829 227 habitants, 2 % of total national population of Colombia). Most of the Caquetá citizens (67.4 %) lived in municipal capitals located mainly at the Amazonian Piedmont. The population of the four municipalities studied here accounted for 129 677 habitants living inside municipal capitals and 28,644 habitants outside them (DANE 2005). Almost third of the land use is agricultural, of which 0.5 % is covered by crops and 28 % by pastures for cattle ranching with a stocking rate of 0.5 cows per hectare. The rest of the surface at the lowlands is covered by primary and secondary forests (71.5 %) (Caquetá 2010), within which about 11 % is covered by wetlands, where riparian wetlands are the most abundant, followed by interfluvial marshes, oxbow lakes and floodplain complexes (Ricaurte et al. 2012).

Fig. 1 The study area comprises the Municipalities of Albania, Belen de los Andaquíes, Morelia and Florencia



Method

We used participatory methodologies as PRA and participatory mapping (PM) (Chambers 1994, 2010). The stronghold of these methods consists in the capacity to generate knowledge on the tangible and non-tangible elements necessary for the successful management of the ecosystems (Chambers 2010), as well as to allow stakeholders to express their desires and concerns, which should be included in decision-making processes (Sayer et al. 2013).

Primary data were collected during 13 workshops organized in the proximity of wetlands that were selected based on a stratified random sampling design taking into account four wetland types (marsh, oxbow lake, riparian wetland, wetland complex) (Ricaurte et al. 2012) (Table 1; Fig. 1). Workshops were performed at decreasing water regime, during normal working time, with a maximal duration of 5 h. Participants were selected by using snowball sampling, i.e. we contacted key regional informants as community leaders and environmental advisors of governmental agencies, who identified key local stakeholders to participate at the workshops. A total of 81 women and 158 men of different age, sectors and disciplines such as peasants, farmers, teachers, local leaders, fishermen, policy makers and also school students, were interviewed. This group represented the 12.4 % of the population that live around the selected wetland sites, which accounted for a total of 1931 persons for a total number of 397 households at the time of this study. Based on estimates provided by Clarke (1988) and Meidinger (2003) for the accurate minimum sample sizes for ecological surveys and map assessment, a 12.4 % sample was considered to be representative for the population

Table 1 Description of the wetland types covered in this study according to Ricaurte et al. (2012), and the number of workshops and participants

Wetland type	Description	No. of workshops	No. of participants
Marshes	Periodically waterlogged, covered by grassy shrub coverage, and located in the interfluves, along the low-order streams, black Amazonian water	1	11
Oxbow lakes	Permanently waterlogged, called locally as "madre viejas" or "lagunas", located on the flooded active river floodplains, covered by grassy and woody vegetation, black and clear Amazonian water	3	56
Riparian wetlands	Permanently waterlogged, located along the 1st–5th order streams of the interfluve in the elongated and narrow V-shaped valleys and channels with flat bottom, with woody vegetation, black Amazonian water	6	120
Wetland complexes	Habitat related to the meander scroll bars, located on the frequently flooded active river floodplains along the 6th and higher order rivers, with grassy and woody vegetation, black Amazonian water	3	52

under study, with 95 % of confidence and 4 % of maximum error.

The tools we implemented at the workshops were selected on the basis of Chambers (1994, 2010), and included semi-structured interviews, informal mapping and direct field observations. In order to establish baselines for a sustainable management concept, we chose four relevant, tangible and non-tangible elements for wetland valuation with emphasis on the provisioning ecosystem services, being (i, ii) the notion about the wetland plants and animals and their respective use options, (iii) the livelihoods of the local population derived from wetlands, and (iv) pressures or drivers of change relevant to wetland condition. Lastly (v) we asked the people to provide sketches of their perception about these four issues in form of hand drawn maps. We also included further complementary questions concerning land tenure, credibility in public institutions, rights of access to natural resources, acceptance of existing environmental laws, alternative ways to use the wetland natural resources, and decrease of ecosystem services in comparison with the past offer.

Semi-structured interviews were focused on the topics previously mentioned. At the workshops participants were asked to split them voluntarily into five groups, to join the most preferred topic and to contribute their knowledge to it. After that, each group analyzed the collected data and presented their results to all participants of the workshops, where they faced their information with the knowledge of other participants to cross-check answers. This process has been established as triangulation (Chambers 1994; Bhandari 2003). Informal mapping consisted in sketching the wetland location and its surrounding area, including the natural sources of water as small streams and rivers connected to it, the types of land uses, the small subsistence gardens, the houses, roads, and other landscape elements they considered relevant to wetland state. One-day direct field observation was performed at each wetland based on rapid assessment protocols (Fennessy et al. 2004) and conducted by researchers with ecological and social background (limnologist, botanist, zoologist, and environmentalist) and two local co-researchers. The latter were selected in mutual agreement by the participants directly at the workshops, gathering the "most knowledgeable" information about the wetland plants, animals and other related wetland aspects. The final result was protocolled in form of hand-written cardboards and hand-drawn maps. Data bases on GIS-data on wetlands, and taxonomical and ecological data bases on the vegetation and animals were provided by Ricaurte et al. (2004, 2012). Data were analyzed based on frequencies of responses within each topic and grouped into categories applying descriptive statistics (Bhandari 2003) by using SPSS (version 22, New York, NY, USA).

