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Protected areas as elicitors of human well-being in a developed region: A new synthetic (socioeconomic) approach

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ABSTRACT

The socioeconomic impact of protected areas, crucial to conservation, has been investigated mainly in low-income, highly biodiverse, contexts. However, studies are needed on the impact of protected areas in high-income places managed for millennia. This work evidences spatial relationships of protected areas and human well-being changes in a highly biodiverse area of southern Spain. We calculated well-being using a synthetic indicator (called the P_2 distance) that integrates information from 22 socioeconomic variables using an iterative procedure to weight the input variables. We used 22 variables to describe well-being according to the categories proposed by the Millennium Ecosystem Assessment. The results reveal significant increases in well-being in Andalusian municipalities between 1989 (when these protected areas were designated) and 2009. This increase was significantly higher in municipalities within protected areas. We also found that a protected municipality increases in well-being irrespective of the size of the protected area encompassing it or the areal percentage covered by the protected area. These results strongly evidence a spatial correspondence between protected areas and improvement of the well-being of local municipalities in areas with long histories of human management.

1. Introduction

Can protected areas improve the well-being of local inhabitants? Or, do protected areas limit local economic development? This question is inherently related to the concept of protected area: sites where certain human activities are limited in order to maintain the ecological integrity of the site. Currently, the socioeconomic effect of protected areas is a crucial topic in the context of nature conservation (Adams et al., 2004; Dudley et al., 2014; Roe et al., 2013). This has become one of the key issues influencing the social acceptance of protected areas (Dudley et al., 2014) worldwide. In the last 20–30 years, scientists have created a compelling set of case studies on the socioeconomic impact of protected areas, providing evidence for both the advantages and disadvantages of such protection (Coad et al., 2008; Upton et al., 2008).

It is not easy to establish a general rule to explain the impact of protected areas on socioeconomic features of local human settlements (and buffer areas surrounding protected areas), partly because of the multifaceted local impact that can be exerted under any circumstance (Mackenzie, 2012). However, it is widely accepted that biodiversity loss and well-being are linked problems and that conservation and human well-being should be considered together (Adams et al., 2004). The relationships between protected areas and socioeconomic features are so intricate that they are difficult to describe thoroughly. Like some other social and scientific issues, they can be considered "wicked" problems (Webber, 1973). The complexity of assessing the impact of protected areas on well-being can be exemplified with the concept of confounding variables: effects that are contemporaneous with the protection and could also have an effect on well-being (masking the effect of protection) (Ferraro and Hanauer, 2014; Ferraro and Pattanayak, 2006). Thus it is not easy to distinguish between the effects provoked by protection on well-being from others provoked by different social or biophysical variables. For example, is the observed change in well-being provoked by protection or by the

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remoteness of the area? The existence of these confounding factors make it difficult to pinpoint the real cause-effect relationships (Andam et al., 2010). This problem is also common when assessing the effectiveness of parks as tools to protect biodiversity (Naughton-Treves et al., 2005; Porter-Bolland et al., 2012). It is possible to minimise the problem of confounding variables using several approaches (Ferraro and Pattanayak, 2006): (A) baseline characteristics can be used to compare between communities living in protected areas and others with similar features not affected by protected areas. Thus it is possible to control the initial conditions that could affect well-being (Andam et al., 2010; Ferraro and Pattanayak, 2006). (B) Covariate factors that could influence well-being (Ferraro and Hanauer, 2010). (C) Control groups. A set of communities or areas that are not protected but are similar to the protected ones (Kleijn and Sutherland, 2003). The results provided by studies that do not minimise the effect of confounding factors should be considered as correlations instead of cause-effect relationships.

The most relevant socioeconomic costs of protected areas are related to displacement (forced evacuation of local communities from their land due to the creation of a protected area in the surroundings) (Coad et al., 2008; Geisler and De Sousa, 2001; West et al., 2006), which provokes economic impoverishment. However, some displacement processes have improved well-being in local communities (Karanth, 2007). Changes in land tenure can also be considered an important cost (Bedunah and Schmidt, 2004). On the other hand, protected areas can provide significant benefits to local communities. The benefits of nature conservation are evident at a global scale (Balmford et al., 2002): Well-conserved ecosystems can offer more ecosystem services (Cardinale et al., 2006; Costanza et al., 2007) in addition to promoting tourism at the local scale (Ezebilo and Mattsson, 2010; Sims, 2010). This improvement in the capacity of ecosystems to provide services could be transferred to local communities that depend upon protected-area management.

Here, we present a diachronic analysis (1989 and 2009) where the main objective is to describe the relationship of protected areas with respect to well-being (measured as an aggregate of different indicators) in a high-income, highly populated, and biodiverse Mediterranean region of southern Spain. We have compared the well-being of municipalities in 1989 (when the protected areas were declared) and 2009. This diachronic analysis follows the hypothesis that well-being depends on natural-resource conservation (Adams et al., 2004). Specifically, we investigated three questions: (A) Did well-being significantly change in the municipalities between 1989 and 2009? (B) Are the observed changes in well-being related to the presence of protected areas? And (C) Is the well-being ratio from 1989 to 2009 related to the area of municipalities and protected areas? Fig. 1 shows both our conceptual model and the proposed hypothesis.

