Environmental representativeness and the role of emitter and recipient areas in the future trajectory of a protected area under climate change

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Abstract
Environmental representativeness and the role of emitter and recipient areas in the future trajectory of a protected area under climate change. We propose a protocol to estimate the effects of climate change on species inhabiting a reserve by assessing the location of areas with similar environmental conditions to a focal protected area, both now and in the future. Following this protocol it is possible to estimate: (i) the level of change that will occur in the current climatic conditions of a reserve; (ii) the present location of the areas with similar conditions to those this reserve will have in the future (emitter areas); and (iii) the location of the areas that in the future will have similar environmental conditions to those existing in the studied protected area (recipient areas). This knowledge can be used to anticipate and adapt the protected area against future changes. In this study, we used an Iberian reserve representative of the Mediterranean conditions, the Cabañeros National Park, as an example to calculate the extension, fragmentation and location of the areas with climatic conditions similar to those of the reserve. We also determined the connectivity between these areas and their degree of anthropic alteration.

Key words: Cabañeros, Reserves, Climatic representativeness, Conservation, Climate change

Resumen
La representatividad ambiental y la importancia de las áreas emisoras y receptoras en la evolución ante el cambio climático de un área protegida. Proponemos un protocolo para estimar los efectos del cambio climático en las especies que habitan una reserva, evaluando la ubicación de las áreas con condiciones ambientales similares a un área focal protegida, tanto ahora como en el futuro. Siguiendo este protocolo es posible estimar: (i) el cambio que se producirá en las condiciones climáticas actuales de una reserva, (ii) la ubicación actual de las áreas con condiciones similares a las que tendrá esta reserva en el futuro (áreas emisoras) y (iii) la localización de las áreas que en un futuro tengan condiciones ambientales similares a las existentes en el área protegida estudiada (áreas receptoras). Este conocimiento puede utilizarse para anticiparse y adaptar el área protegida a los futuros cambios. En este estudio se ha utilizado como ejemplo la reserva del Parque Nacional de Cabañeros, representativa de las condiciones mediterráneas, para calcular la extensión, la fragmentación y la localización de las áreas con condiciones climáticas similares a las de la reserva; asi mismo, se ha determinado la conectividad de estas áreas y su grado de alteración antrópica.

Palabras clave: Cabañeros, Reservas, Representatividad climática, Conservación, Cambio climático

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Introduction

Protected areas (PAs) are essential for the conservation of biodiversity and most institutions attempt to integrate them into their national and international conservation strategies (Pressey et al., 2007; Palomo et al., 2014; Visconti et al., 2015). They are a crucial tool to mitigate threats related to human activity (Rodrigues et al., 2004), not only by limiting biodiversity loss (Dudley and Parish, 2006), but also by keeping natural ecosystems functional and by providing shelter for species therein. Historically, the creation of PAs has been driven by socio–economic, aesthetic and political criteria rather than by scientific or conservationist reasoning (Pressey, 1994; Fraschetti et al., 2002; Joppa and Pfaff, 2009), overlooking the fact that they should be ecologically and environmentally representative (Visconti et al., 2015). Determining the environmental representativeness of protected areas is thus a fundamental issue in systematic conservation planning and the maintenance of biodiversity (Margules and Pressey, 2000; Pressey et al., 2007; Laurance et al., 2012).

