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Mapping forest ecosystem services: From providing units to beneficiaries

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ABSTRACT

Some of the main research questions in the assessment ecosystem services include how to integrate ecological and social information into the analysis and how to make it spatially explicit. We mapped six ecosystem services delivered by forests in the Sierra Nevada Mountains (south-east Spain) from the supply- to the demand-sides, taking into account the influence of protected areas on the capacity of supply services. Semi-structured interviews and geographical information system sources were used to map the supply-side, whereas 205 face-to-face questionnaires were distributed to assess and map the demand-side. Our results show the existence of consistent ecosystem service bundles in terms of both the supply- and demand-sides, particularly between erosion control–recreational hunting and between mushroom harvesting–nature tourism. We found a spatial scale mismatch for the erosion control, with its supply at the local scale and its demand at the regional–national scales, with implications at the institutional scale at which it should be managed. Consequently, mapping both the supply- and demand-sides is essential for environmental decision making because it can indicate where management interventions should be focused, either by defining high-priority areas for protection or defining the institutional scale at which these services should be managed.

1. Introduction

The ecosystem service concept is currently the focus of both scientific activities (Fisher et al., 2009; Vihervaara et al., 2010; Seppelt et al., 2011) and environmental policy actions, e.g., the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the targets of the Convention of Biological Diversity (CBD) for the year 2020. Despite the increasing scientific and political attention on ecosystem services, several research areas need to incorporate the ecosystem service framework into environmental conservation programmes. One of the most important gaps in scientific knowledge is related to the spatial distribution of multiple ecosystem services from a multidisciplinary approach, which involves the use of biophysical and socio-economic information (Anton et al., 2010). As the evaluation of ecosystem services addresses the complex relationships between humans and ecosystems ((MA) Millennium Ecosystem Assessment, 2005; Bennett et al., 2009; Martín-López et al., 2009), attempts to define the spatial analysis of ecosystem services should include both the capacity of the ecosystems to deliver services to society, i.e., the supply-side, and the social demand for using a particular ecosystem service in a specific area, i.e., the demand-side (Tallis and Polasky, 2009; De Groot et al., 2010; Haines-Young and Postchin, 2010; Bastian et al., 2012). The capacity of ecosystems to supply particular services that benefit people is usually considered to be a service-providing unit (SPU), i.e., the ecosystem structures and processes that provide a specific ecosystem service at a particular spatial scale (Luck et al., 2009; Harrington et al., 2010). If the capacity of a SPU is changed, the satisfaction of social demands for the ecosystem service might be affected (Burkhard et al., 2012). The ecosystem service beneficiaries (ESBs) are those stakeholders who benefit from and demand of the ecosystem services or someone who is or may be involved or affected positively by a given environmental or management public policy (modified from Harrington et al. (2010)) (Fig. 1). Box 1 shows the definitions of the key concepts used in this study.

Despite the importance of the spatial identification and delineation of SPUs and ecosystem service demands, its integrated analysis remains a key challenging research issue (Anton et al., 2010; De Groot et al., 2010; Reyers et al., 2010; Seppelt et al., 2011), and few studies have spatially analysed both sides of ecosystem service assessment (e.g., van Jaarsveld et al., 2005; McDonald, 2009; Burkhard et al., 2012; Kroll et al., 2012). In fact, the identification of supply-demand mismatches across landscapes is also one of the key

Abbreviations: ESBs, ecosystem service beneficiaries; MCA, multiple correspondence analysis; PCA, principal component analysis; SPUs, service-providing units.

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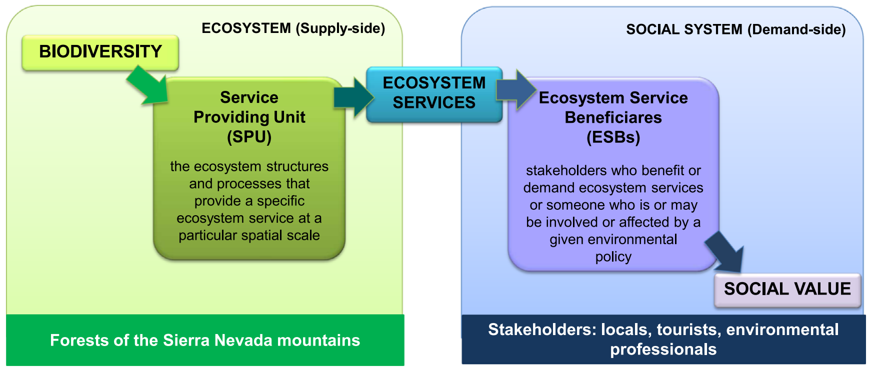

Fig. 1. Framework for mapping ecosystem services considering both the ecological capability to deliver them (supply-side) and the use and value by stakeholders (demand-side). Modified from Haines-Young and Postchin (2010).

Box 1–Definitions of key concepts for mapping ecosystem services.

Ecosystem services: direct and indirect contributions of ecosystems to human well-being (De Groot et al., 2010).
Service-providing units (SPUs): the ecosystem structures and processes that provide a specific ecosystem service at a particular spatial scale (Harrington et al., 2010; Luck et al., 2009).
Ecosystem service beneficiaries (ESBs): stakeholders who benefit from and demand of the ecosystem services or someone who is or may be involved or affected positively by a given environmental or management public policy (modified from Harrington et al., 2010).
Hotspot: an area that provides large components of a particular service, delineated here as the richest 5% of grid cells for each service (Bai et al., 2012; Egoh et al., 2009; Chan et al., 2006).

issues to be addressed in specific environmental and conservation strategies, as in the case of the new European Biodiversity Strategy to 2020 (Maes et al., 2011) or the National Strategic Plan of the Natural Heritage and Biodiversity of Spain ((MARM) Ministerio de Medio Ambiente y Medio Rural y Marino, 2011). As mapping tools allow an ecosystem to be analysed for the supply of ecosystem services in a suitable way while also taking into account the social demand for those services, the spatial visualisation approach constitutes a powerful tool for supporting environmental and landscape decision making (Sherrouse et al., 2011; Burkhard et al., 2012; Kroll et al., 2012; Gulickx et al., 2013).

Within this context, the main purpose of this study is to explore the spatial mismatch between the delivery of ecosystem services by forest ecosystems and the use and valuation of them by the beneficiaries. In Spain, forest ecosystems occupy an important extension, represent the habitat of terrestrial biodiversity and provide a diverse flow of ecosystem services (e.g., timber, harvesting, beekeeping, climate regulation, erosion control, and recreational activities) ((EME) Millennium Ecosystem Assessment of Spain, 2011). For this objective, we specifically: (1) mapped SPUs and explored the role of forests in determining ecosystem service hotspots, (2) analysed the social value of ecosystem services and determined the spatial scale at which these ecosystem services were valued by different ESBs, (3) identified the existing ecosystem service trade-offs and synergies in both the supply-side (i.e., SPUs) and the demand-side (i.e., ESBs), and (4) analysed the relationship between different conservation strategies (i.e., National Park, Natural Park, and non-protected areas) and the capacity of forests ecosystems to supply services. For these objectives, we mapped the ecosystem service supply and demand by forests in a semi-arid Mediterranean mountain, i.e., the south-east of Spain. This study is part of a wider research project on ecosystem services in south-east Spain in which different approaches, from biophysical to social, have been used (Castro et al., 2011; García-Llorente et al., 2011a, 2012a).

2. Study area

The study area is located in south-east Spain and covers 8 municipalities in the Granada and Almería provinces (58,627 ha and nearly 10,000 inhabitants). A socio-demographic profile of each municipality present in the study area is represented in Table 1.

This location corresponds to the socio-economic administrative limit of the main ESBs of the forest ecosystem services delivered by the eastern part of the massif of the Sierra Nevada Mountains (Fig. 2), which has been declared a Natural Park (1989) and National Park (1999). Both designations refer to different conservation strategies: the National Park designation involves a strict conservation level, whereas Natural Park implies a medium conservation level that allows traditional and cultural management practices.

