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What can nature conservation strategies learn from the ecosystem services approach? Insights from ecosystem assessments in two Spanish National Parks

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What can conservation strategies learn from the ecosystem services approach? Insights from ecosystem assessments in two Spanish Protected Areas

Abstract

Biodiversity conservation strategies that overlook the interests of local people are prone to create conflicts. The ecosystem service approach holds potential for more comprehensively integrating the social dimension into decision-making in protected areas, but its implementation in conservation policies is still in its infancy. This research assesses the extent to which ecosystem services have been implemented in conservation strategies in protected areas. The study was conducted in two outstanding Spanish protected areas, covering a wetland (Doñana Natural and National Parks) and a Mediterranean mountain system (Sierra Nevada Natural and National Parks). Data were collected from deliberative workshops with managers and researchers, face-to-face surveys with users and a review of management plans. We found that, beyond intrinsic values of ecosystems and biodiversity, these areas provide multiple ecosystem services that deserve further attention to ensure their sustained delivery. Our research shows that environmental managers and researchers have different perceptions and priorities regarding ecosystem services management compared with ecosystem service users. Environmental managers and researchers in both protected areas perceived that human-nature relationships and ecosystem services are already widely included in management plans, if often not explicitly. We found that different ecosystem service categories receive uneven attention in management plans. These contained measures to manage provisioning and cultural services whereas measures for managing regulating services were perceived to be largely absent. We conclude by summarizing insights on how the ecosystem service approach may enhance the consideration of social interests in the management of management protected areas.

Keywords

Deliberative workshop; document analysis; management plan; National Park; Natural Park; perception.

INTRODUCTION

Protected areas are key instruments for conserving biodiversity (Juffe-Bignoli et al. 2014; Watson et al. 2014). However scholars have pointed to some limitations of this conservation model, including their isolation from the broader territorial matrix, lack of support by local communities, and inability to prevent land use change beyond their administrative boundaries (Rands et al. 2010; Venter et al. 2014). In the context of global change, conservation strategies need to integrate a wider social-ecological systems perspective and pay attention to diverse social interests on ecosystem services while preserving ecosystem integrity and health (Ban et al. 2013; Palomo et al. 2014a; Cumming et al. 2015). To address this need, ecosystem services has been proposed as a potentially useful argument to increase social support for conservation and avoid protected area isolation through broader consideration of the ecological processes sustaining ecosystem service flows both within and outside the protected area (Bertzky et al. 2012; Palomo et al. 2013, 2014b; Cumming 2016).

The ecosystem services approach extends conservation objectives beyond intrinsic values to cover social, economic, and cultural values of nature (Cowling et al. 2008; López-Hoffman et al. 2010). It recognizes the wide range of benefits that protected areas provide (Dudley et al. 2011), and the importance of recognising the multiple and often conflicting interests of social actors in their management (García-Nieto et al. 2015). Because benefits from ecosystem services accrue at multiple scales, the ecosystem services approach allows managers and scientists to better understand protected areas within the broader social-ecological systems in which they are embedded (Palomo et al. 2014a; Cumming et al. 2015; Cumming 2016) overcoming the classical conservation vs. development model. It can also reflect the tension between users at different scales, such as local users (i.e. farmers) and users outside the boundaries (i.e. tourist population) of protected areas (e.g. Iniesta-Arandia et al. 2014). Moreover, it can uncover existing and potential social conflicts between management and use, especially when conservation policies are applied without due consideration of the interests and needs of local communities (Kovacs et al. 2014). Finally, ecosystem services might constitute a boundary concept (Hauck et al. 2015) that facilitates the engagement of different stakeholder groups in the management of the protected area (Bertzky et al. 2012; Palomo et al. 2014c).

As the ecosystem services concept has begun to gain momentum in science and policy agendas, the incorporation of ecosystem service arguments within conservation policies is increasingly encouraged by regulatory frameworks at international and national levels (Stolton and Dudley 2010; Dudley et al. 2011). One of the principal recommendations of the Millennium Ecosystem Assessment for protected areas is to develop, through legal, policy, and other effective means, stronger societal support based on the benefits and values of the

services the protected areas provide (MA 2005). In this context, international organisations are paying growing attention to ecosystem services in protected areas. For example, the International Union for the Conservation of Nature (IUCN) included the term ecosystem services in their definition of protected areas in 2008 (Dudley 2008). The importance of ecosystem services in the design and management of protected areas has been also recognised in the Strategic Plan for Biodiversity 2011-2020 and in the Aichi Biodiversity Target 11: '*By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape*'. In Europe, the 2020 EU Biodiversity Strategy calls for protecting and restoring ecosystems and the services provided by protected areas (Target 2; European Commission 2011). The ecosystem services approach is also being gradually implemented in national legislations. For example, Spain has passed a Biodiversity Law (Ley 42/2007) and a Sustainable Rural Development Law (Ley 45/2007) that aim to protect biodiversity and ecosystem services and address rural abandonment affecting cultural landscapes. In spite of these policy developments, explicit use of the ecosystem services approach in international, regional and local conservation strategies is still rare (Thompson et al. 2011). This may reflect the need to address several scientific challenges before the approach can be operationalized in protected areas. These include improving understanding of the benefits and ecosystem services provided by biodiversity in protected areas to human wellbeing, and clarifying the role that local communities and other stakeholders play in the management of ecosystem services in protected areas and their surroundings (Juffi-Bignoli et al. 2014; Bonet-García et al. 2015; Velasco et al. 2015). A recent publication demonstrated a positive relationship between the distribution of protected areas in Andalusia and human wellbeing indicators, where protected areas act as attractors of policies promoting human wellbeing (Bonet-García et al. 2015). As noted by Mace et al. (2014), in the last 50 years conservation frames have evolved from the notion of "nature for itself" (where the focus is on preserving pristine and intact ecosystems apart from humans), towards "nature for people" (where the value of services and benefits that ecosystems provide for human wellbeing are recognised and used to justify their conservation) and "people and nature"(where humans and ecosystems are not seen as separate elements, but as integrated socio-ecological systems). However, while in the first case management indicators are well-established (e.g. number of species listed in threatened catalogues or the size of protected areas); metrics and management models under the new conservation frames are still at an

early stage of development, reflecting the challenge of more comprehensively incorporating social aspects into conservation.