Climate plays a key role when estimating environmental diversity (Faith and Walker, 1996a, 1996b; Parmesan, 2006; Chen et al., 2011; Triviño et al., 2013; IPCC, 2014) as it is a major factor conditioning biological assemblages and ecosystem characteristics (Woodward et al., 2004). However, climate is changing rapidly as a consequence of human actions. Reports from the Intergovernmental Panel on Climate Change indicate that substantial variations in climate have occurred due to the emission of greenhouse gases, and that these changes will continue to occur in the near future (IPCC, 2007, 2014). Keeping in mind that PAs have spatially fixed boundaries and are often surrounded by a matrix of transformed land uses, one might wonder what the environmental representativeness of protected areas is when the climate is changing. PAs could be considered islands representing particular environmental and biotic conditions and they may also serve to avoid the negative influence of anthropic actions. However, the effects of climate change could make these areas ineffective for their intended purpose (Lobo, 2011). On one hand, if the species that inhabit a protected area are influenced in their distribution and abundance by climatic conditions, each PA would become a recipient of outside fauna and flora. On the other hand, protected areas would also emit or export individuals to other settlements which, in the future, would represent the environmental conditions currently existing in this area. These processes of change could lead to (i) the disappearance of individuals, populations or species (Bestion et al., 2015); (ii) an increase in the evolutionary forces that promote the in situ adaptation to new conditions (Hoffmann and Sgrò, 2011); and (iii) the decline of populations and/or emigration of individuals into new territories (Mason et al., 2015; 'spatial adaptation' according to Hengeveld, 1997). Available evidence shows that the populations of some species have declined within PAs as consequence of climatic changes, while other species have undergone a population growth or colonized a reserve for the first time (Thomas and Gillingham, 2015).

Although PAs may act as natural shelters against the effects of climate change (Thomas and Gillingham, 2015; Gaüzere et al., 2016), creating corridors between them can facilitate their inter–connection (Haddad et al., 2015). PAs representing different climate conditions should be connected in order to minimize the threat of local extinction and maximize the adaptive and dispersive possibilities of organisms.

Most studies that select the location of possible reserves keeping climate change scenarios in mind have used distribution models able to anticipate the geographic response for each species to changes in climate (Jones et al., 2016). Such predictions have several drawbacks (Lobo, 2015). For example, they may produce inconsistent and unreliable results because they do not include estimations about the real and direct effect of climate variables in delimiting the occurrence and abundance of species (Araújo et al., 2011; Felicísimo et al., 2011). Using individual predictive species distribution models to estimate the possible future location of areas that should be protected is a hazardous strategy. This is because the many uncertainties of each individual model may lead to the misappropriation of conservation resources in some regions. Moreover, identifying climatically favourable territories for species without taking future and possible changes in land use into account can also lead to an inefficient selection of areas (Faleiro et al., 2013; Jones et al., 2016).

Instead of trying to estimate the effects of climate change on the species inhabiting a reserve, we here propose an approach based on estimating the location of areas with environmental conditions similar to those of a focal PA, both now and in the future. Assuming that the environmental conditions of a PA are the main determinants of its conservation value (Albuquerque and Beier, 2015), we propose estimating (i) the present location of the areas with similar conditions to those this PA will have in the future (emitter areas), and (ii) the future location of the areas that will have similar environmental conditions to those currently existing in the focal PA (recipient areas). If we cannot reliably predict the future distribution of each species because we do not know the true and contingent effects of climate on each one, the proposed approach aims to estimate the environmental representativeness of a protected area to derive conservation strategies. This knowledge can be used to anticipate and adapt PAs against future changes. In this work, we used an Iberian reserve that is representative of Mediterranean conditions, Cabañeros National Park, as an example of focal PA: (i) to estimate the current and future climate representativeness of this reserve; (ii) to evaluate the level of change that will occur in its current climatic conditions, calculating the extension, fragmentation, connectivity and location of the climatic conditions that Cabañeros currently represents and will represent in the future; and (iii) to identify recipients and emitter areas under a future climate change scenario, as well as the connectivity of these areas to the focal PA, taking into account the degree of anthropic alteration of the entire Iberian territory.