The ecosystem services delivered by the forests of this area have been recognised in relation with the provision of services, such as timber or fruit harvesting (Arias Abellán, 1981). In the last decades, intense reforestation was conducted with the aim of fostering regulating services, such as erosion control and hydrological regulation. The diverse community of Mediterranean shrubs (i.e., *Cistus* spp., *Genista* spp., and *Rosmarinus* spp.) and trees species (e.g., chestnuts (*Castanea sativa*) and almonds (*Prunus dulcis*)) have also sustained the service of beekeeping. In addition, the presence of certain species of wildlife (i.e., Iberian wild goat (*Capra pyrenaica*), wild boars (*Sus scrofa*), red-legged partridge (*Alectoris rufa*), and Iberian hares (*Lepus granatensis*)) supports recreational hunting. Finally, the ecological value of the area increases the significance of nature tourism (Vacas Guerrero, 2001).

3. Methodology

We mapped both the supply and demand-sides of ecosystem services by delineating SPUs and identifying the spatial scale at which ESBs demand forest ecosystem services. We selected those ecosystem services that are relevant in the study area (García-Llorente et al., 2012a,b), which were also previously identified as important in forest systems (Naidoo and Ricketts, 2006; Harrison et al., 2010; Chiabai et al., 2011; (EME) Millennium Ecosystem Assessment of Spain, 2011; Maes et al., 2011), as follows:

Table 1
Socio-demographic profile of the municipalities in the study area: population, age, education, and employment variables are included.
Source: the Andalusian Multi-Territorial Information System (http://www.juntadeandalucia.es/institutodeestadisticaycartografia/sima/index2.htm).

Municipality	Population			Age				Formal education (%)				Employment (%)		
	Total inhabitants	% Female	% Male	Average (years old)	% < 15	% 15–64	% > 65	Illiteracy	Non-formal education	First-second degree	University	Primary sector	Secondary sector	Tertiary sector
Abla	1501	50.2	49.8	44.2	12.1	60.7	27.2	4.1	25.1	60.0	10.8	10.4	22.9	66.7
Abrucena	1418	50.4	49.6	42.3	14.0	62.1	23.9	7.8	4.9	82.1	5.1	37.0	25.9	37.0
Bayárcal	341	49.3	50.7	44.6	10.9	61.6	27.6	10.0	38.1	48.5	3.3	24.5	17.0	58.5
Fiñana	2489	51.0	49.0	41.1	16.5	60.5	23.0	10.2	31.3	52.8	5.7	21.9	37.7	40.5
Huéneja	1220	49.1	50.9	44.1	13.1	59.5	27.4	2.7	34.6	57.6	5.1	17.9	36.6	45.5
Láujar de Andarax	1836	50.4	49.6	40.0	15.0	64.6	20.4	7.7	27.3	57.9	7.1	13.9	40.9	45.2
Ohanes	781	49.8	50.2	46.2	12.4	56.1	31.5	7.4	34.9	53.0	4.7	35.4	18.7	46.0
Paterna del Río	375	48.0	52.0	48.1	8.3	59.7	32.0	1.5	44.9	51.6	2.1	22.6	20.0	57.4

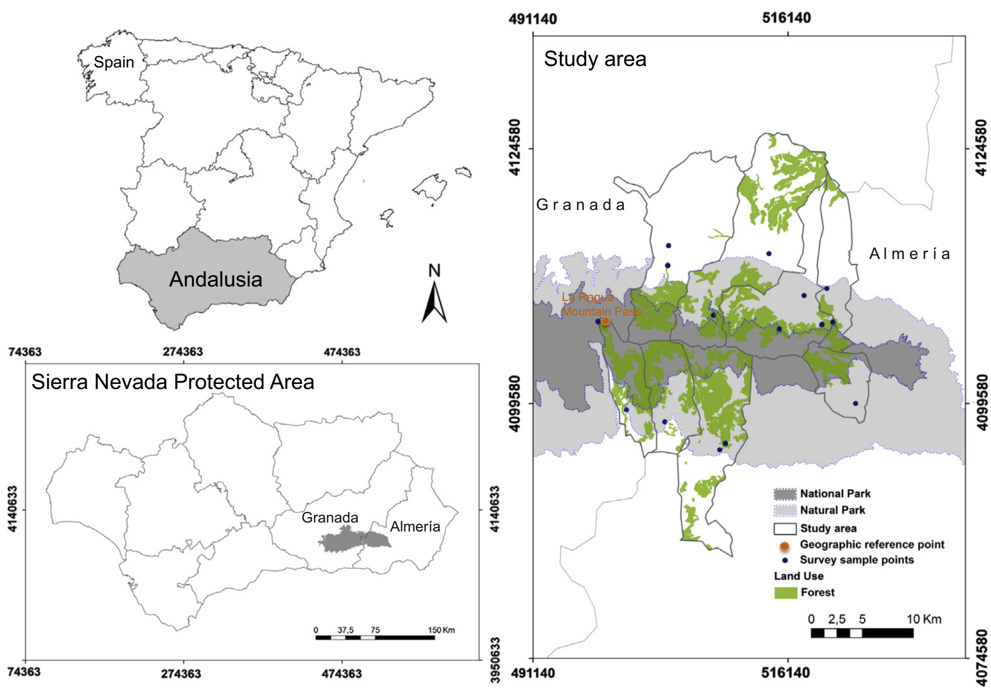

Fig. 2. Map of the study area. The municipalities correspond to the limits of the users of the main ecosystem services, and the limits of the protected area represent the conservation administrative limits. The sample points of the social survey are shown.

(1) timber, mushroom harvesting, and beekeeping as provisioning services; (2) erosion control as a regulating service; and (3) nature tourism and recreational hunting as cultural services.

3.1. Mapping service-providing units

We used different indicators to map the ecosystems' capacity to supply services to society and different data sources, such as semi-structured interviews with key local stakeholders (see Appendix A), and existing GIS sources and models. The key stakeholders comprised environmental and local development professionals, farmers, foresters, mushrooms gatherers, and hunters.

The proxies and data sources used for each studied ecosystem service are shown in Table 2. The proxies employed for mapping each SPU were the following: (1) the surfaces identified as "*Forestry exploitation*" and "*Logging area*" for mapping timber; (2) the legal and authorised use area for mushroom harvesting; (3) the suitable areas for beekeeping production models; (4) the areas where erosion control was high, as calculated through the Universal Soil Loss Equation (USLE) model; (5) trails and public facilities as proxies of nature tourism; and (6) the number of prey for hunting in each hunting preserve as a proxy of recreational hunting. The use of these proxies implies certain shortcomings in this research because the information explicitly spatial presented (i.e., proxies of every ecosystem service analysed) was processed according to different methodologies. In addition, some layers were not complete for the all the study area, and therefore, they do not reflect the total provision of specific ecosystem services.

The delivery of these analysed ecosystem services was mapped using a grid approach with 1 × 1 km resolution (N=829); the grid cells at the border were not used for the analysis to avoid a potential bias of local effects (Schneiders et al., 2012). This method is similar to those previously used in studies of ecosystem service mapping (e.g., Chan et al., 2006; Holland et al., 2011; Schneiders et al., 2012). For each ecosystem service, we identified SPU hotspots through the delineation of the richest 5% of the grid

Table 2
Summary of the indicators used for mapping service-providing units (SPUs) and their descriptions, proxies, data sources, and the statistical analyses in which they were used. P=Pearson correlation, PCA=principal component analysis, U=*U*–Mann Whitney.

Ecosystem service	Description	Proxy	Source	Statistical analysis
Timber	*Cartographic base SIOSE of Andalusia (2005)* *Public Forests of Andalusia, detailed scale (2010)*	Forestry exploitation surface Logging area	REDIAM—Environmental Information Network of Andalusia Interviews to key local stakeholders (*N*=6)	P; PCA
Mushroom harvesting	*Digitisation of authorised-use area in the Mushroom´s use map in Bayárcal Municipality*	*Authorised area for mushroom harvesting*	*Bayárcal Municipality.* Department of Environment of the Andalusian government Interviews to key local stakeholders (*N*=5) Order for mushroom and other wild fruits harvesting in public forests of Bayarcal (Almería), B.O.P. n° 200 15 October 2007	P; PCA
Beekeeping	*Map of suitable areas for beekeeping production in the public forest ecosystems of Andalusia (2005)*	Area categories for beekeeping production	REDIAM—Environmental Information Network of Andalusia	P; PCA
Regulating				
Erosion control	*Soil erosion calculation model in Andalusia by USLE (historic trend 1992–2006)*		REDIAM—Environmental Information Network of Andalusia	P; PCA
Cultural				
Nature tourism	*Public facility and public routes, detailed scale (2010)*	Trails and Public facilities	REDIAM—Environmental Information Network of Andalusia Interviews of key local stakeholders (*N*=4)	P; PCA
Recreational hunting	*Hunting activity in Andalusia (2009–2010)*	Categories for number of prey for hunting	Department of Environment of the Andalusian government Interviews of key local stakeholders (*N*=5)	P; PCA
Land uses	*Land uses (2009)*	Land-use categories	Cartographic System of Andalusia Regional Andalusian government	*U*
Management strategy	*Protected Area planning data model: current Natural Resources Management Plan zonification (2010)*	Typology of Protected Area (Non-protected; Natural Park; National Park)	REDIAM—Environmental Information Network of Andalusia	*PCA*

cells, as performed in previous studies (e.g., Chan et al., 2006; Egoh et al., 2009; Bryan et al., 2011; Bai et al., 2012).