We examine the extent to which ecosystem services are recognized and have been implemented in conservation strategies in protected areas. In particular, we pursue the following specific objectives: (I) to analyze the importance of ecosystem services provided by protected areas for different stakeholders groups, including managers and researchers (as the groups responsible for assessing and implementing ecosystem services in conservation policies) and users, comprising local communities and tourist perspectives; (II) to assess trends in the delivery of ecosystem services to identify those that may be most vulnerable or threatened (i.e. services considered as important by stakeholders but in risk of decline or declining) or contradictions between management and use (e.g. ecosystem services considered important by managers, but not recognised by users or vice versa); (III) to explore the opportunities and limitations perceived by managers and researchers for implementing ecosystem services in conservation policy and practice; and (IV) to examine the extent to which ecosystem services are already represented in current management plans.

Our research draws on data collected in two of the most important protected areas of the Andalusia region (southern Spain): Doñana (a coastal wetland and dune system) and Sierra Nevada (a Mediterranean mountain ecosystem; Fig 1). Both as been previously conceived as social-ecological systems since they share important ecological and cultural values associated with unique ecosystems, endemic species and traditional management practices, expressed in unique cultural landscapes (Palomo et al. 2014b). Doñana protected area is considered one of the most important wetland areas in Spain (Serrano et al. 2006), while the Sierra Nevada protected area holds singular mountain landscapes with unique botanical interest and geological and geomorphological structures (Gómez-Ortiz et al. 2013). Nevertheless, both areas experience environmental conflicts resulting from land use changes driven by conservation policy, intensive agriculture, urbanization or rural abandonment (Gómez-Baggethun et al. 2010; Martín-López et al. 2011; Iniesta-Arandia et al. 2014; Zorrilla et al. 2014). Land-use changes in these protected areas are often contested by stakeholders who hold varied interests on which ecosystem services are promoted or constrained by existing management plans (Gómez-Baggethun et al. 2013).

METHODS

We used different methods to fulfil each of our specific objectives. Data on ecosystem service perceptions across stakeholder groups were collected from questionnaires and workshops (objective I, Table 1). Face to face

surveys were conducted to assess the ecosystem service preferences of local users and tourists (objective I). Tables showing a classification of ecosystem services within each of the study areas were provided to the respondents, who were asked to select the four services that they considered most important. The surveys were conducted during 2008-2011 (*N*=1183) (see Table 1). Considering that the population in both protected areas and its socio-economic influence area corresponds to nearly 71,500 inhabitants in Sierra Nevada and 42,500 inhabitants in Doñana both samplings are statistically representative at a confidence level of 95%. Our sample integrates data from previous research in the two study areas (e.g. Gómez-Baggethun 2011a, 2013; Palomo et al. 2013; Iniesta-Arandia et al. 2014; García-Llorente et al. 2015). Quantitative data collected from the questionnaires were analysed using descriptive statistics. In addition, differences in perceived importance among all services was calculated using the Friedman non-parametric statistical test and differences in perceived importance between groups of services was calculated using the Dunn multiple comparison test.

Participatory workshops were organized in Doñana (21 participants) and Sierra Nevada (20 participants) to assess the ecosystem service perceptions of managers and researchers. Workshop participants included protected area managers, staff from the National Park Agency and from the regional environmental agency, and social and environmental sciences researchers working in the study areas. Participants were split into five groups of four to five people, where managers and researchers worked together to identify the five ecosystem services they deemed the most important in each protected area (objective I). To do so, we used tables showing service classifications which were defined in the mentioned previous research in the study areas.

To assess ecosystem service trends in the protected areas (objective II), workshop participants were asked to discuss the trend (declining, stable-declining, stable, stable-improved and improved) of selected services and to identify associated drivers and pressures. Here, vulnerable ecosystem services were defined as services considered as important by managers and researchers but in risk of decline or declining (Iniesta-Arandia et al. 2014; Oteros-Rozas et al. 2014). To supplement the data obtained from the workshops, we reviewed data from the Sustainable Development Plans (SDP) for both protected areas (SDP Sierra Nevada 2004; SDP Doñana 2010) about drivers and pressures affecting ecosystem services (Table 1). Finally, the data collected in the workshops and surveys were combined in bubble diagrams in order to identify vulnerable ecosystem services (objective II).

These diagrams also allow the ecosystem service perceptions of managers and researchers to be compared with those of tourists and local users (objective I) to identify contradictions between management and use.

To explore opportunities and limitations for integrating the ecosystem services concepts into conservation policy and practice (objective III), we asked three questions in the workshops about the type of information that was used in the design of conservation plans. These questions aimed to collect information on (1) whether protected area management plans include sufficient information to address landscape planning; (2) the extent to which this information took into account human-nature relationships; and (3) the extent to which the ecosystem service framework was adopted. Human-nature relationships in the second question refer to the ways in which people relate to their environment and the different dimensions of this relationship (e.g. the position of the relationship or its character) in a broad sense (Flint et al. 2013). The third question was particularly focused on the ecosystem services approach as a way of understanding such human-nature relationships. These questions provided insight into how knowledge sources shaped conservation plans.

Finally, to analyse the extent to which ecosystem services were represented in management plans (objective IV), we reviewed the Steering Plan for Use and Management (PRUG) in force for each of Sierra Nevada National and Natural Parks (Decree 238/2011), Doñana National Park (Decree 48/2004) and Doñana Natural Park (Decree 97/2005). In addition, we reviewed the Plan for the Regulation of Natural Resources (PORN), reports that both protected areas submit to the Spanish Senate every three years for the periods 2004-2007 and 2007-2010, as well as their annual reports for the period 2010-2015 (Table 1). Following the methodology used by Palomo et al. (2014b), we scrutinized all these documents in order to check the implementation of management and conservation plans, actions, and permitted uses of ecosystem services. We considered a service was contemplated when plans included guidelines to manage it through sectoral or working plans (the full reference title of each plan is provided in the results section), even if in most cases they did not use the ecosystem service approach and terminology in an explicit way.

RESULTS

Stakeholder perceptions on the importance of ecosystem services

In the workshops conducted with managers and researchers in both protected areas, six services were selected by at least one group. These included two provisioning services (food from agriculture and freshwater), one regulating service (habitat for species), and three cultural services (scientific knowledge, nature tourism, and aesthetic values). In Sierra Nevada, managers and researchers also remarked on the primary importance of other regulating services such as air quality, climate regulation, water regulation, and erosion control. In Doñana,

participants also highlighted the importance of food from livestock, environmental education, and existence values (in terms of satisfaction from conserving biodiversity; Table 2).

