PREFACE

My role in the Project was to think of a particular topic that interested me and that I wanted to develop further for my professional career. I chose Conservation in Private Protected Areas. Then I had to think of original ideas for a research project, which contributed in an innovative way for biodiversity conservation in my country. Later I discussed the idea with my supervisor, created a draft of the project proposal, and went to the field in Colombia. While I was there, I restructured the project, collected secondary data from NGOs, and went to the field in order to collect the necessary data.

My main problems were the acquisition of secondary data from the government and NGOs, and learning how to use the Geographic Information Systems Arc Gis, because I did not feel confident with the little knowledge that I acquired in the Keys Skills lessons.

Biological Conservation

I chose Biological Conservation because the topic I selected, the Convention on Biological Diversity Target Achievement by Protected Areas, has a global relevance that goes beyond my study area. Furthermore I believe the approach to my project is innovative, and its framework combines the science (Protected Areas) and practice of conservation (Management Effectiveness), and may have applications for future policies in my country. In addition, similar articles have been published in this journal.

The contribution of Private Nature Reserves to the Convention on Biological Diversity target for ecosystem representation in the Colombian Llanos Ecoregion.

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Abstract

Statutory Conservation Areas (SCAs) play a vital role in achieving the Convention on Biological Biodiversity's (CBD) goal of effectively conserving 10% of all ecological regions. However, complementary strategies such as Private Nature Reserves (PNRs) and Indigenous Reservations (IRs) may also contribute significantly towards achieving this target. Focussing on the Llanos Ecoregion in Colombia, the research presented here investigates if SCAs can exclusively achieve this target at an area level, if this coverage provides a comprehensive ecosystem representation, and to what extent conservation categories such as PNRs and IRs may contribute towards these objectives. Using a rapid management effectiveness methodology, the research also assesses the effectiveness of PNRs. The research shows that SCAs cover 6.11% of the ecoregion but provide the target 10% coverage for only 22 of the 100 ecosystems present, and therefore are not enough to achieve the CBD target. However, when PNRs and IRs are included, 10% coverage is achieved for 55 of the ecosystems. PNRs seem to be "filling the gaps" to some extent in terms of ecosystem representation despite their small extension of 0.35%. The research also demonstrates that PNRs have been managed effectively and that a wider focus is needed to analyze the real contribution of PNRs to biodiversity conservation and for the support of local livelihoods. This research suggests that private land conservation deserves greater attention from government bodies and funding institution.

Key words: Convention on Biological Diversity, Orinoco Basin, Llanos Ecoregion, Private Nature Reserves, Ecosystem Coverage, Effectiveness.

Introduction

In 1992 the Convention on Biological Diversity (CBD) was signed, and later, in 2002, the Conference of the Parties of the set the target of 10% of each of the world's ecological regions being effectively conserved by 2010 (CBD-COP7 Decision V11/30). Since 2002, the use of statutory conservation areas (SCA) has been a key strategy in mitigating the worldwide biodiversity crisis - approximately 12% of the global land surface is in protected areas (Chape et al. 2005). However, less than half of these SCAs are managed primarily for biodiversity conservation and a more realistic estimate of area coverage for conservation is 5.1% (Hoekstra et al. 2005). Despite efforts to establish protected areas over the last few decades the global protected-area network (GPN) has significant gaps and is far from reaching its goal of comprehensively conserving biodiversity (Brooks et al. 2008; Rodrigues et al. 2004). In addition, the financial resources currently available are insufficient to meet the needs of many SCAs, particularly in the developing world (Bruner et al. 2004). An average operating budget for parks that only supplies 30% of their budgetary needs (James et al. 2001) leads to inadequate staff, equipment, and other management necessities (IUCN 2004). This contributes to the loss and degradation of important natural resources, as it limits both the coverage and the management effectiveness of established protected areas and therefore their ability to accomplish their stated conservation objectives (Bruner et al. 2004). Furthermore, the exponential expansion of the protected area system since the signature of the CBD has outpaced institutional and financial capacity for actual government management in developing countries (Bruner et al. 2004).

Meanwhile, land use change outpaces conservation at alarming rates and is a key driver in biodiversity loss Millennium Ecosystem Assessment (MA)(2005). One third of the world's land has already been turned over to agriculture or urbanised, and projections suggest that a second third could be lost within the next 100 years (Wood et al. 2000). The exponential growth of anthropogenic activities has transformed ecosystems into fragmented, semi-natural landscapes (Ochoa-Ochoa et al. 2009), disrupting natural biological pathways for plant and animal dispersal outside the limits of SCAs (Becker et al. 2007).

It is clear that the current network of global protected areas is insufficient to safeguard the world's biodiversity (Brooks et al. 2008; Rodrigues et al. 2004) and that it is therefore necessary that these areas be complemented with alternative conservation strategies (Gallo et al. 2009; Lindenmayer 2002). Recently, several calls have been made to recognize social initiatives such as Private Nature Reserves (PNRs) and Indigenous Reservations (IRs) to land conservation as a crucial element in conservation for an important number of species not protected by governmental in SCAs(Ochoa-Ochoa et al. 2009) and for their contribution to the creation of a more comprehensive Global Protected area Network (GPN) (CBD (2006b)).

The extension of protected areas and the percentage of area coverage are recognized indicators in measuring progress towards the CBD target. However, these indicators may provide only superficial information about the political commitment of the countries, and fail to measure whether protected areas are effectively achieving the conservation objectives that created them (Chape et al. 2005). Instead, the following indicators have been proposed to measure real progress towards the achievement of CBD goals. (i) Effectiveness of coverage: how much and what biodiversity is included within protected areas? (ii) Effectiveness in achieving conservation objectives: are protected areas being managed effectively? (Chape et al. 2005).

Recently worldwide protected area coverage and effectiveness assessments have been carried out to assess real progress toward the CBD target. For example, currently Colombia is assessing its national system of protected areas at a system level and reports that approximately 13.21% of land is under some form of protection, which reaches the CBD goal at least at a national level (Vásquez et al. 2009). However, despite efforts by the Colombian government to create a representative system of protected areas in all ecoregions, some remain under-represented in the national system of protected areas (SINAP) (Romero et al. 2008).

The aims of this paper are to determine whether the SCAs are achieving the CBD target in terms of area coverage in one of Colombia's ecoregions and whether this achievement will also provide adequate coverage at the ecosystem level. It also investigates to what extent PNRs and IRs can complement SCAs, and how effectively PNRs have been managed to achieve their objectives. The study system is the Llanos Ecoregion, geographically part of the Orinoco Basin, a region with an area of 991.587 km^2 shared between Colombia and Venezuela (35% and 65% respectively)(Correa et al. 2005). The basin is recognized as one of the eight strategic ecosystems for humanity (WWF 2010).