Results

Local knowledge on wetland plants and animals, and their respective use options

The majority of the plants identified by the stakeholders (45 %) were typical wetland species as they had also been reported in our earlier study (Ricaurte et al. 2012). However, a significant portion of plants (26.9 %) corresponded to grasses for livestock, and these species were introduced or favored by the partial conversion of wetlands into farmland. The majority of the invasive grasses were introduced in the region by governmental initiatives from the 1970s (Velásquez and Cuesta 1990). In total, 44 species were mentioned by the stakeholders belonging to 21 families (Appendix 1). The most abundant were grasses (Poaceae, 26.9 %), palms (Arecaceae, 21.8 %), rushes (Juncaceae, 9.2 %) and legumes (Fabaceae, 8.4 %). *Mauritia flexuosa* palm was the most frequently mentioned (11 % of all plants reported), followed by *Juncus* sp. 9.2 %, *Echinochloa* sp. 7.6 %, *Nasturtium* sp. and *Brachiaria decumbens* 6.7 %, and *Zygia latifolia* and *Heliconia* sp. 5.9 %.

The uses of the plants were classified into seven categories. Among them were fodder (26.9 %), medicine (20.2 %), handicraft (16 %), and construction material (15.1 %) (Fig. 2). Each plant species was associated to at least one type of use. For instance, the fruit of *M. flexuosa* palm is used for food and fodder and the leaves and trunk as construction material. *Oenocarpus bataua* palm is also used as medicine, aliment (milk and oil), in making handicrafts and construction of houses. Similarly, many of the forage grasses, in spite of being widespread throughout the region as the principal food source for cattle, are also used as material for handicrafts. Tree species of hoop wood (*Z. latifolia*) and trichanthera (*Trichantera gigantea*) were identified as useful for the reforestation of the streams and wetlands (9.2 %), in spite of being traditionally used as medicine and livestock feed.

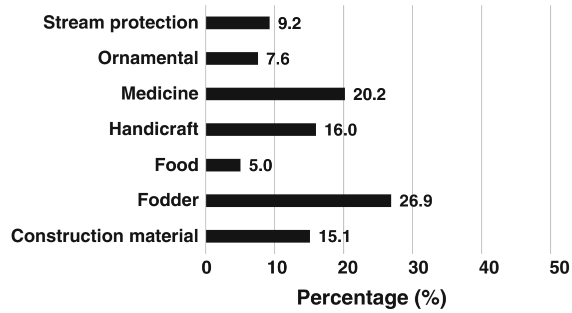


Fig. 2 Uses of the wetland plants identified by the local stakeholders at the workshops

With regard to animals, the people's knowledge varied according to the classes of fauna. There, a total of 123 species belonging to 80 families were registered; 31.8 % of them were birds (31 families), 27.8 % were fish (16 families), 22.3 % were mammals (22 families), 16.9 % were reptiles (9 families) and 1.1 % were amphibians (2 families) (Appendix 2). In the largest group, the birds, a large number of generalist bird species associated to all wetland habitats and to anthropogenic landscapes were named, the most representative being the order of Passeriformes. Icterids (Icteridae, 5.5 %) was the most named bird family including species such as the russet-backed oropendola (*Psarocolius angustifrons*) and the shiny cowbird (*Molothrus bonarensis*), followed by the parrots and macaws (Psittacidae, 2.7 %) such as the mealy amazon (*Amazona farinosa*) and chestnut fronted macaw (*Ara severa*). Of the fish, stakeholders reported many different species, above all 50.9 % Characiformes, 23.1 % Siluriformes (catfishes), and 14.4 % Perciformes, representing approximately the proportions of these orders in the Amazonia (Lowe-McConnell 1975, 1987). Species such as trahira (*Hoplias malabaricus*), pink-tailed characin (*Chalceus* sp.), catfish (*Pimelodus* sp.), electric eel (*Electrophorus electricus*), *Brycon* sp., and *Bujurquina* sp., were among the most frequent. For the mammals the most registered families were: Dasyproctidae (2.1), Didelphidae (1.9 %), Caviidae and Agoutidae (1.8 %), Echimyidae (1.6 %) and Sciuridae (1.4). Southern opossum (*Didelphis marsupialis*), nine-banded armadillo (*Dasypus novemcintus*), capybara (*Hydrochoerus hydrochaeris*), and mountain paca (*Agouti paca*) were the most frequently mentioned animals. With regard to the reptiles, the families Viperidae (3 %), Iguanidae (2.4 %), Colubridae (2.2 %), and Anoliidae (1.8 %) were most frequently reported. Of them, common lance head and common green iguana (*Bothrops atrox* and *Iguana iguana,* 2.4 %), brown caiman (*Caiman crocodilus*, 2 %), coral cylinder snake (*Anilius scytale*, 1.8), and *Boa constrictor* (1.6), represented the most frequently listed species. The amphibians constituted the group with the lowest

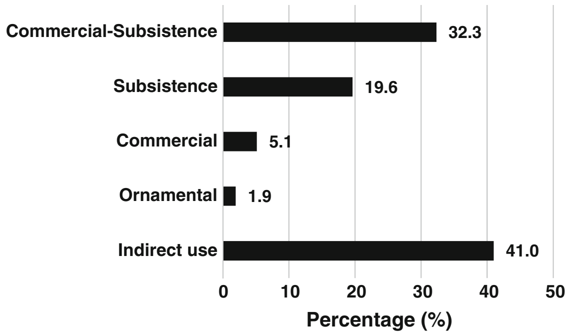


Fig. 3 Uses of the animals related to wetlands identified by the local stakeholders at the workshops

number of known species, namely the cane toad (*Rhinella marina*) and smoky jungle frog (*Leptodactylus pentadactylus*), belonging to the Bufonidae and Leptodactylidae families, respectively.