Survey results suggested the ecosystem services deemed most important by respondents in both protected areas included food from agriculture and freshwater as provisioning services, air quality as a regulating service and nature tourism and tranquillity and relaxation as cultural services (Table 3). We also found that the perception of ecosystem service importance varied significantly between users of the two protected areas. As expected, fishing and shell fishing, an important economic activity for locals in Doñana, were selected among the most important services, whereas clean energy from wind farms and solar panels, currently expanding in the Sierra Nevada mountains, were selected as among the most important services in this protected area. Moreover, Doñana users placed greater emphasis on habitat for species, soil fertility and prevention of invasive alien species, while Sierra Nevada users highlighted the importance of regulating services such as erosion control, and water and climate regulation. Finally, Doñana users gave more emphasis to cultural services than Sierra Nevada respondents. In particular, they expressed the importance of aesthetic values, environmental education, and scientific knowledge.

Our data show that food from agriculture, freshwater, and nature tourism stand out as important ecosystem services from both the deliberative workshops with managers and researchers, as well as the survey respondents. However, we found that managers and researchers considered regulating services to a higher degree. In addition, for managers and researchers the production of scientific knowledge was one of the most important services provided in the protected areas. This finding fits a key purpose of National Parks, which are expected to contribute to research and scientific knowledge. This service was considered less important by the surveyed users, especially in Sierra Nevada.

Trends in ecosystem services provided in the protected areas

From the set of services identified as most important by managers and researchers in Doñana, only freshwater was classified as vulnerable (with a declining trend), mainly due to the overharvesting of groundwater for irrigation of intensive agriculture in the surroundings of the protected area (Table 2). This trend is consistent with data provided in the SDP, which notes that freshwater provision is threatened by overexploitation and pollution from intensive agriculture and urbanisation. Three ecosystem services were evaluated as stable: food from livestock, habitat for species, and aesthetic values. The SDP highlights how extensive livestock raising is integrated into conservation strategies as well as the importance it holds for people in Doñana in terms of social recognition because of its emblematic species, singular landscapes, and links to local culture (see also Gómez-

199 Baggethun et al. 2010). Trends in scientific knowledge were evaluated as stable-improving while trends in the
200 services of food from agriculture, existence values, environmental education, and nature tourism were evaluated
201 as improving.

202 Among the services perceived as important by Sierra Nevada managers and researchers, trends in two of them,
203 food from agriculture and erosion control, were classified as declining and hence as vulnerable. The former was
204 perceived as declining because of the low market competitiveness of extensive agriculture and the latter because
205 of the consequences of land abandonment on soil conditions. Again, the assessed trends are consistent with
206 information provided in the SDP, which notes a shift from traditional agriculture towards intensive agriculture
207 with higher short-term market profitability since traditional and small scale agricultural activities have a lower
208 capacity for innovation and competition in markets. Climate regulation, water regulation and aesthetic values
209 showed a stable-declining trend (Table 2) because of the impact of deforestation activities during the fifties, the
210 modernisation of irrigation channels and urban expansion. Aesthetic values were threatened by urban expansion,
211 skiing infrastructure, and the abandonment of cultural landscapes, amongst other factors. Finally, trends in
212 freshwater, air quality, and habitat for species were evaluated as stable. Habitat for species was classified as
213 stable since it has points of improvement and decline. Improvements are related to restoration actions, adaptive
214 management and social awareness, whilst declines are related to key pressures such as mass tourism, habitat
215 fragmentation, land use change and climate change. Trade-offs between ecosystem services were also identified.
216 For example, increases in recreational ecosystem services associated with nature tourism (and mainly ski
217 tourism) were reported to occur to the detriment of water-related services (e.g. through freshwater
218 overexploitation). Similarly, agricultural intensification and overgrazing was reported to have negative
219 consequences on traditional agriculture and soil quality.

220 Finally, when comparing the assessed level of vulnerability of a given service with its social importance (Fig 2),
221 we found that food from agriculture and erosion control in Sierra Nevada and freshwater in Doñana need urgent
222 protection measures, because in spite of their importance, they are in a vulnerable state. It is also interesting to
223 notice that food from agriculture showed an improving trend in Doñana but a declining trend in Sierra Nevada.
224 In Doñana this improvement has been related to the inclusion of technology in agricultural activities, while in
225 Sierra Nevada its decline was expressed in terms of the abandonment of traditional practices.

226 **Opportunities and limitations for implementing ecosystem services in management plans**

227 In response to the questions about the information used to design management plans within protected areas,

Doñana managers and researchers reported that they suffered from significant limitations in information availability (Table 4). However, according to workshop participants, information problems stemmed from: (i) lack of communication between managers and researchers (25%), (ii) lack of coordination among governance sectors (e.g. conservation with agriculture) and lack of public participation (25%), (iii) interest bias in some research and conservation priorities (25%), (iv) difficult integration of different sources of knowledge (13%), (v) lack of social studies (6%), and (vi) difficulties of applying some types of knowledge (6%). In Sierra Nevada, reported limitations included: (i) growing complexity and uncertainty from global environmental change (36,5%), (ii) difficult communication between managers, researchers and citizens (36,5%), (iii) lack of social studies (9%), (iv) difficult integration of different sources of knowledge (9%), and (v) interest bias in some research and conservation priorities (9%).

Workshop participants in both protected areas believed that human-nature relationships were widely included in management plans, although this perception was slightly higher in Sierra Nevada (Table 4). Some of the explanations given in both areas regarding remaining challenges for management based on a social-ecological systems perspective include: the perception of humans as external to nature, the adoption of strict conservation criteria without the consideration of social dimensions, lack of a historical perspective, low public participation, and disagreement regarding the role of traditional management practices in the protected areas. Most of the challenges were related to how the relationship between humans and nature was conceived in both protected areas (e.g. hierarchical, humans as part of (or separate from) nature, or integrated). Finally, about half of the workshop participants considered that the ecosystem service framework is already integrated in the management of the protected areas to some extent through the management plans and systemic approaches (if not always explicitly, at least in an implicit and/or intuitive way).

