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Article

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Contemporary Economics

Provided in Cooperation with:
University of Finance and Management, Warsaw

Suggested Citation: Rosefielde, Steven (2020) : Modelling natural capital: A proposal for a mixed multi-criteria approach to assign management priorities to ecosystem services, Contemporary Economics, ISSN 2300-8814, University of Finance and Management in Warsaw, Faculty of Management and Finance, Warsaw, Vol. 14, Iss. 1, pp. 22-37, https://doi.org/10.5709/ce.1897-9254.330

This Version is available at:
https://hdl.handle.net/10419/297462

Primary submission: 31.01.2019 | Final acceptance: 14.10.2019

Modelling Natural Capital: A Proposal for a Mixed Multi-criteria Approach to Assign Management Priorities to Ecosystem Services

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ABSTRACT

Investment in natural capital is increasingly necessary and urgent considering the increasing loss of global biodiversity and the associated social and economic losses. Ecosystem services are tools for quantifying the stock of natural capital and there is great concern about their assessment and valuation. However, there remains a substantial gap between the large amount of information available about ecosystem services and the information required to support decisions and this undermines the efficiency of their management. Multi-criteria analysis techniques can be very useful to efficiently develop decision-making processes to properly channel investment and optimize the costs associated with conservation. This paper proposes an innovative mixed methodology for multi-criteria analysis to assign priorities to ecosystem services in protected areas in terms of importance and vulnerability. The model was applied by a group of experts to prioritize 20 ecosystem services in the Ordesa and Monte Perdido National Park. In order to collect and analyze the individual valuations, a mixed method of Analytic Hierarchy Process (AHP) and Goal Programming (GP) was used, and to aggregate the valuation criteria, a Joint Relevance Index (JRI) was used, which presents the relative importance of each service in an aggregated way. The results show that conservation policies should be primarily directed towards lifecycle maintenance and water conditions. Depending on the vulnerability of the services, conservation policies should be channeled towards provisioning services related to wild animals and wild plants. Considering the relative importance of services in the park, priority should be oriented to lifecycle maintenance, water conditions and intellectual interaction with the environment.

KEY WORDS: natural capital, ecosystem services, conservation management, AHP, GP.

JEL Classification: Q57; H83; O18

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1. Introduction

The economic aspects of ecosystems were first studied in the early 1990s. Some concepts such as "natural capital", "ecosystem services" and "valuation of environmental services" began to acquire relevance, given the growing loss of biodiversity worldwide and the social and economic losses that this entails (Costanza & Daly, 1992; Costanza et al., 1997; Öberg & Alexande, 2019). Natural capital can be considered to be any stock that generates a flow of useful goods and services or natural income over time (Costanza & Daly, 1992). "On the other hand, natural capital can be considered as a set of natural resources or services that need to be consciously managed, but that can be used in standard cost-benefit calculations" (Missemer, 2018).

Currently, about $52 billion a year are spent on conservation projects around the world, mostly from

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public funds and philanthropists. The Credit Suisse Group provides an estimated $300-400 billion per year needed to preserve the health of terrestrial ecosystems and oceans, and therefore, also the Earth's stock of natural capital in the form of air quality, water quality and biodiversity. To meet this need for funding and to be able to preserve our precious ecosystems would require an additional capital of between 200 and 300 billion dollars (Huwyler et al., 2016). In order to cover this financing gap, attracting private capital may be an interesting solution, but it would be necessary to count on risk-adjusted returns on investment ratios (Rautera et al., 2018). In this sense, efficiency is not only advisable, but essential, as it is the only guarantee for investors that things are being done well. Investment in natural capital must be seen as an investment and not an expense, and although in absolute terms this seems very high, if we consider the value of the contribution of environmental services, in relative terms, they are not so high. Considering that carbon sink services and crop pollination have been valued at $2 trillion and $6 trillion (Balmford et al., 2002). In this sense, Balmford et al. (2002) estimated that the total cost-benefit ratio of an effective global program for wildlife conservation is at least 100:1.

Concern about the analysis of conservation costs to ensure efficiency in the conservation of natural capital is reflected in the 10th Conference of the Parties to the Convention on Biological Diversity, in Japan (UNEP, 2010). This convention set 20 conservation objectives considering the costs of actions to be undertaken, including improvements in programs to improve the status of endangered species. These data seem to indicate that a consensus has been reached in the scientific community on the need to consider costs throughout the systematic conservation process and at all levels (Bayramoglu et al., 2018).

