Assessing linkages between ecosystem services, land-use and well-being in an agroforestry landscape using public participation GIS [1]

Nora Fagerholm [a, b], Elisa Oteros-Rozas [a, c], Christopher M. Raymond [d], Mario Torralba [a], Gerardo Moreno [e], Tobias Plieninger [a]

a Department of Geosciences and Natural Resource Management, University of Copenhagen, Rolighedsvej 23, 1958 Fredriksberg C, Denmark

b Department of Geography and Geology, University of Turku, 20014 Turku, Finland

c Social and Participatory Action Research Group, Department of Anthropology, Universidad Pablo de Olavide, Seville, Spain

d Environment and Sustainability Institute, School of Geography, University of Exeter, UK

e Forestry School, University of Extremadura, Plasencia 10600, Spain

Corresponding author:

E-mail address: ncf@ign.ku.dk (N. Fagerholm)

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Abstract

While a number of studies have applied public participation GIS (PPGIS) approaches to the spatial assessment of ecosystem services, few have considered the associations between the spatial distribution of ecosystem services and the context-specific nature of self-reported well-being. In this study, we engage the general public to identify and map a range of ecosystem services that originate in place-based, local knowledge and explore the context-dependent nature of subjective well-being. We con- ducted a PPGIS survey with 219 local residents in a Spanish agroforestry (dehesa) landscapes and analysed the spatial patterns of mapped ecosystem services, their relation to land cover, protected area and common land patterns. In addition, we explored the landscape values contributing to people's well-being; and the relationships between ecosystem services in different land covers, landscape values and socio-demographic characteristics. A mosaic of landscape types (i.e., the landscape) provided more ecosystem services (especially cultural and provisioning) to people compared with the individual land system of agroforestry. However, land tenure and public access significantly guided the spatial practices and values of the people beyond the preferred landscape types. The contribution of the landscape to well-being is largely related to values based on interactions among people and the landscape, as tranquillity/relaxation and people-people interactions such as being with family and friends. We discuss the specific contribution of agroforestry landscapes to the provision of ecosystem services and human well- being. We conclude that the integration of the applied methods of social-cultural assessment on the one hand links to ecosystem services frameworks but on the other hand represents a more holistic conceptualisation of people's benefits from landscapes.

Introduction

Assessment and mapping of ecosystem services contributes to understanding the supply and demand of services, to supporting stakeholders in decision-making, and to informing political priorities for environmental sustainability, for example in the European Union (Maes et al., 2012). Whilst biophysical mapping and economic assessment remain a focus of ecosystem services research (e.g. Reyers et al., 2013), emerging research further integrates social-cultural perspectives (e.g. Scholte, van Teeffelen, & Verburg, 2015). Recent studies consider social complexity, analysing issues of benefit distribution, values and interests and power around ecosystem services (Daw, Brown, Rosendo, & Pomeroy, 2011; Felipe-Lucia et al., 2015). Research is also directed toward a deeper understanding of the links between ecosystems and human well-being (e.g. Berbe s-Bla zquez, 2012; Bieling, Plieninger, Pirker, & Vogl, 2014; Hausmann, Slotow, Burns, & Enrico, 2015; Villamagna & Giesecke, 2014).

Participatory approaches are particularly useful to explore stakeholders' knowledge, preferences, practices, perceptions and values around ecosystem services (Villamor, Palomo, Santiago, Oteros-Rozas, Hill, 2014). In particular, public participation GIS (PPGIS) and a range of other participatory mapping approaches enable an assessment of the social complexity of ecosystem services (Brown & Fagerholm, 2015; Raymond, Kenter, Plieninger, Turner, & Alexander, 2014), including multiple place-based practices and values, emerging from everyday embodied subjective experience and accumulated knowledge (Ingold, 1993; Stephenson, 2008; Williams & Patterson, 1996). They communicate the assigned environmental values, i.e. the judgements regarding the worth of objects such as places, ecosystems and species with benefits for landscape management (Ives & Kendal, 2014; Seymour, Curtis, Pannell, Allan, & Roberts, 2010; Van Riper & Kyle, 2014).

While a number of studies have used PPGIS to elicit ecosystem services (see Brown & Fagerholm 2015 for a recent review), few studies have considered the spatial associations between the spatial distribution of ecosystem services and human well-being. Human well-being is a multi-dimensional concept which has a fundamental role in the ecosystem services framework (Villamagna & Giesecke, 2014). The Millennium Ecosystem Assessment (MA) recognised five dimensions of well-being: 1) basic material for a good life; 2) freedom of choice; 3) health; 4) good social relations, and; 5) security (MA, 2005). These aspects represent three core domains in which humans benefit from the environment: physically, psychologically and socially. Recent research has highlighted the importance of assessing the context-specific nature of self- reported well-being. Well-being is strongly associated with perceived environmental qualities (as measured by marking of negative and positive qualities on a map using PPGIS) in both urban and suburban contexts (Kytta, Broberg, Haybatollahi, & Schmidt-Thome, 2015). Weber and Anderson (2010) compared the perceived well-being benefits that park users obtained from regional and urban parks. Across both contexts, common preferences included enjoying nature, escaping personal/social pressures, escaping physical pressures and enjoying the outdoor climate. In a study of short interviews, Bieling et al. (2014) studied ways that natural surroundings and everyday landscapes contribute to people's well-being and the kind of linkages that emerge to ecosystem services and landscape values, revealing an outstanding importance of cultural values.

Social-cultural assessment of ecosystem services and their contributions to people's well-being have received limited attention in multifunctional agroforestry landscapes (Fagerholm, Torralba, Herzog, Burgess, & Plieninger, 2015). Agroforestry is the deliberate human

management of trees/shrubs with agricultural crops or livestock (Mosquera-Losada, McAdam, Romero-Franco, Santiago-Freijanes, & Rigueiro-Rodríguez, 2009). Agroforestry aims to integrate commodity production with sustainability issues (in particular related to poverty alleviation, food security and soil and biodiversity conservation), while striving to be compatible with local farming practices (Nair, 2007). In fact, agroforestry systems provide multiple ecosystem services, ranging from the pro- vision of food, feed and fibre through to non-commodity outputs, such as climate, water and soil regulation and recreational, aesthetic and cultural heritage values (e.g. McAdam, Burgess, Graves, Rigueiro-Rodríguez, & Mosquera-Losada, 2009; Smith, Pearce, & Wolfe, 2013). In Europe, agroforestry has frequently shaped highly appreciated cultural landscapes with long traditions (Eichhorn et al., 2006; Plieninger et al., 2015) and has significant potential to advance sustainable rural development (http://www. agforward.eu).

Many researchers have been concerned about the insufficient focus on the social-cultural sphere and associated processes in understanding the contributions that nature's services provide to humans (e.g., Chan, Satterfield, & Goldstein, 2012; Schroter et al., 2014; Setten, Stenseke, Moen, 2012). This concern is particularly apparent in agroforestry landscapes. Studies involving local people and other stakeholders defining agroforestry-related ecosystem services have been documented only in limited case study research (Fagerholm et al., 2015). One exception is Hartel et al. (2014) who interviewed rural inhabitants in an area of Romania about their perceptions of ecosystem services in changing silvopastoral landscapes. Provisioning services such as firewood, water and crops, but also healthy soils were particularly valued. Oteros-Rozas et al. (2014) surveyed attitudes and perceptions of ecosystem services regarding a Spanish transhumance network with residents and visitors with the most important services revealed as fire prevention, air purification and livestock. Preferences have also been studied with the use of landscape photographs, for example by Pinto-Correia Barroso, Surova , Menezes (2011) in a study eliciting visual preferences for Portuguese montado agroforestry landscapes. García-Llorente et al. (2012) performed a comparative analysis between different typical landscapes in Spain, including the dehesa agroforestry landscapes, with the result that dehesa is among the highest valued by people in terms of visual preference and in willingness to pay for conserving it, and also among the landscapes with more capacity to supply multiple ecosystem services.