The average value of the ecosystem service supply score was calculated per 1×1 km grid cell to perform the statistical analysis. To estimate the co-variation of the delivery of ecosystem services, we used the Pearson correlation test after data transformation to cope with normality. Here, a statistically positive correlation between some ecosystem services indicates that more of one ecosystem service implies more of another, entailing service synergies, and a statistically negative correlation between some ecosystem services indicates that more of one service implies less of another, involving ecosystem service trade-offs.

Lastly, to define which portions of the landscape supply a diverse flow of ecosystem services, we overlapped the maps of specific SPUs to create a map of overlapping ecosystem services. Then, we used the maps *land use* for 2009 in Andalusia (see Table 2) to test the capacity of different lands-use types (i.e., forests, shrublands, grasslands, open spaces with little or no vegetation, inland waters, croplands, and urban and industrial areas) to deliver a diverse flow of ecosystem services. The *U*–Mann Whitney test was used to identify which land-use types have more capacity to deliver a diverse flow of forest ecosystem services.

3.2. Mapping the social demand for ecosystem services

To map the social demand for forest ecosystem services, social sampling was conducted through face-to-face questionnaires with ESBs of different profiles, including locals, tourists, protected area managers, and researchers. For this purpose, we assessed the perception of the important ecosystem services as an indicator of how different ESBs valued and demanded them. Each respondent selected the four most demanded ecosystem services from a panel using pictures of potential services provided. Appendix B shows the list of potential ecosystem services provided by the study area that was shown to the respondents, including a graphical illustration and an example in the study area. The use of panels with pictures and an example of each service in the study area has been previously used in the ecosystem service literature to facilitate respondents' comprehension of ecosystem services (e.g., Calvet-Mir et al., 2012; Martín-López et al., 2012). Here, we restricted the analysis to the six forest ecosystem services named above. The respondents were also asked about their place of residence to calculate the spatial scale at which the analysed ecosystem services were demanded. The demand-side was mapped by establishing buffers of distances (six buffers that enclosed different spatial scales) designed through the distance from the place of the respondent's residence to the study area. The description of the variables obtained from the sampling is shown in Table 3.

Overall, 205 direct face-to-face questionnaires were completed during the period of May 2009–February 2010, covering 15 sampling points across 8 municipalities and including protected area offices, urban zones, agrarian offices, recreational areas, and others (Fig. 2). The sampling was randomly selected and restricted to individuals over 18 years old. The questionnaires were tested through prior pre-sampling.

We used the Chi-squared test to test the effect of the scale (local vs. non-local) at which the ecosystem services were demanded by ESBs. The local scale was defined as a 50 km distance from the respondents' place of residence to the study area, and the non-local scale was defined for longer distances (see Table 3).

3.3. Multivariate analysis to identify the trade-offs and synergies of ecosystem services based on biophysical and social data

Multivariate analyses were conducted to explore the possible trade-offs and synergies between ecosystem services. In particular, a principal component analysis (PCA) was applied to analyse the

Table 3
Summary of variables used in the demand analyses of ecosystem services, their description, and the analysis in which they were used.

Ecosystem service	Type	Description	Statistical analysis
Provisioning			
Timber	Binary	When the respondent recognised the importance of timber from holm oak, olive tree, and pine wood as an important service in the area (1 = yes; 0 = otherwise)	Chi-square; MCA
Mushroom harvesting	Binary	When the respondent recognised mushroom harvesting as an important service in the area (1 = yes; 0 = otherwise)	Chi-square; MCA
Beekeeping	Binary	When the respondent recognised honey as an important service in the area (1 = yes; 0 = otherwise)	Chi-square; MCA
Regulating			
Erosion control	Binary	When the respondent recognised the importance of erosion control, e.g., through terraces, in the area (1 = yes; 0 = otherwise)	Chi-square; MCA
Cultural			
Nature tourism	Binary	When the respondent recognised the importance of recreational activities related to ecotourism in the area (1 = yes; 0 = otherwise)	Chi-square; MCA
Recreational hunting	Binary	When the respondent recognised the importance of recreational hunting (small game or big game hunting) in the area (1 = yes; 0 = otherwise)	Chi-square; MCA
Spatial-scale indicators			
Distance buffers	Ordinal	Distance from the place of residence to the geographic reference point *La Ragua Mountain Pass* (Buffer 1 $\leq$ 15 km; Buffer 2 = 15–50 km; Buffer 3 = 50–100 km; Buffer 4 = 100–300 km; Buffer 5 = 300–600 km; Buffer 6 $\geq$ 600 km)	Mapping
Local	Binary	Local beneficiaries were defined as those individuals whose place of residence was included in the distance buffers 1 and 2, with a maximum distance of 50 km. (1 = local; 0 = non-local)	Chi-square

MCA = multiple correspondence analysis.

relationships in the supply of forest ecosystem services and the influence of the conservation strategy on delivering ecosystem services. We used Bartlett's test of sphericity to ensure the reliability of the correlation matrices for the PCA (Bartlett, 1950), and the relationships among the ecosystem service demands were analysed using multiple correspondence analysis (MCA). The variables used are included in Table 2 and Table 3.

PCA and MCA were used to identify the synergies and trade-offs in the supply and demand of ecosystem services, respectively. Here, we were able to reduce the six-dimensional space of both the supply and demand of ecosystem services as much as possible. We used PCA to examine to what extent the SPUs spatially overlapped (synergies) and differed (trade-offs). The Kaiser criterion (i.e., eigenvalue > 1) was used to select the principal components accounting for most of the variance of the measures of the ecosystem services supply (Kaiser, 1960). We used MCA to explore the correlations (synergies) and differences (trade-offs) among the social demands for ecosystem services.

All the statistical analyses were performed using the software package XLSTAT 2009.

4. Results

4.1. Service-providing units in forests

The values of the six ecosystem service SPUs in the study area are shown in Fig. 3. The distribution of the SPUs was different among the ecosystem services. Although timber and mushroom harvesting were highly localised to particular areas, nature tourism was located at the summit of the Sierra Nevada within the National Park.

The spatial correlation results between the SPUs are provided in Table 4. We found a significant positive relationship between cultural services, i.e., nature tourism and recreational hunting. Furthermore, nature tourism was positively correlated with mushroom harvesting. However, nature tourism was negatively correlated with the other provisioning services, i.e., timber and beekeeping. Recreational hunting was also negatively correlated with beekeeping.

The six ecosystem services overlapped in space, as illustrated in Fig. 4, showing that the most diverse flow of ecosystem services was provided inside the boundaries of the Sierra Nevada Protected Area (i.e., National and Natural Parks). Furthermore, the *U*–Mann Whitney test showed that the ecosystems of forests (U = 66,137; p-value < 0.0001), grasslands (U = 40,546; p-value < 0.0001), and open spaces with little or no vegetation (U = 90,449; p-value = 0.004) enhance the supply of the major ecosystem services.

4.2. Mapping the social demand for ecosystem services

Overall, we found that the most demanded ecosystem service was nature tourism, followed by timber, erosion control, recreational hunting, mushroom harvesting, and beekeeping (Table 5). When we considered the beneficiary scale (local or non-local), we found differences in the ranking of these preferences. In particular, these differences were statistically significant for erosion control, which was more important at the non-local scale, and for recreational hunting, which had the opposite trend. Thus, more non-local people (18.1%) demanded erosion control than local people (9.9%). In contrast, more local people demanded recreational hunting (14.4% of locals) than non-local beneficiaries (6.4% of non-locals).