Following the conservation systematics of Margules and Pressey (2000), efficiency in the conservation of natural capital can be addressed with two approaches: where and how to invest. The analysis of efficiency from the first approach is based on investment in areas of exceptional ecological value, where less effort would be required to obtain the same results in terms of conservation. From the first Conference of the Parties in Rio in 1992 to the objectives set in Aichi for the period 2011-2020, conservation goals have been set in terms of protected areas. Currently there are 202,467 protected areas in the world, covering almost 20 million km2 or 14.7% of the planet's land area, without considering Antarctica, which means that we are not far from reaching the target of 17% set in Aichi by the Convention on Biological Diversity (Jones et al., 2018). The setting of these goals was a fundamental first step to establish international commitments to protect wilderness areas. However, it was not until the beginning of the century that attention began to be paid to the efficiency of the designation of protected areas. The analysis of efficiency from the second approach: how to invest, can also be explained by answering the question "are resources being allocated optimally for conservation in these areas?"

The problem of allocating resources for the implementation and development of conservation actions, once an area has been protected, is another important issue for efficiency analysis (Tsaurkubule, 2017; Yang & Grigorescu, 2017). In order to do this, firstly, it is necessary to identify and measure what we have to conserve, and secondly, where the economic resources are going to be channeled (Guaita et al., 2019a; Martin et al., 2019). In other words, first measure, and then decide. In this sense, multi-criteria analysis techniques for decision making have been successfully used to prioritize resources in natural resource conservation, due to their capacity to add different attributes for a single joint result (Pérez-Rodríguez et al., 2018). In addition, these techniques are particularly suitable for the management and design of public policies due to their capacity to develop participatory processes, guaranteeing their transparency and generating useful information for decision making (Brauers, 2018; de Castro-Pardo & Urios, 2017; Guaita et al., 2019b; Roy et al., 2019).

Ecosystem services (ESs) are the key conceptual tool for developing an ecologically based theory of natural capital. In other words, they constitute the bridge between Ecology and Economy when referring to the ecological capacity to sustain economic activity (Gómez-Baggethun & de Groot, 2007). Therefore, the valuation of ESs in protected areas makes it possible to quantify the natural capital in an efficient manner since, in these places, the relative importance of environmental services is greater than in other places. On the other hand, the prioritization of environmental services ensures the efficiency of decision-making processes. This would

 DOI: 10.5709/ce.1897-9254.330

permit, among other things, the optimal channeling of resources for space management towards the most important or vulnerable services.

The objective of this work is to propose a methodology that uses a mixed multi-criteria analysis technique to define the priorities for the management of ESs, to aid decision-making processes and to define efficient conservation policies in protected areas. The main contribution of this work is the proposal of a methodology to prioritize environmental services applicable to protected areas of the world, to optimize governance processes and efficiently channel resources for their conservation. In the second section theoretical framework is presented, in the third section the methodology, in the fourth section the results and their discussion and in fifth section the conclusions are provided.

2. Theoretical Framework

The valuation of environmental services is becoming increasingly important in our society. Ecosystems provide a range of services that are essential for human well-being, health, livelihoods and survival (Costanza et al., 2014; Sengupta et al., 2017) and both their assessment and valuation are considered increasingly necessary for their proper management. At a global level, the Strategic Plan for Biodiversity, based on the Aichi objectives (UNEP, 2010), sets the valuation of biological diversity and its dissemination as one of its priority axes. Within this framework, the World Bank has created a working group called Wealth Accounting and the Valuation of Ecosystem Services (WAVES), which develops studies on wealth accounting and the valuation of ESs, in addition to valuing the environmental wealth of countries in terms of health.

In the scientific field, the study of the valuation of environmental services has increased considerably in the last decade (Costanza et al., 2017). Some works have analyzed and developed different valuation methodologies (Maes et al., 2015; Maes et al., 2016) or have developed indicators for their measurement (Lee & Lautenbach, 2016; Maes et al., 2016). Other works have developed and applied different mapping techniques (Maes et al., 2014; Martínez-Harms & Balvanera, 2012; Burkhard et al., 2018; Walz et al., 2019). The valuation of environmental services in protected areas adds value to their management in terms of efficiency, since in protected areas there is a greater concentration of natural capital than in other places and generally a better state of conservation and therefore, greater production capacity. Thus, studies on the valuation of environmental services in protected spaces are increasingly frequent (Heagney et al., 2018; LUC, 2015; Marta-Pedroso et al., 2016; Martín-López et al., 2011; Mayer & Woltering, 2018; Swemmer et al., 2017)

Although all these studies show a growing demand for information regarding the impact of decisions on ESs and human benefits, there is still a substantial gap between this research and the information required to support decisions (Uhde et al., 2015; Olander et al., 2017; Bildirici & Özaksoy, 2019). Therefore, multi-criteria decision analysis methods have been promoted as an alternative approach to monetary economic valuation of ESs in a cost-benefit analysis framework (Saarikoski et al., 2016) and several works have been developed that analyze these techniques. Aznar et al. (2014) proposed a mixed multi-criteria model to obtain an indicator of the Total Economic Value of an environmental asset based on its individual components and applied it in the wetlands of Eastern Spain. Estruch-Guitart and Valls-Civera (2019) used the Analytic Multicriteria Valuation Method to assess the ESs of a park in Spain. Martín and Mazzotta (2018) showed the usefulness of multi-criteria techniques to support the valuation of non-monetary SEs and compared the results of four aggregation methods: Global and Local Multi-attribute Scaling, the Analytic Hierarchy Process, and Compromise Programming. Kenter et al. (2016) demonstrated the importance of deliberative methods, including for the monetary valuation of ESs. Saarikoski et al. (2019) used these techniques to add the ESs provided by peatlands in Finland in participatory processes. Although there are more and more studies that use multi-criteria techniques to aggregate ESs in monetary and non-monetary valuation processes, to date, no methodology has been proposed to prioritize environmental services in protected areas.