In summary, agroforestry systems provide great potential for environmental conservation and sustainable rural development, but the ecosystem services of European agroforestry and their contributions to human well-being have not been scrutinized from a social-cultural perspective (Fagerholm et al., 2015). In this study, our aim is to understand the importance of ecosystem services from agroforestry for local people in a spatially explicit way at the landscape scale, and to reveal the contribution of agroforestry landscapes to subjective well-being. We present a first social-cultural assessment of ecosystem services provided by a European type of agroforestry through PPGIS methods. Furthermore, the relationships between contribution of a landscape to subjective self-reported well-being and spatially explicit mapping of land- scape practices and values have not been explored before. The particular focus of this paper is the Spanish dehesa e a traditional, low-input, extensive agroforestry system composed of open, heterogeneous canopies of holm oak (Quercus ilex) and cork oak (Quercus suber) with a shrub or annual herbaceous understory. Dehesas are estimated to cover about 2.3 million ha in Spain (Moreno & Pulido, 2009).

Our specific objectives are:

1. to quantify and map the spatial distribution, patterns and intensities of ecosystem services perception by local people and explore the differences between different actors;
2. to compare and contrast the number and type of ecosystem services identified and their spatial relation to land cover, protected areas and common land patterns;
3. to identify the linkages between the perception of landscape and subjective well-being;
4. to explore the relationships between the ecosystem services demanded in different types of land covers and identified landscape values attached to subjective well-being and socio-demographic characteristics;
5. to elucidate the specific contribution of agroforestry systems to the provision of ecosystem services.

Methods

Study area

The study was carried out within the Llanos de Trujillo plains in Caceres Province, south-western Spain (390 310 5000 N, 50 560 0400 W). The study area comprises four municipalities (Trujillo, La Aldea del Obispo, La Cumbre, Torrecillas de la Tiesa; extent: 94,000 ha, Fig. 1), and is commonly regarded as a region that most residents identify with and/or depend on for their lifestyles and livelihoods. Dominant land cover types in the four municipalities are dry grassland (38%), holm oak dehesas (33%), shrublands (16%) and extensive cereal crops (11%) (Fig. 2). The Llanos de Trujillo has a gently rolling relief, interrupted by river valleys and some mountains (altitude 350e550 m). Climate is typically Mediterranean with mild and humid winters and very hot summers with annual rainfall around 600 mm. The land use systems of the area provide a diverse flow of ecosystem services, with production of high-quality food, water regulation, minimization of soil erosion and the pro- vision of recreation being most important. In total, 24% of the territory in the municipalities is part of the Natura 2000 Network of protected areas, including the extensive Almonte river system and open plains. Monfragüe national park is located in the northern part of the study area, receiving 300,000 visitors per year.

The four municipalities have in total 11,511 inhabitants, the largest one being Trujillo with 9085 inhabitants. Trujillo has a high proportion of senior inhabitants, with almost three times more persons older than 64 years compared to people between 20 and 64 years. Population density is low (12.8 inhabitants/km2). The un-employment rate is 15%. The main economic activity is agriculture in the three small villages (between 29% and 43% of the active population). In contrast, only 7% of Trujillo's active population works in agriculture. The main agrarian activity is livestock breeding. Most of the farmlands are concentrated in large estates, with around 80% of the lands being in estates of >100 ha extent. Tourism is increasing importance in the local economy associated with high nature values, birdwatching and gastronomy. Privately owned lands are dominant, but each municipality, with the

exception of Trujillo, includes also limited extent of common land (in total 259 ha) with heterogeneous land tenure.

Typology of ecosystem services with respective indicators and self-reported measure of human well-being

We developed a locally relevant ecosystem service typology that places specific focus on the social-cultural dimension of landscapes, based on the existing typologies (e.g. de Groot, Wilson, & Boumans, 2002; Costanza et al., 1997; MA, 2005; EEA, 2014). In addition, typologies of landscape and ecosystem services and values for participatory research were considered (e.g. Brown & Reed, 2000; Raymond et al., 2009; Valles-Planells, Galiana, & Van Eetvelde, 2014; Appendix A). Our typology aims to capture both the tangible and abstract/symbolic/intrinsic benefits of ecosystem services in relation to local actors' everyday lives and covers provisioning, cultural, regulating and supporting services. The ecosystem service indicators, mapped by the local actors, were selected and linked to respective services based on previous studies on perceptions of ecosystem services in agroforestry systems (Campos, Ovando, & Montero, 2008; Campos, Oviedo, Caparros, Huntsinger, Coelho, 2009; Hartel et al., 2014) and by reflecting the results on ranking positive aspects of agroforestry by farmers and other land management stakeholders in the AGFORWARD workshops (reports downloadable through http://www.agforward. eu/index.php/en/FarmerNetworks.html).

In addition, the ecosystem service mapping approach was complemented with a self-reported measure of human well-being aiming to capture the contribution of landscape to respondent's well-being not addressed or restricted to the mapped typology or the MA categorisation. Subjective and self-reported well-being can be assessed in a variety of ways, including composite measures, life satisfaction surveys such as the quality of life index and the sustainable livelihoods framework (Villamagna & Giesecke, 2014). We applied a free-listing method to identify the linkages between the perception of landscape and subjective well-being (cf. Bieling et al., 2014). The method is rapid to perform and not restricted to applying an explicit terminology, such as ecosystem service categorisation, but allows informants openly to express their linkages to landscape.

Informants and sampling approach

Informants were chosen as full or part time local residents, including farmers and land owners, as well as people who had previously lived in the four municipalities but now living elsewhere and still working in the area. Residents were recruited through purposive stratified sampling based on three stratification criteria of: 1) municipality, 2) gender and 3) age (young people/young adults 15e29 yrs, middle-aged 30e59 yrs, seniors 60 yrs). The first criterion was based on geographical balance and the latter two were in proportion to the local census data (INE, 2015). Informants in each stratum were chosen by convenience sampling on site and approached in key public locations, such as market places, cafes, schools and health care centres (Bieling et al., 2014; Lopez-Santiago et al., 2014; Scolozzi, Schirpke, Detassis, Abdullah, & Gretter, 2014). Also two school classes participated. In addition, people who work or have worked in agriculture or forestry were recruited through snowball sampling.

Data collection through a web-based PPGIS survey

Data collection was performed during ten days in May 2015 through a web-based PPGIS survey operated on a laptop or tablet computer and implemented through the Maptionnaire software. The contents and functionalities were tested with eight participants in March 2015. The survey was in most cases filled in with the help of a facilitator but designed to be self-administered. The sur- vey started with mapping as point data the informants' home locations and subsequently ecosystem service indicators categorised under: 1) activities (e.g. various outdoor activities, harvesting products from nature, spending time together with other people); 2) feeling and valuing (e.g. beautiful landscapes, appreciation of local culture, cultural heritage and history, appreciation of plants, animals and ecosystems) and; 3) special place (Appendix A). After each mapped item, a pop up window opened to collect subsequent attribute data. Informants could map an unlimited number of places for ecosystem service indicators. The background map was Bing satellite image with overlaid Open Street Map objects. In order to ensure spatial scale coherence in mapping, a minimum zoom level for point placement was given reflecting the focus on landscape scale.

Ecosystem service indicator mapping was followed by the open free-listing question (cf. Bieling et al., 2014): 'How does this area and the opportunities it offers contribute to your well-being? Please briefly write and describe here anything that comes to your mind (e.g. list shortly the three most important things)'. The subsequent survey pages included questions on socio-demographic characteristics and self-estimated knowledge of and relationship to the study area, shown to have a significant influence on ecosystem service perceptions (e.g. Brown & Reed, 2009; Palomo, Martín-Lopez, Potschin, Haines-Young, & Montes, 2013; Lopez-Santiago et al., 2014; Van Riper & Kyle, 2014).