In this sense, we found that local ESBs placed more value on those services with extractive values that are mainly associated with provisioning services (e.g., timber, mushroom harvesting, and beekeeping) (Table 5 and Fig. 5) and recreational hunting (Fig. 6C). In contrast, non-local ESBs at the regional and national scales highly demanded erosion control and nature tourism (Table 5 and Fig. 6).

4.3. Trade-offs and synergies of ecosystem services based on biophysical and social data

We reduced the six-dimensional SPU space to three dimensions in which the selected components (F1, F2, and F3) had an eigenvalue higher than 1 and accounted for 59.5% of the total variance (see Appendix C). The results from Bartlett's test of sphericity indicated that the correlation matrix was not random (χ^2 = 133.10; d.f. = 20; p-value < 0.0001). The first two components (F1 and F2) of PCA are shown in Fig. 7A. On the one hand, cultural services (e.g., nature tourism and recreational hunting) and erosion control had highly positive contributions to F1, and

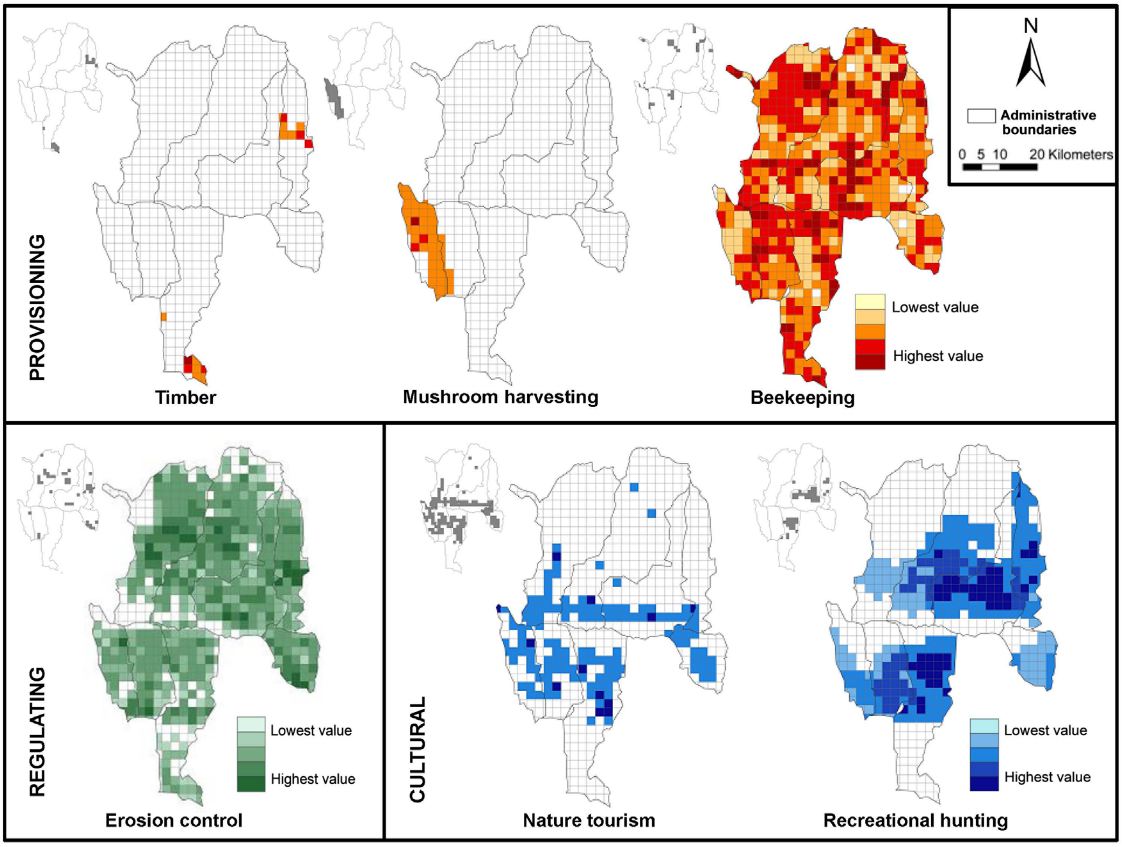

Fig. 3. Spatial distributions of the six service-providing units (SPUs) in the study area. The maps of the hotspots for each of the SPUs are show in grey.

Table 4
Pearson correlation test between service-providing units (SPUs).

	Provisioning		Regulating		Cultural	
	Timber	Mushroom harvesting	Beekeeping	Erosion control	Nature tourism	Recreational hunting
Timber	1					
Mushroom harvesting	−0.039	1				
Beekeeping	0.022	−0.008	1			
Erosion control	0.042	−0.023	0.042	1		
Nature tourism	−0.069*	0.171**	−0.161**	0.033	1	
Recreational hunting	0.009	−0.041	−0.101**	0.267**	0.079*	1

Statistical significance at the *5% and **1% levels.

beekeeping and timber had negative contributions to F1. Thus, F1 could be interpreted as a trade-off between the delivery of the provisioning services related to non-protected areas and other services in connection with Sierra Nevada Natural Park. On the other hand, nature tourism and mushroom-harvesting supply contribute highly to the positive scores of F2, being highly related to the National Park strategy (Fig. 7A).

The MCA revealed two main components accounting for 55.8% of the variance of the social demand for ecosystem services (Fig. 7B). As in the previous analysis, the first component (F1) was described by the relationship between the social demands for recreational hunting (mainly related to local ESBs) and erosion control (mainly related to non-local ESBs) (in positive scores), and by the relationship between mushroom harvesting and nature tourism (in negative scores). The second component (F2) is represented by the trade-off between beekeeping (in positive scores) and recreational hunting (in negative scores). The MCA results are shown in Appendix D.

5. Discussion

5.1. Defining ecosystem service bundles based on SPUs and social demands

Our analysis of the spatial patterns of the ecosystem services illustrated how these services are located and where the trade-offs and synergies among the ecosystem services fell, allowing us to define the ecosystem service bundles (Raudsepp-Hearne et al., 2010). Here, we define ecosystem service bundles as a set of ecosystem services that appear together across space, referring either to the supply-side (i.e., SPU) or the demand-side (i.e., ESBs). In fact, we identified ecosystem service bundles by analysing both SPUs through spatial analysis and ESBs through social sampling.

On the supply-side, we found three different bundles: (1) erosion control–recreational hunting, (2) timber–beekeeping, and (3) mushroom harvesting–nature tourism (Fig. 7A). On the one hand, the ecosystem service bundles could be explained because many regulating services involve the production of some provisioning and cultural services (Raudsepp-Hearne et al., 2010), such as the erosion control–recreational hunting bundle. On the other hand, the higher values of nature tourism corresponded with the higher values of mushroom harvesting, indicating that the extractive use of mushrooms has an important recreational value. In fact, mushroom harvesting should be considered both a provisioning and cultural service because it has two main values: an extractive direct value, which is mostly related to the provisioning category, and a recreational value, which is mostly related to the cultural category. Thus, the mushroom ground in the area is an interesting nature tourism point. Then, we questioned how far an ecosystem service could be classified by exclusive categories (i.e., provisioning, regulating, or cultural).

Taking into account conservation strategies, although extractive services (i.e., timber and beekeeping) are closely related to areas without any protection strategy, the services related to recreational activities (i.e., mushroom harvesting and nature tourism) are mostly delivered inside the National Park borders. Lastly, the conservation strategy conducted at the Natural Park protection level enhances the supply of erosion control and recreational hunting (Fig. 7A).