We identified four types of use for the animals, with 32.3 % of them being considered for commercial-subsistence, 19.6 % subsistence, 5.1 % commercial, and 1.9 % ornamental, whereas the 41 % of the cases did not present any direct use, as for example for food, ornamental, or medicine (Fig. 3). But these species have an indirect use concerning the general ecosystem functioning. We found that the fish represented the most commonly used group, as they made up 65.2, 27.9 and 25 % of the commercial-subsistence, subsistence and commercial uses, respectively; the majority of the reported cases have already been identified as regionally economically important species (Salinas and Agudelo 2000). The size of the fish determined the type of use: small fishes are more common in wetlands and are used for subsistence, for ornamental trade and as bait, while large-sized fishes generally inhabit larger rivers and are targeted by commercial fishing, which is a livelihood of great social and economic importance in the region (Rodríguez 1991; Barthem and Goulding 1997; Agudelo et al. 2000; Barthem and Fabré 2004). The birds accounted for 100 % of the ornamental use, but up to 59.6 % of them did not register any use, whereas 27 % were used for subsistence (27 %). The mammals were also identified as an important group used by the local people, with 25.4 % being used for commercial-subsistence and 27 % for subsistence. The reptiles were reported for commercial (65.6 %) and subsistence uses (18 %). The amphibians were classified into the indirect use category.

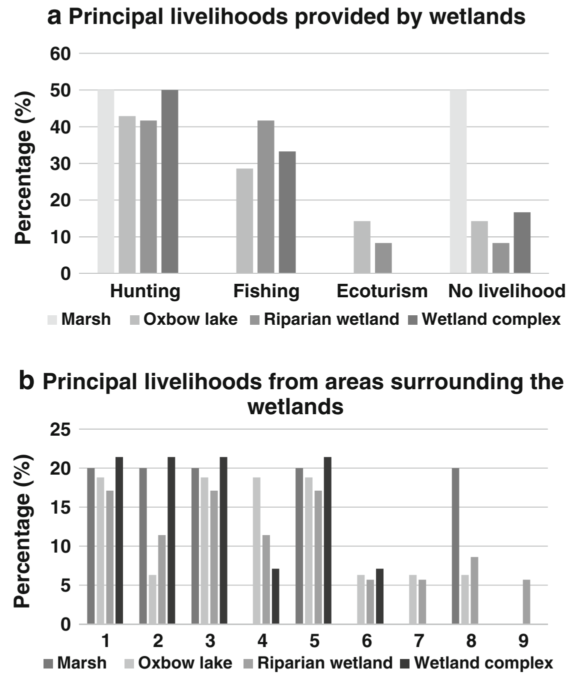


Fig. 4 Relative importance (%) of the livelihoods supported by provisioning ecosystem services of the wetlands at the Amazonian Piedmont in Colombia. **a** Indicates the four livelihoods, which are directly delivered from wetlands, and **b** the nine livelihoods identified by local people, which take place in areas close to wetlands, but that indirectly are related to the wetland ecosystem services as for instance water and biota supply or soils productivity. *1* Subsistence agriculture, *2* Commercial agriculture, *3* Cattle ranching, *4* Hunting, *5* Fishing, *6* Fish farming, *7* Forestry, *8* Poultry farming, *9* Pig farming

Livelihoods and ecosystem services

The results from the workshops indicated that there are two groups of dependency of the people's livelihoods on the wetlands. The first group summarizes a direct use of wetland resources mainly for hunting (44.4 %), fishing (33.3 %), and tourism (7.4 %). In some wetlands the inhabitants declared that they were not using any kind of wetland resources (14.8 %) (Fig. 4a). The second group comprises livelihoods that occurred outside of the wetland areas, but that were indirectly related to wetlands (Fig. 4b). Here, the main livelihoods on which people depended were subsistence agriculture, cattle ranching and fishing, all three activities with a percentage of 18.6 %. Likewise, commercial agriculture (12.9 %) and hunting (11.4 %) were considered as important livelihoods,

Table 2 Set of the ecosystem services identified by the local people at the workshops

Ecosystem service category	Ecosystem services identified
Provisioning	
Food	Hunting
	Fishing
	Agriculture
	Cattle ranching
	Fish farming
	Poultry farming
	Pig farming
Fresh water	Water for drinking purposes
	Water for irrigation and industry
Fiber, timber, fuel	Timber for building and construction
	Fodder
Genetic materials	Medicinal plants and animals
	Ornamental plants and animals
	Production of handicrafts
Regulating	
Stream protection	Erosion control
Cultural	
Ecotourism	Scenic landscape elements
Education	Local and scientific knowledge environmental awareness
Supporting	
Biodiversity	Habitat for species