Analysis

Characteristics of informants and identified ecosystem services were analysed through descriptive statistics and Chi square tests for significant associations. The spatial distribution, patterns and intensities of mapped ecosystem service data were described, firstly, by calculating the Euclidian distance between informant home and mapped locations as it was expected that variation in distance might explain spatial patterns (Brown, Reed, & Harris, 2002; Fagerholm, Kayhko, Ndumbaro, & Khamis, 2012). Secondly, we studied the spatial arrangement of the indicator point layers with nearest neighbour statistics (NN) to explore random distribution (Ebdon, 1985). NN statistics measures the Euclidian distance between each point and its nearest neighbours and divides this with the distance in a hypothetical randomly distributed point layer. Thirdly, we generated density surfaces from the point layers using quadratic Kernel function (Silverman, 1986) e a method widely applied to describe intensity and visualise the spatial pat- terns of ecosystem service indicators mapped through PPGIS (Brown & Fagerholm, 2015).

In order to analyse land cover types and conservation status of the locations mapped by the informants, each ecosystem service indicator layer was overlaid with CORINE land cover (2006, EEA, 2013) and Natura 2000 protected area data (EEA, 2012). Due to the small width of the linear features (200 m for rivers) in the Natura 2000 data, the data set was buffered with 300 m distance to appreciate the uncertainty in point placement (cf. Lechner et al., 2014). In addition, these shares on places mapped on various land covers and protected areas were compared with the spatial extent of land cover types and Natura 2000 areas in the study area

as a proxy measure to indicate potential under- or over-representation. For this purpose, an extended study area was defined including the four municipalities and areas outside them with mapped point locations, collectively buffered to a radius of 1000 m defining the landscape context. A spatial layer of common land was produced based on contextual knowledge and overlaid with ecosystem service indicator layers. As Natura 2000 data, also common land was buffered with 300 m radius for the analysis. Common land extent in the four municipalities and the shares of mapped places were compared.

The answers from the open free-listing question were coded following the Cultural Values Model (CVM) developed byStephenson (2008, cf. also Bieling et al., 2014), which presents an approach for conceptualizing the multiple ways in which people value landscapes. The holistic model integrates landscape as bio-physical and social-cultural phenomenon under three components of values attributed to landscapes: forms, practices and processes, and relationships. We identified 28 landscape values within the three categories including 'forms' such as physical, tangible and measurable aspects (e.g., nature, historic features, good food); 'practices and processes' including both human practices and natural processes (e.g., clean water, hunting, health), and; 'relationships' i.e. values based on peopleepeople interactions in the landscape or on peopleelandscape interactions (e.g. tranquillity, freedom, social interactions). Bieling et al. (2014) showed in their study that people's responses to the wellbeing question go beyond the ecosystem services category and, therefore, we also chose the more inclusive CVM for analysis.

Finally, we performed a Redundancy Analysis (RDA), i.e. a multivariate ordination technique (e.g. Martín-Lopez et al., 2012; Rao, 1964) that allows for simultaneous observation and analysis of more than one outcome variable. RDA is the multivariate analogue of regression and we used it to explore the potential relation between landscape perception (i.e. the frequency of ecosystem services mapped by individuals on different types of CORINE land cover classes, dependent variables), subjective well- being (i.e. the landscape values identified by individuals, independent variables) and socio-demographic characteristics of respondents (independent variables). For this analysis, in order to have a comparable number of observations per CORINE category, we merged them into six land cover categories (urban, agriculture, water, grassland, agroforestry and sparsely vegetated) that had sufficient ecological similarity in the study area (Tables 3 and Appendix C).

Results

Informant characteristics

The majority of the informants lived in Trujillo and the three other study area municipalities (94%) with the rest scattered across the neighbouring areas (Table 1). Both genders were almost equally represented with 46% of informants being 30e59 years old, 24% under 30 years and 30% above 60 years. Almost a fifth (18%), especially men, were working in agriculture or forestry (29% of men but only 7% of women, c2(1, N 219) 19.26, p 0.000). Self-estimated knowledge of the area was claimed extremely good (40%) or quite good (39%) with only 5% indicating poor knowledge of the area. Those who had a residential relationship to the area tended to estimate their knowledge higher compared to those who worked or had moved out from the area (c2(12, N ¼ 215) ¼ 49.0, p ¼ 0.000).

Identified ecosystem services and their spatial patterns

A total of 2594 places were mapped in the survey as significant sites of ecosystem service provision with a mean amount of 12 places per informant (min 3, max 30, SD 4.2, Table 2). These sites were located on average 9.2 km from the informants' homes (see Appendix B for distance, nearest neighbour and intensity analyses) and the majority (58%) of places were related to cultural services. Places for outdoor activities (17%), mainly for walking, were the most mapped. These areas were valued by all informant groups, but people working in agriculture and forestry valued them to a lower degree (14%) than all other groups (c2(1, N ¼ 219) ¼ 3, p ¼ 0.034).

Outdoor activities showed the second most clustered pattern on the landscape (NN ratio 0.31, Z -27.47) and were located closest to informants' home (mean 3.3 km, Fig. 2A).

Frequently mapped cultural services were also sites of beautiful landscapes, social interaction and culture and heritage values (12%, 10% and 10% of mapped places respectively, Table 2). Beautiful landscapes were related to oak trees and the dehesa, to views of the mountains and rivers, and to the panoramic view from the old castle of Trujillo. They were found around the study area, although with a statistically clustered pattern (NN ratio 0.43, Z -19.06). Sites for social interaction were especially related to places where people gathered for a picnic with family or friends or for the town festivities mainly in the vicinity of settlement areas (mean distance to home 5.6 km, max 0.59 points/ha). Culture and heritage values were mainly related to the town of Trujillo, historical bridges in the landscape and other built structures (monuments). These sites showed the most clustered pattern (NN ratio 0.26, Z -22.52) and the highest intensity (max 2.12 points/ha in old Trujillo) out of all indicators (Fig. 3B). Inspirational, spiritual and religious values (5% of mapped places) and sites for intrinsic value of nature (4%) were among the lowest mapped among cultural services, and the latter were more often identified by young people compared to other age groups (c2(1, N 219) 2, p 0.011). Sites for these two values were found scattered in the landscape, resulting in rather low spatial intensities (mean 0.02 points/ha).

Provisioning services totaled to 24% of all mapped places (Table 2). Provision of farm products, mainly meat and eggs, rep- resented 11% of mapped places and were less identified by young people than all other groups (c2(1, N 219) 6, p 0.007). Places for harvesting wild products, such as asparagus and fish, had a share of 13%. Men identified these services more often than women (c2(1, N 219) 3, p 0.032), and young people less than other age groups (c2(1, N 219) 6, p 0.013). Harvesting was much more scattered around the landscape (Fig. 3C) compared with sites for farm products located closer to settlement with a higher spatial intensity (mean distance to home 8.5 vs. 4.7 km, max 0.35 vs. 0.66 points/ha).

Out of regulating and supporting services sites for appreciation of plants, animals and ecosystems were identified more than sites for appreciating environmental capacities such as water regulation (10% vs. 5% of all mapped sites). Both of these were located furthest from homes (<16 km) with scattered patterns (NN ratio 0.43/0.42, Z-17.35/-13.22) resulting to low spatial intensities (mean 0.2e0.3 points/ha, Fig. 3D)). Special places presented 3% of all mapped places with the smallest spatial extent (4384 ha) and the most scattered pattern (NN ratio 0.65, Z -5.84), most likely due to the limited number of these places.