This study is novel for several reasons: (A) Most studies analysing the relationship between protected areas and well-being focus on areas where the human impact is recent and the economy is still in a developing phase (Canavire-Bacarreza and Hanauer, 2013), while there is a lack of case studies showing the impact of protected areas in places managed by humans for millennia (e.g. the Mediterranean basin). By contrast, this work presents evidence of differential changes in well-being in a high-income area

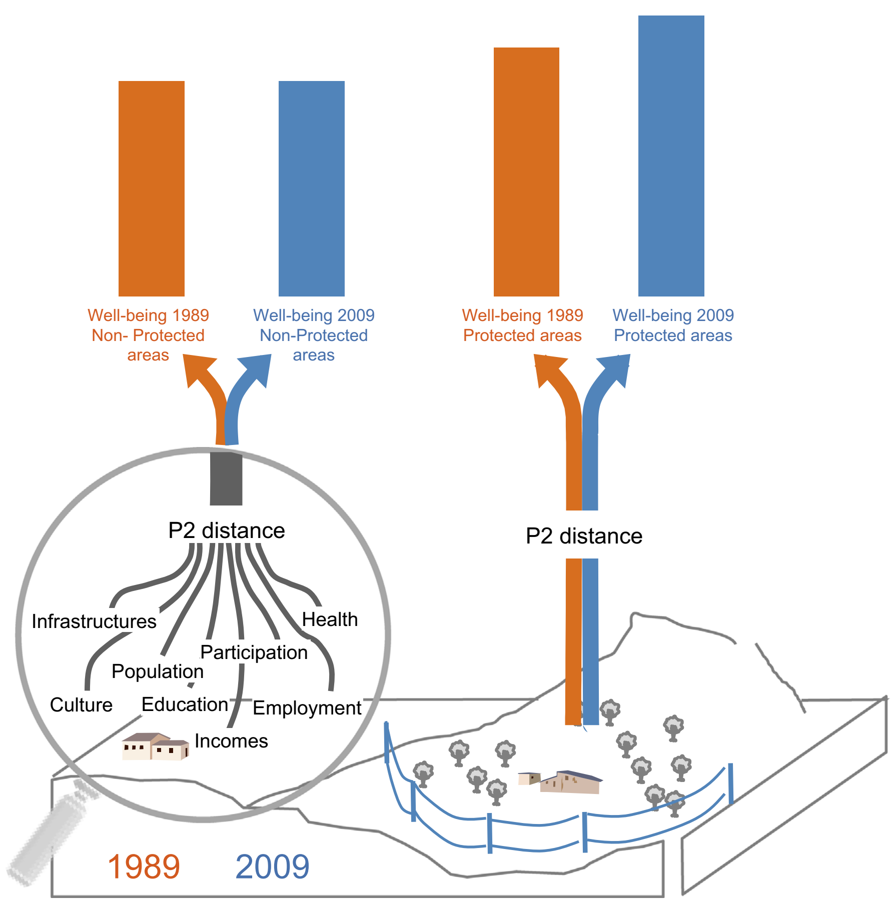

Fig. 1. Well-being is quantified using an aggregated index (P_2 distance) that considers both economic and social indicators. We compared the well-being index among protected and unprotected municipalities over a 20-year time span. The proposed hypothesis states that the well-being increased in Andalusia from 1989 to 2009, but this growth was higher in municipalities affected by a protected area.

between protected and non-protected areas. (B) Our work has a clearly defined baseline to measure pre- and post-treatment well-being otcomes. The first date of our analysis (1989) is the year when the protected areas were declared in Andalusia. Thus, our dataset is robust enough to support the results found. This baseline is used to partially overcome the problems provoked by confounding factors. (C) Most of the studies similar to ours use the GDP (Gross Domestic Product) as a surrogate for well-being. This commonly used indicator is useful to measure only one aspect of the economy (market economic activity). To assess well-being changes, we used a composite indicator called the P_2 distance index, which is a synthetic indicator that combines and weighs a set of simple indicators that help characterise well-being (Somarriba and Pena, 2009; Zarzosa and Somarriba, 2012).

2. Study area

To assess the relationships of protected areas and human well-being, we selected Andalusia as the study area. This Spanish region, located in the south of the Iberian Peninsula, covers 87,597 km^2 with 8.5 million inhabitants. Andalusia is a major biodiversity hotspot in the Mediterranean region (Estrada et al., 2011; López-López et al., 2011; Moreno Saiz, 2003). The floristic richness of vascular plants in Andalusia has been estimated as c. 4000 species, 436 of which are considered endemic. This region hosts 304 indigenous terrestrial vertebrate species (16 amphibians, 27 reptiles, 56 mammals, and 205 breeding birds (Estrada et al., 2011)). More than 859 plant taxa and 161 vertebrates are considered endangered species or species under special protection. Also, there are 96 species of regional interest (50% of the species of regional interest in Spain) and 76 Natura 2000 habitats.

A Network of Protected Areas was created in 1989 to protect this diversity. There are 165 protected areas that occupy more than 20% of the region. In this study, we focus on Natural and National Parks (Fig. 2) as the protected area types that provide the largest area to the network. There are 24 Natural Parks and 2 National Parks that cover almost 18% of the region (155,650 Has). All these parks but one (4996 Has) have also been designated as Special Areas of Conservation (SAC) by the European Natura 2000 Network.

3. Materials and methods

3.1. Datasets

We have employed three main datasets in this study: location of parks, location of municipalities, and well-being of municipalities.

3.1.1. Location of natural and National Parks

Natural Parks can be considered to be *Protected Landscape/seascape* (code V) according to IUCN classification of protected areas (Chape et al., 2008). Areas belonging to this category have an explicit natural conservation plan, but also accommodate a range of profit-making activities. Some Andalusian Natural Parks contain areas that belong to the IUCN category IV: *Habitat/species management area*. These areas are devoted specifically to habitat and species conservation. The two existing National Parks fit well with the IUCN category II: *National Parks*: Areas specifically designated to protect ecosystem functioning but allowing human visits and a supporting infrastructure.