Ecosystem service implementation in current management plans

Our results suggest that the ecosystem service approach is similarly included in the management plans of both protected areas (Table 5). Regulation of the use of provisioning services has been an important issue, in particular for livestock activities, as ensuring the compatibility of traditional activities with conservation is one of the key aims of both protected areas. However, regulating services are included to a lesser extent in management plans. As expressed by managers' during the workshops, both areas have made the effort to include crucial regulating services, such as the design of prevention of invasive alien species programmes in Doñana, and climate change adaptation plans in Sierra Nevada. Nevertheless, vulnerable services, such as erosion control and water regulation, are not included in management plans. We also found specific actions

towards the management of cultural ecosystem services, such as those that regulate nature tourism and environmental education.

DISCUSSION

Multi-targeted protected areas: managing multiple ecosystem services

Results from the workshops with managers and researchers in both protected areas indicate that habitat provision for species was perceived as one of the most important ecosystem services delivered, which is not surprising given that one of the ultimate aims of protected areas is biodiversity conservation creating areas for its preservation. The main objectives of the Plan for the Regulation of Natural Resources (PORN) for both areas (PORN Doñana Natural Park 2005; PORN Sierra Nevada Natural and National Parks 2011) are concerned with: maintaining the ecological integrity of the ecosystems protected, conserving biodiversity, promoting the socio-economic development of local populations, maintaining tourism, conducting environmental education, and contributing to scientific knowledge with applied results for management, amongst others. National parks objectives are complex and multi-targeted, integrating ecological, research, cultural, and socio-economic priorities related to different ecosystem services, as well as users at different scales (local, regional, and national) (Cumming et al. 2015). However, different ecosystem service categories received uneven emphasis in the two studied areas during the workshops.

Emphasis in Doñana was mainly on cultural ecosystem services, and specifically on those that are growing in demand by beneficiaries from urban areas and the regional and national scales (such as nature-based tourism and environmental education), which currently gain prominence above locally experienced cultural services (such as sense of identity) (see Gómez-Baggethun et al. 2011a, 2013). In contrast, workshop participants in Sierra Nevada put greater emphasis on regulating services. This divergent pattern may be explained, among other things, by the different mind-set that motivated their conservation strategies. Doñana natural protected area PRUG has the aim of protecting emblematic vertebrates and the habitat for these species (Decree 48/2004; Decree 97/2005), while Sierra Nevada natural protected area is more linked to the protection of vegetation (based on the interaction of freshwater-soil-vegetation). Doñana natural protected area PRUG has the aim of protecting emblematic vertebrates and the habitat for these species (Decree 48/2004; Decree 97/2005), while Sierra Nevada natural protected area is more linked to the protection of vegetation (based on the interaction of freshwater-soil-

vegetation) and the distinctiveness/uniqueness of its geological, geomorphological and cultural landscapes (Decree 238/2011; Gómez-Ortiz et al. 2013; Palomo et al. 2014b).

In Doñana, as in Spain more broadly, conservation efforts target mainly emblematic species, such as the Iberian lynx (*Lynx pardinus*), the Iberian imperial eagle (*Aquila adalberti*), or particular aquatic birds, such as greylag goose (*Anser anser*), red-knobbed coot (*Fulica cristata*), white-headed duck (*Oxyura leucocephala*), and eurasian Spoonbill (*Platalea leucorodia*) (Martín-López et al. 2009), which attract a high number of birdwatchers from all around the word (Múgica and De Lucio 1996; Gómez-Baggethun et al. 2011b). In fact, Doñana has been identified as one of the areas of high-value vertebrate diversity (Rey Benayas and de la Montaña 2003). The mountains of Sierra Nevada, however, are one of the hotspots of vascular plant diversity and degree of endemism (Lobo et al. 2001). Climate change is one of the drivers of change for vegetation communities in Sierra Nevada, with an impact on wet grassland communities (locally known as borreguiles) and high mountain scrublands (*Genista* sp, *Cytisus* sp, etc) (Bonet et al. 2010). Thus, conservation efforts target endemic mountain vegetation species (e.g. borreguiles), the unique mountain and cultural landscapes and the preservation of traditional land use practices adapted to mountain ecosystems (e.g. traditional irrigation ditches, farming on terraces) and the maintenance of regulating services, such as hydrological regulation and water purification (Aspizua et al. 2010; Gómez-Ortiz et al. 2013).

Stakeholder priorities for conservation practices

We found divergences between the priorities of workshop participants and ecosystem service users, with scientific knowledge being the most notable case. Scientific knowledge was acknowledged by workshop participants as standing out amongst the main aims of the protected areas, as contributions to research and scientific knowledge are a key stated purpose of National Parks (Decree 97/2005, Decree 238/2011); these result is also coherent with previous studies where scientific purposes were particularly attached to protected areas, especially by environmentalists (Van Riper and Kyle 2014). However, our results suggest that the priorities of managers and researchers towards ecosystem services diverge from those expressed by surveyed ecosystem service users, most of whom did not identify scientific knowledge production as amongst the most important services (Fig 2). Not surprisingly, scientific knowledge is mainly related to managers' and researchers' interests. In fact, previous studies indicate that scientific knowledge in Doñana is not sufficiently transferred to decision-makers and the broader society (Moreno et al. 2014). These findings suggest that more effort should be made to communicate scientific knowledge in a format that is more useful for decision-making and society.

In Sierra Nevada, traditional and small scale farms have limited access to technical information and knowledge derived from scientific research. In this case, it is essential to co-produce research and policy agendas with small scale farmers. In those cases, collaborative research between scientists, managers, and local users (e.g. farmers and livestock keepers) under an adaptive co-management approach could be an effective way to connect scientific priorities with conservation and socio-economic needs (Caudron et al. 2012). In addition, in Sierra Nevada there is a lot of research being conducted on climate change, which is a key issue for the Mediterranean mountains (Zamora et al. 2015). Disseminating this knowledge among users and integrating it into research and management processes could help to establish collaborative research, as has been promoted since 2007 through the creation of the Sierra Nevada Global Change Observatory, as part of the international initiative of GLObal CHAnge in Mountain REgions (GLOCHAMORE; http://mri.scnatweb.ch/en/projects/glochamore). Equally important is the promotion of further engagement of ecosystem service users in the management of protected areas, as they influence conservation decisions and are influenced by them, but also to achieve more inclusive, supported, realistic, and transparent plans (Ban et al. 2013). Finally, collaborative work between scientists and protected area managers, such as presented here, can help identify research priorities for conservation practice. In this case, our analysis demonstrated that only some ecosystem services considered as vulnerable and important by stakeholders were part of the management plans of both protected areas, so vulnerable services still warrant attention.