Spatial relation of mapped services to land cover, protected areas and common land patterns

When looking at the relationship to land cover, most of the mapped places were distributed in grasslands (27%), and the rest on agricultural (21%) and agroforestry (18%) areas, urban surfaces (17%), sclerophyllous vegetation or forest (11%), sparsely vegetated areas (6%) and water (1%) (Table 3, Fig. 2). Almost half (45%) of all sites for provisioning services were found on grasslands and agroforestry areas. Farm products were also especially related to urban areas, where people commonly had chicken and home gardens. Cultural services were also most prevalent in grassland (28% of the mapped cultural services), urban areas (22%) and agroforestry areas (18%). Sites for outdoor activities, social interaction and beautiful places were especially found on grasslands and agroforestry areas. The sites for appreciation of local culture, cultural heritage or history dominated in urban areas. Grasslands and agroforestry areas (23% and 20% of mapped sites respectively) were the most typical for regulating and supporting services.

Comparison of these figures to the spatial extent of different land covers in the extended study area showed that sclerophyllous vegetation/forest (11% of places vs. 19% of land), agroforestry areas (18% of places vs. 25% of land) and water (1% of places vs. 2% of land) were less represented than the extent of the land cover. Agricultural areas, grasslands and sparsely vegetated areas showed slight overrepresentation. Then again, urban areas were much more characterized by mapped places (17%) compared to the spatial extent of this land cover type (1%).

Forty-one percent of all mapped places fell inside Natura 2000 protected areas, which corresponded to their spatial extent in the extended study area (42%). In the extended study area the pro- portion of protected areas increased significantly compared with the four municipalities (24%) which highlights that people actively search for certain ecosystem services in these areas. Especially regulating and supporting services were related to protected areas, with appreciation of plants, animals, wildlife, and ecosystems presenting the highest share of 61% of mapped places within Natura areas. More than half of the places were found within Natura 2000 areas also for environmental capacities, beautiful places and appreciations of local culture, cultural heritage or his- tory. Least related to protected areas were farm products and outdoor activities.

Common land areas occupied only 0.3% of the four municipalities, with half of them (53%) being grasslands and the rest arable land (26%), agroforestry areas (18%) and urban areas (3%). These land areas small in extent attracted 7% of all assigned places by informants. They were especially related to outdoor recreation (34% assigned to common land), farm products (20%) and social interaction (16%).

Landscape values contributing to subjective well-being

Between 9 and 11 landscape values were identified under the three categories of landscape values (Table 4). Clearly the most frequently mentioned were the relationships, especially tranquility/relaxation and social interaction, which 74% and 32% of informants mentioned respectively. More than 10% also mentioned nature (forms), no contamination/clean environment, work, fresh/ clean air, quality of life/living well and outdoor activities (practices and processes) and family interaction (relationships). When respondents were asked about the

contribution of the local landscape to subjective well-being, many values that had not been identified within the ecosystem services framework were mentioned (e.g., tranquility/relaxation, place attachment, quality of life/living well, and comfort/everything is close).

Linkages between the perception of ecosystem services provision in different land covers, subjective well-being and socio-demographic characteristics of respondents

The RDA indicates a statistically significant relationship between the frequency of mapped ecosystem service indicators in the different categories of land cover, the subjective well-being and the socio-demographic characteristics of respondents ($p < 0.0001$, from 500 permutations). The first three axes (with eigenvalue > 1, after Kaiser criterion) absorbed 88.6% of inertia (Appendix C). The first axis (38.3% of inertia) opposed agroforestry, in the positive side, and urban landscapes, in the negative (Fig. 4). More intensively mapped ecosystem services in agroforestry areas were associated with older male respondents working in agriculture or forestry, and with a self-reported high knowledge of the area. These respondents related their well-being with nature, biodiversity, health, the good relation between low prices and good services and the resulting comfort. On the opposite side, people mapping more ecosystem services in urban areas were typically women and students that tended to relate their well-being with historic features, beauty, tranquility and leisure. The second axis (33.9% of inertia) was largely influenced by a high frequency of mapped ecosystem services in grasslands and pasturelands, particularly by people with a high level of formal education, that work as administrative workers, professionals or managers. These people related the effects of the landscapes on their well-being to a clean environment, freedom, silence, hunting, fishing, harvesting and other outdoor activities. The third axis (16.4% of inertia) was represented by agriculture on the positive side and urban landscapes on the negative. Older people, retired and those working in the administration tended to relate their well-being with family interaction, comfort and tranquility. On the opposite side, respondents dedicated to home duties or students more frequently mapped ecosystem services more intensively in urban landscapes. They also perceived the relation between the landscapes and their well-being through biodiversity and cultural features/traditions.

Discussion

Key findings from ecosystem service mapping

Our participatory mapping identified a local-level appreciation for all categories of ecosystem services. The clearest appreciation was expressed for provisioning and cultural services including outdoor recreation, harvested products, aesthetics, farm products and social interaction. This finding shows that people practice multiple forms of recreational, hobby, small-scale farming and gathering activities that generate coupled provisioning and cultural services. Sites for outdoor activities, farm products and social interaction were also found closest to informants home, which represent the common and important practices and values in everyday life. Sites for recreation and social interaction were found closest to people's place of residence, coinciding with the findings presented by Brown et al. (2002) and Fagerholm et al. (2012). Outdoor activities and culture and heritage values were also the most

spatially clustered services. While outdoor activities cover extensive areas surrounding all municipalities, the culture and heritage values were more clustered with the city centre of Trujillo. Appreciation for ecosystem services was relatively consistent and homogenous across municipalities, genders, age groups and different professions. However, there were differences in two aspects: younger people tended to have less appreciation for provisioning services, which is possibly an indication of a loss of practical engagement with nature through agricultural practices (cf. Gomez-Baggethun, Mingorría, Reyes-García, Calvet, & Montes, 2010). Farmers expressed more appreciation for provisioning services and less for cultural services, especially for outdoor recreation, which confirms our hypothesis that they have different ways of engaging with the local landscape and more 'productivist behavior' compared with residents involved in professional occupations (Burton, 2004, 2012; de Snoo et al., 2013). Also Bieling et al. (2014) observed that farmers' relationship to land is more often based on material factors and less on recreation.

Relations between ecosystem services and use, protection and ownership of land

The spatial overlay of land cover and ecosystem services did not show any areas of over or underrepresentation, except for urban areas that have a high coverage of cultural and heritage values, and provisioning services related to home gardens. Ecosystems outside settlement areas were rather similar in their service provision. We may conclude that people appreciate ecosystem services provided by the heterogeneous structure of various land covers which represent the landscape as a whole, rather than assigning values on individual land systems.

Protected areas showed a clear pattern of low provisioning and very high regulating services, in particular appreciation of plants, animals, wildlife and ecosystems (as also found by Castro et al., 2015). Although the overall landscape is multifunctional, there is obviously a separation between protection and production landscapes. Similarly, Raymond & Curtis (2013) found that formally acknowledged areas of high environmental significance attracted more social values related to conservation, e.g. biodiversity, natural significance and intrinsic values. Interestingly, cultural ecosystem services were appreciated inside and outside Natura 2000 areas to a similar degree, so evidently both production and conservation landscapes are able to provide them.

The clearest pattern was found for the small share of common lands, which had disproportionally high levels of provisioning and cultural services. These results support the view that land tenure and public access to land are important determinants of ecosystem service provision (Brown, Weber, & de Bie, 2014; Hausner, Brown, & Lægreid, 2015). We conclude that public access to land guides the spatial practices and values of the people beyond the potentially preferred landscape types. Hence, interpretation of data collected with a PPGIS method also requires the acknowledgement of land tenure and access patterns, especially in the context of dehesa landscapes with extensive areas without public access. Strong differences between ecosystem service provision among different forms of land tenure was also found in biophysical studies (e.g. Schaich & Plieninger, 2013).