Despite its importance, to date there has been no study in the Llanos Ecoregion to assess the ecosystem coverage given by all categories of protected areas, including PNRs (officially and not officially recognized) and IRs. There has also been no assessment of the overall extent of complementarity between different categories of protected areas, and whether this complementarity contributes toward achieving the CBD 10% target. This is the first time that the role of PNRs and their contribution to the Colombian National System of Protected Areas is analyzed.

Methods

Study area

Colombia occupies the north-western limit of South America between 12°26′46 N, 4°13′30 S, 66°50′54 E and 79°02′33 W. It has an area of approximately 1,142,000 km2 and is a geographically diverse country. The western part is mostly mountainous as the northern South American Andes subdivide into three mountain ranges (Armenteras et al. 2009) "The Llanos" Ecoregion is situated in the North eastern part which comprises mostly plains which are below 500 m elevation, and covers an area of 188,349 km^2

(18,834,900 ha). It is bordered by the Guayabero and the Guaviare rivers in the south, the Andes in the west, and the Arauca, the Capanaparo and the Meta rivers in the northwest and the Orinoco river in the east (Correa et al. 2005) (Fig. 1).

Vegetation types found in the Llanos Ecoregion include a wide variety of savannas, gallery forests, seasonal swamp forest, “morichales" characterized by the presence of the palm *Mauritia flexuosa,* the Orinoco "vegas" (evergreen forests of 8 to 20 m canopy height), and drier forest with semi deciduous trees with a well-developed understory (WWF and McGinley 2007). On average, the mean annual temperature is 27°C, with lows in June, July, December and January, and highs in March and April, but the differences between the coldest and hottest months are very small (2°C). In contrast, daily differences range from 13°C to 17°C (WWF and McGinley 2007).

The Colombian Llanos ecoregión is less diverse and has fewer endemic species than adjacent ecoregions such as the Andes and Amazonia(Rangel et al. 1995). Most biodiversity is found in the forests, although an important system of wetlands that expands considerably in the rainy season also contributes significantly to resident and temporary fauna such as migratory birds (WWF and McGinley 2007). Today less than 4% of the Colombian population (1,712,454 inhabitants), lives in this ecoregion, mainly farmers, settlers and indigenous populations(Correa et al. 2005). This last group, mainly located in Indigenous Reservations is estimated to include approximately 57,000 inhabitants representing 14% of the total Colombian indigenous population(Correa et al. 2005).

The Llanos ecoregion is relatively unaffected by anthropogenic activities, despite being transformed since prehispanic times, first with the extraction of gold and later by settlement and economic development such as cattle raising, which remains one of the principal activities in the area (Correa et al. 2005). However in recent years activities mainly related to the extraction of natural resources have become relevant in the ecoregion: deforestation, the illegal fauna trade, illegal crops, agriculture, biofuel industries and oil extraction(WWF and McGinley 2007). Currently the ecoregion is recognized to have great potential for oil extraction, and this activity is increasing significantly(Andrade et al. 2010). These activities severely threaten the biodiversity and water basins of the ecoregion(Correa et al. 2005).

Complementarity

To evaluate the extent of complementarity in ecosystem representation between Statutory Conservation Areas (SCAs), Private Nature Reserves (PNRs) and Indigenous Reservations (IRs), I collected Geographic information on protected areas from several official UAESPNN(2009b) and non governmental organizations RESNATUR (2006a), FNH-Nodo Orinoquia (2010b) . For those PNRs with no information I either digitized from mainly hand drawn maps on 1:50,000 maps, or created the polygons based on Global Positioning System (GPS) points provided by external sources. When the official maps were too old or inaccurate I visited the PNRs and the site boundaries were georeferenced using a GPS.

Other sources of information, such as the Ecosystems map of Colombia IAvH-IGAC (2004), Indigenous ReservationS of Colombia, were added to create a GIS database, that for the first time includes 99.5% of all the categories of officially recognized protected areas and not officially recognized PNRs as well as IRs. All the spatial analyses were performed using GIS package ArcGIS (ESRI).

For the purposes of this paper, 10% area coverage is denominated as the conservation target, based on the (CBD 2010) First, I calculated the area and percentage of coverage in the Llanos ecoregion by the three main protected area types (SCAs, IRs and PNRs). I then calculated the total area of each of the 100 Ecosystem Classes which occur in the Llanos Ecoregion according to the Ecosystems of Colombia map , and overlaid the layers of protected areas and ecosystem classes to calculate the area coverage of each ecosystem type by each protected area type.

To evaluate ecosystem complementarity I used three methods. For evaluating complementarity in terms of ecosystem extension, I calculated the total percentage area protected, and the ecosystem percentage covered by each type of conservation category (SCAs, PNRs and IRs). I analyzed the percentages of ecosystem coverage by each category with respect to coverage in total and by the other categories using Spearman's correlations. Negative correlation indicates that the two categories were conserving different types of ecosystem, which I defined as complementarity. Significant positive correlations would indicate a lack of complementarity (i.e. the different protected area types were conserving the same ecosystem types). All the statistical analyses were carried out using SPSS (SPSS Inc Chicago, IL).

I also evaluated which of the ecosystem types were achieving the CBD target of 10% coverage exclusively in one of the different categories of protected areas, and which achieved 10% coverage thanks to contributions from more than one of the three protected area categories.

For further assessment of complementarity in ecosystem classes I first divided the 100 types of ecosystems present in the study area into 5 classes: Agroecosystems, Forests, Savannas, Wetlands and Water bodies. The ecosystem types that were difficult to classify in one category were set as "Others". To indicate to what extent PNRs and IRs complemented SCAs in the classes mentioned above I first calculated complementarity metrics of each class, as proposed by Gallo (2009).

$$\text{Complementarity metric of a class} = Mc = \frac{((Pc * R) - Sc)}{((Pc * R) + Sc)}$$

Where Pc = the percentage of the ecosystem class conserved by PNRs; R = the total area of SCAs in the region divided by that of PNRs; Sc = the percentage of the class conserved by SCAs. I used the same complementarity metric class formula for IRs. In this case all the values in the formula indicate as Pc, were change to Pi = the percentage of the ecosystem class conserved by IRs.