3. Materials and Methods

3.1. Study Area

The Ordesa and Monte Perdido National Park (OMPNP) (Parque Nacional de Ordesa y Monte Perdido) is a protected area located in north-eastern Spain, in the Spanish Central Pyrenees. The OMPNP

was originally declared a National Park in 1918 and extended in 1982. Among other international recognitions, the park is an area of Special Protection for Birds, ZEPA (1988), Biosphere Reserve (1977) and UNESCO World Heritage site (1997). The National Park covers 15,608 ha and has a peripheral protection zone of 19,679 ha. Its demarcation includes territories in 5 municipalities in the province of Huesca: Torla, Fanlo, Puértolas, Tella-Sin and Bielsa, although within the National Park there is no population nucleus (Benito-Alonso, 2010).

The mountainous landscape is nestled in a limestone massif, with a structural relief shaped by the passage of powerful glaciers and highly developed karstic erosion, which prevents water flowing on the surface, meaning that there are no large lake formations. There is a large altitude difference of 2,655 m. and one of its most outstanding features is the presence of large limestone cliffs, which can exceed 1,000 m in height (Benito-Alonso, 2010). Traditionally, the OMPNP was a grazing area where one could observe a rural way of life that was prevalent in the mountainous regions of Europe in the past, and which has only been conserved intact throughout the twentieth century in this part of the Pyrenees. Its anthropogenic landscape is made up of villages, farms, fields, high-altitude pastures and mountain roads. However, today its main economic activity is tourism. Other traditional rural activities have been relegated to the background. The continued decline of extensive livestock activity, mainly sheep farming, since 1995, is especially striking (Bernués & Olaizola, 2012). The territory's main socio-economic problem is depopulation and currently the area has a population density of less than 4 inhabitants/km2. This means, among other things, that traditional land-use decline is being changed into extensive forest recovery and the loss of "cultural landscapes" (García et al., 2012).

3.2. Methodology

The proposed methodology follows a structured process with 5 stages: (a) selection of the participants in the process and identification of the ecosystem services, (b) design of a questionnaire and collection of individual preferences about each service according to its importance and vulnerability in the natural area, (c) treatment of inconsistencies in individual ratings, (d) aggregation of individual ratings into a joint solution for the importance criterion and a joint solution for the vulnerability criterion and (e) obtaining a Joint Relevance Index (JRI) to obtain a final rating that considers both the relative importance and the vulnerability of each service.

3.3. Selection of Participants and Identification of Services

The selection of participants was based on two criteria: representativeness and good knowledge of the environment. Representativeness refers to the ability of each participant to provide the focus or point of view of a group of people with common interests. Good knowledge of the environment is essential, as the questionnaire requires in-depth knowledge of the territory. It is therefore recommended that the participants be local inhabitants with a high level of knowledge about the environment and/or technicians in the protected area.

The identification of environmental services should follow an international classification. This is important so that the results are comparable with those of other protected areas in the world and for long-term monitoring of their evolution.

To identify the ESs, it is advisable to use a deliberative process, so that different approaches can be exchanged and discussed. The results of the process should be collected in a database which will serve to generate a pool of information from which the questionnaire to collect the valuations will be designed.

3.4. Survey Design and Collection of Individual Valuations

In order to collect the data, a Saaty type paired comparison survey was used, in which an assessment is required for each pair of ESs based on two criteria: importance and vulnerability. The relative importance of an ES in this protected space compared to the rest of the ESs. Vulnerability refers to its propensity to suffer damage or losses that are very likely or probable in the medium term.

The Analytic Hierarchy Process (AHP) considers individual preferences and valuations via value judgements about the relative importance of the criteria and the alternatives taken by pairs. This methodology is based on three stages: modelling, valuation,

 DOI: 10.5709/ce.1897-9254.330

and prioritization and synthesis (Saaty, 2001). In the modelling stage, the criteria and problem alternatives are identified and organized according to a hierarchical structure. In the assessment stage, the preferences, tastes and desires of the actors are collected through the judgments included in the so-called matrices of paired comparisons (Moreno- Jiménez, 2002). Finally, in the stage of prioritization and synthesis, local, global and total priorities are obtained.