The contribution of landscapes to subjective human well-being

The open ended well-being question posed allowed us to recognise landscape values that had not been mapped as ecosystem services, such as tranquillity and comfort. Many of the

identified values were linked to the constituents of well-being in the MA (MA, 2005), especially to freedom, health, social relations, and security. Our approach revealed that the contribution of landscape to subjective well-being is largely related to relationships, i.e. the values based on interactions among people and the landscape, as tranquillity/relaxation and people-people interactions such as meeting with family and friends. Stephenson (2008), working with indigenous Maori communities, found that older people who had more experience with different elements of the landscape mentioned relationships more frequently, and that their understanding of the landscape arose from its temporality (e.g. historic events, traditions). In contrast, we found, on one hand, that older people and those with a self-reported high knowledge of the area linked their well-being to nature, biodiversity, health and low price level for living combined with good services, i.e. to forms and practices. On the other hand, students and young people, who might have limited experience with different elements of the landscape, tended to express the significance of landscapes in terms of relations, for example leisure. These trends were related to urban areas, aligning with patterns that emerged in the ecosystem service mapping.

The role of agroforestry

One of the starting points of our study was the assumption that, based on evidence from biophysical assessments (Smith et al., 2013; Torralba, Fagerholm, Burgess, Moreno, Plieninger, 2016), agroforestry systems would generally provide higher levels of ecosystem services than other land use systems. Indeed, our respondents allocated multiple ecosystem services to agroforestry lands within our study area. However, the intensity was not higher than for the surrounding agricultural or semi-natural areas. These areas clearly differ from agroforestry land in their vegetation structure and visual appearance but they are also managed by low-input land-use systems, have a high share of semi-natural habitats and are of overall high nature value (Veen, Jefferson, de Smidt, & van der Straaten, 2009). Moreover, grasslands are also culturally relevant to local people (Stenseke, 2006). Again, we find that it is less individual land-use systems, but rather our study landscape as a whole that provides ecosystem services to people, though agroforestry is an important part of this landscape with long traditions and historical roots. The trends in our RDA, which found that people working in agriculture and forestry and those with a better knowledge of the area had a higher appreciation for the ecosystem services in agroforestry areas, point to a second explanation: the dehesas of our study area are mostly in large private ownership and usually do not offer access to the public. Many people simply may not have physical access to these lands and are therefore unable to allocate ecosystem services to them as discussed above.

Consideration of the method

Our research approach was based on the engagement of the general public to map ecosystem services that originate in place-based local knowledge and to the exploration of the context-dependent nature of subjective well-being. The applied approach was successful in capturing experience-based individual practices, uses and values related to these landscapes and related the direct and indirect ecosystem benefits to the actual people that derive and demand them. However, differences between the mapping and the self-reported well-being approaches could be observed.

PPGIS approaches have been applied to successfully assess especially provisioning and cultural benefits (e.g. Brown, Montag, & Lyon, 2012; Fagerholm et al., 2012; Raymond et al., 2009; Sherrouse, Clement, & Semmens, 2011) which our study also confirmed. In particular, cultural services are often inferred from proxies such as recreation and tourism locations, scenic beauty or cultural heritage sites. In fact, the recent literature on ecosystem services indicates that the mapping of cultural services lags behind mapping of other services (Crossman et al., 2013; Martínez-Harms & Balvanera, 2012). Hence, there is a need to acknowledge and map a broader variety of cultural services (Chan et al., 2012; Daniel et al., 2012; Setten et al., 2012). Our well-being approach managed to capture the context-specific social-cultural values arising from and related to the landscape and natural surroundings as a whole, placing emphasis not on predefined value typologies but on a grounded perspective. Consistent with earlier work (Berbes-Blazquez, 2012; Bieling et al., 2014), certain values were not conceptualised as ecosystem services. We conclude that the integration of these two methods of social-cultural assessment on the one hand links to established ecosystem services frameworks but on the other hand acknowledges a more holistic nature of people's benefits from landscapes.

Based on the experiences from this study, we believe that our facilitated approach (as opposed to the more frequent type of self- administered surveys) has high potential to increase data quality and participant motivation, and to reduce dropout rate during the survey. Survey data collection with an online interface and a facilitated approach has to our knowledge not been applied with web- based PPGIS so far. Facilitation allowed in-depth discussion with the informants on the meanings and placement of the mapped attributes. This increased spatial data precision and probably also the amount of mapped attributes compared to self-administered surveys.

Our research had focus on one time layer (present) and was performed at local scale and we highlight that comparative assessments across spatial and temporal scales would be needed. Also, involvement of a broad set of actors beyond local residents such as visitors, local action groups, farmer or conservation associations and authorities, would be of importance when truly aiming to capture multiple interests, values and power asymmetries.

Conclusions

Our study shows that in multifunctional and heterogeneous landscapes it is less individual land systems or ecosystems that provide multiple and coupled ecosystem services to people, but instead it is the landscape as a whole in which all land systems share a key role. However, land tenure and public access significantly guide the spatial practices and values of the people beyond the potentially preferred landscape types. Hence, we call for further clarification of the role of land systems, land tenure and also of the different categories of protected areas to ecosystem service provision.

Our study also highlights the importance of the multidimensional and context-specific, social-cultural sphere in understanding the contributions that nature's services provide to humans and their well-being. To advance understanding of these relationships, more research should be directed to the links between ecosystems and human well-being in the context of natural surroundings and everyday landscapes, including a systematic exploration of the various social-cultural assessment methods and their specific contributions.

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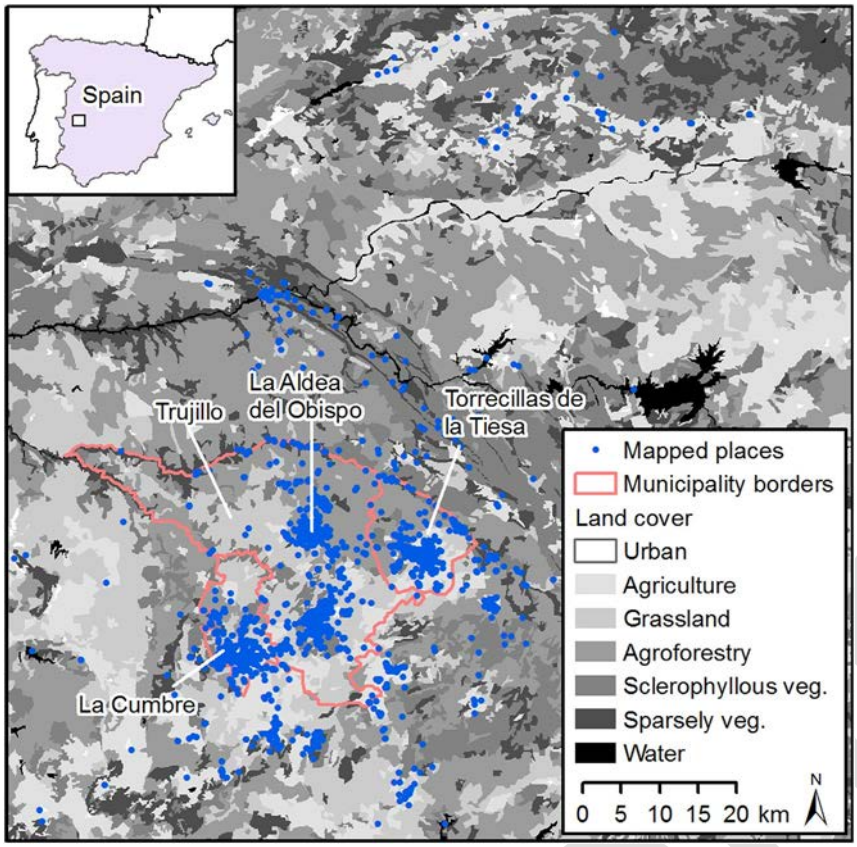

Fig. 1. Study areas, the four neighbouring municipalities of Trujillo, Torrecillas de las Tiesas, La Cumbre and La Aldea del Obispo. La Aldea del Obispo is a small enclave within Trujillo.