If the percentage of the ecosystem class (e.g. Savannas) conserved by SCAs divided by the percentage of the class conserved by PNRs was the same as R, then Complementarity metric class Mc = 0. But if there was one and a halftimes as much Savannas in PNRs as would be expected by the regional ratio of R, then Mc = 0.2. I used this arbitrary threshold of one and a half times as a guideline to indicate the classes in which PNRs or IRs strongly complemented SCAs

Effectiveness of Private Nature Reserves

I reviewed the principal methodologies that have been used lately worldwide and in Latin America (especially Colombia), to assess the management effectiveness of protected areas. Evaluations have been made using a wide variety of methodologies; most of them using the International Union for Conservation of Nature (IUCN) World commission of protected areas Protected area management Effectiveness Framework (Hocking et al. 2000). For this research I also interviewed local experts in protected area management effectiveness assessment, as well as PNRs owners, to ensure that the assessment included a comprehensive set of accepted indicators and criteria of effectiveness.

Drawing on the IUCN (Hocking et al. 2000) framework and the Colombian management effectiveness assessment AEMAPPS (2009a) the methodology proposed by (Mayorquin et al.) was modified for this research.

Taking the principle that "*Private Nature Reserves are effective if they contribute to the maintenance or recuperation of the natural capital, if they are financially viable and if they contribute to the construction of social fabric"*, a set of criteria was drawn up to assess reserve effectiveness .The five criteria and their associated indicators which contributed to overall management effectiveness scores were:

BIODIVERSITY - The strategic importance of the reserve to contribute to the maintenance and enhancement of biodiversity at local and landscape scales. Indicators related: i) the connectivity of the reserve to natural areas; ii) the biological importance of the reserve; iii) the perceived resilience and management measures in place in the reserve against threats to its objectives and other objectives.

PRODUCTIVE CAPITAL – Financial capacity for biodiversity conservation and sustaining local livelihoods. Indicators related: i) financial sustainability of the reserve; ii) funding strategies; iii) compatibility of financial productivity with conservation objectives of the reserve; iv) self-sufficiency of the reserve to provide food security.

ECOSYSTEM SERVICES – The capacity of the reserve to provide benefits to biodiversity and human welfare: reserve owners were asked to list the extent and to whom the reserve provided ecosystem services following the classification by (Mertz et al. 2007) i) provision, ii) regulation, iii) cultural and iv) supporting ecosystem services

GOVERNABILITY – Capacity for successful management of the reserve due to its management capacity and planning tools : Owners were asked to assess the extent to which reserve management and planning was. Indicators related: i) Governable within the reserve, ii) Capable of contributing towards a collective local/regional conservation impact , iii) Recognised in its surroundings iv) Coherent with the reserve's objectives, iv) Able to transcend constraints to achieve the reserve's objectives vi) Monitored with respect to reserve's objectives

VISIBILITY – Recognition of the reserve by official bodies: i) Local Government recognition; ii) Recognition by environmental authorities.

To implement the rapid management effectiveness assessment methodology for PNRs I contacted their owners and they were invited to participate in this research. The owners that were selected were those who after first contact, participated in one of the three workshops on PNRs management held in the cities of Puerto Carreño, San Martín or Bogotá. Also if an owner could not attend any of the workshops but expressed an interest in participation, they were visited directly in the PNRs. Two of the PNRs in the Arauca state were dismissed due to illegal conflicts in the area. The number of PNRs taking part in the survey were (14) and constituted alsoa representative geographic sample of PNRs in the ecoregion. Only one of them (7%) was subscribed to the official government agency (UAESPNN) while the remaining 13 (93%) were instead subscribed to Private Nature Reserves Association Network (RESNATUR) which is officially recognized as an articulation organization, Resolucion 0185(2008).

Prior to starting the reserve effectiveness interview, reserve owners received a 10 to 15 minute presentation on the research, the objectives and the effectiveness of protected areas in general. They were also told that the interview would be confidential and that their identities would not be revealed or discernable. The implementation of the methodology lasted between 1 to 3 hours and consisted of a questionnaire of general information, with a first set of open basic questions followed by the questions for the different criteria used as indicators. Open questions were also included due to the gaps of available information for PNRs in Colombia. For the PNRs that were visited I toured the reserves and did semi-structural interviews for a more informed understanding of the issues covered in the methodology

To confirm the findings of the methodology I reviewed key documents (such as PNRs brochures and management plans) and other relevant information (e.g., photos, inventories) to help validate my interview and observation data. I then quantified the information provided by the landowners or managers of the PNRs. Since each criterion has a different number of indicators I transformed the data, so all criteria ended with a maximum weight of 3 with a maximum total of 15 when all the criteria were added. For PNRs where the criterion were not applicable (e.g. Productive Capital) I scored them as “No answer” and were ranked as 1.5. To measure the level of management effectiveness I added all the criteria and created a scale of success for management effectiveness (Table 1). The data were analyzed through descriptive statistics, and using ranked correlations to see the relation between the different criteria.

RESULTS

Complementarity

The remaining natural and seminatural ecosystems represent 77.7% of the area in the Llanos Ecoregion (14,635,835 has). SCAs covered 6.11%, PNRs 0.35% and IRs 7.88% of the Llanos Ecoregion, giving a total area coverage of 14.34%. SCAs alone represent 58 types of ecosystems to some degree and met the conservation target for only 22%. PNRs represent 40 different ecosystems to some degree but only met the conservation target for 1% of them. IRs represents 71 ecosystems to some degree and met the conservation target for 34% of them.

When PNRs were considered the number of ecosystems that went from having no protection from SCAs to having some degree of protection improved by 9%, and 1% met the conservation target. If IRs were also included, the number of ecosystems having some degree of protection improved by 25%, and a further 32% met the conservation target. Hence, including all three types of protected area met the conservation target for 55% of the ecosystems in the ecoregion, more than double the original conservation target achievement by SCAs alone.

Overall, there was no evidence for complementarity in the percentage coverage of eco systems by SCAs and by PNRs (Spearman's ρ= 0.052 df= 82, p= 0.642). There was marginal complementarity between the percentage of ecosystems covered by IRs and PNRs (ρ=-0.105, df=82, p= 0.305), and IRs and SCAs (ρ= -0.086, df= 82, p= 0.305) but in both cases this was not significant. The ecosystems with larger extension had significantly less coverage from protected areas overall (ρ=-0.219, df= 82, p= 0.047) but a significantly greater coverage by PNRs (ρ= 0.541, df= 82, p< 0.001). In addition, there was marginal evidence of Complementarity in PNRs percentage coverage compared with combined coverage by SCAs and IR (ρ= -0.197, df= 82, *p*= 0.075).

For evaluating complementarity between the different ecosystem classes towards the conservation target, IRs was the category that met the 10% conservation target exclusively for the overall total and for most of the ecosystem classes with the exception of Agroecosystems. SCAs met the conservation target entirely for relatively few ecosystem classes, followed by PNRs (Fig. 2)

For complementarity in ecosystem classes there was strong complementarity by IRs in the Savannas ecosystems (Complementarity metric class (Mc=0,4) and in Others ecosystems (Mc=0.36)(Table. 2).