Most of the Natural Parks (17) were officially designated as protected areas in 1989. Some others (5) were designated between 1985 and 1988. Finally, one Park was designated in 1999 and another one in 2003. On the other hand, the two existing

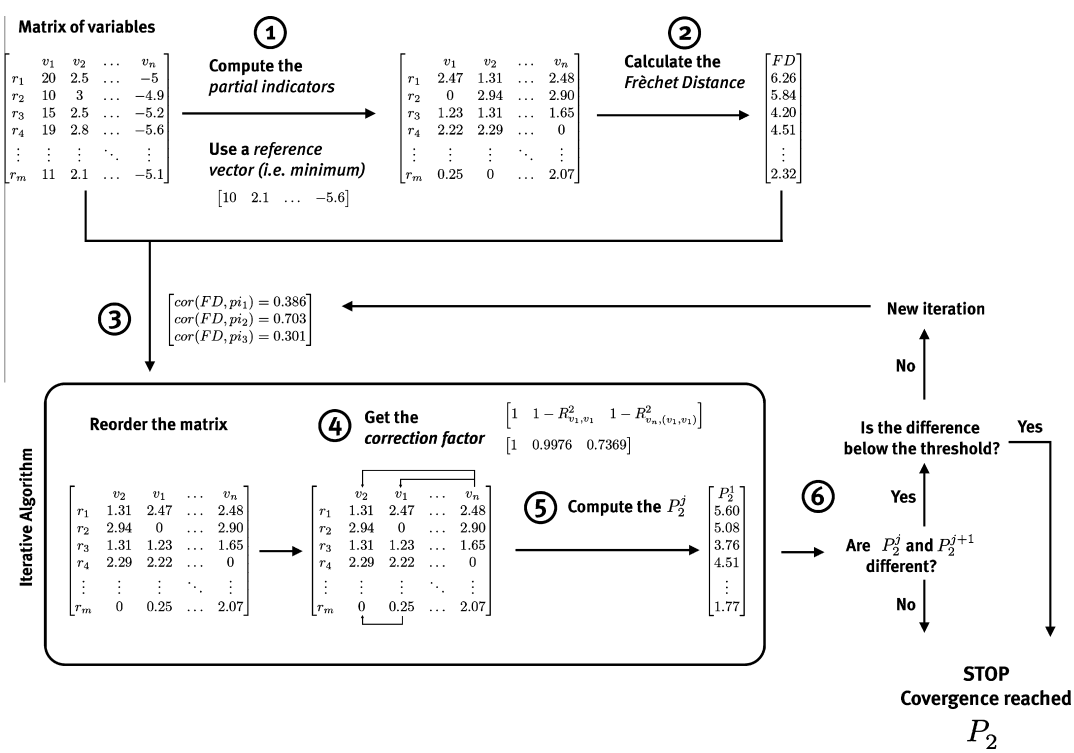

Fig. 2. Schematic representation of P_2 distance computation. (1) The partial indicators are computed from initial matrix of variables according to Eq. (1) and using reference vector. Then de Frèchet Distance (FD) is computed (2). The next step is to determine the order of entrance of the variables to compute according to the correlation of partial indicators and FD (3). Once the matrix is reordered, the correction factors of each variable are determined (4) and the first P_2 distance (P_2^1) is computed (5), applying Eq. (3). Finally the difference between P_2^j and P_2^{j+1} is evaluated (in an initial iteration the FD and the P_2^1 are compared). If the difference is zero, the iterative algorithm stops (6); otherwise the matrix is reordered according to the correlation of partial indicators, and the last P_2^j obtained and a new P_2 is computed. For more details see text.

National Parks have been included in this work because they are surrounded by Natural Parks designated in 1989 (acting as a buffer zone *sensu* UNESCO biosphere reserves). All these protected areas include the most important natural areas of Andalusia in terms of biodiversity, geodiversity, and ecosystem conservation.

3.1.2. Municipalities

Municipalities in Spain are administrative units governing a city or town. There are 771 municipalities in Andalusia with areas ranging from 1.95 km^2 to 1250 km^2. We have excluded some municipalities that underwent changes in their borders during the time span used in this work (1989–2009). Thus, our dataset contains 749 municipalities (97.14%) that cover 98.63% of the total area of Andalusia. The Institute of Statistics and Cartography of Andalusia provided the spatial borders of the municipalities.

3.1.3. Dependent variable (well-being in municipalities)

Human well-being is an abstract and dynamic concept related to satisfaction with life. Thus, this concept contains psychological and subjective elements that are difficult to quantify. Surrogates of well-being such as GDP have been traditionally used (Costanza et al., 2014) in order to avoid the complexity brought about by the aforementioned subjectivity. However, GDP was not designed to measure social or economic well-being (Costanza et al., 2014; Kubiszewski et al., 2013). In recent years, some social scientists have developed a set of alternative measures of well-being that relies on weighted composite indicators (Van de Kerk and Manuel, 2008; Vemuri and Costanza, 2006). These techniques integrate both subjective and objective indicators to assess human well-being. They also take into account human capabilities (Distaso, 2007; Nussbaum and Sen, 1993) as well as needs (Clarke, 2005; Costanza et al., 2007; Doyal and Gough, 1991; Streeten, 1981). We have calculated the well-being of Andalusian municipalities using a set of 22 indicators grouped into 8 thematic categories (population, health, employment, economy and income, infrastructure and services, education, culture and leisure, social participation; see Table 1 for details). This hierarchy between indicators and dimensions helps to provide a comprehensive picture of well-being (Costanza et al., 2014, 2007).