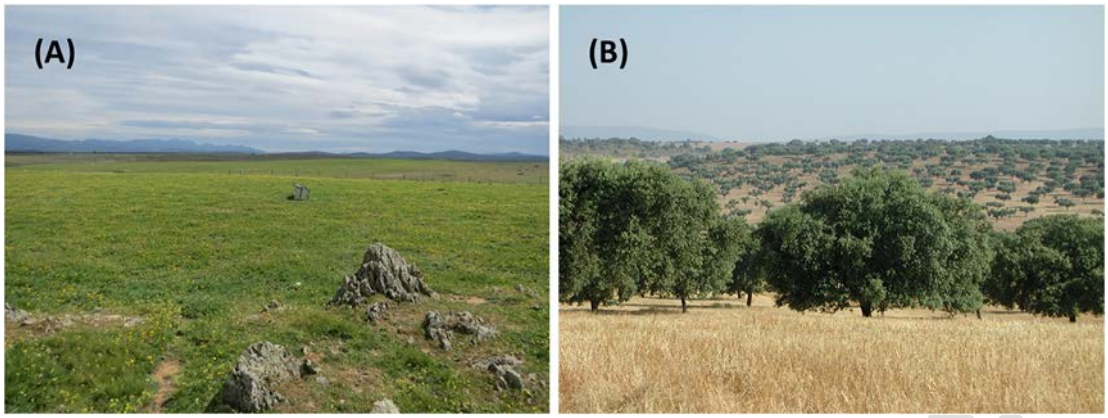

Fig. 2. Examples of (A) open pasture and (B) holm oak dehesa areas.

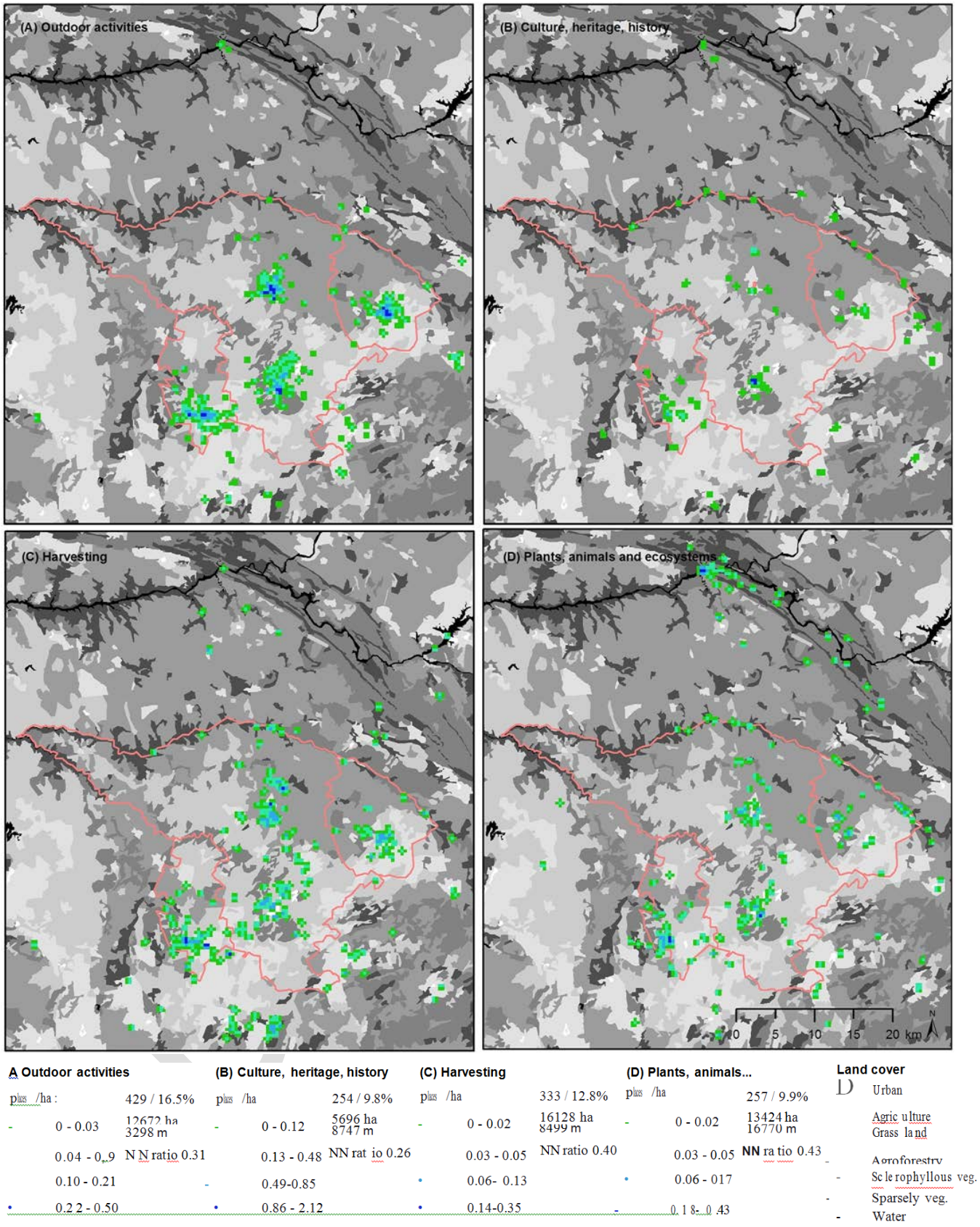

Fig. 3. Spatial intensity (points/ha) for four ecosystem service indicators of outdoor recreation (A), appreciation of local culture, cultural heritage or history (B), harvested products (C) and appreciation of plants, animals and ecosystems (D). Descriptive data indicate the number of mapped points and relative proportion of all mapped points per indicator, area (ha), average distance (m) from informant home to mapped point locations, and nearest neighbour ratio.