In order to obtain a hierarchical structure of the ESs to be assessed, each participant was offered the option of expressing their intensity of preference, on a Saaty type scale with 1–9 points (2001), about a pair of ESs according to their importance and vulnerability. When two ESs have the same importance or vulnerability, a score of 1 is assigned to that comparison, while a score of 9 indicates the absolute importance or total vulnerability of one ES over the other.

3.5. Analysis and Correction of Inconsistencies

Although AHP is very useful for collecting subjective preferences, individual assessments are often inconsistent. In this case, when the number of participants in the process is a small, loss of information should be avoided. Saaty set acceptable consistency when the consistency ratio (CR) is equal to or less than 0.10 (Saaty, 2001). However, in pairwise comparisons, primary results frequently have a Consistency Ratio greater than 0.10, as judgment calls have innate subjectivity.

This paper proposes the use of a method of Goal Programming (GP) to correct inconsistent primary results. GP is a linear programming technique used to solve complex problems related to the optimization of natural resources. GP finds compromise solutions that may not fully satisfy all the goals but do reach certain satisfaction levels set by the decision-maker. For this purpose, an objective function and some limitations are defined. The constraints of the model are formed by the relationship between the objective of the achievement level for each attribute with this attribute linking itself through negative and positive deviations. Moreover, another constraint must be added to make the real solution of the problem possible.

To correct inconsistent matrices (CR<0.10), the Archimedean GP model based on González-Pachón and Romero (2004) was applied as indicated in equations 1–5.

$$\text{Min } \sum_l (n_l^{(1)} + p_l^{(1)})^p + \sum_s (n_s^{(2)} + p_s^{(2)})^p + \sum_t (n_t^{(3)} + p_t^{(3)})^p \quad (1)$$

s.t.

$$w_{ij} - m_{ij} + n_l^{(1)} - p_l^{(1)} = 0, \quad l=1, 2,\ldots, n(n-1), \quad (2)$$

$$w_{ij} w_{ji} + n_s^{(2)} - p_s^{(2)} = 1, \quad s = 1,2, \ldots, \frac{n(n-1)}{2}, \quad (3)$$

$$w_{ij} w_{jk} - w_{ik} + n_t^{(3)} - p_t^{(3)} = 0, \quad t=1, 2,\ldots., n(n-1)(n-2), \quad (4)$$

$$0.11 \leq w_{ij} \leq 9 \quad \forall i, j. \quad (5)$$

Where:

$n_l^{(1)}$ and $p_l^{(1)}$ are the negative and positive deviations of the goal, respectively, for the constraints that ensure the condition of similarity in the position l, $n_s^{(2)}$ and $p_s^{(2)}$ are the negative and positive deviations of the goal, respectively, for constraints that ensure the condition of reciprocity in the position s, and $n_t^{(3)}$ and $p_t^{(3)}$ are the negative and positive deviations of the goal, respectively, for constraints that ensure the condition of consistency at position t.

m_{ij} are the components of the matrix M for each pair of criteria.

w_{ij} are the components of matrix W, formed by the weights that represent the most similar weights to the components of the original M matrix for each pair of criteria ij.

Let $M=(m_{ij})_{ij}$ a general matrix given by a participant, there is a set of positive numbers, $(w_l \ldots w_n)$, such that $m_{ij}=\frac{w_i}{w_j}$ for every $i,j=1,\ldots,n$.

As a result, consistent matrices are obtained that are as similar as possible to the original ones, fulfilling the conditions of similarity, consistency and reciprocity required by matrices built using pairwise comparisons. This model has already been successfully applied to correct inconsistencies in paired matrices for planning in protected areas (de Castro et al., 2019).

3.6. Joint Assessments for the Importance Criterion and for the Vulnerability Criterion

Once the inconsistencies were corrected, each of the consistent matrices was normalized and aggre-

gated into a single matrix using a geometric mean. Finally, the final weights were obtained using the *eigenvalue* method. These weights represent the relative importance of each of the ESs analyzed, and as many weights were obtained as ESs evaluated according to the importance criterion and as many weights as ESs evaluated according to the vulnerability criterion.

3.7. Balanced final assessment

Finally, a Joint Relevance Index was used to obtain a ranking of the most relevant environmental services in terms of importance and vulnerability. To do this, the distance between the weights of the ESs in terms of importance and the weights of the ESs in terms of vulnerability were minimized, and the ESs were selected with maximum and minimum weights and distances. These ESs were the most important in simultaneous terms of vulnerability and importance.

The Joint Relevance Index (JRI) makes it possible to quantify the final aggregate weights, which takes into account the importance of each evaluated service and its vulnerability in a balanced way. JRI can be calculated using equations 6 and 7:

$$JRI=\sum_{i=1}^{I}[(w_i^R + w_i^V)(1+BF)] \quad (6)$$

$$\text{Where BF}=\frac{\sqrt{\sum_{i=1}^{n}(d_i^{ES}-D)^2}}{\sqrt{\sum_{i=1}^{n}(d_i^{FS}-D)^2}+\sqrt{\sum_{i=1}^{n}(d_i^{ES})^2}} \quad (7)$$

Where:

w_i^R is the weight of the preference of each ES for Relevance criteria in each category.

w_i^V is the weight of the preference of each ES for Vulnerability criteria in each category.