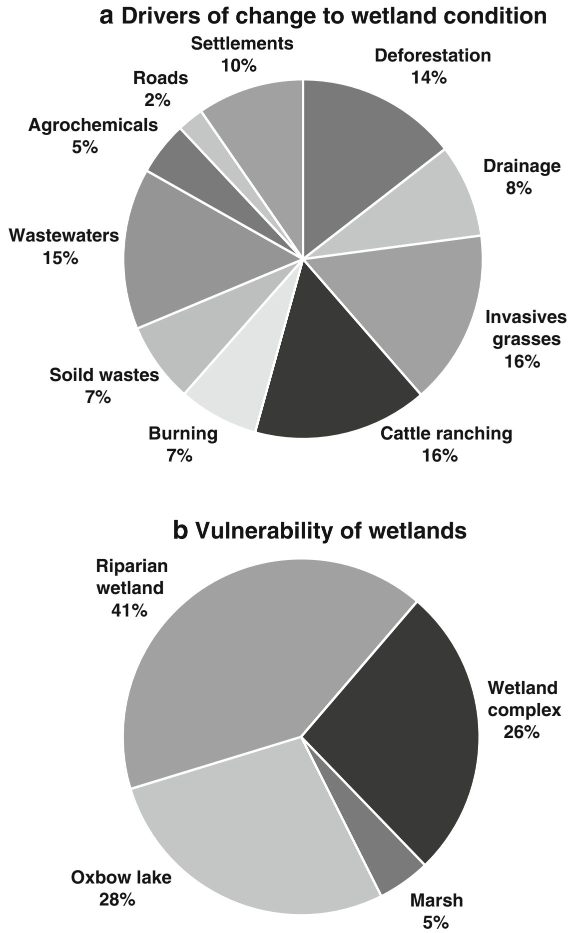


Fig. 5 Relative importance (%) of the principal driver of change to wetland condition identified by the local stakeholders (**a**) and the vulnerability of each wetland type against the identified threats (**b**)

followed by poultry farming (7 %), fish farming (5.7 %), forestry (4.3 %) and pig farming (2.9 %), which were of minor importance.

Summarizing all uses of plants and animals together with the types of livelihoods identified by the stakeholders, we found that 77.7 % of them are delivered by supporting ecosystem services (Table 2), as expected from the methodological approach proposed for our analysis. Additionally we determined that there are other types of values and goods important for the local livelihood strategies, which included around 11 % of cultural, 5.5 % of regulating, and 5.5 % of supporting ecosystem services.

Drivers of change in the wetlands

In total, ten major causes of wetland alteration and loss were identified (Fig. 5a). The participants of the workshops observed that they are clearly linked with the two most powerful dynamics that are currently transforming the Amazon: the advance of the agricultural frontier and urbanization. In this context, cattle ranching, invasive grasses, deforestation, drainage, and burning were the most important causes for wetland conversion. Other causes of change in wetland conditions ranged from wastewaters and construction of settlements to pollution by solid wastes and agrochemicals. Among the wetland types, the most threatened ones were the riparian wetlands with the highest amount of mentioned drivers of change (41 %), followed by the oxbow lakes, wetland complexes, and marshes (Fig. 5b).

Discussion

Ecosystem services and local livelihoods

Our analysis illustrates the effectiveness of participatory methods for facilitating information sharing and learning processes in already consolidated agricultural landscapes such as the Amazonian Piedmont in Colombia. It highlights the socio-economical role of small and middle-sized wetlands within a surrounding agricultural matrix and corroborates the importance of wetlands for human well-being (Finlayson et al. 2005; De Groot et al. 2006).

According to the participants of the workshops the provisioning ecosystem services of wetlands constitute an additional and important source of income for farm households. This supplementary income is obtained from fishing, hunting, subsistence or small-scale agriculture, fish farming, poultry farming, and pig farming. It is combined with the daily-salary or yearly-percentage that the peasants or *campesinos* earn as workers at the large cattle ranches and monoculture plantations. The majority of the participants were poor peasants, who possessed small terrains, whereas the large-scale landowners live further away in large cities. This nested agrisystem of small and large units (*minifundio-latifundio*) consists in small-sized farms supporting a single family with subsistence farming, surrounded by huge estates belonging to a single landowner with extensive livestock farming (Fajardo 1983). Although this background leads to differences between collective and individual interests, it is clear that wetlands are supporting both productive systems, e.g. by providing water.

The valuation of ecosystem services is often influenced by external processes. In our case, participants identified cultural ecosystem services like ecotourism associated to the presence of huge extensions of *M. flexuosa* palm swamps (*cananguchales*). Few years ago, these sites were regularly visited during weekends for leisure activity and for the multiple use of this plant. However, due to armed conflicts in the region, ecotourism currently has decreased, as safety cannot be warranted. Loss of these values facilitates the environmental deterioration of the *cananguchales* and irreversible loss of important ecosystem services that were not noted by the local stakeholders, such as carbon and water storage.

We recognized an increasing demand for wetland provisioning ecosystem services in order to complete the rural livelihood strategies that satisfy the basic well-being of the local people. An increase of human welfare of the poor people is an important element to restore the flow of the wetland ecosystem services (Bagstad et al. 2013).