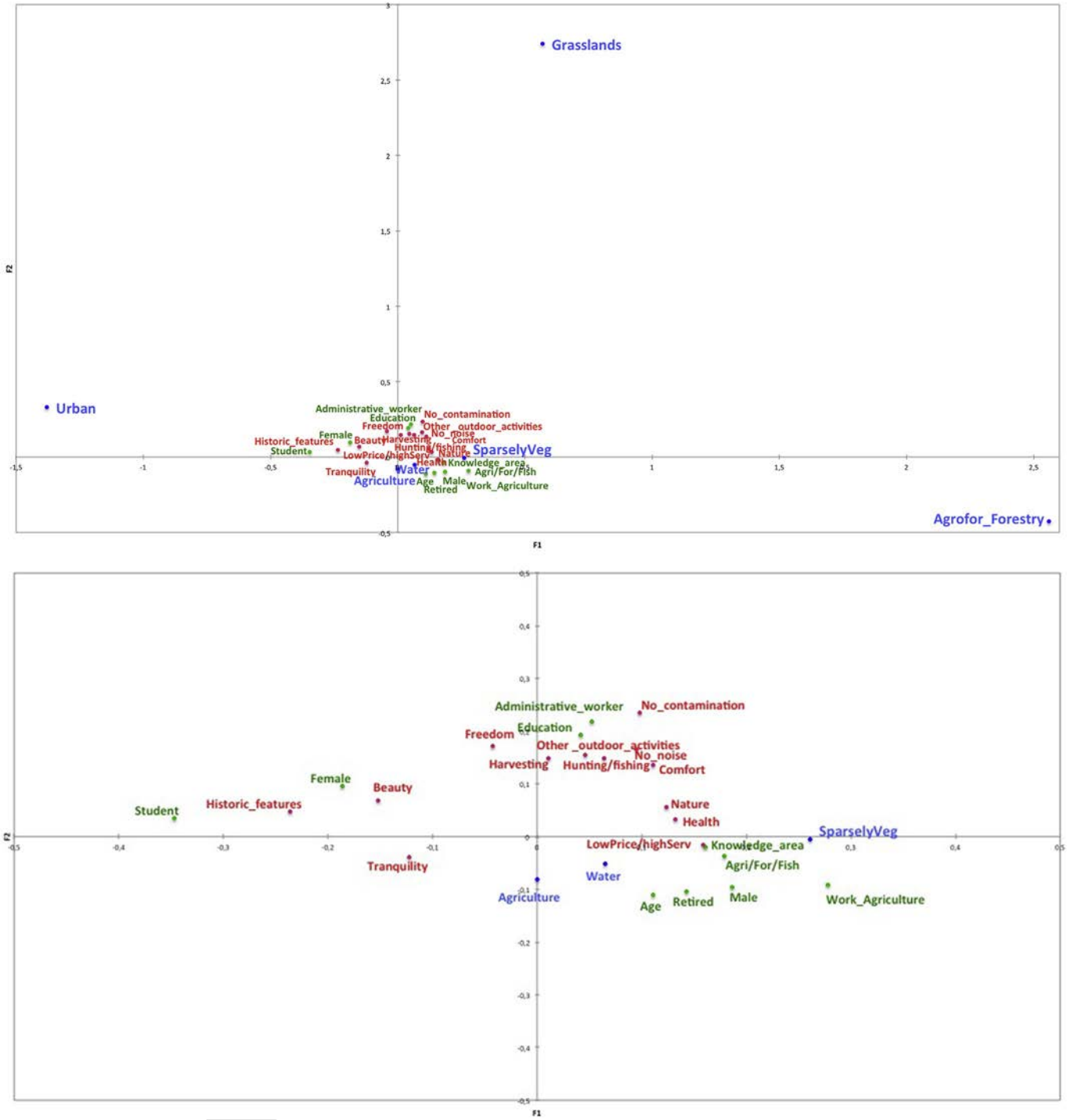

Fig. 4. Scatter plot of the first two axes of the redundancy analysis (RDA). In blue, dependent variables, i.e. land cover types. In red and green, independent variables, i.e. socio-demographic and landscape values respectively. For a good readability, only variable with the largest absolute values of the scores in the first two axes are represented. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1. Informant characteristics. a: Number of informants varies according to informants who responded each question.

	n[a]	%
Municipality		
Trujillo	94	42.9
La Cumbre	49	22.4
Torrecillas de la Tiesa	47	21.5
Aldea del Obispo (La)	15	6.8
Aldeacentenera	4	1.8
Zorita	4	1.8
Ibahernando	2	0.9
Jaraicejo	2	0.9
Herguijuela	1	0.5
Madroñera	1	0.5
	219	100.0
Gender		
Men	112	51.1
Women	107	48.9
	219	100.0
Age category		
15–29 yrs	53	24.2
30–59 yrs	100	45.7
≥60 yrs	66	30.1
	219	100.0
Work related to agriculture or forestry		
No	179	81.7
Yes	40	18.3
	219	100.0
Household size		
1	20	9.3
2–3	113	52.6
4–6	82	38.1
	215	100.0
Household monthly net income		
Above median (≥2200 €)	57	30.3
Below median (≤2200 €)	131	69.7
	188	100.0
Highest level of education		

	n[a]	%
Higher university degree	18	8.8
Polytechnic or lower university degree	19	9.3
Vocational training	28	13.7
Upper secondary school/college	24	11.7
Primary or secondary school	102	49.8
No formal schooling	14	6.8
	205	100.0
Relationship to study area		
I live here full time	181	82.6
I live here part time or seasonally	17	7.8
I work here and live in another place	14	6.4
I used to live here but I currently live outside this area	3	1.4
	215	100.0
Self-estimated knowledge of the area		
Extremely good	88	40.2
Quite good	86	39.3
Moderate	30	13.7
Quite poor	11	5.0
Extremely poor	0	0.0
	215	100.0

Table 2. Number of mapped points and their relative proportion for all informants, women, men, different age groups, and agricultural and forestry workers.

	All (n = 219)		Men (n = 112)		Women (n = 107)		15–29 yrs (n = 53)		30–59 yrs (n = 100)		≥60 yrs (n = 66)		Agric./forestry (n = 40)		Non-agric./forestry (n = 179)	
	No. of places (2597)	% places	No. places (1352)	% places	No. places (1242)	% places	No. places (605)	% places	No. places (1193)	% places	No. places (796)	% places	No. places (495)	% places	No. places (2099)	% places
Provisioning services	627	24.2	352	26.0	275	22.1	120	19.8	296	24.8	211	26.5	149	30.1	478	22.8
Farm products	294	11.3	156	11.5	138	11.1	49	8.1	139	11.7	106	13.3	65	13.1	229	10.9
Harvested products	333	12.8	196	14.5	137	11.0	71	11.7	157	13.2	105	13.2	84	17.0	249	11.9
Cultural services	1495	57.6	753	55.7	742	59.7	370	61.2	668	56.0	457	57.4	259	52.3	1236	58.9
Outdoor activities	429	16.5	221	16.3	208	16.7	101	16.7	191	16.0	137	17.2	69	13.9	360	17.2
Social interaction	270	10.4	128	9.5	142	11.4	80	13.2	117	9.8	73	9.2	47	9.5	223	10.6
Beautiful landscape or landmark	306	11.8	158	11.7	148	11.9	67	11.1	143	12.0	96	12.1	60	12.1	246	11.7
Appreciation of local culture, cultural heritage or history	254	9.8	133	9.8	121	9.7	61	10.1	116	9.7	77	9.7	41	8.3	213	10.1
Inspirational, spiritual or religious place, feeling or value	136	5.2	59	4.4	77	6.2	29	4.8	57	4.8	50	6.3	21	4.2	115	5.5
Appreciation of a specific place as such, independent of any benefit to humans	100	3.9	54	4.0	46	3.7	32	5.3	44	3.7	24	3.0	21	4.2	79	3.8
Regulating/supporting services	398	15.3	211	15.6	187	15.1	90	14.9	190	15.9	118	14.8	74	14.9	324	15,4
Appreciation of	257	9.9	139	10.3	118	9.5	55	9.1	120	10.1	82	10.3	43	8.7	214	10.2

	All (n = 219)		Men (n = 112)		Women (n = 107)		15–29 yrs (n = 53)		30–59 yrs (n = 100)		≥60 yrs (n = 66)		Agric./forestry (n = 40)		Non-agric./forestry (n = 179)	
	No. of places (2597)	% places	No. places (1352)	% places	No. places (1242)	% places	No. places (605)	% places	No. places (1193)	% places	No. places (796)	% places	No. places (495)	% places	No. places (2099)	% places
plants, animals, wildlife ecosystems etc.																
Appreciation of environmental capacity to produce, preserve, clean, and renew air, soil and/or water	141	5.4	72	5.3	69	5.6	35	5.8	70	5.9	36	4.5	31	6.3	110	5.2
Other special place or area to me	74	2.9	36	2.7	38	3.1	25	4.1	39	3.3	10	1.3	13	2.6	61	2.9
Total	2594	100.0	1352	100.0	1242	100.0	605	100.0	1193	100.0	796	100.0	495	100.0	2099	100.0
Mapped places per informant	11.8		11.1		11.6		11.4		11.9		12.1		12.4		11.7	

Table 3. Land cover classes (Corine Land Cover, CLC, 2006) and Natura 2000 areas, and common land areas characterising ecosystem services and their indicators mapped by the informants. Land cover (LC) class share (%) of extended study area sums up to 99.9% as there are some minor land cover classes in the study area where mapped places were not assigned to, and these were excluded from the table.