BF represents the Balance Factor which can be calculated using equation 7, that is based in Pang and Liang (2012).

d_i^{ES} represents the absolute difference normalized, $d_i^{ES}=|\propto_i^R-\propto_i^V|$

$\propto_i^R$ is the weight of the preference of each ES for relevance criteria.

$\propto_i^V$ is the value of the conjoint preference for each ES for vulnerability criteria.

$0\leq d_i^{ES}\leq D$, when value of D is $S=\{s_\propto|\ \propto=0,1,\ldots,l\}$, so D=l, and D represents the maximum disagreement possible.

The value of the Balance Factor for each ES will always be $0\leq BF^{ES}\leq 1$, when $BF^{ES}=0$ each ES obtains the same importance in terms of importance and vulnerability, and when $BF^{ES}=1$, each ES obtains the most divergent weights in terms of importance and vulnerability.

The result provided by the Joint Relevance Index represents the aggregated results of all ESs included in each category, considering the criteria of importance and vulnerability in a joint balanced way.

4. Results and Discussion

4.1. Participant Selection and Identification of Services.

In order to validate the proposed model, a pilot study involving a panel of OMPNP experts was carried out. These participants are experts in the area of study and the natural environment. The panel of experts is made up of five OMPNP technicians, the mayor of one of the main municipalities of the protected area, a representative of a prominent NGO in this area, and a representative of the Government Board of the Regional Government of Aragón. A deliberative meeting was organized with the purpose of identifying the ESs. In such a meeting, all the ESs classified in The Common International Classification of Ecosystem Services (CICES) were analyzed. As a result of this process, 20 ESs were identified in the OMPNP, which are described in the Supplementary Material.

These services were identified on the basis of two hierarchical levels, which are displayed in Figure 1.

4.2. Survey Design and Collection of Individual Assessments

A Saaty-type survey was used to collect individual assessments (Saaty, 2001). This survey compares ESs identified at the two hierarchical levels by means of pairwise comparisons. The surveys were sent on-line between June and July 2019. The pairwise comparison matrices were constructed based on the answers collected from the survey questionnaires, resulting in 16 matrices of dimensions 3x3, 16 matrices of dimensions 4x4 and 32 matrices of dimensions 8x8.

 DOI: 10.5709/ce.1897-9254.330

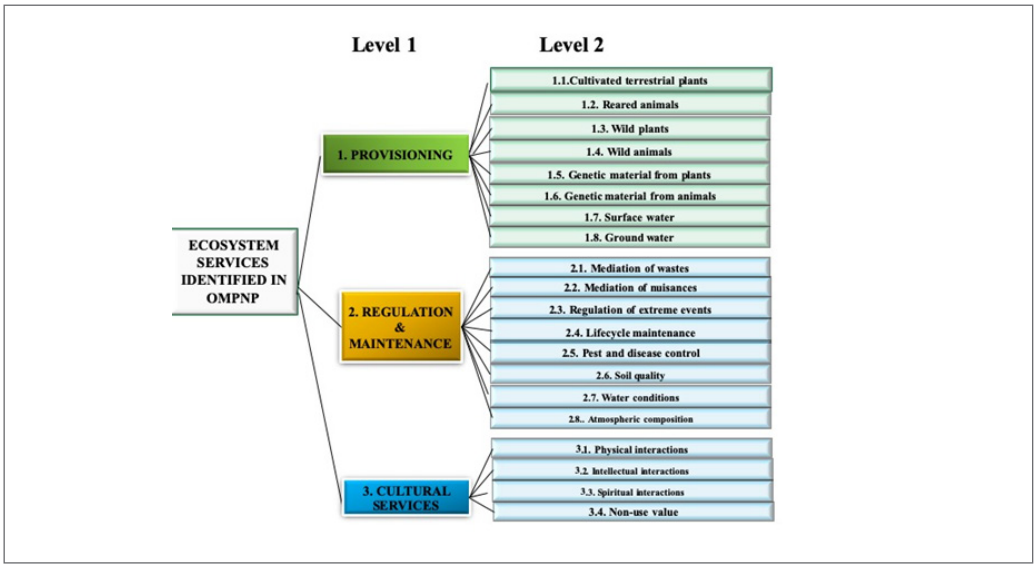

Figure 1. Hierarchical structure of the ESs identified in the OMPNP.

Table 1. Total and inconsistent matrices and retrieved information.

	Total	Inconsistent	Retrieved information
3x3	16	5	31.25 %
4x4	16	4	25 %
8x8	32	25	78.12
Total	64	32	50%

4.3. Survey Design and Collection of Individual Assessments

A total of 64 matrices were analyzed, 32 of which were inconsistent. As a result of applying equations 1-5, all inconsistent matrices were corrected and 50% of the information was retrieved (Table 1).