For areas of high economic growth and urban expansion in Amazonia such as the Colombian Piedmont, the landscape approach (Sayer et al. 2013) seems to be the most feasible solution, as it strengthens the local integrity and sustainable elements of traditional use forms mixed with new sustainable usage, for example the use of some palm fruit for handicrafts, food (ice cream, juice, cookies, candies), beauty creams, essential oils, house construction; reeds (handicraft, house construction); and small-sized fishes with potential ornamental use. New ways of using resources, such as the multiple use of the non-wood-products of the *Mauritia* palms (fiber, fruit pulp, etc., see Ricaurte et al. 2012; Manzi and Coomes 2009; Aquino et al. 2012; Holm et al. 2008 for details) are the backbone of a self-perception and the cultural integrity of the local communities which is—in turn—key to conservation and sustainable management. These people would never fell the palms or drain the palm swamps for its use as pasture. However, these local user groups are not well prepared for the competition with lobby-driven, short-gain-oriented large scale land user. Reinforcement of the local users may be given by designating specific reserve types that allow a certain amount of harvest (like the 'reservas extrativistas' in Brazil, Leff et al. 2002), moreover, the economic competitiveness can be strengthened by green' labels that warrant an adequate remuneration of the work-intensive use of natural wetland products (Butler and Laurance 2008).

Wetland vulnerability: perceptions and global impacts

When we talk about wetlands in the upper northwestern part of the Amazon basin, the Amazonian Piedmont in Colombia, we are referring to the challenges and implications for maintaining and properly handling one of the major hydrological catchments of the world, the Amazon. Unfortunately, lack of management practice of this vast geographic area can have global impact in reduced ecosystem services concerning water retention, carbon sequestration, and climate regulation sedimentation (Erwin 2009).

Our study revealed that the local communities are facing a complex array of constraints for the supply of water, and for the disposal of sewage. In spite of acknowledging that water supply is the most important ecosystem service derived from the wetlands, with a key role for provisioning livelihoods, participants in the workshops were more concerned about the quality and quantity of the water flowing in the lower order (1st–5th) streams. Only in the municipal capitals aqueducts and sewers exist, but in the rest of the area domestic, agricultural, and livestock sewage are dumped directly to the streams and rivers, from which drinking water is supplied. In earlier days, the carrying capacity of the wetland systems was sufficient to cope with this problem. Today it is aggravated by the fast growing population, deforestation of the headwaters and by the impact of non-degradable and/or toxic waste substances, e.g. use of mercury in gold mining, waste of coca production, etc. Another important aspect mentioned by the stakeholders was water scarcity. People have observed how in the last decade the amount of water has declined drastically, to the point that formerly perennial low order streams now dry up in dry season, from March to July. This is specifically worrying in an area that receives nearly four meters of rainfall a year.

On the other hand, most of the participants of the workshops were clearly aware of the limits in carrying capacity of the animal and plant populations. Specifically fishermen observe the locally occurring fish stocks with great care, moreover, the fishing rights are traded between generations, in order to maintain the stocks of natural resources, as also known from other Amazonian regions (Junk et al. 2000; Agudelo et al. 2011). Changes in the biodiversity were also evidenced from the identified bird species, which are mostly generalists and typically adapted to anthropogenic landscapes, what has been considered as an indicator of drastic regime shifts in ecological systems (Andrade et al. 2011).

Our data show also that the traditionally managed wetlands of our study area are endangered hot spots for cultural diversity, as a large portion of the land area is used for cattle ranching and the rest for agriculture of annual (beans, rice, corn, pineapple, sugarcane) and permanent crops (rubber, oil palm, banana, coffee, fruit) today (Caquetá 2010). On the other hand, the use of wetland products is only of local importance, for subsistence and short-distance trade. Even fish on commercial markets is mostly obtained from other localities in the Colombian Amazon region as Puerto Leguízamo on the Putumayo River (Içá river in Brazil) (Agudelo et al. 2006; Agudelo et al. 2011). This lack of valorization diminishes traditional cultural knowledge and makes the wetlands vulnerable to large-scale exploitation projects. A specific land-use concern for the natural ecosystems arises from current developments in mining and oil palm production. The stakeholders are well aware of this imminent threat, but feel helpless as they are facing a large group of lobbyists. Our analysis on the stakeholders, institutions, and legal aspects in the context of this study have shown that (i) local communities have only very limited credibility and trust into public institutions dealing with environmental issues, (ii) there is a considerable set of laws for protecting the wetlands but the laws are not enforced adequately, (iii) there is an increasing interest of national and international organizations on the Amazonian Piedmont, but these projects are still in an early phase and do not yet have the environmental and socioeconomic impacts feared by the local communities.

We also observed that most of the anthropogenic conversion has occurred in the rapidly growing rural–urban transition zones. Cities in the Amazonian Piedmont are growing without or with hardly any urban planning, resulting in major impacts on the ecological status of the wetlands in the rural–urban zones. Above all, riparian wetlands and oxbow lakes have been drained and filled to build settlements and in many cases they act as solid waste landfills. Apart from the purely ecological effects, wetland destruction in the outskirts and inside cities also leads to social degradation. The pattern observed in our study, for example in the municipalities of Florencia and Morelia, is representative of a worldwide phenomenon. Wetlands and riparian areas of streams in growing cities of developing countries tend to be "marginalized" in terms of urban planning in a double sense: humid areas are not correctly integrated into the planning of the bulk of urban area and become neglected. This makes them attractive for the social groups that are marginalized by the society, i.e. poor and unskilled people replace the traditional, knowledgeable riparian and wetland settlers, a phenomenon that is causing social, environmental and public healthcare problems at the same time. Classically, urban administrations react to this problem by regularly demolishing the slum colonization, urging the marginalized people to move along with the expanding urbanization frontier, and so on. Urban planning concepts that integrate the traditional knowledge for the sustainable use and the maintenance of the cultural and biological diversity of wetlands in urban zones are urgently needed to end this vicious circle.