LC category	Urban		Agriculture						Grassland, pasture		Agroforestry, sclerophyllous, forest					Sparsely vegetated, wood/shrubland					Water	Total	Natura 2000 (inside)	Common land (inside)
LC class (CLC level 3 value)	Continuous urban fabric (1)	Discontinuous urban fabric (2)	Non-irrigated arable land (12)	Permanently irrigated land (13)	Fruit trees and berry plantations (16)	Olive groves (17)	Complex cultivation patterns (20)	Land principally agriculture, with natural vegetation (21)	Pastures (18)	Natural grasslands (26)	Agro-forestry areas (22)	Broad-leaved forest (23)	Coniferous forest (24)	Mixed forest (25)	Sclerophyllous vegetation (28)	Mineral extraction sites (7)	Transitional woodland-shrub (29)	Bare rocks (31)	Sparsely vegetated areas (32)	Burnt areas (33)	Water bodies (41)	LC total		
Provisioning services	76	1	52	0	0	8	56	60	0	168	116	9	1	0	41	0	27	0	0	0	12	627	197	57
Provisioning services %	12.1	0.2	8.3	0.0	0.0	1.3	8.9	9.6	0.0	26.8	18.5	1.4	0.2	0.0	6.5	0.0	4.3	0.0	0.0	0.0	1.9	100.0	31.4	9.1
Farm products	70	0	17	0	0	3	37	39	0	70	44	1	0	0	12		1	0	0	0	0	294	70	39
Harvested products	6	1	35	0	0	5	19	21	0	98	72	8	1	0	29		26	0	0	0	12	333	127	18
Cultural services	333	1	80	3	3	14	91	103	0	411	262	36	0	3	83	1	45	1	18	0	7	1495	622	120
Cultural services %	22.3	0.1	5.4	0.2	0.2	0.9	6.1	6.9	0.0	27.5	17.5	2.4	0.0	0.2	5.6	0.1	3.0	0.1	1.2	0.0	0.5	100.0	41.6	8.0
Outdoor activities	54	0	50	1	0	3	42	47	0	147	57	1	0	0	18		6	1	1	0	1	429	115	61
Social interaction	43	0	16	1	0	3	24	15	0	72	71	5	0	0	12		7	0	0	0	1	270	106	30
Beautiful landscape or landmark	44	1	4		1	4	8	11	0	84	62	21	0	2	34		12	0	16	0	2	306	160	5
Appreciatio	136	0	2	1	0	2	6	12	0	44	32	2	0	0	6		10	0	1	0	0	25	150	14

LC category	Urban		Agriculture						Grassland, pasture		Agroforestry, sclerophyllous, forest					Sparsely vegetated, wood/shrubland					Water	Total	Natura 2000 (inside)	Common land (inside)
LC class (CLC level 3 value)	Continuous urban fabric (1)	Discontinuous urban fabric (2)	Non-irrigated arable land (12)	Permanently irrigated land (13)	Fruit trees and berry plantations (16)	Olive groves (17)	Complex cultivation patterns (20)	Land principally agriculture, with natural vegetation (21)	Pastures (18)	Natural grasslands (26)	Agro-forestry areas (22)	Broad-leaved forest (23)	Coniferous forest (24)	Mixed forest (25)	Sclerophyllous vegetation (28)	Mineral extraction sites (7)	Transitional woodland-shrub (29)	Bare rocks (31)	Sparsely vegetated areas (32)	Burnt areas (33)	Water bodies (41)	LC total		
n of local culture, cultural heritage or history																						4		
Inspirational, spiritual or religious place, feeling or value	38	0	5	0	0	2	8	13	0	35	17	5	0	0	7	1	5	0	0	0	0	136	49	3
Appreciation of a specific place as such, independent of any benefit to humans	18	0	3	0	2	0	3	5	0	29	23	2	0	1	6	0	5	0	0	0	3	100	42	7
Regulating/ supporting services	14	1	19	3	1	8	7	12	1	90	78	43	3	1	56	0	42	0	11	1	7	398	230	10
Regulating/ supporting services %	3.5	0.3	4.8	0.8	0.3	2.0	1.8	3.0	0.3	22.6	19.6	10.8	0.8	0.3	14.1	0.0	10.6	0.0	2.8	0.3	1.8	100.0	57.8	2.5
Appreciation of plants, animals, wildlife ecosystems etc.	7	1	11	1	1	6	5	7	1	57	47	32	2	0	32	0	33	0	10	0	4	257	156	5

LC category	Urban		Agriculture						Grassland, pasture		Agroforestry, sclerophyllous, forest					Sparsely vegetated, wood/shrubland					Water	Total	Natura 2000 (inside)	Common land (inside)
LC class (CLC level 3 value)	Continuous urban fabric (1)	Discontinuous urban fabric (2)	Non-irrigated arable land (12)	Permanently irrigated land (13)	Fruit trees and berry plantations (16)	Olive groves (17)	Complex cultivation patterns (20)	Land principally agriculture, with natural vegetation (21)	Pastures (18)	Natural grasslands (26)	Agro-forestry areas (22)	Broad-leaved forest (23)	Coniferous forest (24)	Mixed forest (25)	Sclerophyllous vegetation (28)	Mineral extraction sites (7)	Transitional woodland-shrub (29)	Bare rocks (31)	Sparsely vegetated areas (32)	Burnt areas (33)	Water bodies (41)	LC total		
Appreciation of environmental capacity to produce, preserve, clean, and renew air, soil and/or water	7	0	8	2	0	2	2	5	0	33	31	11	1	1	24	0	9	0	1	1	3	141	74	5
Other special place or area to me	15	0	9	0	0	2	3	7	0	17	9	4	0	0	4	0	2	0	1	0	1	74	26	5
Other special place or area to me %	20.3	0.0	12.2	0.0	0.0	2.7	4.1	9.5	0.0	23.0	12.2	5.4	0.0	0.0	5.4	0.0	2.7	0.0	1.4	0.0	1.4	100.0	35.1	6.8
All	438	3	160	6	4	32	157	182	1	686	465	92	4	4	184	1	116	1	30	1	27	2594	1075	192
All %	16.9	0.1	6.2	0.2	0.2	1.2	6.1	7.0	0.0	26.4	17.9	3.5	0.2	0.2	7.1	0.0	4.5	0.0	1.2	0.0	1.0	100.0	41.4	7.4
LC class/Natura 2000/common land share (%) of study area	1.2	0.1	8.6	0.7	0.5	2.7	3.7	2.8	0.1	25.6	24.6	6.0	0.6	0.2	11.7	0.0	8.0	0.1	0.4	0.0	2.2	99.9	41.9	1.3

Table 4. Number and percentage of informants mentioning specific landscape values categorised as forms, practices and processes, and relationships.

Forms	Informants mentioning	% Informants mentioning
Nature	45	20.5
Biodiversity	14	6.4
Natural/farm products	12	5.5
Historic features	11	5.0
Climate	10	4.6
Low prices/high services	9	4.1
Cultural features/traditions	6	2.7
Good food	3	1.4
Practices and processes		
No contamination/clean environment	29	13.2
Work	27	12.3
Fresh/clean air	24	11.0
Quality of life/living well	24	11.0
Other outdoor activities	19	8.7
Health	13	5.9
Leisure/entertainment	12	5.5
No noise	6	2.7
Hunting/fishing	4	1.8
Harvesting	4	1.8
Clean water	1	0.5
Relationships		
Tranquility/relaxation	162	74.0
Social interaction	70	32.0
Family interaction	25	11.4
Place attachment	19	8.7
Beauty	18	8.2
Comfort/everything is close	17	7.8
Optimism/happiness/love	13	5.9
Safety	10	4.6
Freedom	10	4.6