One of the key steps of these weighted composite measures is the selection both of indicators and dimensions (Somarriba and Pena, 2009). Authors select different dimensions (thematic areas) depending on data availability, specific socioeconomic features of the study area, purpose, etc. Likewise, the dimensions and single variables need to be adapted to both the spatio-temporal scale and the economy of the study area (e.g. some indicators used to compare well-being among countries cannot be used at a municipal scale: number of hospitals/10,000 population). We selected a set of dimensions and indicators corresponding to four components of human well-being (Table 1) identified in the Millennium Ecosystem Assessment (MEA). We are missing only the MEA's category called "security". We found no indicator to include in this category. However, we are aware that this mapping between indicators and categories is subjective and can be discussed. In any case, the P_2 computation is not affected by the categories used to group the indicators. We computed the well-being index by using the P_2 distance index, a synthetic index that combines all of these indicators into a single value. The P_2 distance (Somarriba and Pena, 2009) is a synthetic indicator created to calculate well-being and other related social indicators (e.g. to measure poverty (Zarzosa, 2009) and development (Cuenca García et al., 2010; Martín et al., 2015; Martín et al., 2013). This approach has also been used to build synthetic indicators in other disciplines such as environmental indexes (Escobar, 2006; Montero et al., 2010), mother and child health in developing countries (Ray, 2014) or tourism (Blancas et al., 2012; Blancas et al. 2011; Lozano-Oyola et al., 2012).

Table 1
Indicators used to compute the well-being index. The first column shows the "Millennium Ecosystem Assessment" categories to which each indicator belongs. This set of indicators was selected to assess the well-being in a developed region. We have also considered only those indicators that are applicable both in 1989 and 2009 (i.e. density of cell phones is not a good indicator). All indicators were taken from the Institute of Statistics and Cartography of Andalusia.

MEA's dimensions	Indicators	Description
Basic material for a good life	Employed population	[number of employed people $\geqslant$ 16 years old/population from 15 to 64 years old] $*$ 100
	Unemployed population	[number of unemployed/population from 15 to 64 years old] $*$ 100
	Business activity	[number of business activities/total population] $*$ 1000
	Personal Income	[total income of people/total population]
	Buses	[number of buses/total population] $*$ 1000
	Lorries	[number of lorries/total population] $*$ 1000
	Vans	[number of vans/total population] $*$ 1000
	Cars	[number of cars/total population] $*$ 100
	Phone lines	[number of phone lines/total population] $*$ 100
	Schools	[number of public primary schools/total population] $*$ 1000
	Elementary students	[number of elementary students in public schools/total population] $*$ 1000
	Elementary teachers	[number of elementary teachers in public schools/total population] $*$ 1000
	Public libraries	[number of libraries in public schools/total population] $*$ 1000
Freedom for choice and action	International migration	[Number of migrations from the municipality to any other foreign destination/total population] $*$ 100
	Interior migration	[Number of migrations from any other Spanish origin to an Andalusian municipality/total population] $*$ 1000
	Voter turnout	[number of voters/total population] $*$ 1000
Good social relations	Hotels	[number of hotels/total population] $*$ 1000
	Restaurants	[number of restaurants/total population] $*$ 1000
Health	Births	[Live-born infants/total population] $*$ 1000
	Population growth	[Difference between births and deaths/total population] $*$ 1000
	Aging index	[number of people $\geqslant$ 65 years old/number of people < 15 years old] $*$ 100
	Healthcare centres	[Number of primary health centres/total population] $*$ 1000

The P_2 *distance* is a quantitative distance indicator capable of combining several variables expressed in different units (Montero et al., 2010). It allows comparisons between entities (both temporal and spatial) and is considered to be an exhaustive synthetic indicator because it is not based on a reduction of information. It considers all the valuable information contained in the variables used to build it. This property allows the inclusion of a great number of variables, since all redundant variance is removed by the process itself, as is the multicollinearity (Montero et al., 2010).

The P_2 *distance* satisfies the properties of existence, determination, monotony, uniqueness quantification, invariance, homogeneity, transitivity, exhaustiveness, additivity, invariance compared to the base reference, conformity, and neutrality (Zarzosa and Somarriba, 2012).

To calculate the P_2 distance, we started with a matrix X of order (m, n) in which m is the number of spatial units (countries, municipalities, etc.) and n is the number of variables. Each element of this matrix, x_{ri}, is the value of the variable i in the spatial entity r. The P_2

distance indicator calculates the distance of each spatial entity with regard to a theoretical spatial entity of reference. Initially, a distance matrix D is calculated as:

$$d_{ri} = |x_{ri} - x_{*i}| \tag{1}$$

where x_{*i} is the *r-th* element of the reference base vector $X_* = (x_{*1}, x_{*2}, \ldots, x_{*n})$. For each variable a reference value must be defined to compare different spatial entities.

The minimum value is often used in sociological studies (Rodríguez Martín, 2011; Somarriba and Pena, 2009; Zarzosa and Somarriba, 2012); but any other vector (i.e. maximum, average, a user-defined vector, etc.) that reflects the ideal condition with which to compare the spatial entities can also be used. We used the minimum value and we also computed the absolute value of the difference in order to avoid treating positive differences and negative differences in the same way (Somarriba et al., 2014).