Management Effectiveness

The number of PNRs analysed using the methodology proposed were 14 and they represented about 39% of all contactable officially and non officially recognized PNRs in the study area (n=36).

According to the scale of valuation proposed in the methodology (Table. 1), twelve (86%) of the reserves were managed at least moderately successfully, with eight of them (57%) being successful to extremely successful. When I considered all the PNRs the average score was 8.7/15 and therefore moderately successful.

In the analysis of the PNRs scores per criterion I found that Productive Capital and Biodiversity (Spearman's ρ =0.125, df=13, P=0.003), Biodiversity and Governability (ρ =0.64, df=13, P=0.013), Productive Capital and Governability (ρ =0.761, df=13, P=0.002) and Ecosystems services and Governability (ρ =0.54, df=13, P=0.047) were significantly related, this was also true for Biodiversity with Ecosystem services (ρ =2.417, df=13, p=0.016).

My results also showed in general PNRs provide most of the ecosystem services, in all categories (Fig. 4).

Discussion

This study focused on the area coverage and the effectiveness of protected areas as a means to achieve CBD targets for conservation in a relatively “intact” but threatened part of Colombia, the Llanos Ecoregion(WWF and McGinley 2007). I found evidence for an important role for private nature reserves (PNRs) and Indigenous Reservations (IRs) in complementing protected area coverage by statutory conservation areas (SCAs). I also found that a high proportion of PNRs in the region are managed effectively.

Area coverage and complementarity

Despite the remaining natural and seminatural ecosystems represent 77.7% of the area in the Llanos Ecoregion (14,635,835 has), these ecosystem may be indeed mostly “seminaturals”, which implies an ecosystem whose structure and function have been modified partly as result of human activities (Andrade et al. 2010).

The area coverage provided by Statutory Conservation Areas (SCAs) exclusively was just 6.11% of the total Llanos ecoregion, not enough to achieve the CBD target. In terms of area, Private Nature Reserves (PNRs) cover a small percentage (0.35%). Interestingly, if Indigenous Reservations (IRs) are included the area coverage doubled, reaching 14.35% and achieving the 10% target.

The ecosystem representation provided by SCAs exclusively is also not enough. Although they represent, to some degree, at least 58 of the ecosystems in the study area, the conservation target was only achieved for 22 of the total 100 ecosystems occurring in the region. If PNRs were added, target achievement increased for only one ecosystem type. However, if IRs were also included then the 10% target was achieved for 55% of the ecosystems present in the area.

Despite the small area and reduced contribution of PNRs towards target achievements, my results indicate that there is some complementarity in ecosystem representativeness, and that PNRs are filling the gaps left by SCAs coverage, representing, 10% of ecosystems absent of any SCAs coverage. This pattern may be explained by the initial design of Colombian National Parks, set to preserve sites of special ecological interest without aiming to comprehensively cover national ecosystems. Meanwhile, the PNRs network has been expanding, showing a willingness to conserve habitats despite the opportunity cost and regardless of the absence of effective incentives. This raises the question of how much more improved would be the network of PNRs if effective incentives were placed by the Colombian government.

Despite today we can not answer this question, The Llanos Ecoregion presents a perfect opportunity for test it in the future. Extensive territories owned by privates owners, is the ideal scenario for the creation of new PNRs and to strengthen the actual PNRs network through effectively managed incentives. This would increase the complementarity between PNRs and SCAs creating a more representative system at ecosystem level and saving the Colombian government from the acquisition costs of creating new SCAs, as has occurred in other parts of the globe(Pence et al. 2003).

Interestingly IRs represent, to some degree, 71% of the ecosystem types in the study area and display strong evidence of complementarity. My results suggest that in terms of overall ecosystem extension IRs present some complementarity with both SCAs and PNRs. Applying the complementarity metric class in the different ecosystem classes I showed significant evidence of complementarity for Savanna and Other ecosystems (Table .2), revealing the importance of IRs ecosystem coverage. When I analyzed the conservation target in ecosystem classes such as Forests IRs achieved exclusively the 10% coverage target for 30% of the ecosystems. Furthermore, when IRs were analyzed together with SCAs and PNRs, the target achievement number doubled the target provided by SCAs exclusively, increasing the numbers up to 55 ecosystems.

The area extension of IRs in the study area exceeds the area of SCAs. In Colombia IRs extension exceed by approximately 14 million hectares the actual 22,439,090 ha estimated for the National System of Protected areas SINAP (Vásquez and Serrano 2009). The number and extension of IRs have increased exponentially since in 1991 the Colombian Constitution was signed, which allowed indigenous people rights over their territories. Despite the important extension of IRs in the study area and other ecoregions in the country, the SINAP does not officially recognize IRs as a protected area category, although their important contribution to biodiversity conservation has been noted (Andrade and Ruiz 2009). The inclusion of IRs in national protected area systems is still not a measure usually adopted by governments, sometimes due also to the reluctance of Indigenous communities(Dudley 2008) .The important contribution that IRs may have for the future in addition to the extensive overlapping of IRs and SCAs in Colombia(Vásquez et al. 2009), requires a discussion of the possible inclusion of IRs that match the definition of "protected areas" in the Colombian National System of Protected Areas (SINAP).

Effectiveness of protected areas

Conserving the land by protected area designation is important, however the question remains whether the different categories of protected areas are being effectively managed. In fact CBD refers to effective conservation(CBD 2010), but this concept and its measurements are often ignored. The management effectiveness of SCAs in Colombia has been addressed by some studies(e.g. Armenteras et al. 2009).In this paper historical deforestation rates were analyzed suggesting that National Parks (i.e. SCAs designated and managed at a national level) and some IRs (at least at a national level) were an effective barrier to deforestation and suggesting that they can be effective ways of protecting the forests (Armenteras et al. 2009). Avoiding deforestation is an important signal that protected areas are having substantive results on land-use changes however, is not a conclusive test; biodiversity can be significantly compromised by invisible threats, such as hunting (Naughton-Treves et al. 2005) and some of these areas may be suffering from the "empty forest" syndrome (Redford

1992). Despite the importance of deforestation rates studies, the absence of local and regional SCAs in these kind of analysis (whose governance and effectiveness is more uncertain;(Vásquez et al. 2009))make it difficult to conclude the real effectiveness of the network of SCAs.