On the demand-side, we found two main bundles: (1) erosion control–recreational hunting and (2) mushroom harvesting–nature tourism (Fig. 7B). We found that the social demand for nature tourism corresponds with the mushroom harvesting demand. Considering the influence of the protected area on forest ecosystems, nature tourism is highly promoted by environmental management and also involves other activities (such as mushroom

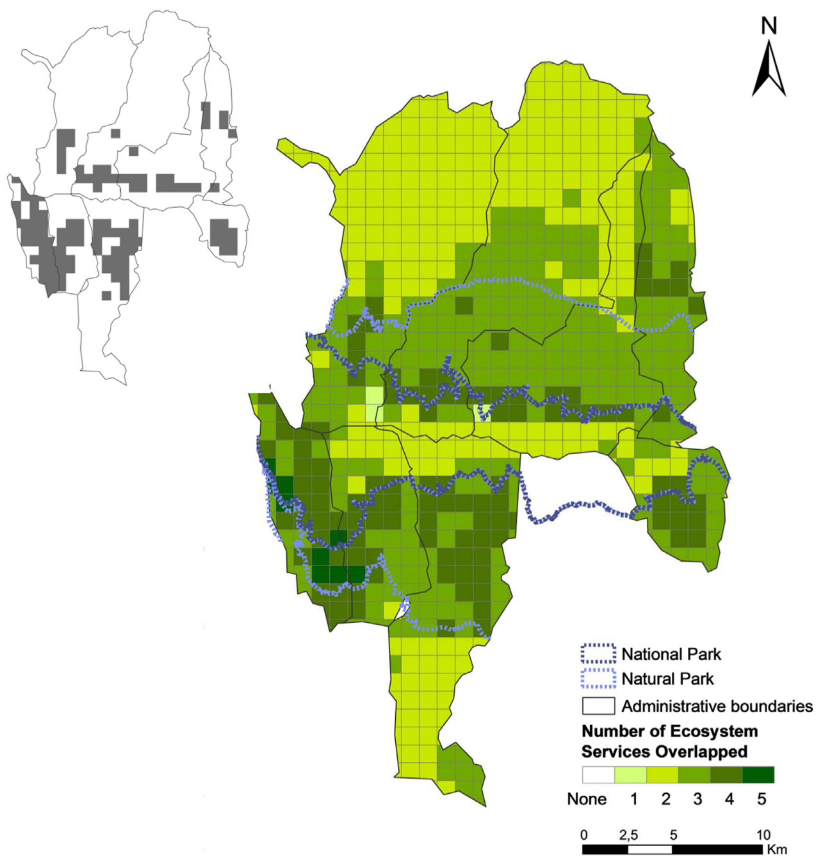

Fig. 4. Ecosystem service hotspots.

Table 5
Mean values (standard deviation in parenthesis) for social demand at the local and non-local scales. The differences among the demands for ecosystem services at the local and non-local scales were tested using the Chi-squared test.

	Total sample	Local	Non-local	χ^2
Provisioning				
Timber	0.205 (0.405)	0.234 (0.425)	0.170 (0.378)	1.281
Mushroom harvesting	0.078 (0.269)	0.099 (0.300)	0.053 (0.226)	1.491
Beekeeping	0.063 (0.244)	0.081 (0.274)	0.043 (0.203)	1.272
Regulating				
Erosion control	0.137 (0.344)	0.099 (0.300)	0.181 (0.387)	2.884*
Cultural				
Nature tourism	0.468 (0.500)	0.423 (0.496)	0.521 (0.502)	1.957
Recreational hunting	0.107 (0.310)	0.144 (0.353)	0.064 (0.246)	3.427*
N	205	111	94	

SD=standard deviation.
Statistical significance at the *5% level.

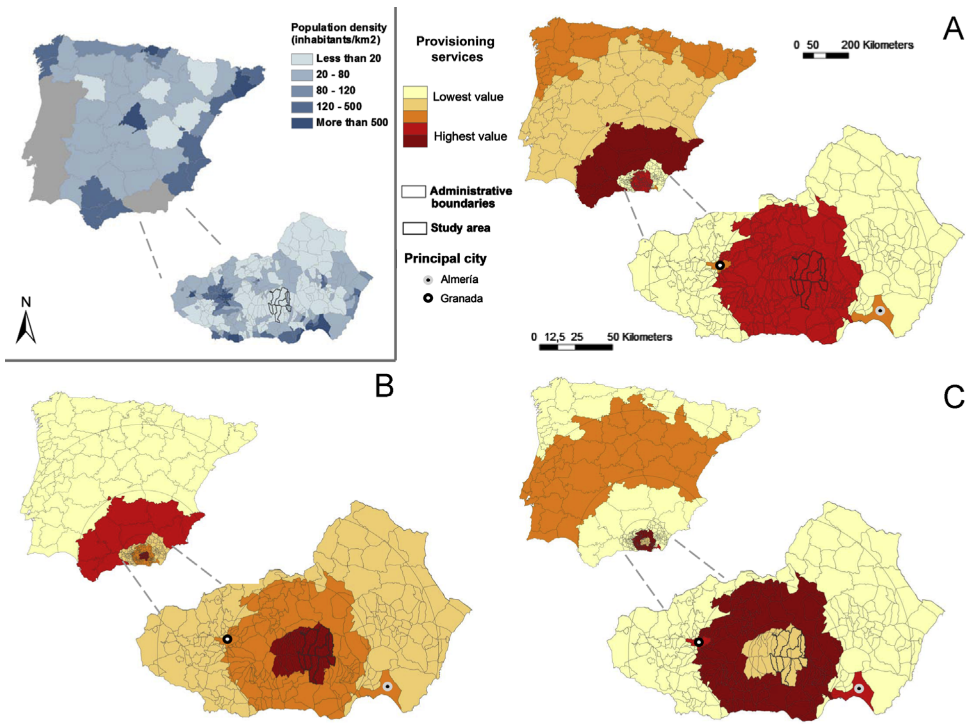

Fig. 5. Map of the population density and spatial distributions of the beneficiaries (ESBs) of provisioning services at the Iberian Peninsula and regional scales (Almería and Granada provinces): (A) timber, (B) mushroom harvesting, and (C) beekeeping. The circular lines represent the six distance categories.

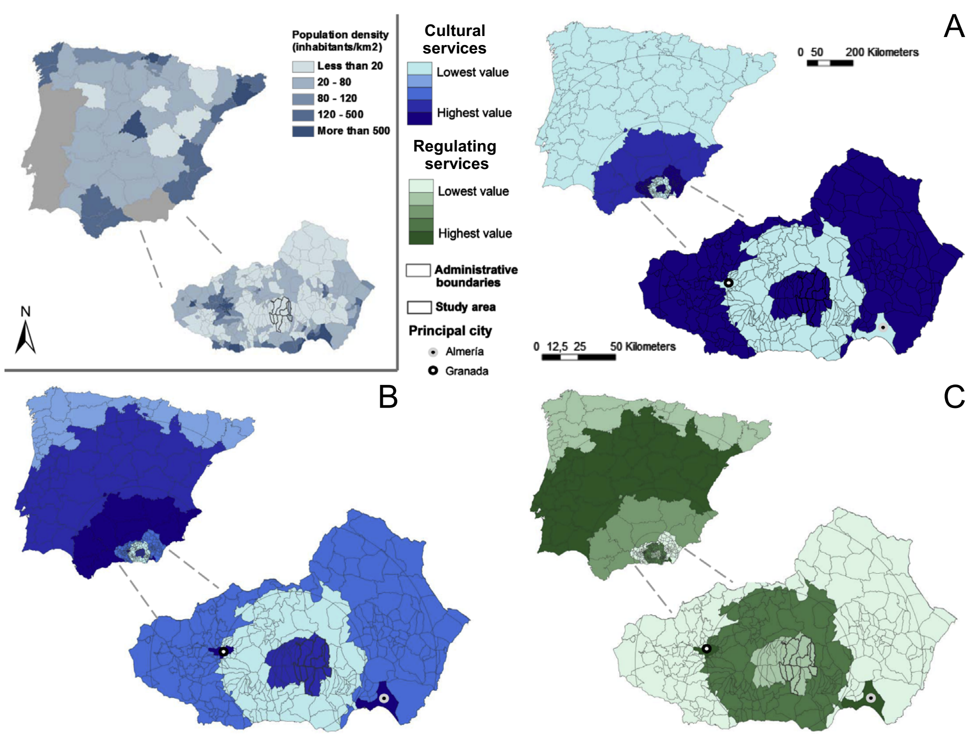

Fig. 6. Map of the population density and spatial distributions of the beneficiaries (ESBs) of regulating and cultural services at the Iberian Peninsula and regional scales (Almería and Granada provinces): (A) recreational hunting, (B) nature tourism, and (C) erosion control. The circular lines represent the six distance categories.

harvesting), noting that the bundles found on the demand-side are the same as those found on the supply-side. This finding suggests a coherent relationship between social demands and the biophysical capacity to supply services, which ultimately can suggest that some forest ecosystems and social system are coupled in the study area. The maintenance of coupled human–nature