Considerations for sustainable management

In a period of dwindling biodiversity, all efforts need to be combined to develop concepts for the coexistence of man and biota. The concept of full exclusion of human use of natural resources is hardly feasible in large and remote areas, as enforcement of e.g. National Park rules is hampered by the lack of personnel. On the other hand, the pressure on the last remaining natural areas is increasing every day due to the local and global demographic and economic development, which may make the exploitation of a given resource economically feasible when interests are increasing. Although wetlands are clearly of great importance, we consider that their role in the regional livelihood strategies and in the land use plans has been largely ignored. Thus we argue for a landscape approach, which might help to optimize decision making in and management of these ecosystems by identifying and prioritizing wetlands for conservation and restoration, as well as the appropriated livelihoods for their sustainable use towards the reduction of poverty and the restoration of the ecosystem services flows. As more innovative and sustainable alternatives are developed from the wetland resources, the diversification of the regional livelihoods is greater and the inhabitants can create alternative livelihoods, enabling them to change their career as day-laborer on cattle ranches and improve their quality of life.

In some cases, participatory decisions are taken among the local population, e.g. for tree logging. Decisions are taken jointly, which tree should be selected for logging, and which ones should be preserved for a future moment, e.g. after trees have sufficiently reproduced. In the studied communities, participatory approach has not yet been fixed into written rules, as it is the case as e.g. in the Mamirauá reserve (Koziell and Inoue 2006). However, the access to the natural resources in some areas of the Amazonia in Colombia is restricted by the armed groups outside the law (C. L. Sánchez, Bogotá, pers. comm.). It is necessary to create cooperatives or strengthen the already existing ones (for example the fishing cooperatives), to replace the current predominant livestock and monocultures in the area of converted wetlands, and to promote the empowerment of the local communities in different ways through the natural resources.

As a conclusion to this case study we emphasize the importance of managing the Amazonian Piedmont in Colombia, and other regions of the Tropics with similar socio-economic constraints, from a wetland perspective. This implies restoring wetland connectivity through the improvement of the wetland vegetation and water quality, by linking or considering wetlands as a stepping stones for wildlife, by resizing of protected buffer's wide according to streams orders, and by recovering the importance of the wetlands in local livelihood strategies. To achieve this goal, one has to distinguish between already known management elements, e.g. legal enforcement of the existing protective laws, specifically in the context of large land conversion projects and to promote environmental education and research to draw from our knowledge considering e.g. an economic assessment of the livelihoods and ecosystem services obtained from wetlands, options for bio-trade, a detailed assessment of the main drivers of change to wetland condition, and more detailed ecological and biodiversity studies in the Amazonian Piedmont.

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Appendix 1

See Table 3.

Appendix 2

See Table 4.

Table 3 List of plants reported by the participants at the workshops

Name	Species	Common name	Use
Acanthaceae	*Trichanthera gigantea* (H. & B.) Nees.	Nacedero	Fodder, reforestation, stream protection
Arecaceae	*Alaeis guineensis* Jacq.	Palma africana	Food, ornamental
	Bactris spp.	Chontaduro	Food
	Cocos nucifera L.	Palma coco	Food
	Desmoncus giganteus	Palma chontillo	Medicine
	Euterpe precatoria Mart.	Palmicha	Handicraft
	Iriartea deltoidea Ruiz & Pav.	Palma bombona	Ornamental
	Mauritia flexuosa L.f.	Canangucha	Construction material, food, fodder
	Oenocarpus bataua Mart	Palma milpesos	Construction material, fodder, handicraft, medicine
Bignoniaceae	*Crescencia cujete* L.	Totumo	Handicraft
Brassicaceae	*Nasturtium* sp.	Berro	Medicine
Bromeliaceae	*Fascicularia* sp.	Chupalla	Ornamental
Caricaceae	*Carica papaya* L.	Papayo	Food
Crassulaceae	*Kalanchoe pinnata* (Lam.) Pers.	Hoja santa	Medicine
Cyatheaceae	*Cyathea microdunta*	Palma boba	Medicine
Cyperaceae	*Lagenocarpus guianensis* Lind. & Nees	Cortadera	Medicine
Fabaceae	*Andira* sp.	Cobre	Medicine
	Gliricidia sepium	Mataratón	Medicine
	Mimosa spp.	Dormidera	Medicine
	Zygia latifolia (L.) Fawc. & Rendle	Carbon	Reforestation, stream protection
Heliconiaceae	*Heliconia* sp.	Platanillo	Ornamental
Juncaceae	*Juncus* sp.	Junco	Handicraft
Lamiaceae	*Hyptis* sp.	Suelda con suelda	Medicine
Marantaceae	*Ischnosiphon arouma* (Aubl.) Körn	Guaruma	Ornamental
Melastomataceae	*Arthrostemma volubile* Triana	Cañagria	Medicine
	Miconia sp.	Pepito	Medicine
Passifloraceae	*Passiflora* sp.	Badea	Food
Piperaceae	*Piper* sp.	Cordoncillo	Medicine