Ecosystem services interactions and trade-offs

One of the main risks to protected areas derives from a system of polarized territorial planning, where natural areas, often protected through 'fortress conservation policies' are embedded in an ecologically degraded territorial matrix devoted to economic development (de Fries et al. 2007; Joppa et al. 2008; Radeloff et al. 2009). Land use change and intensification outside protected areas create border effects that impinge upon the ecosystem services delivered within the protected area (Martín-López et al. 2011; Palomo et al. 2014c).

In Sierra Nevada, ski tourism has a negative impact on erosion, hill stability and landscape quality (Moreno et al. 2014). In addition, since the 1950s, the upper mountainous areas of Sierra Nevada have experienced strong depopulation with the abandonment of traditional agriculture. In contrast, the lower areas with milder climates (near the coast) have developed competitive, intensive greenhouse horticulture (Aznár-Sánchez et al. 2011), which also has led to decreasing aquifer levels and soil contamination (Sánchez-Picón et al. 2011).

In the surroundings of Doñana, the growth of intensive agriculture (Gómez-Baggethun et al. 2011a; Martín-López et al. 2011) and land use change (Zorrilla et al. 2014) are affecting regulating services such as water

regulation, habitat for species, and erosion control, due to high levels of pesticides, nitrogen and phosphorus compounds (Olías et al. 2007; Tortosa et al. 2010). Similarly, beach tourism has had negative impacts on water quality and quantity. For example, increased water demand from the growth of coastal tourist resorts has been associated with a drop in the phreatic level of Doñana's main aquifer (Custodio et al. 2009; Moreno et al. 2014). In both areas, a few provisioning and cultural services with high market value are being promoted at the expense of other ecosystem services, especially regulating services and non-commodified cultural services (Gómez-Baggethun et al. 2011a). Additional conservation efforts are required to protect vulnerable, but essential ecosystem services in both protected areas, including freshwater supply and erosion control in Doñana and food from agriculture, erosion control, climate regulation, water regulation, and aesthetic values in Sierra Nevada.

Opportunities and limitations for implementing ecosystem services in conservation policies

Our results show that most workshop participants (managers and researchers) demand more and better information to make accurate management decisions. Specifically in Doñana, they felt that they suffer from a lack of information availability. This result is paradoxical; Doñana is one of the most studied and documented protected areas in Spain (Voth 2007). As noted by Cook et al. (2012), protected area managers have to take complex conservation decisions whilst taking into consideration diverse and multifaceted factors such as biodiversity threats, conservation effectiveness, financial cuts and species distributions (Young et al. 2012). Managers never have full information for making management decisions, which always are shrouded in some degree of uncertainty. Even decisions that could seem simple in ecological terms need to take into account complex socio-economic and political aspects (Cook et al. 2012).

In both protected areas, the importance of including social dimensions in conservation (e.g. demands of local users) was recognized, and the ecosystem service perspective is already included to some extent in management plans. The analysis of which ecosystem services are included in protected area management plans reveals which ecosystem aspects are addressed and which ones need to be included in conservation strategies (Wilkinson et al. 2013). The management plans of Doñana and Sierra Nevada protected areas (particularly in Doñana), focus on provisioning and cultural services (without explicitly using the ecosystem services term), whereas regulating services are included to a lesser extent (Palomo et al. 2014b). Paradoxically, regulating services generally have a higher dependence on core ecosystem processes and hence play a major role in the long-term capacity of protected areas to sustain biodiversity and ecosystem functions, so a stronger focus on ecological regulating processes might be needed. At the same time, their inclusion in conservation plans is complex and further studies are needed to better understand their interaction with ecological components (Harrison et al. 2014), as well as for

delimiting indicators and measures of performance for conservation strategies. As mentioned before, in contrast with Doñana, Sierra Nevada protected area has taken steps in that direction by participating in creating a Global Change Observatory for Mountain Regions (http://wiki.obsnev.es/index.php/Objetivos) which incorporates and makes accessible biophysical, social, and ecosystem service information and indicators.

CONCLUSIONS

Our research reveals important challenges for the management of protected areas in the context of growing conflicts over ecosystem services delivery and control. We suggest that the frame of "nature and people" (sensu Mace 2014) and an understanding of protected areas as social-ecological systems (Palomo et al. 2014a, Cumming et al. 2015; Cumming 2016), can help to tackle some of these challenges, such as protected areas´ limited capacity to prevent border effects and their propensity to create environmental conflicts with local users.

In order to strengthen a social-ecological approach to protected areas several challenges need to be met, including: (i) identifying the main ecosystem services provided by protected areas under a given management regime, and the beneficiaries and losers from this management, (ii) advancing the recognition that socio-economic context affects conservation plans and vice versa; (iii) assessing how ecosystem services are implemented in conservation strategies and the main difficulties that are encountered in doing so; and (iv) appraising how pressures originating outside the boundaries of protected areas impinge upon their long-term capacity to sustain biodiversity and ecosystem services. This should help to delineate the relationships between different ecosystem services and establish priorities in conservation. In line with Iniesta-Arandia et al. (2014), we consider that these priorities could be established by combining information on the importance of different ecosystem services for people and their vulnerability. In this research, ecosystem services identified as both vulnerable and critically important (and hence as priority conservation targets) include freshwater supply and erosion control in Doñana, and water regulation, climate regulation, aesthetic values, and food from agriculture in Sierra Nevada. While we believe that biodiversity conservation should remain at the core of conservation strategies, we contend that, besides the criteria of managers and researchers, protected areas should take broader consideration of the demands on ecosystem services by their immediate users (e.g. local people that depend on access to resources for their livelihoods). However, our analysis demonstrated that only some ecosystem services considered as vulnerable and important by stakeholders are recognized in the management plans of the protected areas. Conservation plans should make greater recognition of those ecosystem services considered critically relevant by different users, as well as the diversity of conflicting perceptions. Proper consideration of multiple ecosystem service perceptions (i.e. needs by local populations and their expectations) can be an important step

405 towards the co-management of protected areas. In addition, higher efforts should be made to assess the
406 connection between protected areas and human well-being (Bonet et al. 2015). This can help to prevent or reduce
407 environmental conflicts in protected areas, strengthen social support for their management and increase the
408 human wellbeing of local populations.