4.4. Joint Assessments for the Importance Criterion and the Vulnerability Criterion

Consistent individual assessments were aggregated separately for the importance and vulnerability criteria. To do so, we normalized individual weights, then aggregated them using a geometric mean, and then determined the eigenvalue. These results represent the relative significance of each ES according to its importance and the relative significance of each ES according to its vulnerability (Figure 2).

In the example shown, the most important ESs were Lifecycle maintenance and Water conditions and the most vulnerable were the services associated with Wild

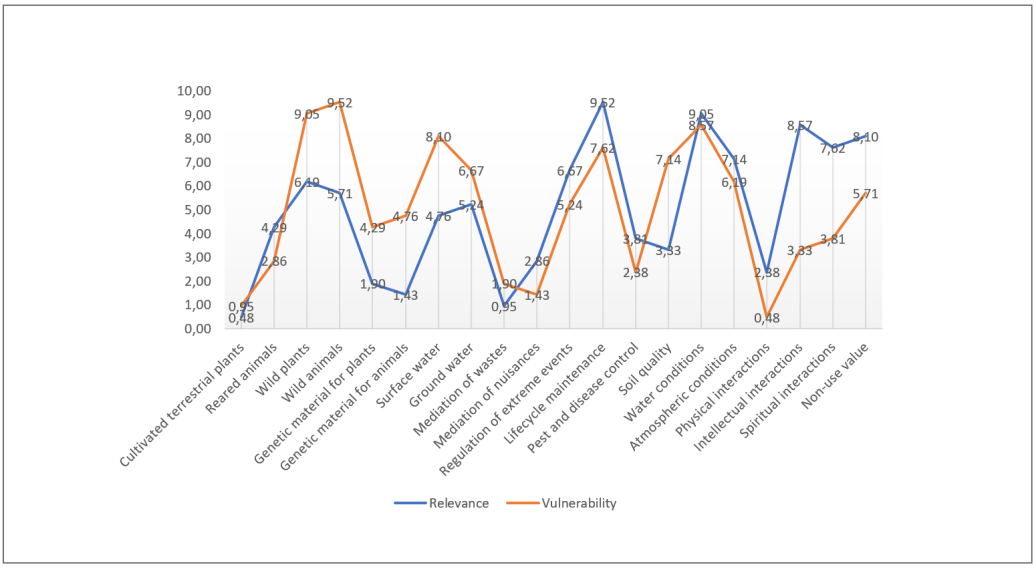

Figure 2. Aggregate assessments of each service according to its relative importance and aggregate assessments for each service according to its vulnerability.

animals and Wild plants. Lifecycle maintenance, Water conditions, Atmospheric conditions, and Non-use value show high scores for both importance and vulnerability; therefore, it may be advisable to revise the allocation of resources for their conservation.

Those ESs that are not especially prominent in the OMPNP but are especially vulnerable, such as Wild animals, Wild plants or Surface water, may not require additional resources for conservation at this time, but it may be advisable to initiate follow-up plans for these ESs if they are not already underway.

4.5. Balanced Final Evaluation.

At level 1, the results aggregated by means of JRI have assigned weights of 42.07% for regulatory ESs, 38.43% for provisioning ESs and 19.50% for cultural ESs (Table 2). This means that provisioning services have obtained higher scores and shorter distances in terms of relevance and vulnerability. Thus, the results aggregated using the JRI yielded balanced weights considering the importance and vulnerability criteria, which weighs the global assessments calculated on extreme values using BF. This factor "rewards" ESs with similar importance and vulnerability scores, while maintaining the priority of high scores. Figure 3 shows the ranking of the PNOMP ESs and the final weights aggregated using JRI at level 2.

Lifecycle maintenance has obtained the highest scores in importance and the fifth-highest position in terms of vulnerability. The aggregated results have rated this ES the best, resulting in a balanced weighting between the two criteria. Water conditions has obtained the second-best position in aggregated terms. On the other hand, cultivated terrestrial plants and physical interactions obtained the worst aggregated weights. Although the distances between the importance and vulnerability scores are small, the scores were very low, which is why they have ranked the worst in the global ranking. OMPNP is characterized by its geomorphology and, closely linked to it, its hydrology. The many watercourses that run through the territory are torrential. Besides, they overcome steep slopes, so the speed of the water is very high. Also characteristic of this area are the numerous springs, natural drain hole, and underground watercourses in karstic terrain, which are increasingly better studied and known from the speleological point of view, but little known from the limnological point of view. On the other hand, the