The real effectiveness of SCAs is linked to the historical process of creation of protected areas in Colombia. The lack of a clear regulation of the SINAP (just established in June 2010), produced a protected areas system with extensive categories of protected areas and each category with several different objectives. Some of these categories were questionable as suitable criteria for protected area designation (e.g. Soil conservation district, Productive forest reserve – each of which relate partly to human exploitation)(Vásquez et al. 2009). In addition, the declaration of protected areas (especially by local and regional authorities) without uniform and adequate regulation, and with the absence of allocation of resources and management plans has in many cases led to poorly managed or unmanaged protected areas (Vásquez et al. 2009) that can be denominated as "paper parks (Bonham et al. 2008)".

Effectiveness of conservation in private nature reserves

As with statutory protected areas, evaluating the importance of PNRs only on the basis of the number of hectares protected is a limited approach, and the effectiveness of management also needs to be considered (CBD 2010) This research suggests that in general PNRs are being effectively managed and are achieving their conservation objectives; 85% of PNRs were successful to some degree and 58% were extremely successful. On average the score was 8.7/15, ranked as moderately successful.

The results of the assessment of PNRs suggest that Productive capital and Governability are both positively related to the biodiversity criterion. It is logical that in many cases if more money is available for management and more planning measures are in place, then stakeholders do not need to extract natural resources and can focus more effectively on biodiversity conservation. Governability is positively correlated with ecosystem services, which may suggest that if correct planning is in place then the importance of the reserve for providing ecosystem services will be easily recognized. Interestingly, Visibility is neither related to Biodiversity nor to Productive Capital, suggesting that effective management can be achieved without formal government recognition. This result is important as in this research (13) of the 14 PNRs analyzed were in fact subscribed to Private Nature Reserves Association Network (RESNATUR) which is officially recognized as an articulation organization but not directly subscribed to the Colombian government.

Despite the fact that PNRs may not be achieving a full coverage of biodiversity in the study area, they provide a public function (Monteferri and Coll 2009) and may be providing important ecosystem services that support local livelihoods, not only of PNRs stakeholders but to local adjacent communities (e.g. Indigenous communities and towns). For example my results suggest that in general PNRs provide most of the ecosystem services, in all categories(Fig. 4.).

A valid criticism of these results may be that they overestimated the the ecological services in the area. To try to mitigate this uncertainty I asked for each of the Ecosystems services listed who would be the possible beneficiaries. This required the PNRs stakeholders to provide a more appropriate way of listing ecosystem services.

It is clear that the methodology used to assess effectiveness of PNRs may have limitations. The fact that this category of protected area allows sustainable production and biodiversity conservation make this task even more difficult(Peñuela 2009). I found that one of the main limitations was that some of the PNRs stakeholders were unaware of many of the issues approached by this methodology (e.g. threats and ecological services). Another important limitation was the insufficient knowledge of PNRs stakeholders to provide accurate information about their areas. Nevertheless, PNRs stakeholders provide significant traditional and local knowledge. To reduce some of these limitations further basic research and monitoring as well as capacity building for PNRs incentives are needed. More involvement by NGOs and government agencies, and closer interaction of the universities and research centres to provide adequate academic information will provide a more accurate information that will allow a better understanding of conservation in private lands. However this methodology is an attempt to develop a flexible tool with a more holistic view of the contribution toward biodiversity conservation and sustaining local livelihoods.

The role of PNRs for conservation

Even though my results reveal strong evidence of effective management of PNRs the question remains whether PNRs are able to contribute effectively to biodiversity conservation in the long term? A main criticism towards PNRs is that in general they generally tend to be too small and isolated and therefore they will not be able to provide sustainable protection for biodiversity (Sims-Castley et al. 2005). The Llanos Ecoregion presents an extensive range of PNR sizes from 2 ha to > 10.000 ha. In fact, even very small reserves can be the last possibility for many species populations as these areas can provide important connectivity (e.g. riparian corridors)in fragmented landscapes (Lima and Gascon 1999). This connectivity could reduce extinction rates, prevent inbreeding depression in isolated fragments, and be sufficient for species with limited spatial and temporal needs (e.g. migratory birds and plants) (Sims-Castley et al. 2005). Even if small reserves are not suitable for many species (e.g. top predators) (Laurance et al. 2002; Lees and Peres 2008; Michalski et al. 2006) and they could have indeed negative effects on some taxa (e.g. ecological traps, population sinks (Lees and Peres 2008), these corridors are preferable to no corridors at all (Lees and Peres 2008). Many forest species have low tolerance to open habitats, and the absence of these connections could lead to the depletion of local populations(Bennett 1998,2003) necessary for local livelihoods.

Despite this critics and others not addressed by this research, the important contribution by PNRs toward conservation has been recognized Worldwide for protecting species outside SCAs (Ochoa-Ochoa et al. 2009) and for complementing Global Protected area Networks (Gallo et al. 2009; IUCN 2004; Naughton-Treves et al. 2005).

It is probable that neither PNRs themselves nor the SCAs network will be enough to achieve a comprehensive representation of biodiversity. Nevertheless, is not a question of what category of protected areas is better rather, if they can complement each other and contribute to biodiversity conservation. PNRs can provide additional extension of SCAs and could be the necessary bridge to connect the already isolated SCAs in the study area. The construction of Tuparro Biosphere Reserve for example, a corridor between PNRs and Tuparro National Park(2010a), may be a good starting initiative to improve connectivity in the study area. Further scientific research on monitoring co-management tools and incentives need to be carried out to evaluate this important possibility.

Conclusions

This research addressed the question of the CBD goal at ecoregion level. My results indicate that SCAs, IRs and PNRs together achieve coverage for more than 10% of the Llanos Ecoregion. However, is this enough to achieve comprehensive representation of all the ecosystems present in the ecoregion? The answer seems to be "no". Biodiversity is not evenly distributed on the global land surface and thus even when protected areas around the globe exceed the 10% conservation target they fail to provide adequate coverage, to species, ecosystems, habitats and even biomes (Brooks et al. 2008). In fact, the real effective percentage coverage may even lower but due to the absence of global systematic data on the effectiveness of protected areas, it is difficult to provide an accurate gap analysis. Nevertheless the policy implication is clear, conservation goals should be measured by biodiversity, not by area (Brooks et al. 2008; Rodrigues et al. 2004).

These serious limitations of the indicators to assess real progress towards the 10% CBD target, may lead to misinterpretations by decision makers and by politicians. For example, the success of achieving 13.4 % protected area coverage of Colombia's territory is often reported. However this "national success" when analyzed at a regional level reveals a different story, as has been demonstrated in this research and in national reports(Romero et al. 2008). The risk of the CBD indicators is that they may be used incorrectly by "decision makers and politicians" to provide a false feeling of security of safeguarding biodiversity comprehensively. It is increasingly necessary assessments at ecoregion levels including all the different categories with comparable effectiveness data of all protected area categories.