For each variable, d_{ri}, represents the distance between the *r-th* entity and its reference value. To avoid heterogeneity in the measuring units of the variables, we calculated a partial indicator. This partial indicator is calculated in the same way as the d_{ri} value, but divided by the standard deviation of each variable $\left(\frac{d_{ri}}{\sigma_i}\right)$. With these partial indicators, we calculated the Frèchet Distance (FD) as

$$\mathrm{FD}(r) = \sum_{i=1}^{n} \frac{d_{ri}}{\sigma_i} = \sum_{i=1}^{n} \frac{|x_{ri} - x_{*i}|}{\sigma_i}; \quad r = 1, 2, \ldots, m \tag{2}$$

This is the maximum value that the P_2 index can reach for each spatial entity. The FD concept of distance is valid only in a theoretical situation of uncorrelated indicators. However, it is common to find direct relationships between the partial indicators, implying that FD includes duplicate information. For this problem, a correction is introduced into FD, resulting in the P_2 distance, which is computed as:

$$P_2(r) = \sum_{i=1}^{n} \left\{ \left(\frac{d_{ri}}{\sigma_i}\right)\left(1 - R^2_{i,i-1,i-2,\ldots,1}\right) \right\}; \quad r = 1, 2, \ldots, m \tag{3}$$

where $R^2_{i,i-1,i-2,\ldots,1}$ is the determination coefficient of the regression of each partial indicator on the others $(i-1, i-2, \ldots, 1)$. This coefficient measures the part of the variance of each variable explained by the linear regression estimated using the above variables. As a result, the factor $(1 - R^2_{i,i-1,i-2,\ldots,1})$ prevents redundancy by removing from the partial indicators the information already contained in the aforementioned indicators. This factor, called the *correction factor* (Pena, 1977), subtracts the proportion of variation of the observed values that is due to linear dependency. Note that if all the partial indicators are uncorrelated, i.e. $R^2 = 0$, then the P_2 distance is equal to FD. The order of entrance of the partial indicators is a critical issue within this method. We needed to find a procedure to decide which partial indicator comes first in contributing its variance to the global index (Montero et al., 2010). We used an iterative algorithm to resolve this issue and to determine the weights of each variable.

In an initial step, given that FD (see Eq. (2)) contains the information of all partial indicators, the variable most closely correlated to FD is the variable that contributes the most in variance to the overall index, and consequently the first variable to enter. Thus, the ranking of correlation of partial indicators with FD determines the order of entrance of variables in the first iteration. With this order, the first P_2 distance is calculated according to Eq. (3). The result is called P_2^1.

In the second step, the correlation of each variable with this P_2^1 index is calculated, and the resulting ranking is used to determine once more the order of entrance when re-computing the P_2 distance, resulting in a second index called P_2^2.

This process is repeated iteratively until convergence is reached: when the difference between two contiguous P_2^j is zero. The final P_2 is then the first index P_2^j that has no differences with respect to the following index P_2^{j+1}.

We calculated the well-being index for the municipalities in 1989 and 2009 following the abobe-described approach. Fig. 2 summarises the procedure used to compute P_2 index.

3.2. Statistical analysis

All analyses were performed using R software (R Core Team, 2013), including several packages: boot (Canty and Ripley, 2014), Kendall (McLeod, 2011), p2distance (Pérez-Luque et al., 2012), party (Hothorn et al., 2006), spatstat (Baddeley and Turner, 2005).

The following paragraphs describe the statistical analyses performed in order to answer three relevant questions.

3.2.1. Did well-being in the municipalities significantly change between 1989 and 2009?

The non-parametric paired Wilcoxon signed-rank test was used to compare well-being between 1989 and 2009 because the data did not meet the normality and homoscedasticity assumptions. To determine whether the overall difference significantly differed from zero, we computed differences by drawing 9999 bootstrap replicates from the data. A Monte-Carlo *p-value* with the correction proposed by Davison and Hinkley (1997) was computed. We generated 99% confidence intervals for mean effect sizes by bootstrapping ($n = 9999$ permutations). We also calculated Hedge's effect size (g) for the difference.

For each municipality, we computed a well-being ratio (WR) as the ratio between the well-being in 2009 and well-being in 1989

$$\mathrm{WR} = \frac{W_{2009}}{W_{1989}} \tag{4}$$

A value of WR greater than 1 indicates well-being improvement whereas a value less than 1 indicates worsening over the time period considered.

3.2.2. Are the observed changes in well-being related to the presence of protected areas in Andalusia?

We performed a non-parametric Wilcoxon signed-rank to compare the well-being ratio (Eq. (4)) between municipalities inside and outside the protected areas. We also computed differences using bootstrap ($n = 9999$ simulations) to test whether the overall difference significantly differed from zero. Then, Monte-Carlo *p-value* with the correction proposed by Davison and Hinkley (1997) and confidence intervals (at 99% level) for the mean difference were computed. Finally we also calculated Hedge's effect size (g) for the difference between protected and non-protected municipalities.

We also conducted a moving-average window analysis to assess the spatial distribution of well-being and Natural Parks. For each municipality, we calculated the average well-being ratio of its neighbours considering a changing radius from 2 to 30 km (2, 3, 4, 5, 8, 10, 12, 15, 20, and 30 km). Then we calculated the average well-being ratio for all protected and non-protected municipalities at any single window radius. We finally computed Kendall's rank correlation for the two series (protected and non-protected municipalities).

3.2.3. Is the well-being ratio between 1989 and 2009 related to the surface area of the municipalities and protected areas?

The relationship between the average well-being of each protected area and its surface area was evaluated using Pearson's correlation coefficient. We also created a classification tree to explore the relationship between the well-being of all the protected municipalities and the percentage of their area affected by Natural Parks. This methodological approach sequentially partitions the dataset based on predictor variables into the most pure class memberships (Verbyla, 1987).