Table 3 continued

Name	Species	Common name	Use
Poaceae	*Axonopus micay*	Pasto micay	Fodder
	Axonopus scoparius	Pasto imperial	Fodder
	Brachiaria decumbens	Pasto braquiaria	Fodder
	Brachiaria humidicola	Pasto umedicula	Fodder
	Cynodon sp.	Pasto estrella	Fodder
	Echinochloa sp.	Pasto aleman	Fodder
	Guadua sp.	Guadua	Construction material, handicraft
	Homolepis aturensis	Pasto guadilla	Fodder
	Hyparrhenia rufa	Pasto puntero	Fodder
	Oryza sp.	Pasto arroz	Fodder
	Paspalum notatum	Pasto grama dulce	Fodder
	Pennisetum purpureum	Pasto elefante	Fodder
Pontederiaceae	*Eichhornia* sp.	Buchon, Lirio	Fodder, handicraft
Tiliaceae	*Heliocarpus americanus L*	Balso	Construction material
Urticaceae	*Cecropia* sp.	Yarumo	Food, medicine
	Urera baccifera (L.) Gaudich. ex Wedd.	Pringamosa	Medicine

Table 4 List of the animals reported by the participants at the workshops

Class	Family	Species	Common name	Use
Amphibians	Bufonidae	*Rhinella marinus*	Sapo	Indirect use
	Leptodactylidae	*Leptodactylus pentadactylus*	Rana	Indirect use
Birds	Accipitridae	*Buteo magnirostris*	Aguila	Indirect use
	Alcedinidae	*Chloroceryle torquata*	Martín pescador	Indirect use
	Anatidae	*Dendrocygna autumnalis*	Patos de laguna	Indirect use
		Oxyura dominica	Pato caracolero	Indirect use
	Anhimidae	*Anhima cornuta*	Buitre	Indirect use
	Ardeidae	*Bubulcus ibis*	Garza blanca	Indirect use
		Nycticorax nycticorax	Guacó	Indirect use
	Boconidae	*Brachygalba lugubris*	Picón	Indirect use
	Caprimulgidae	*Caprimulgus nigrescens*	Gallina ciega	Indirect use
	Cathartidae	*Coragips atratus*	Chulo	Indirect use
	Columbidae	*Columbina talpacoti*	Torcaza, Tórtola	Subsistence
	Corvidae	*Cyanocorax violaceus*	Algodón	Indirect use
	Cotingidae	*Caphalopterus penduliger*	Toropisco	Indirect use
	Cracidae	*Ortalis motmot*	Guacharaca	Subsistence
		Penelope perpicax	Pava tarro	Subsistence
	Cuculidae	*Crotophaga ani*	Garrapatero, Jiriguelo	Indirect use
	Falconidae	*Daptrius ater*	Cacambra	Indirect use
		Milvago chimachima	Gavilán	Indirect use
	Hirundinidae	*Atticora fasciata*	Golondrina	Indirect use
	Icteridae	*Cacicus cela*	Toche, Tominejo	Indirect use
		Hypopyrrhus pyrohypogaster	Toche	Indirect use
		Icterus chrysater	Curillo	Indirect use
		Molothrus bonarensis	Cuervo, Chamón	Indirect use
		Psarocolius angustifrons	Mochilero	Indirect use
		Psarocolius decumanus	Cudillo	Indirect use
	Laridae	*Sterna superciliaris*	Gaviota	Indirect use
	Opisthocomidae	*Opisthocomus hoazin*	Pava, Pava edionda	Indirect use
	Pandionidae	*Pandion haliaetus*	Aguila	Indirect use
	Picidae	*Melanerpes cruentatus*	Carpintero	Indirect use
	Psittacidae	*Amazona amazonica*	Cotorra	Ornamental
		Amazona farinosa	Lora real	Ornamental

Table 4 continued

Class	Family	Species	Common name	Use
		Amazona ochrocephala	Loro catarnica	Ornamental
		Ara severa	Guacamaya, Papagayo	Indirect use
		Brotogeris leucophthalmus	Loro comejenero	Commercial-Subsistence
		Pionites melanocephala	Patilico	Indirect use
	Rallidae	*Aramides wolfi*	Chilacos	Indirect use
		Porphyrio martinica	Gallo de laguna, Gallienta	Subsistence
	Strigidae	*Glaucidium* sp.	Buho	Indirect use
	Thraupidae	*Paraoria gularis*	Cardenal	Indirect use
		Thraupis episcopus	Azulejo	Indirect use
	Threskiornithidae	*Eudocimus ruber*	Garza roja, vaquera, corocora	Indirect use
		Phimosus infuscatus	Ibis	Indirect use
	Tinamidea	*Tinamus* sp.	Panguana	Subsistence
	Trochillidae	*Anthracotorax nigricollis*	Colibrí	Indirect use
	Trogloditidae	*Troglodites aedon*	Cucarachero	Indirect use
	Turdidae	*Turdus ignobilis*	Embarrador	Indirect use
	Tyrannidea	*Myarchus* sp.	Toreador	Indirect use
		Pitangus sulfuratus	Pitojuice, Pitufi	Indirect use
	Tytonidea	*Tyto alba*	Lechuza	Indirect use
Fishes	Anostomidae	*Schizodon* sp.[a]	Cheo	Commercial-Subsistence
	Apteronotidae	*Apteronotus* sp.	Caloche	Subsistence
	Characidae	*Astyanax* sp.	Sardina	Subsistence
		Brycon sp.[a]	Sábalo	Commercial-Subsistence
		Mylossoma sp.[a]	Garopa, Palometa	Commercial-Subsistence
		Piaractus sp.[a]	Cachama	Commercial-Subsistence
		Serrasalmus sp.[a]	Piraña	Commercial-Subsistence
		Salminus sp.[a]	Dorada	Commercial-Subsistence
	Cichlidae	*Bujurquina* sp.	Jacho	Commercial-Subsistence
		Cichlasoma sp.[a]	Mojarra	Commercial-Subsistence
		Crenicichla sp.[a]	Botello	Commercial-Subsistence
		Satanoperca sp.[a]	Juan viejo	Commercial-Subsistence
	Ctenoluciidae	*Boulengerella* sp.	Aguja	Commercial
	Curimatidae	*Prochilodus* sp.[a]	Bocachico	Commercial-Subsistence
	Electrophoridae	*Electrophorus electricus*	Temblón	Subsistence