Furthermore, scientists and politicians should remember that to achieve the CBD goal for many people is not to reduce the loss of biodiversity rather it is about eating, having shelter and staying healthy (Kaimowitz and Douglas 2007). I urge the importance of broader scope by politicians, decision makers and researchers for the inclusion of alternative strategies for conservation coverage, such as PNRs and IRs that may contribute to achieve the complexity of the CBD Goal and provide support to local livelihoods. If we fail to support and recognize these strategies, the options of conserving biodiversity and sustaining local livelihoods may be lost forever.

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References

CBD/COP7 decision V11/30.

2004. Ecosistemas de la cuenca del Orinoco Colombiano del año 2000, escala 1:250.000, información cartográfica digital en formato shapefile, coordenadas planas origen Bogotá. Convenio IAvH,IGAC, Bogotá.

2005. Millennium Ecosystem Assessment Ecosystems and Human Well-being: Biodiversity Synthesis. World Resources Institute, Whashington, DC.

2006a. Mapa de las reservas naturales de Colombia. Información cartográfica. RESNATUR.

2006b. Perspectiva Mundial sobre Diversidad Biológica 2 de la Secretaria del Convenio sobre la Diversidad Biológica, p. 81 + vii páginas., Montreal.

2008. Resolución 0185 Ministerio de Ambiente Vivienda y Desarrollo Territorial.

2009a. Análisis de Efectividad del Manejo de Áreas Protegidas con Participación Social. Convenio WWF – Unidad de Parques Nacionales Naturales.

2009b. Parques Naturales de Colombia. Información Cartografica. UAESPNN, Bogotá.

2010a. División Orinoco. Fundación Omacha.

2010b. Mapa de las reservas naturales de la Orinoquia. FNH-Nodo Orinoquia <span style="">

Andrade, G., Castro, L., Durán-Durán, A., Becerra, M., 2010. La mejor Orinoquia que podemos construir. Universidad de Los Andes - Corporinoquia.

Andrade, G., Ruiz, J., 2009. Área de Conservación Comunitaria en la "Selva Corazón de la Salud" de Matavén - Colombia. UICN.

Armenteras, D., Rodríguez, N., Retana, J., 2009. Are conservation strategies effective in avoiding the deforestation of the Colombian Guyana Shield? Biological Conservation 142, 1411–1419.

Becker, C.G., Fonseca, C.R., Haddad, C.F.B., Batista, R.F., Prado, P.I., 2007. Habitat Split and the Global Decline of Amphibians. Science 318, 1775-1777.

Bennett, A.F., 1998,2003. Linkages in the Landscape: The Role ofCorridors and Connectivity in Wildlife Conservation, Gland,Switzerland and Cambridge.
Bonham, C., Sacayon, E., Tzi, E., 2008. Protecting imperiled "paper parks": potential lessons from the Sierra Chinajá, Guatemala. Biodiversity and Conservation 17, 1581-1593.

Brooks, T.M., Bakarr, M.I., Boucher, T.I.M., Da Fonseca, G.A.B., Hilton-Taylor, C., Hoekstra, J.M., Moritz, T.O.M., Olivieri, S., Parrish, J., Pressey, R.L., Rodrigues, A.S.L., Sechrest, W.E.S., Stattersfield, A.L.I., Strahm, W., Stuart, S.N., 2008. Coverage Provided by the Global Protected-Area System: Is It Enough? BioScience 54, 1081-1091.

Bruner, A.G., Gullison, R.E., Balmford, A., 2004. Financial Costs and Shortfalls of Managing and Expanding Protected-Area Systems in Developing Countries. BioScience 54, 1119-1126.

CBD, 2010. Convention on Biological Diversity Goals and subgoals, ed. CBD.

Chape, S., Harrison, J., Spalding, M., Lysenko, I., 2005. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. Phil. Trans. R. Soc. B 360, 443-445.

Correa, H.D., Ruiz, S.L., Arévalo, L.M., 2005. Plan de acción en biodiversidad de la cuenca del Orinoco – Colombia / 2005 - 2015 – Propuesta Técnica, p. 273. Corporinoquia, Cormacarena, I.A.v.H, Unitrópico, Fundación Omacha,Fundación Horizonte Verde, Universidad Javeriana, Unillanos, WWF - Colombia, GTZ –Colombia., Bogotá D.C.

Dudley, N.E., 2008. Guidelines for Applying Protected
Area Management Categories, p. x + 86pp. IUCN, Gland, Switzerland.

Gallo, J., Pasquini, L., Reyers, B., Cowling, R., 2009. The role of private conservation areas in biodiversity representation and target achievement within the Little Karoo region, South Africa. Biological Conservation 142, 446 –454.

Hocking, M., Stolton, S., Dudley, N., 2000. Evaluating Effectiveness: AFramework for Assessing the Management of Protected Areas, p. x + 121pp. IUCN, Gland, Switzerland and Cambridge, UK.

Hoekstra, J.M., Boucher, T.M., Ricketts, T.H., Roberts, C., 2005. Confronting a biome crisis: global disparities of habitat loss and protection. Ecology Letters 8, 23-29.

IUCN, 2004. The Durban action plan, pp. 225-264. Vth IUCN World Parks Congress, Durban.

James, A., Gaston, K., Balmford, A., 2001. Can we afford to conserve biodiversity? Bioscience 51, 43-51.

Kaimowitz, D., Douglas, S., 2007. Conserving What and for Whom? Why Conservation Should Help Meet Basic HumanNeeds in the Tropics. Biotropica 39, 567–574.

Laurance, W., Lovejoy, T., Vasconcello, H., 2002. Ecosystem Decay of Amazonian Forest Fragment: A 22 years of investigation. Conservation Biology 16, 605- 618.

Lees, A.C., Peres, C.A., 2008. Conservation value of remnant riparian forest corridors of varying quality for Amazonian birds and mammals. Conservation Biology 22, 439-449.

Lima, M., Gascon, C., 1999. The conservation value of linear forest remnants in central Amazonia. Biological Conservation 91, 241-247.

Lindenmayer, D., 2002. Conserving forest biodiversity a comprehensive multiscaled approach. Island Press, Whashington.

Mayorquin, L., Valenzuela, A., Rangel, J., Evaluación de la efectividad de manejo en reservas naturales de la Sociedad Civil: una propuesta metodológica. Caldasia.

Mertz, O., Munk-Ravnborg, H., Lövei, G., Nielsen, I., Konijnendijk, C., 2007. Ecosystem services and biodiversity in developing countries. Biodivers Conserv 16, 2729–2737.