4. Results

4.1. Did well-being significantly change in the municipalities between 1989 and 2009?

The well-being index was significantly higher in 2009 than in 1989 (well-being index 1989 = 51.04 ± 0.13, n = 749; well-being index 2009 = 57.41 ± 0.16, n = 749; paired Wilcoxon signed-rank test Z = 3397, *p-value* < 0.0001). The mean difference significantly differed from zero (*p-value* = 0.0001, IC 99% = 5.89 – 6.84) and the effect size was very large (*Hedges's* g = 1.622) (Fig. 4a). The well-being ratio ranged from 0.6817 to 1.5728. There were only 32 municipalities (4.27%) with a well-being ratio below 1 (Fig. 3c). The observed increase in well-being followed a well-defined spatial pattern within Andalusia (Fig. 3c). Municipalities from mountain areas (NW, NE, SE) show showed well-being ratios higher than 1, meaning signifying a strong improvement in well-being. Municipalities located in the central part of Andalusia (Guadalquivir Valley) showed a smaller increment in well-being. Finally, some municipalities located in the Mediterranean Coast decreased in well-being.

4.2. Are the observed changes in well-being related to the presence of protected areas in Andalusia?

The distribution of the well-being ratio between 1989 and 2009 spatially matches the distribution of the parks (Fig. 3b). We found significant differences in the well-being ratio between protected (PA) and non-protected (nPA) municipalities (PA = 1.144 ± 0.007, n = 225; nPA = 1.121 ± 0.003, n = 524; Wilcoxon signed-rank test Z = 66,317, p-value = 0.0066) (Fig. 4b). The mean difference significantly differed from zero (p-value = 0.001, IC 99% = 0.0043–0.0428) and the effect size was small (Hedges's g = 0.259). The well-being index in 1989 was similar both in protected and non-protected municipalities, and both increased their well-being in 2009. However, the increment was higher in

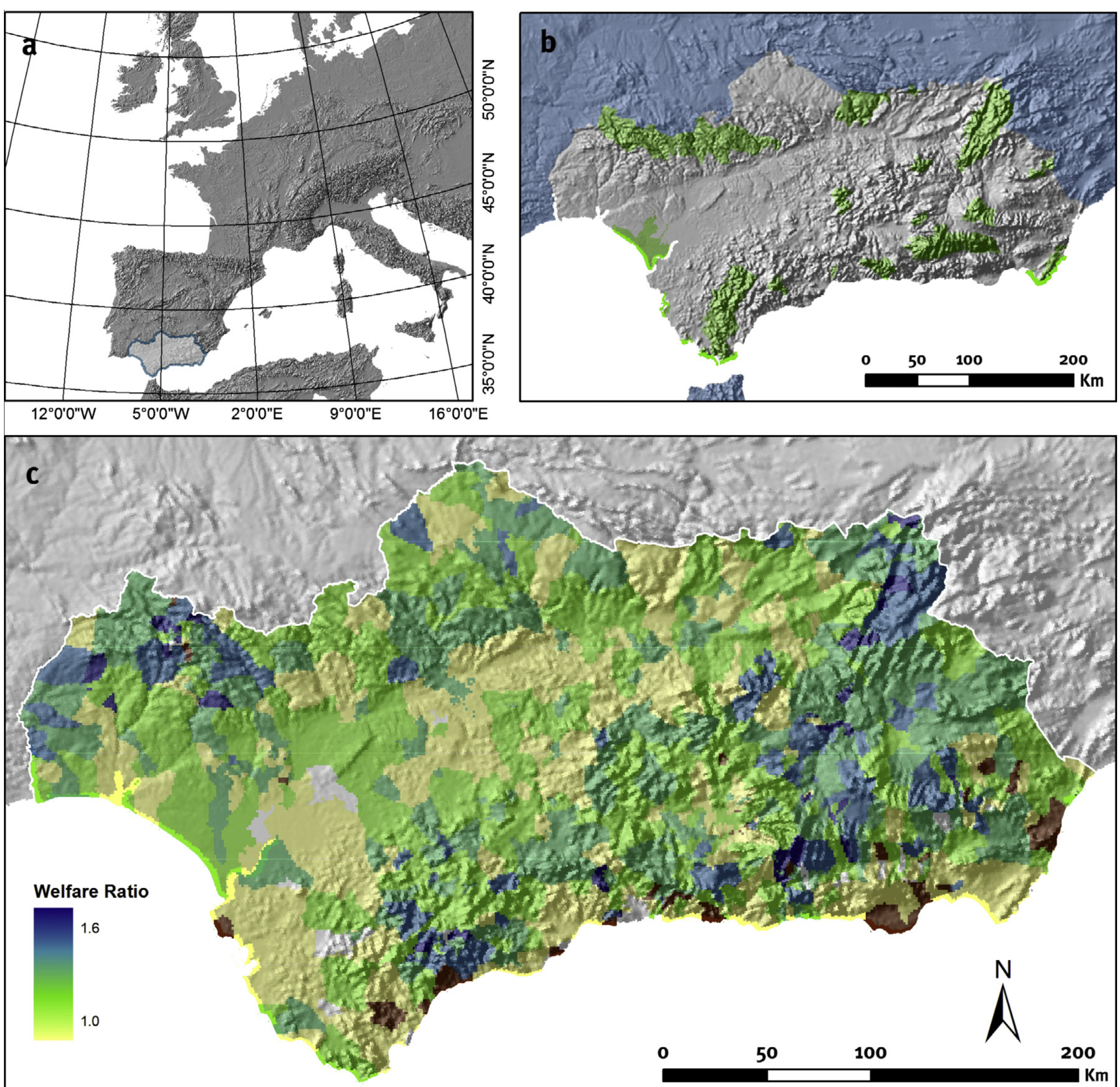

Fig. 3. (a) Location of study area. (b) Distribution of parks (green) in the study area (c). Well-being ratio for Andalusian municipalities. Municipalities with values of Well-being ratio below 1 are shown in red. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