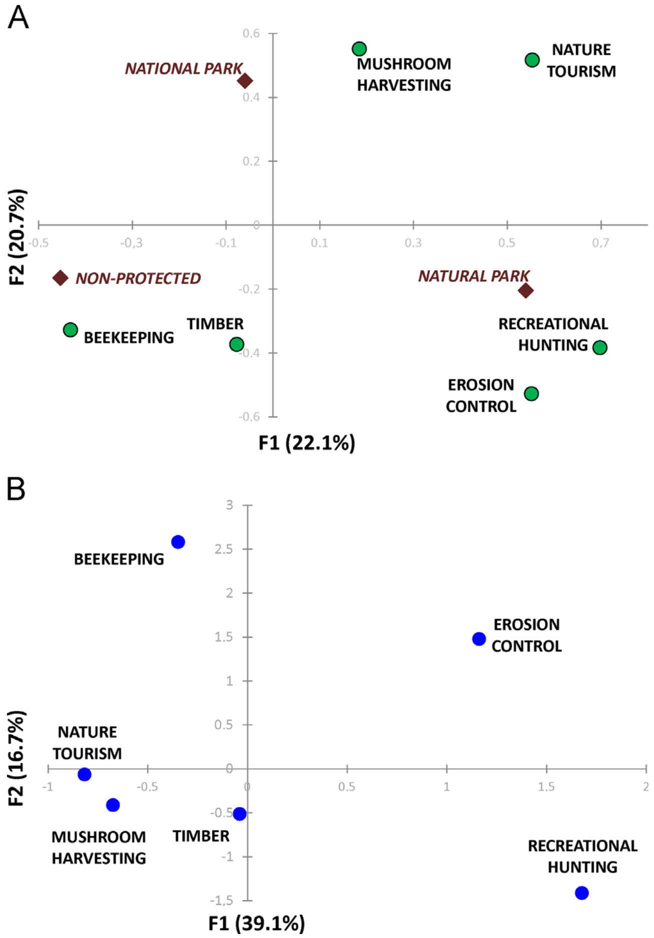

Fig. 7. Biplots of the (A) principal component analysis (PCA) for the ecosystem service supply and their relationship with conservation strategies (i.e., National Park, Natural Park, or non-protected) and (B) multiple correspondence analysis (MCA) for the ecosystem services demand.

systems here could most likely be due to the environmental management promoted by the Natural Park strategy that aims to maintain traditional practices. In fact, it has been acknowledged that a historical co-evolution between humans and nature has occurred in Mediterranean rural areas (Blondel et al., 2010). This co-evolution has been maintained over centuries through traditional extensive management practices in which a diverse flow of ecosystem services is also preserved (Bugalho et al., 2011; García-Llorente et al., 2012a; Martín-López et al., 2012).

5.2. Scale mismatches between the supply and demand of ecosystem services

The spatial scale has been recognised as a key issue in ecosystem services research because a spatial scale mismatch usually exists between the supply- and demand-sides (Hein et al., 2006). In fact, we can classify the ecosystem services based on the spatial relationships between the SPUs and ESBs. Fisher et al. (2009) classified such relationships as (1) in situ, (2) *omni-directional*, and (3) *directional*. The in situ category indicates that the spatial scale at which an ecosystem service is delivered coincides with the spatial scale at which this service is demanded. The *omni-directional* category indicates that the ecosystem service demand occurs within a buffer area surrounding the place of its delivery. Lastly, the *directional* category denotes that the delivery of a service benefits a specific place because a service flow exists in a given direction. In this sense, we show that most of the provisioning services delivered by forests in the south-east of Spain belong to the in situ category because most of the ESBs are situated at the local scale (Table 5 and Fig. 5). In contrast, our results show that erosion control flow is *directional* because most of the beneficiaries are situated at the bottom of watersheds and also regionally *omni-directional* because the respondents at the regional and national scales highly perceived the importance of this service (Table 5 and Fig. 6C). Lastly, we found that the supply-demand flow of both nature tourism and recreational hunting is mainly related to the movement of users, i.e., the use of a service occurs when a flow of people moved to the SPU (Costanza, 2008). However, although recreational hunting is mainly related to rural populations, nature tourism is mostly related to the urban populations of cities in Almería and Granada (Fig. 6A and 6B). In other words, our findings highlight the spatial mismatch that occurred between the SPUs and ESBs for certain ecosystem services, such as erosion control and nature tourism.

5.3. Implications for environmental management

Consideration of the spatial scale at which the ecosystem services are supplied and the location at which the beneficiaries demand these services is essential to design environmental management policies, because it indicates where management interventions should be focused (Chan et al., 2006), either in defining high-priority areas for the protection of ecosystem service delivery or in defining the institutional scale at which these services should be managed, which is derived from the spatial pattern of their demand.

On the one hand, mapping ecosystem service hotspots could also enhance conservation goals because they represent priority areas for maintaining key ecosystem services for human well-being (see Fig. 4) and for conserving forest ecosystems underlying the supply of these services (Egoh et al., 2007, 2009; Bai et al., 2012). Consequently, these high-priority areas should be taken into account by the managers of the protected area. As Fig. 4 shows, most of the ecosystem service hotspots are still included inside the limits of the Natural and National Park, indicating that the current conservation strategy of the Sierra Nevada protected area preserves the flow of ecosystem services delivered by its forests.

On the other hand, when we use the ecosystem service framework in the environmental management process, the spatial scales play an important role in terms of (1) the ecological scale at which a given ecosystem service is supplied, (2) the scale at which different ESBs demand this service, and (3) the institutional scale at which it is or should be managed. However, the spatial scale of a given ecosystem service could differ with regard to its delivery, demand by ESBs, and management by institutions (Hein et al., 2006). Our findings show a spatial scale mismatch for erosion control, with its supply at the local scale and its demand at the regional–national scales (Table 4), suggesting that this regulating service should be managed considering its social interest at the regional–national scale, and thus, the decision-making process should involve different spatial scales. The fact that our results are consistent with similar patterns shown by other studies in Spain (García-Llorente et al., 2011b; Martín-López et al., 2012), in which local stakeholders recognise in a major way the importance of provisioning services and non-local people recognise regulating and cultural services, emphasises the need to consider these results in the design of environmental policies.

Therefore, mapping the supply and demand of ecosystem services is a key step to identify the appropriate institutional scale for environmental decision-making (Kroll et al., 2012).

In addition, the study area in which this research occurred is not only a priority in terms of environmental conservation but has also been classified by Spanish law as a rural area at a priority level to be revitalised ((MARM) Ministerio de Medio Ambiente y Medio Rural y Marino, 2010), whereby the focus is to improve social well-being by promoting socio-cultural, economic, and environmental conditions. We expect that the findings of this study will constitute guidelines for the design of the suitable management of the forest ecosystem services in semi-arid Mediterranean mountain systems, taking into account both the supply- and demand-sides of ecosystem services as well as the environmental and socio-economic dimensions.

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Appendix A. Semi-structured interview

DATE Interview N°

(1) Interviewee's relationship with the study area:
- What is your profession?
- How long have you been living in the area?
- Have you ever out migrated?
  - Where?
  - When?
  - Why?
  - When did you come back?
- How many generations have been living in the area?

(2) Interviewee's information about the importance and evolution of ecosystem services in the study area (the question is referred to the specific ecosystem service aimed of analysis; i.e., timber, mushroom harvesting, nature tourism and recreational hunting):
- When did you begin to do this activity?
- How has the trend of this activity been during the last fifty years?
- How was its management fifty years ago?
- And how is it now?
- Why do you think the management has changed (if applicable)?
- How will be the trend of this activity during the next fifty years?

(3) Information about conflict, weakness, and problems of management in connection with the ecosystem services surveyed (the question is referred to the specific ecosystem services analyzed in this study; i.e., timber, mushroom harvesting, nature tourism and recreational hunting):
- What are the current management problems?
- Do you know which jobs derivate from this activity?
- Do you meet people whose job is linked to this activity?
- Is the Sierra Nevada Protected Area important to you?
- What are the most relevant conflicts related to Protected Area?

(4) Relationship between the ecosystem services analysed and cultural or traditional contributions (the question is referred to the specific ecosystem services analysed in this study; i.e., timber, mushroom harvesting, nature tourism and recreational hunting):
- How does this activity influence your own well-being?
- How does this activity influence local people well-being?
- Could you tell me some proverb or saying associated with timber, mushroom harvesting, nature tourism and/or recreational hunting?
- Which species are the most important to carry out this activity?
- Where are the principal sites to carry out this activity located?
- Could you explain me the current management cycle related to this activity?
- How much quantity of mushrooms/timber/game is approximately harvested every year?
- What is it used for?
- Where is the material exported (if applicable)?
- How did you learn to harvest it? Who did you learn it from?