Michalski, F., Boulhosa, R.L.P., Faria, A., Peres, C.A., 2006. Humanwildlife conflicts in a fragmented Amazonian forest landscape: determinants of large felid depredation on livestock. Animal Conservation 9, 179-188.

Monteferri, B., Coll, D., 2009. Conservación privada y comunitaria en los países amazónicos, 1 ed. edn, Lima, Peru.

Naughton-Treves, L., Buck, M., Brandon, K., 2005. The role of protected areas ins conserving biodiversity and sustaining local livelihoods. Annu. Rev. Environ. Resour. 30, 219-252.

Ochoa-Ochoa, L., Cardona-Urbina, N., Vazquez, L., Flores-Villela, O., 2009. The Effects of Governmental Protected Areas and Social Initiatives for Land Protection on the Conservation of Mexican Amphibians. PLoS ONE 4, 8.

Pence, G.Q.K., Botha, M.A., Turpie, J.K., 2003. Evaluating combinations of on-and off-reserve conservation strategies for the Agulhas Plain, South Africa: a financial perspective. Biological Conservation 112, 253-273.

Peñuela, L., 2009. Nodo Orinoquia de la Asociación Red Colombiana de Reservas Naturales de la Sociedad Civil. Fundacion Horizonte Verde, Villavicencio.

Rangel, J.O., Sanchez, H., Lowly-C, P., Aguilar-P, M., 1995. Región de la Orinoquia, pp. 238-252.

Redford, K., 1992. The Empty Forest. Bioscience 42, 412-422.

Rodrigues, A., Andelman, S., Bakarr, M., Boitani, L., 2004. Effectiveness of the global protected area network in representing species diversity. Nature 428, 640-643.

Romero, M., Cabrera, E., Ortiz, N., 2008. Informe sobre el estado de la biodiversidad en Colombia 2006-2007, p. 186 p. Instituto de Investigación Alexander von Humboldt, Bogotá, D.C.

Sims-Castley, R., Graham, K., Beverly, G., 2005. Socio-economic significance of ecotourism-based private game reserves in South Africa's Eastern Cape Province. Private Protected Areas 15, 8-18.

Vásquez, V.H., Serrano, M.A., 2009. Las Áreas Naturales Protegidas de Colombia, Bogotá.

Wood, S., Sebastian, K., Scherr, S.J., 2000. Pilot analysis of global ecosystems: Agroecosystems. WRI and IFPRI.

WWF, 2010. The Orinoco Basin.

WWF, McGinley, M.T.E., 2007. "Llanos." In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment).

Figure 1. Map locating the Llanos Ecoregion in Colombia with its principals basins, and cities. The thick black line encloses the ecoregion. Andes mountains in the main part of the figure are in white. The right corner figure shows the complete Llanos Ecoregion

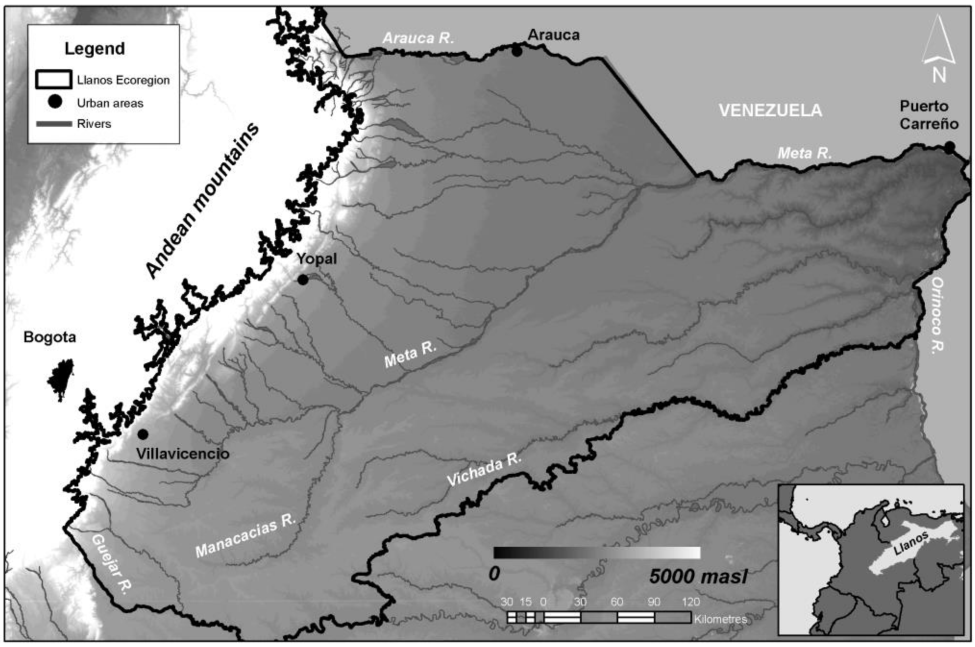


Figure 2. Number of ecosystems that achieved the 10% conservation target exclusively in each category of protected area and with the contribution of two or more categories. n= Number of ecosystems in each ecosystem category. N= Total number of ecosystems (100). Agroecosystems (A) n=8, Forests (F) n=50, Savannas (S) n=29, Wetlands and Waterbodies (W & W) n=6, Other ecosystems (O) n=7, and Total ecosystems (T). Target met entirely by Indigenous Reservations (IRS) not Statutory Conservation areas (SCAs) or Private Nature Reserves (PNRs) (dark blue bars). Target met entirely by PNRs not SCAs or IRs (red bars), target met entirely by SCAs not PNRs or IRs (green bars), contribution to successful target achievement by both IRs and PNRs (purple bars), contribution to successful target achievement by both SCAs and IRs (light blue bars).