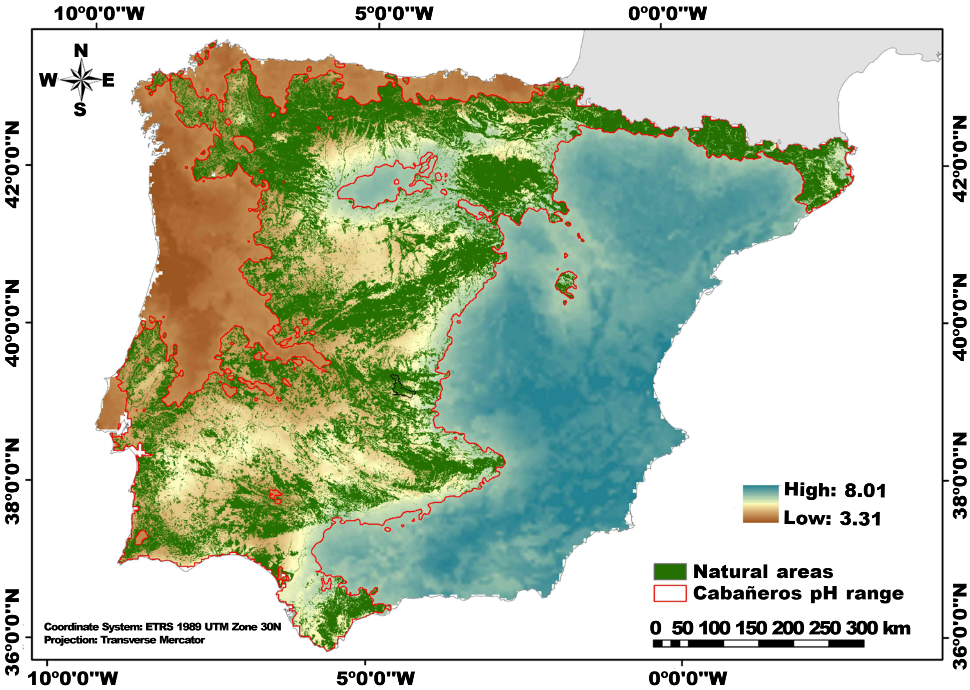

Fig. 1. Regions with similar edaphic conditions to those existing in the Cabañeros National Park, which in addition have natural land uses. The color range represents pH variation.

Fig. 1. Regiones con condiciones edáficas similares a las del Parque Nacional de Cabañeros y que además poseen usos del suelo naturales. El gradiente de colores representa la variación en pH.

Material and methods

The focal protected area

Cabañeros was declared a National Park in 1995. It is located in the region of Montes de Toledo in central Spain (39.414 N, –4.509 W) between the provinces of Ciudad Real and Toledo. It covers an extension of 40,856 hectares. Its elevation oscillates between 520 and 1,448 m a.s.l., with an average altitude of 788 m. Cabañeros bioclimatically represents the Mediterranean region. Most of the territory belongs to the mesomediterranean bioclimatic type (520–1,000 m), while the supramediterranean bioclimatic type (1,000–1,450 m) only appears in the NE part of the region (Rivas Martinez, 1987).

Origin of climatic data

Data on current climate come from the University of Extremadura (see methodology in Felicísimo et al., 2011) and include data about mean maximum monthly daily temperature, minimum monthly daily temperature, average monthly temperature and total monthly precipitation from 1950 to 2007 for the whole Iberian Peninsula. Using this primary source of climatic information at a resolution of 1 km^2 UTM grid cells and the formulas of Valencia–Barrera et al. (2002) and López Fernández and López (2008) we built a total of 23 bioclimatic variables (table 1). As Felicísimo et al. (2011) do not provide future monthly climatic data, we used WorldClim data (http://www.worldclim.org/) at a resolution of 30 arc seconds (~ a cell of 0.82 km^2). The model we selected was the IPSL–CM5A–LR from the Pierre Simon Laplace Institute (Dufresne et al., 2013), specifically that from the fifth assessment report (AR5) that predicts a mean increase in temperature of 1.3 ºC around 2050 (RCP6.0) (Van Vuuren et al., 2011). We selected this climatic projection for its intermediate character concerning greenhouse gas emissions and socioeconomic assumptions. We used the predicted values of the four primary climatic variables mentioned formerly for 2070 (mean maximum monthly daily temperature, minimum daily monthly temperature, average monthly temperature and total monthly precipitation) to derive the same 23 bioclimatic variables for the future as those obtained for present times following the explained procedure.