(5) Socio-demographic information:
- What is your level of education?
- How old are you?
- What is your profession?
- Where is your habitual residence located?

Appendix B

Potential ecosystem services detected as provided in the area, and included in the direct face-to-face questionnaires conducted. (Ecosystem services indicated in bold type correspond with ecosystem services analysed). For more details, see García-Llorente et al., 2012a.

Category	Sub-category	Example in semi-arid watersheds	Graphical illustration
Provisioning	Traditional agriculture	Olive tree, almond tree, vine, cereal, fruit orchard	Image here
	Intensive agriculture	Pepper, tomato, green bean, melon, watermelon, zucchini	Image here
	Livestock	Sheep, goat, cow	Image here
	Forest harvesting	Mushrooms	Image here
	Fibre harvesting	Tussock-grass Stipa tenacissima	Image here
	Freshwater	Agriculture and human consumption	Image here
	Clean energy	Wind power and solar energy	Image here
	Timber	Holm oak, olive tree and pine wood	Image here
	Beekeeping	Honey	Image here
Regulating	Air quality	Air purification through vegetation	Image here
	Climate regulation	CO_2 sequestration and rain processes control through vegetation	Image here
	Habitat for maintaining important species	Natural protected areas such as the Albuferas del Adra (White-headed duck (*Oxyura leucocephala*))	Image here
	Water regulation	Riparian vegetation, water infiltrations	Image here
	Water purification	Aquatic plants	Image here
	Erosion control	Terraces, deforestation	Image here
	Soil fertility	Water courses and riversides	Image here
Cultural	Spiritual values	Satisfaction for species conservation: fartet (*Aphanius iberus*), wild goat (*Capra pyrenaica*)	Image here
	Tranquility and relaxation	Water, snow and mountainous landscapes	Image here
	Local Ecological Knowledge (LEK)	Traditional water management, ethnographic museums, agriculture in terraces, basketwork	Image here
	Environmental education	Books and activities about the environment and traditions in the study area	Image here
	Recreational hunting	Small game and big game hunting (rabbit, partridge, wild boar, and goat)	Image here
	Nature tourism	Hiking, horse riding, mountain activities	Image here
	Rural tourism	Related country houses, gastronomy and agrotourism	Image here
	Aesthetic value	Beautiful landscapes such as mountains with snow	Image here
	Local identity	Feel a special bond with the Alpujarra region	Image here

Appendix C.

Factor loadings derived from the principal component analysis (PCA) to show the trade-offs and synergies between ecosystem services based on service-providing units.

Ecosystem services	**Factor loadings**		
	F1	F2	F3
Provisioning			
Timber	–0.077	–0.372	–0.024
Mushroom harvesting	0.184	0.552	0.618
Beekeeping	–0.432	–0.327	0.705
Regulating			
Erosion control	0.552	–0.527	0.340
Cultural			
Nature tourism	0.553	0.517	0.074
Recreational hunting	0.698	–0.383	–0.057
Eigenvalue	1.324	1.242	1.003
Variance explained (%)	22.065	20.693	16.724
Variance accumulated (%)	22.065	42.758	59.482

Appendix D.

Factor loadings derived from the multiple correspondence analysis (MCA) to show the trade-offs and synergies between ecosystem service demands.

Ecosystem services	Factor scores		
	F1	F2	F3
Provisioning			
Timber	−0.039	−0.511	−1.517
Mushroom harvesting	−0.674	−0.411	1.831
Beekeeping	−0.348	2.582	−1.121
Regulating			
Erosion control	1.162	1.480	0.516
Cultural			
Nature tourism	−0.817	−0.062	0.133
Recreational hunting	1.677	−1.411	0.315
Eigenvalue	0.198	0.187	0.172
Inertia explained (%)	39.055	16.723	1.087
Inertia accumulated (%)	39.055	55.778	56.865

References

Anton, C., Young, J., Harrison, P.A., Musche, M., Bela, G., Feld, C.K., Harrington, R., Haslett, J.R., Pataki, G., Rounsevell, M.D.A., Skourtos, M., Sousa, J.P., Sykes, M.T., Tinch, R., Vandewalle, M., Watt, A., Settele, J., 2010. Research needs for incorporating the ecosystem service approach into EU biodiversity conservation policy. Biodivers. Conserv. 19, 2979–2994.

Arias Abellán, L., 1981. La repoblación forestal en la vertiente norte de Sierra Nevada. Cuadernos Geográficos 11, 283–306.

Bai, Y., Zhuang, C., Ouyang, S., Zheng, H., Jiang, B., 2012. Spatial characteristics between biodiversity and ecosystem services in a human-dominated watershed. Ecol. Complex. 8, 177–183.

Bartlett, M.S., 1950. Tests of significance in factor analysis. Br. J. Stat. Psychol. 3, 77–85.

Bastian, O., Haase, D., Grunewald, K., 2012. Ecosystem properties, potentials and services—The EPPS conceptual framework and an urban application example. Ecol. Indic. 21, 7–16.

Bennett, E.M., Peterson, G.D., Gordon, L.J., 2009. Understanding relationships among multiple ecosystem services. Ecol. Lett. 12, 1394–1404.

Blondel, J., Aronson, J., Bodiou, J.-Y., Boeuf, G., 2010. The Mediterranean Region Biological Diversity in Space and Time. Oxford University, Oxford.

Bryan, B.A., Raymond, C.M., Crossman, N.D., King, D., 2011. Comparing spatially explicit ecological and social values for natural areas to identify effective conservation strategies. Conserv. Biol. 25, 172–181.

Bugalho, M.N., Caldeira, M.C., Pereira, J.S., Aronson, J., Pausas, J.G., 2011. Mediterranean cork oak savannas require human use to sustain biodiversity and ecosystem services. Front Ecol. Environ. 9, 278–286.

Burkhard, B., Kroll, F., Nedkov, S., Müller, F., 2012. Mapping ecosystem service supply, demand, and budgets. Ecol. Indic. 21, 17–29.

Calvet-Mir, L., Gómez-Baggethun, E., Reyes-García, V., 2012. Beyond food production: ecosystem services provided by home gardens. A case study in Vall Fosca, Catalan Pyrenees, Northeastern Spain. Ecol. Econ. 74, 153–160.

Castro, A.J., Martín-López, B., García-Llorente, M., Aguilera, P.A., López, E., Cabello, J., 2011. Social preferences regarding the delivery of ecosystem services in a semiarid Mediterranean region. J. Arid Environ. 75, 1201–1208.

Chan, K.M.A, Shaw, M.R., Cameron, D.R., Underwood, E.C., Daily, G.C., 2006. Conservation planning for ecosystem services. Plos Biol. 4, e379.

Chiabai, A., Travisi, C.M., Markandya, A., Ding, H., Nunes, P.A.L.D., 2011. Economic assessment of forest ecosystem services losses: cost of policy inaction. Environ. Resour. Econ. 50, 405–445.

Costanza, R., 2008. Ecosystem services: multiple classification systems are needed. Biol. Conserv. 141, 350–352.

De Groot, R.S., Alkemade, R., Braat, L., Hein, L., Willemen, L., 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecol. Complex. 7, 260–272.

Egoh, B., Rouget, M., Revers, B., Knight, A.T., Cowling, R.M., van Jaarsveld, A.S., Welz, A., 2007. Integrating ecosystem services into conservation assessments: a review. Ecol. Econ. 63, 714–721.

Egoh, B., Reyers, B., Rouget, M., Bode, M., Richardson, D., 2009. Spatial congruence between biodiversity and ecosystem services in South Africa. Biol. Conserv. 142, 553–562.

(EME) Millennium Ecosystem Assessment of Spain, 2011. Millennium Ecosystem Assessment of Spain—Managing Biodiversity and Ecosystem services for human well-being. Fundación Biodiversidad, Ministerio de Medio Ambiente y Medio Rural y Marino, Madrid, Spain.

Fisher, B., Turner, R.K., Morling, P., 2009. Defining and classifying ecosystem services for decision making. Ecol. Econ. 68, 643–653.

García-Llorente, M., Martín-López, B., Montes, C., 2011a. Exploring the motivations of protesters in contingent valuation: insights for conservation policies. Environ. Sci. Pol. 14, 76–88.