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Table 1. Ecosystem service assessment methods used in the data gathering.

Data collection method		Doñana	Sierra Nevada	Objectives
Consultative	Participatory workshop	With managers and researchers, *N*=21; 2011 (duration: two half-days)	With managers and researchers, *N* =20; 2011 (duration: two half-days)	I, II, III
	Panel assessment (preference rating)	Face to face questionnaires with locals and tourist, *N* 384; 2008-2009	Face to face questionnaires with locals and tourist, *N*= 799; 2009-2011	I
Non-consultative	Document analysis	Sustainable Development Plans (SDP)		II
		Steering Plan for Use and Management (PRUG), Plan for the Regulation of Natural Resources (PORN), Annual reports, Senate Reports for two periods.		IV

Table 2: Ecosystem services selected during participatory workshops because of their delivery importance (expressed as number of groups (N) that selected them). The trend (in bold) has been characterised in terms of declining, stable-declining, stable, stable-improved, improved. "-" indicates that the ecosystem service was not selected as being in the top five most important by any group for the case study area. Trend rationale is based on the reasons given during the workshops and document analysis of the Sustainable Development Plans (SDP).

Ecosystem Services	**Sierra Nevada**			**Doñana**		
	N	**Trend and rationale from workshops**	**Trend and rationale from SDP**	**N**	**Trend and rationale from workshops**	**Trend and rationale from SDP**
Food from agriculture	1/5	**Declining** Low competitiveness in markets	Small scale farms ("minifundios") have low innovation capacity, low valorization in markets of local products, and land abandonment. Transformation towards intensive agriculture systems is more profitable in short term	4/5	**Improved** Higher production and area (mainly in terms of intensive agriculture), sustainable practices are increasing too	Incorporation of new irrigation and fertilization technologies. Still needs improvements
Livestock	-			1/5	**Stable** Its quality is improving	Livestock grazing is a positive and compatible activity with conservation
Freshwater	4/5	**Stable** Improvement of irrigation canals	Groundwater overexploitation in some areas due to intensive agriculture. The acequia system (water canals) diverts water away from snowmelt to guarantee the presence of water during dry seasons, preserving water flows and habitat for vegetation plant species	4/5	**Declining** Overexploitation and pollution	Hydrological deficit and water and groundwater pollution due to agricultural practices and urban development
Air quality	1/5	**Stable** Higher protection and monitoring		-		
Climate regulation	2/5	**Stable-declining** Fewer forested areas and higher energy consumption	Deforestation taking place centuries or decades ago to obtain carbon or wood, to cultivate the land and overgrazing.	-		
Habitat for species	5/5	**Stable** Improvement in terms of restoration actions, adaptive management and awareness, worse in terms of mass tourism, habitat fragmentation, land use change and climate change	Uncontrolled urbanization (sky rise resorts), non-regulated harvesting of medicinal plants	5/5	**Stable** In some areas functionality is increasing because of restoration, key species conservation and invasive alien species eradication, others suffer important damage because of habitat fragmentation	Diverse and singular ecosystems, but habitat fragmentation for agrarian and urban uses and infrastructure, presence of invasive alien species

Water regulation	3/5	**Stable-declining** Vegetation cover is maintained	Modern irrigation canals affect water flows	-		
Erosion control	1/5	**Declining** Abandonment of traditional agriculture practices and overgrazing in some (time) periods	Erosion risk and hill instability due to natural reasons, but also related to: degradation of vegetation on riverbanks, use of heavy machinery, skywards expansion of buildings, abandon of traditional practices in hills, livestock overgrazing	-		
Existence values	-			3/5	**Improved** Higher population interest	Emblematic species presence
Environmental education	-			2/5	**Improved** Increasing number of environmental programs	Tourist and recreational activities conducted in relation to the environment
Scientific knowledge	2/5	**Improved** Higher resources and research centres more interested		4/5	**Stable-improved** Higher number of projects and inversions, however there are not enough knowledge from social disciplines	Techniques and scientists focus on the environmental field
Nature tourism	5/5	**Stable-improved** Better information, opportunities to put into practice and increased facilities and initiatives	Increasing interest in nature and cultural tourism	3/5	**Improved** More enterprises and visitors	It has gained importance; different resources and services are adopted for its promotion (establishments; guided visits, etc.).
Aesthetic values	2/5	**Stable-declining** Urban expansion, land-use change and traditional practices abandon	Ski slopes expansion and uncontrolled urbanization Low environmental awareness of tourists and locals	1/5	**Stable** Some landscapes improved because of social recognition, but the opposite happened in others	Distinctive landscapes of high recognition

6

Table 3: Social importance of ecosystem services expressed by users (in percentage of respondents who perceived the importance of each ecosystem service, ranging the percentage for each service from 0% to 100%) considered in each protected area (Sierra Nevada and Doñana). Differences of perceived importance among services is calculated by the Friedman test (** indicates statistical significance at $p<0.05$) and letters represent statistically different groups of important ecosystem services as identified by the Dunn test, $p<0.05$. Nine groups were found for Sierra Nevada (from "a" to "i") and six for Doñana (from "a" to "f"), alphabetically the services associated with groups with first letters (ie. "a or b") were more socially important than those groups of consecutive letters (ie. "f" or "g").

Ecosystem services	**Sierra Nevada**		**Doñana**	
	Important ecosystem services (in %)	Dunn groups	Important ecosystem services (in %)	Dunn groups
Provisioning				
Food from agriculture	37.05	a-b	35.48	a
Livestock	20.53	c-d-e-f	18.77	b-c-d
Fishing /shell fishing	-	-	15.29	b-c-d-e-f
Fresh water	37.17	a-b	21.39	b
Clean energy	20.78	c-d-e	-	-
Timber	11.51	e-f-g-h-i	13.97	c-d-e-f
Regulating				
Air quality	31.04	b-c	34.63	a
Climate regulation	16.02	d-e-f-g-h	13.93	b-c-d-e-f
Habitat for species	9.76	f-g-h-i	22.22	b-c-d-e
Water regulation	12.14	e-f-g-h-i	7.85	f
Erosion control	12.52	e-f-g-h-i	7.85	f
Soil fertility	7.13	h-i	14.78	b-c-d-e-f
Invasive alien species prevention	2.25	i	10.56	d-e-f
Cultural				
Existence values (Satisfaction of conserving biodiversity)[1]	20.15	d-e-f-g	11.96	e-f
Tranquillity and relaxation	26.66	b-c-d	28.96	b
Environmental education	10.39	e-f-g-h-i	23.26	b-c
Scientific knowledge	1.88	i	15.83	b-c-d-e-f
Recreational hunting	7.13	h-i	10.12	e-f
Nature tourism	42.80	a	46.91	a
Aesthetic values	9.64	g-h-i	28.96	b
Local identity	6.88	h-i	18.76	b-c-d-e-f
Friedman test (Q)	1490.77**		727.63**	

[1] Related also to the practice of traditional processions or the conception of nature as something sacred (mainly in Doñana).