Table 4 continued

Class	Family	Species	Common name	Use
	Erythrinidae	*Hoplerythrinus* sp.	Guaraja	Commercial-Subsistence
		Hoplias sp.[a]	Dentón	Commercial-Subsistence
	Loricariidae	*Glyptoperichthys* sp.	Corroncho	Subsistence
		Hypostomus sp.[a]	Cucha	Commercial-Subsistence
		Pterygoplichthys sp.[a]	Zapatero	Commercial
	Parodontidae	*Parodon* sp.	Corunta	Commercial-Subsistence
	Pimelodidae	*Calophysus macropterus*[a]	Simí	Commercial-Subsistence
		Pseudoplatystoma sp.[a]	Pintadillo	Commercial-Subsistence
		Leiarius sp.[a]	Barbudo	Commercial-Subsistence
		Pimelodus sp.[a]	Nicuro	Commercial-Subsistence
		Zungaro zungaro[a]	Pejesapo	Subsistence
	Potamotrygonidae	*Potamotrygon* sp.[a]	Raya	Subsistence
	Salmonidae	*Oncorhynchus* sp.[a]*introducida*	Trucha	Subsistence
	Sciaenidae	*Pachyrus* sp.[a]	Burra	Subsistence
		Plagioscion sp.[a]	Curvinata	Subsistence
	Synbranchidae	*Synbranchus* sp.	Guyumbo	Commercial
	Trichomycteridae	*Trichomycterus* sp.	Chillona	Commercial-Subsistence
Mammals	Agoutidae	*Agouti paca*	Boruga	Commercial-Subsistence
	Atelide	*Lagothrix lagotricha*	Mono bombo	Subsistence
	Bradypodidae	*Bradypus variegatus*	Oso perezoso	Indirect use
	Callitrichidae	*Mico* sp.	Mico	Subsistence
	Canidae	*Cerdocyon thous*	Perro de monte, Zorro	Indirect use
	Caviidae	*Hydrochoerus hydrochaeris*	Chigüiro	Commercial-Subsistence
	Cebidae	*Saimiri sciureus*	Mico chichico	Indirect use
		Sapajus apella	Mico maicero	Indirect use
	Cervidae	*Odocoileus virginianus*	Venado	Subsistence
	Characidae	*Sciurus granatensis*	Ardilla	Indirect use
	Dasypodidae	*Dasypus novencintus*	Armadillo, Gurre	Commercial-Subsistence
	Dasyproctidae	*Dasyprocta fuliginosa*	Guara	Commercial-Subsistence
		Myoprocta sp.	Tintín	Commercial-Subsistence
	Didelphidae	*Didelphis marsupialis*	Chucha	Subsistence
	Echimyidae	*Proechimys* sp.	Rata	Indirect use
	Erethizontidae	*Coendou prehensilis*	Puercoespin	Subsistence

Table 4 continued

Class	Family	Species	Common name	Use
	Felidae	*Leopardus pardalis aequatorialis*	Tigrillo	Commercial
	Leporidae	*Sylvilagus brasiliensis*	Conejo	Commercial-Subsistence
	Mustelidae	*Eira barbara*	Comadreja	Indirect use
		Pteronura brasiliensis	Nutria	Indirect use
	Mymecophagidae	*Myrmecophaga tridactyla*	Oso hormiguero	Indirect use
	Phyllostomidae	*Artibeus* sp.	Murcielago	Indirect use
	Pitheciidae	*Pitheca monachus*	Mico volador	Indirect use
	Sciuridae	*Sciurus granatensis*	Ardilla	Indirect use
	Tayassuidae	*Tayassu pecari*	Cerrillo	Subsistence
Reptiles	Aniliidae	*Anilius scytale*	Serpiente coral	Commercial
	Bobidae	*Boa constrictor*	Guio	Commercial
	Colubridae	*Clelia clelia*	Cazadora	Indirect use
		Helicops angulatus	Sepiente canangucha	Indirect use
		Oxybelis aeneus	Serpiente bejuca	Indirect use
	Crocodylidae	*Caiman crocodylus*	Babilla	Commercial-Subsistence
	Iguanidae	*Iguana iguana*	Iguana	Subsistence
	Podocnemididae	*Podocnemis expansa*	Tortuga charapa	Subsistence
	Polychrotidae	*Anolis* sp.	Lagartija	Indirect use
	Testudinidae	*Chelonoidis denticulata*	Tortuga morrocoy	Commercial-Subsistence
	Viperidae	*Bothrops atrox*	Pelo de gato	Indirect use
		Bothrops lineatuus	Serpiente voladora	Indirect use
		Bothrops sp.	Serpiente cabeza de candado	Indirect use
		Lachesis sp.	Serpiente verrugosa	Indirect use

[a] Economically important fish species in the region

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