García-Llorente, M., Martín-López, B., Díaz, S., Montes, C., 2011b. Can ecosystem properties be fully translated into service values? An economic valuation of aquatic plant services. Ecol. Appl. 21, 3083–3103.

García-Llorente, M., Martín-López, B., Iniesta-Arandia, I., López-Santiago, C.A., Aguilera, P.A., Montes, C., 2012a. The role of multi-functionality in social preferences toward semi-arid rural landscapes: an ecosystem service approach. Environ. Sci. Pol. 19-20, 136–146.

García-Llorente, M., Martín-López, B., Nunes, P.A.L.D., Castro, A.J., Montes, C., 2012b. A choice experiment study for land-use scenarios in semi-arid watershed environments. J. Arid Environ. 87, 219–230.

Gulickx, M.M.C., Verburg, P.H., Stoorvogel, J.J., Kok, K., Veldkamp, A., 2013. Mapping landscape services: a case study in a multifunctional rural landscape in The Netherlands. Ecol. Indic. 24, 273–283.

Haines-Young, R., Postchin, M., 2010. The links between biodiversity, ecosystem services and human well-being. In: Rafaelli, D.y, Frid, C. (Eds.), Ecosystem Ecology: A New Synthesis. BES Ecological Reviews Series. Cambridge University Press, Cambridge.

Harrington, R., Anton, C., Dawson, T.P., De Bello, F., Feld, C.K., Haslett, J.R., Kluvánkova-Oravská, T., Kontogianni, A., Lavorel, S., Luck, G.W., Rounsevell, M.D.A, Samways, M.J., Settele, J., Skourtos, M., Spangenberg, J.A., Vandewalle, M., Zobel, M., Harrison, P.A., 2010. Ecosystem services and biodiversity conservation: concepts and a glossary. Biodivers. Conserv. 19, 2773–2790.

Harrison, P.A., Vandewalle, M., Sykes, M.T., Berry, P.M., Bugter, R., de Bello, F., Feld, C.K., Grandin, U., Harrington, R., Haslett, J.R., Jongman, R.H.G., Luck, G.W., Martins da Silva, P., Moora, M., Settele, J., Sousa, J.P., Zobel, M., 2010. Identifying and prioritising services in European terrestrial and freshwater ecosystems. Biodivers. Conserv. 19, 2791–2821.

Hein, L., van Koppen, K., de Groot, R.S., van Ierland, E.C., 2006. Spatial scales, stakeholders and the valuation of ecosystem services. Ecol. Econ. 57, 209–228.

Holland, R.A., Eigenbrod, F., Armsworth, P.R., Anderson, B.J., Thomas, C.D., Heinemeyer, A., Gillings, S., Roy, D.B., Gaston, K.J., 2011. Spatial covariation between freshwater and terrestrial ecosystem services. Ecol. Appl. 21, 2034–2048.

Kaiser, H.F., 1960. The application of electronic computers to factor analysis. Educ. Psychol. Meas. 20, 141–151.

Kroll, F., Müller, F., Haase, D., Fohrer, N., 2012. Rural–urban gradient analysis of ecosystem services supply and demand dynamics. Land Use Pol. 29, 521–535.

Luck, G.W., Harrington, R., Harrison, P.A., Kremen, C., Berry, P.M., Bugter, R., Dawson, T.P., De Bello, F., Diaz, S., Feld, C.K., Haslett, J.R., Hering, D., Kontogianni, A., Lavorel, S., Rounsevell, M., Samways, M.J., Sandin, L., Settele, J., Sykes, M.T., Van Den Hove, S., Vandewalle, M., Zobel, M., 2009. Quantifying the contribution of organisms to the provision of ecosystem services. Bioscience 59, 223–235.

(MA) Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Isl. Press, Washington, DC.

Maes, J., Braat, L., Jax, K., Hutchins, M., Furman, E., Termansen, M., Luque, S., Paracchini, M.L., Chauvin, Ch., Williams, R., Volk, M., Lautenbach, S., Kopperoinen, L., Schelhaas, M-J., Weinert, J., Goossen, M., Dumont, E., Strauch, M.,

Görg, C., Dormann, C., Katwinkel, M., Zulian, G., Varjopuro, R., Ratamäki, O., Hauck, J., Forsius, M., Hengeveld, G., Perez-Soba, M., Bouraoui, F., Scholz, M., Schulz-Zunkel, Ch., Lepistö, A., Polishchuk, Y., Bidoglio, G., 2011. A spatial assessment of ecosystem services in Europe: methods, case studies and policy analysis—phase 1. Partnership for European, Ispra, PEER Report No 3.
Martín-López, B., Gómez-Baggethun, E., González, J.A., Lomas, P., Montes, C., 2009. The assessment of ecosystem services provided by biodiversity: re-thinking concepts and research needs. In: Aronoff, J.B. (Ed.), Handbook of Nature Conservation: Global, Environmental and Economic Issues. Nova Science Publishers, New York, pp. 261–282.
Martín-López, B., Iniesta-Arandia, I., García-Llorente, M., Palomo, I., Casado-Arzuaga, I., García Del Amo, D., Gómez-Baggethun, E., Oteros-Rozas, E., Palacios-Agundez, I., Willaarts, B., González, J.A., Santos-Martín, F., Onaindia, M., López-Santiago, C., Montes, C., 2012. Uncovering ecosystem service bundles through social preferences. PLoS ONE 7, e38970.
(MARM) Ministerio de Medio Ambiente y Medio Rural y Marino, 2010. Programa del Desarrollo Rural Sostenible (2010–2014). Madrid, Spain.
(MARM) Ministerio de Medio Ambiente y Medio Rural y Marino, 2011. Plan Estratégico del Patrimonio Natural y de la Biodiversidad (2011–2017). Madrid, Spain.
McDonald, R., 2009. Ecosystem service demand and supply along the urban-to-rural gradient. J. Conserv. Plan. 5, 1–14.
Naidoo, R., Ricketts, T.H., 2006. Mapping the economic costs and benefits of conservation. PLoS Biol. 4, 2153–2164.
Raudsepp-Hearne, C., Peterson, G.D., Bennett, E.M., 2010. Ecosystem service bundles for analyzing tradeoffs in diverse landscapes. Proc. Natl. Acad. Sci. USA 107, 5242–5247.
REDIAM—Environmental Information Network of Andalusia. Department of Environment of the Andalusian government.(REDIAM; ⟨http://www.juntadeandalucia.es/medioambiente/site/web/rediam/⟩).
Reyers, B., Bidoglio, G., O'Farrell, P., Schutyser, F., Dhar, U., Gundimeda, H., Paracchini, M.L., Gómez Prieto, O., 2010. Measuring biophysical quantities and the use of indicators. In: Kumar, P. (Ed.), The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. Earthscan, London and Washington, pp. 114–147.
Seppelt, R., Dormann, C.F., Eppink, F.V., Lautenbach, S, Schmidt, S., 2011. A quantitative review of ecosystem service studies: approaches, shortcomings and the road ahead. J. Appl. Ecol. 48, 630–636.
Schneiders, A., Van Daele, T., Van Landuyt, W., Van Reeth, W., 2012. Biodiversity and ecosystem services: complementary approaches for ecosystem management? Ecol. Indic. 21, 123–133.
Sherrouse, B.C., Clement, J.M., Semmens, D.J., 2011. A GIS application for assessing, mapping, and quantifying the social values of ecosystem services. Appl. Geogr. 31, 748–760.
Tallis, H., Polasky, S., 2009. Mapping and valuing ecosystem services as an approach for conservation and natural-resource management. Ann. N.Y. Acad. Sci. 1162, 265–283.
Vacas Guerrero, T., 2001. Natural protected spaces as a tourist resource: a method for the study of the Sierra Nevada National Park. Estudios Turísticos 147, 57–84.
van Jaarsveld, A.S., Biggs, R., Scholes, R.J., Bohensky, E., Reyers, B., Lynam, T., Musvoto, C., Fabricius, C., 2005. Measuring conditions and trends in ecosystem services at multiple scales: the Southern African Millennium Ecosystem Assessment (SAfMA) experience. Phil. Trans. R. Soc. 360, 425–441.
Vihervaara, P., Rönkä, M., Walls, M., 2010. Trends in ecosystem service research: early steps and current drivers. Ambio 39, 314–324.