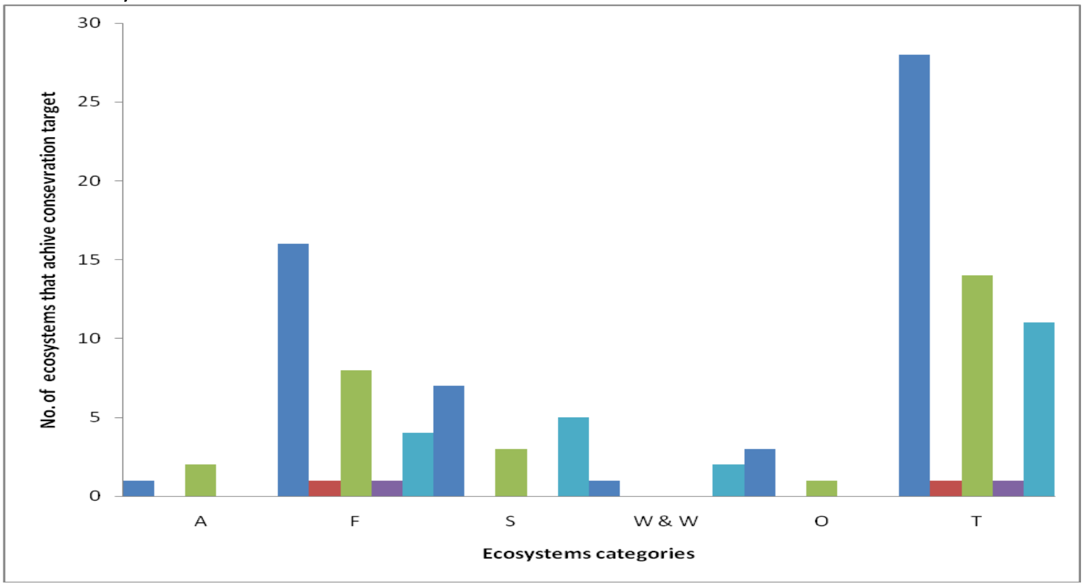


Figure 3. Average score per criterion of PNRs assessed. Biodiversity (B), Productive Capital (PC), Ecosystem Services (ES), Governability and Planning tools (G&P), Visibility (V).

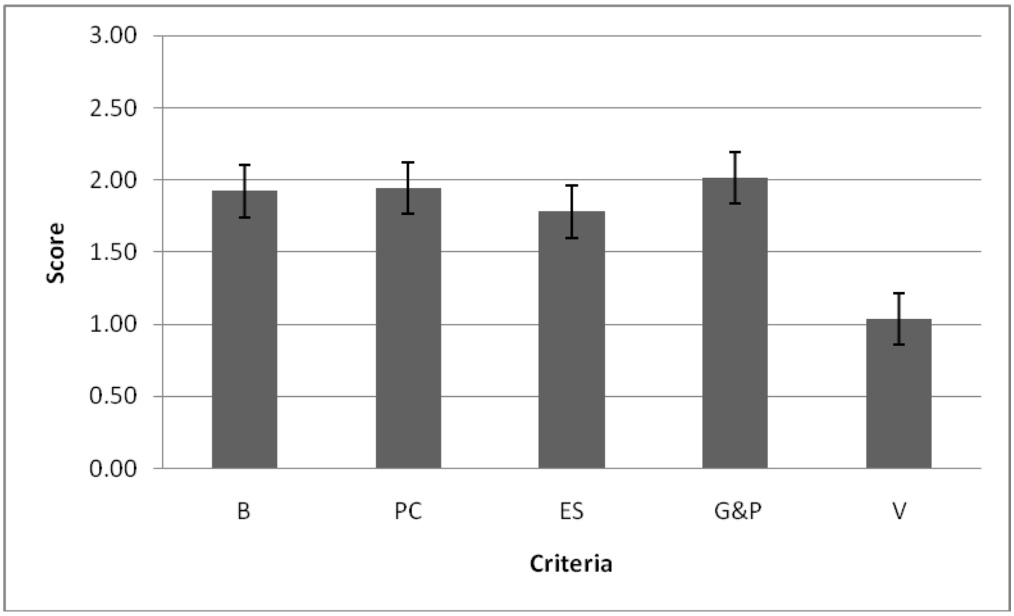
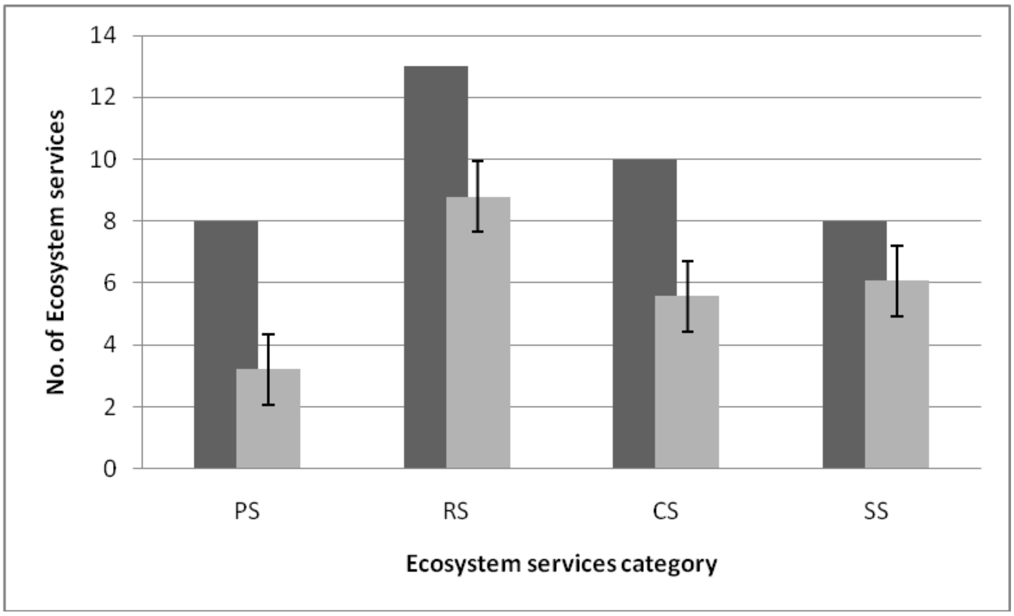


Figure 4. Number of ecosystem services per category. Provision services (PS), Regulation Services (RS), Cultural Services (CS) and Supporting services (SS). Total ecosystem services per each category (black bars). Mean of ecosystems services listed by the PNRs assessed (grey bars**)**



9.2 Tables

Table 1 Management Effectiveness scale valuation.

Valuation scale	Category	Description
12-15	Very successful	There is good achievement of the reserve objectives, and it is important to maintain this level.
9-12	Successful	There is achievement of the reserve objectives, but some management measures should be carried out to improve this level.
6-9	Moderately successful	There is medium-level achievement of the reserve objectives. Management measures must be realized to improve this level.
3-6	Marginally successful	There is low-level achievement of the reserve objectives. Management measures must be realized to improve this level
0-3	Not successful	There is poor achievement on the reserve objectives. Urgent management measures must be done to improve this level.

Table 2 Representation and complementarity of SCAs and PNRs, and SCAs and PNRs for each ecosystems class.

Ecosystem category	% of region	% of PNRs	% of IRs	PNRs complementarity metric	IRs complementarity metric
Agroecosystem	21.82	0.43	1.21	-0.08	-0.81
Forests	21.52	0.43	11.33	-0.03	0.05
Waterbodies and Wetlands	2.58	0.15	5.94	-0.31	-0.05
Savannas	48.25	0.33	10.10	0.09	0.24*
Others	5.82	0.17	7.55	0.03	0.36*

Values in (*) are significant.