 DOI: 10.5709/ce.1897-9254.330

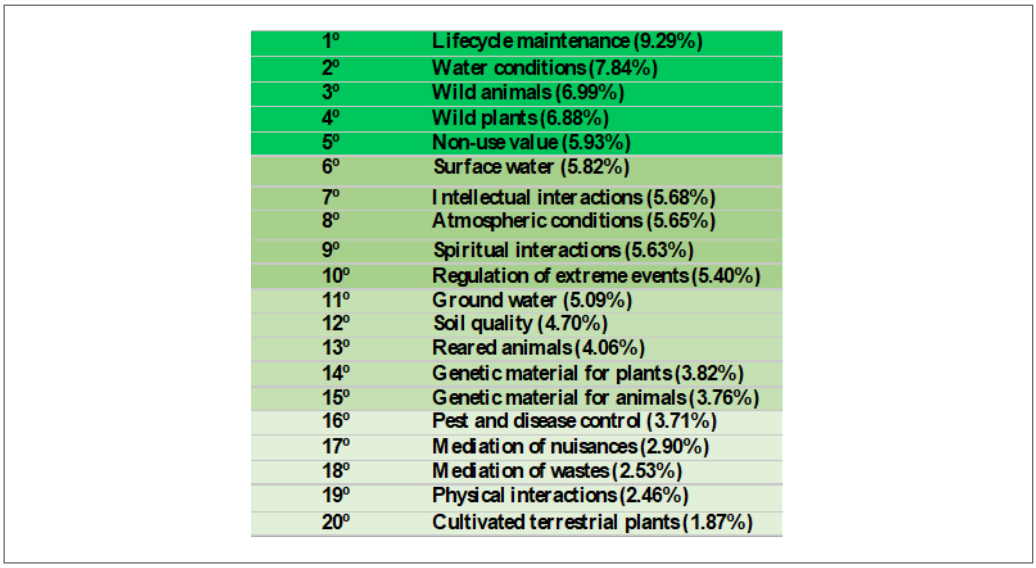

Figure 4. Ranking for OMPNP ESs with weights in parentheses.

Table 2. Aggregated weights, weights according to importance and weights according to vulnerability at the first classification level.

	JRI(%)		Relevance (%)		Vulnerability (%)
Provisioning	38.43	Provisioning	32.09	Provisioning	47.28
Regulation	42.07	Regulation	44.45	Regulation	38.50
Cultural	19.50	Cultural	23.46	Cultural	14.22
	100.00		100.00		100.00

altitude and the unevenness of the landscape do not favor crops, except for meadows and high mountain pastures, which provide food for extensive livestock farming. Sports competitions and some sports practices, such as cycling, are not permitted in the national park and this is included in the Management and Use Plan of the Ordesa and Monte Perdido National Park, which limits physical interactions with the environment in the territory.

Some cultural ESs, such as non-use value ESs and those related to intellectual interactions have obtained high relative importance and high positions in the global ranking. Such ESs are associated with the characteristics of living systems that have an existence value and that enable education and training, scientific investigation, aesthetic experiences that are resonant of culture or heritage. These features are related to the peculiar and extraordinary characteristics of the landscape of this natural space and were the determining factors for its declaration as a national park. It is for this reason that they are "the raison d'ĕtre" of OMPNP. Although their vulnerability is not excessively significant, their importance is, and it would be advisable to monitor these ESs as well, even if they do not require further urgent conservation measures. The results are consistent with the characteristics of the territory and

have made it possible to quantify the relative importance of each ES, which can be useful for allocating economic resources or prioritizing projects within the protected space. Some works have employed multicriteria techniques to prioritize projects in protected natural spaces (Prato, 2004) and to allocate resources for conservation contracts (Hajkowicz et al., 2007).

According to the results obtained in the example, it would be advisable to start monitoring plans oriented to the ESs of lifecycle maintenance, water conditions, wild animals, wild plants and non-use value services, if they do not currently exist. In addition, it should be considered to direct the conservation policies in the OMPNP towards the conservation of lifecycles and water conditions, since these ESs are the most important and vulnerable.

5. Conclusions

Managers of national parks and protected areas face the challenge of evaluating management actions and selecting the preferred one for their alternatives. Prioritization of ecosystem services can help facilitate these decision-making processes in protected areas.

The proposed model has been useful to define priorities for managing ecosystem services in the case study. The results can be used to assist in decision-making processes and to define efficient conservation policies in protected areas. The application of the model in the OMPNP suggests that it would be advisable for conservation policies to prioritize the ESs of lifecycle maintenance and water conditions. In addition, it would be interesting to monitor highly vulnerable ESs, such as wild animals, wild plants and surface water. Special monitoring of non-use value ESs and intellectual interactions should also be carried out. The latter are especially important for the OMPNP as they are closely related to its extraordinary and unique landscape, and although they do not appear to be the most vulnerable ESs, they are the essence of this natural space.

It must be considered that the application of the model has been a pilot study, with the limitations that this entails in terms of its results. However, the model is replicable and allows for the incorporation of the participation of different groups for the assessment of ESs. It would be interesting to apply this model to different protected areas in different contexts and to incorporate the participation of different stakeholder groups of the protected area, as well as to integrate different decision-making levels in areas with different categories of protection.