Table 4: Answers to the questions asked during the participatory workshops.

	Sierra Nevada (%)	**Doñana (%)**
(1) Do you think that the management plans of the protected area include sufficient information to address landscape planning?	Yes: 40 No: 47 Depends: 13	Yes: 6 No: 81 Depends: 13
(2) Do you think that the management plans of the protected area take into account information on human-nature relationships?	Yes: 79 No: 14 Depends: 7	Yes: 69 No: 13 Depends: 18
(3) Does the protected area use the ecosystem service framework in its management?[1]	Very high:13 High:33 Low: 47 None: 7	Very high: 16 High: 47 Low: 32 None: 5

[1] From Palomo et al. (2013).

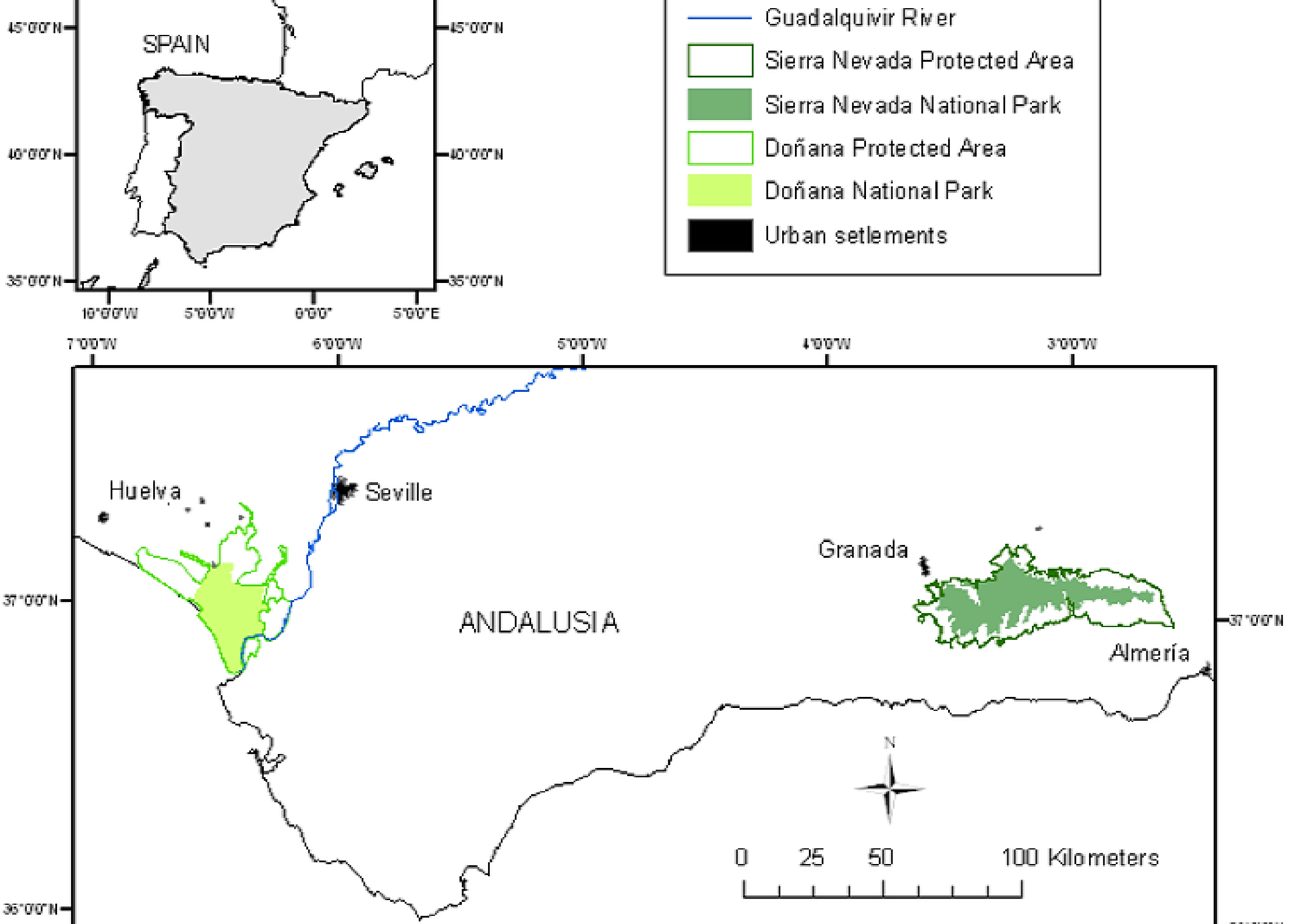
Table 5: Ecosystem services included in protected area management plans through sectoral and working plans developed or under development (the reference title of the management plan is provided). Those ecosystem services considered vulnerable in Table 2 are in bold.