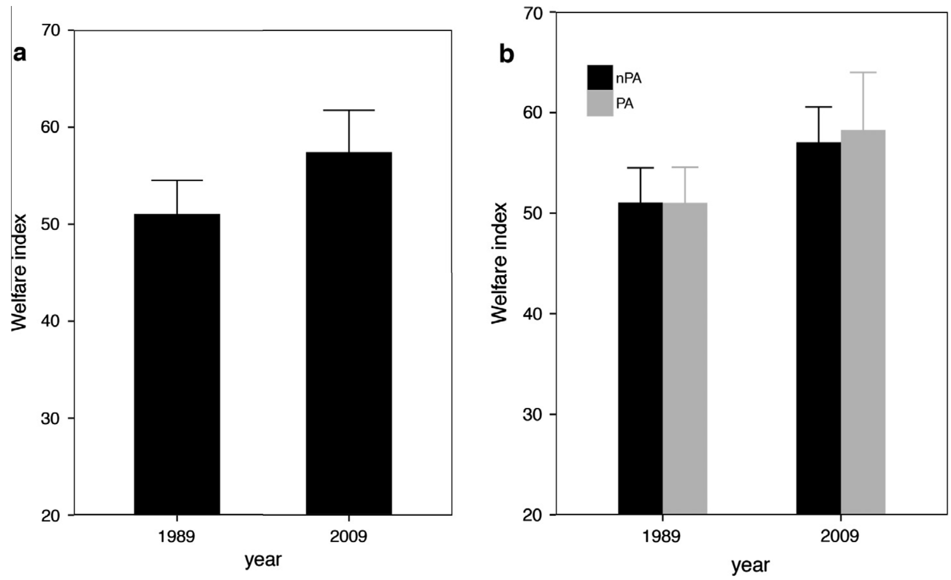

Fig. 4. (a) Well-being of Andalusian municipalities in 1989 and 2009. (b) Comparison of well-being index in 1989 and 2009 between protected and unprotected municipalities of Andalusia. Showing means and standard deviation.

protected municipalities than in non-protected ones (Table 1 and Fig. 4b).

The moving-average windows analysis helped us to describe the spatial relationship between well-being ratio and the distribution of Natural Parks in Andalusia. The average well-being ratio calculated by each window radius for protected municipalities showed a non-significant negative correlation ($tau = -0.289$, p-value = 0.2912, $n = 10$). This result is consistent with the expected one: The higher one is the window radius, the higher the likelihood to include in the window non-protected municipalities (which would decrease the average WR). On the other hand, the average well-being ratio calculated by each window radius for non-protected municipalities shows a non-significant positive correlation ($tau = 0.333$, p-value = 0.22164). This is also consistent with the expected one: The higher the radius, the higher the likelihood of including protected municipalities in the windows (which would increase the average WR).

4.3. Is the well-being ratio between 1989 and 2009 related to the area of municipalities and parks?

We also explored the relationships between well-being ratio and the area of both the municipalities and the parks. No significant relationship was detected between the park area and the well-being ratio of municipalities within each park (Pearson's correlation coefficient: 0.102; p-value = 0.62) (Fig. 5a). On the other hand, considering only protected municipalities, we found the percentage of each municipality covered by a park not to be significantly related to its well-being ratio unless this percentage was close to 100% (Fig. 5b).

5. Discussion

Most of the studies assessing the relationships between human well-being (or poverty) and protected areas focus on developing countries (Ezebilo and Mattsson, 2010; Hübner et al., 2014; Katikiro et al., 2015). We addressed this issue in a high-income European region using a diachronic approach. We assessed the changes in well-being in Andalusia (southern Spain) between 1989 and 2009, exploring the importance of parks in the observed changes. Our results evidence a correlation between the observed changes in well-being and the distribution of parks.

We found a significant increase in well-being in Andalusia from 1989 to 2009. This result matches the evolution of some indicators that contribute to well-being: During this period, the Andalusian per capita GDP grew by nearly 45% (Informe económico de Andalucía: 2010., 2010, "La transformación de Andalucía 1990-2010," 2010). This economic growth is linked to a notable improvement in roads and transportation infrastructures (Jaén García and Piedra Muñoz, 2010). Education also improved in the last few decades in Andalusia. The illiteracy rate shrank from 15% in 1980 to 4% in 2011. Health indicators are also concordant with the observed increase in well-being: The amount of public health-care centres has also increased from 233 in 1980 to 1514 in 2009.

Our results also demonstrate that the distribution of the well-being ratio spatially matches the distribution of parks in Andalusia. Municipalities influenced by a park have a higher well-being ratio than do those in unprotected settings. Well-being increased during the study period in most Andalusian municipalities, but the protected ones registered significantly higher growth.

The observed increase in well-being follows a well-defined spatial pattern within Andalusia. Municipalities from Sierra Morena (NW) and Baetic mountains (NE, SE) show a well-being ratio higher than 1, meaning a strong improvement in well-being. Municipalities located in the Guadalquivir Valley (central area) show a slighter increment in well-being. Finally, some municipalities located on the Mediterranean Coast have declined in well-being. Notably, the spatial distribution of well-being ratio follows a counterintuitive pattern: natural and traditionally depressed areas display a higher well-being ratios than do economically developed and altered areas. This result could be explained by a differential impact of the actions carried out to promote well-being in Andalusia under a spatial perspective: parks seem to have behaved as attractors of policies promoting well-being.