It would also be advisable to continue developing in the future different methods to help decision-making processes in protected areas around the world, which contribute to improving the efficiency of their management and allow better allocation of resources for the conservation of natural capital.

Acknowledgements

This study is part of a project funded by Cátedra de Parques Nacionales. The authors would like to acknowledge Organismo Autónomo de Parques Naturales (OAPN), its director, the entire staff, and the stakeholders of the Ordesa and Monteperdido National Park for their support in this endeavor.

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Appendix

Ecosystem services identified in OMPNP according to CICES classification.

Section	Group	CICES code	Description
Provisioning	Cultivated terrestrial plants for nutrition, materials or energy	1.1.1.1., 1.1.1.2.	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes. Fibers and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)
Provisioning	Reared animals for nutrition, materials or energy	1.1.3.1, 1.1.3.2., 1.1.3.3.	Animals reared for nutritional purposes. Fibers and other materials from reared animals for direct use or processing (excluding genetic materials). Animals reared to provide energy (including mechanical)
Provisioning	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	1.1.5.1., 1.1.5.2. 1.1.5.3.	Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition. Fibers and other materials from wild plants for direct use or processing (excluding genetic materials). Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy
Provisioning	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	1.1.6.1	Wild animals (terrestrial and aquatic) used for nutritional purposes
Provisioning	Genetic material from plants, algae or fungi	1.2.1.1., 1.2.1.2.	Seeds, spores and other plant materials collected for maintaining or establishing a population. Higher and lower plants (whole organisms) used to breed new strains or varieties
Provisioning	Genetic material from animals	1.2.2.1, 1.2.2.2., 1.2.2.3.	Animal material collected for the purposes of maintaining or establishing a population. Wild animals (whole organisms) used to breed new strains or varieties. Individual genes extracted from organisms for the design and construction of new biological entities
Provisioning	Surface water used for nutrition, materials or energy	4.2.1.1., 4.2.1.2.,4.2.1.3	Surface water for drinking. Surface water used as a material (non-drinking purposes). Freshwater surface water used as an energy source

 DOI: 10.5709/ce.1897-9254.330

Ecosystem services identified in OMPNP according to CICES classification (Continued).

Section	Group	CICES code	Description
Provisioning	Ground water for used for nutrition, materials or energy	4.2.2.1, 4.2.2.2, 4.2. X.X.	Ground (and subsurface) water for drinking. Ground water (and subsurface) used as a material (non-drinking purposes). Ground water (and subsurface) used as an energy source
Regulation & Maintenance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	2.1.1.1., 2.1.1.2.	Bioremediation by micro-organisms, algae, plants, and animals. Filtration/sequestration/ storage/accumulation by micro-organisms, algae, plants, and animals
Regulation & Maintenance	Mediation of nuisances of anthropogenic origin	2.1.2.1., 2.1.2.2.	Smell reduction. Noise attenuation
Regulation & Maintenance	Regulation of baseline flows and extreme events	2.2.1.1.	Control of erosion rates
Regulation & Maintenance	Lifecycle maintenance, habitat and gene pool protection	2.2.1.2.	Buffering and attenuation of mass movement
Regulation & Maintenance	Pest and disease control	2.2.1.3.	Hydrological cycle and water flow regulation (Including flood control, and coastal protection)
Regulation & Maintenance	Regulation of soil quality	2.2.4.1, 2.2.4.2.	Weathering processes and their effect on soil quality. Decomposition and fixing processes and their effect on soil quality
Regulation & Maintenance	Water conditions	2.2.5.1.	Regulation of the chemical condition of freshwaters by living processes

Ecosystem services identified in OMPNP according to CICES classification (Continued).

Section	Group	CICES code	Description
Regulation & Maintenance	Atmospheric composition and conditions	2.2.6.1., 2.2.6.2., 2.3. X.X.	Regulation of chemical composition of atmosphere and oceans. Regulation of temperature and humidity, including ventilation and transpiration
Cultural	Physical and experiential interactions with natural environment	3.1.1.1.,3.1.1.2.	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions. Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions
Cultural	Intellectual and representative interactions with natural environment	3.1.2.1., 3.1.2.2., 3.1.2.3., 3.1.2.4.	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge. Characteristics of living systems that enable education and training. Characteristics of living systems. Characteristics of living systems that enable aesthetic experiences that are resonant in terms of culture or heritage.
Cultural	Spiritual, symbolic and other interactions with natural environment	3.2.1.1., 3.2.1.3.	Elements of living systems that have symbolic meaning. Elements of living systems used for entertainment or representation.
Cultural	Other biotic characteristics that have a non-use value	3.2.2.1.,3.2.2.2,3.3. X.X.	Characteristics or features of living systems that have an existence value. Characteristics or features of living systems that have an option or bequest value.

Source: CICES classification

 DOI: 10.5709/ce.1897-9254.330