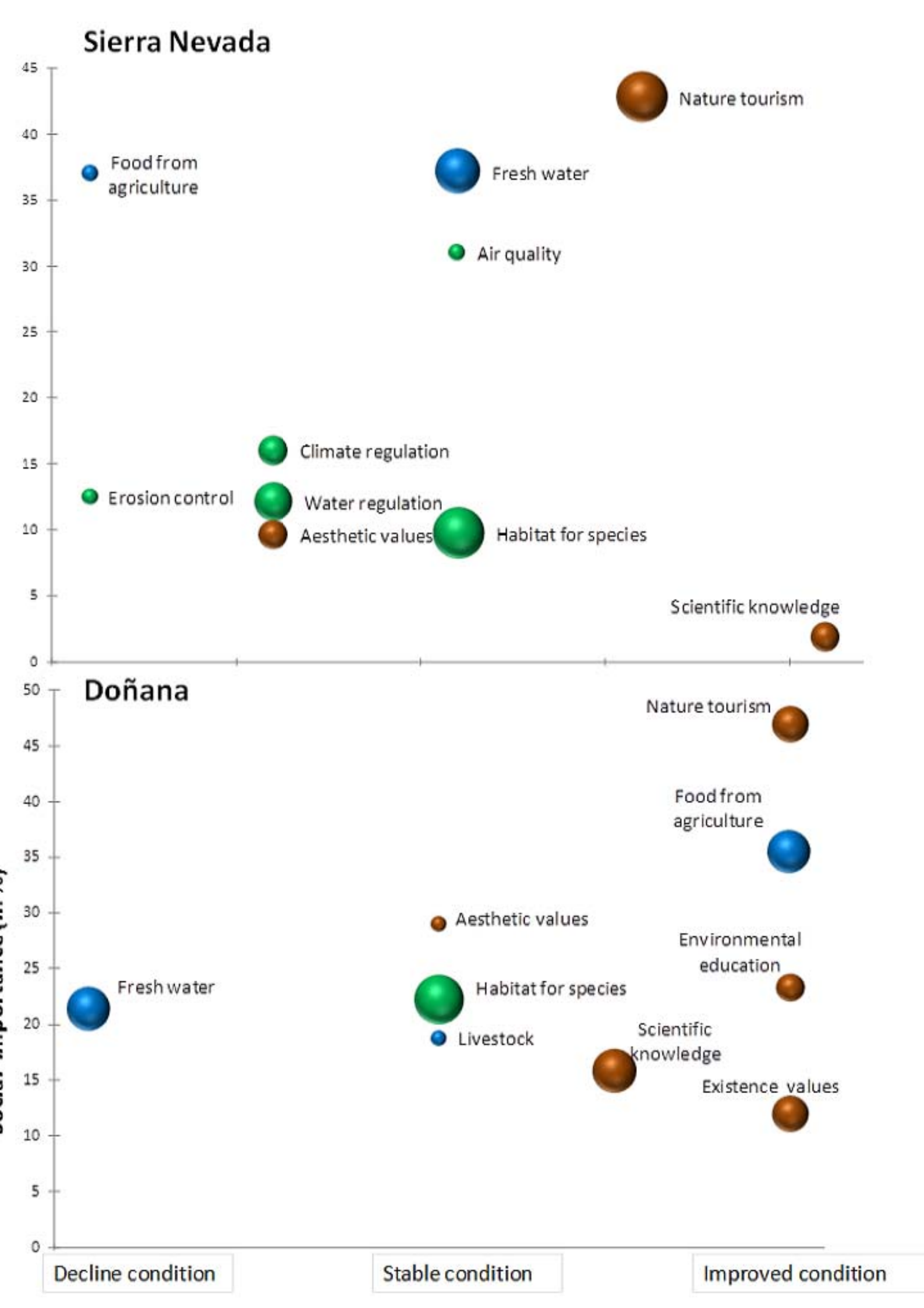
Ecosystem services	Sierra Nevada	Doñana
Provisioning		
Food from agriculture		Territorial Management Plan of Doñana, POTAD
Livestock	Sectoral Plan for Extensive Traditional Livestock	Sectoral Plan for Livestock
Fishing /shell fishing		Plan for shell fishing (*Donax* spp) provision
Forest harvesting	Aromatic plans and mushrooms use	Plan for pine cones provision
Fresh water	Traditional Structures Rehabilitation- freshwater channels	Special plan for irrigation areas and Territorial Management Plan of Doñana, POTAD
Timber	Plan for forest management	Use and management of natural resources
Apiculture	Apiculture use	Sectoral Plan for Apiculture
Regulating		
Climate regulation	Assessed by the Global Change Observatory	
Habitat for species	Biodiversity and geodiversity conservation within the Global Change Observatory Plan for wild ungulates management and Program for naturalisation and diversification of forest mass of repopulation	Biodiversity protection and conservation
Water regulation		Territorial Management Plan of Doñana, POTAD
Erosion control		
Invasive alien species prevention		Invasive alien species control
Natural hazards prevention	Security program towards avalanches, Global Change Observatory assessment and preventive treatments towards wild fires	Preventive forestry against wild fires in Huelva, Project of firewalls
Cultural		
Spiritual values (Religious)		Sectoral Plan of Rocieros transits
Tranquillity and relaxation		
Environmental education	Plan of Public Use and European Charter for Sustainable Tourism in Protected Areas	Sectoral Plan of Public Use and European Charter for Sustainable Tourism in Protected Areas
Scientific knowledge	Plan of Research	Sectoral Plan of Research
Nature tourism	Plan of Public Use and European Charter for Sustainable Tourism in Protected Areas	Sectoral Plan of Public Use and European Charter for Sustainable Tourism in Protected Areas
Aesthetic values		
Local identity	Traditional Structures Rehabilitation	
General	Plan for Sustainable Development	Plan for Sustainable Development

Figure captions

Fig 1 Study area map.

Fig 2 Scatter plots representing the social importance of ecosystem services (blue for provisioning, green for regulating and brown for cultural; expressed as % of the total sample, see Table 4) and its trend (declining, stable-declining, stable, stable-improved, improved) based on managers and researchers information from the participatory workshops. All the ecosystem services included are those selected during the workshop as the most important services delivered by each protected area (Table 2). The bubble size indicates its degree of importance (expressed as number of groups that selected it during the workshops).


SPAIN
45°00'N
40°00'N
35°00'N
10°00'W
5°00'W
0°00'
5°00'E
Guadalquivir River
Sierra Nevada Protected Area
Sierra Nevada National Park
Doñana Protected Area
Doñana National Park
Urban setlements
7°00'W
6°00'W
5°00'W
4°00'W
3°00'W
37°00'N
36°00'N
Huelva
Seville
Granada
Almería
ANDALUSIA
N
0
25
50
100 Kilometers


Sierra Nevada
45
40
35
30
25
20
15
10
5
0
Nature tourism
Food from agriculture
Fresh water
Air quality
Climate regulation
Erosion control
Water regulation
Aesthetic values
Habitat for species
Scientific knowledge
Doñana
50
45
40
35
30
25
20
15
10
5
0
Nature tourism
Food from agriculture
Aesthetic values
Environmental education
Fresh water
Habitat for species
Livestock
Scientific knowledge
Existence values
Decline condition
Stable condition
Improved condition