However, we found no significant relationship between the well-being of municipalities and the area of their surrounding park. Nor did we find a significant relationship between the protected percentage of municipalities and their well-being ratio. These results suggest that the proposed positive effect of nature conservancy on well-being could follow a binary pattern:

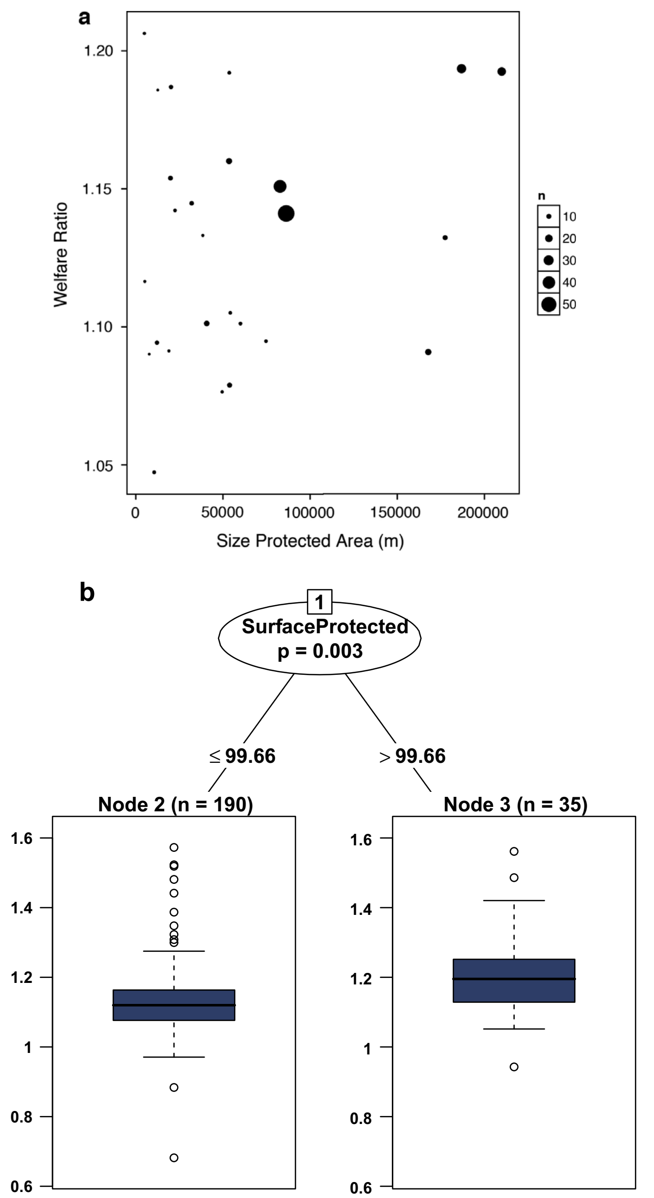

Fig. 5. Spatial relationships between the well-being ratio and area surface of the protected municipalities. (A) Relationship between the size of parks (Has) (*x* axis) and their average well-being ratio (*y* axis). The size of the circle shows the number of municipalities per park. (B) Classification scheme to discriminate the relationship between the area affected by parks in municipalities and the well-being ratio.

protected municipalities increased in well-being irrespective of (a) the size of the park surrounding it and (b) the percentage of its area affected by the park. This result contrasts with the findings of some studies in developing countries, where the percentage of protected area per municipality determined the amount of poverty reduction (Canavire-Bacarreza and Hanauer, 2013). This behaviour could be explained by the differential impacts that some factors can have on well-being. Thus, some managerial actions conducted by government to improve well-being could have a spatially homogeneous impact on local communities affected by parks (e.g. compensation for the restrictions imposed by protection, improvements in health care, etc.). These actions would provoke a direct relationship between the area conserved and the increase in well-being (the higher the area conserved, the higher the improvement in well-being). On the other hand, some other variables could have a spatially heterogeneous impact on local communities. Tourism could be a good example of this pattern. Only some areas of a park act as touristic foci to attract visitors. This would provoke a decline in marginal gains as the area conserved expands.

The regional government of Andalusia has been trying to promote well-being in municipalities in contact with protected areas since 1989. The so-called "socioeconomic influence area of the parks" have received almost 10% (10,000 million €) of the funds provided by European Union since 1989. This amount of money has been invested in promoting sustainable farming, infrastructures, and nature-based tourism in protected areas via European Regional Development Fund (ERDF) and European Social Fund (ESF). In addition, local communities have also benefited from forest management and habitat management (wildfire prevention, forest restoration, etc.) as they have been contracted by the government to execute those tasks. On the other hand, people living within parks have also benefited from the general improvement in health care, education, and infrastructures. Thus, they are living in a well-conserved area surrounded by modern services. This set of reasons could explain the observed correlation between protected areas and well-being increase and can be considered as managerial actions carried out by the government to directly benefit people living in protected areas (Coad et al., 2008). Regarding this topic, it might be useful to assess how these managerial activities can impact the well-being of different groups of local communities in different ways (see Mascia et al., 2010 for an example). This type of analysis could help to describe with detail the mechanism by which the above-mentioned managerial actions foster well-being. For example, which professional or social groups are more benefited (or disadvantaged) by the managerial actions intended to promote well-being? As the datasets used in this study refer to municipalities as a whole, it was not possible to address these kinds of topics.

In conclusion, our novel analytical approach provides strong evidence of a spatial correspondence between nature conservancy and well-being in a developed region (Andalusia, a region as big as some European countries, inhabited by humans for millennia, and a major biodiversity hotspot).

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