Other environmental data

Suitable climatic conditions do not guarantee that a given species can inhabit a locality. To restrict both recipients and emitter areas, we also considered soil characteristics and land uses. Unlike climate,

Table 1. Bioclimatic variables obtained using the formulas provided by Valencia et al. (2002) and López Fernández and López (2008), and also correlations between the values of these variables and the three factors that emerged from a principal components analysis. Values > 0.7 are shown in bold.

Tabla 1. Variables bioclimáticas obtenidas a partir de las fórmulas proporcionadas por Valencia et al. (2002) y López Fernández y López (2008) y correlación entre los valores de estas variables y los tres factores que surgieron de un análisis de componentes principales. Los valores > 0,70 se indican en negrita.

Variable	Factor 1	Factor 2	Factor 3
Precipitation seasonality	**0.9170**	0.2740	0.1457
Temperature seasonality	–0.4825	–0.1465	**–0.8254**
Isothermality	0.5271	0.0435	0.5471
Aridity index (Martonne)	**–0.8480**	0.4296	–0.2883
Continentality index	–0.2414	–0.1544	**–0.8325**
Precipitation contrast	**0.9212**	0.2569	0.1743
Thermal contrast	–0.4221	–0.1351	**–0.8939**
Ombrothermic index I0	**0.7930**	–0.5183	0.2807
Ombrothermic index I5	**0.8497**	–0.3215	0.3637
Annual precipitation	**0.9183**	–0.2122	0.3173
Precipitation in wettest month	**0.9464**	–0.0040	0.2985
Precipitation in driest month	0.3365	**–0.7076**	0.4210
Positive precipitation 0	**0.9131**	–0.1695	0.3315
Positive precipitation 5	**0.8672**	0.1156	0.3660
Emberger's pluviometric ratio	**0.7314**	–0.5931	0.1074
Maximum temperature in warmest month	–0.3436	0.6228	–0.6970
Average monthly maximum temperature	–0.3410	0.6318	–0.6898
Annual mean temperature	–0.1142	**0.9800**	–0.0915
Average monthly minimum temperature	0.1167	**0.9479**	0.2869
Minimum temperature in coldest month	0.1167	**0.9479**	0.2869
Absolute minimum temperature	0.0818	**0.9673**	0.2129
Positive temperature 0	–0.1120	**0.9784**	–0.0964
Positive temperature 5	–0.0763	**0.9772**	–0.0763

soil features are not subject to short–term modifications and are relatively independent of climatic alterations, at least in short time spans. Therefore, if the occurrence of a species is conditioned by both edaphic and climatic characteristics, it will be necessary to consider both requirements to delimit its probable distribution. In this study, we used pH as a general surrogate of the edaphic characteristics. We obtained pH data from the European Soil Data Centre (http://esdac.jrc.ec.europa.eu/; see Reuter et al., 2008) showing continuous pH values for each of the 1 km^2 UTM grid cells of the Iberian Peninsula. Additionally, we used information on land use from the CORINE Land Cover project (www.eea.europa.eu) to limit the edaphic–climatic areas to those with natural conditions. To do this, we reclassified the different land uses recognized in CORINE (level 2; resolution: 100 m^2) for 2011 into three categories: anthropic, semi–anthropic, and natural (table 2), eliminating the localities categorized as anthropic or semi–anthropic from the climatic–edaphic suitable areas. Thus, suitable edaphic areas with natural land uses (fig. 1) constitute the most restricted geographical scenario to represent recipient and emitter areas.

Finally, we downloaded a digital cartography representing the Iberian protected areas included in the Natura 2000 network from Protected Planet (www.protectedplanet.net/) and used this to describe which are, and will be the PAs that have and will have similar environmental conditions to those in Cabañeros.

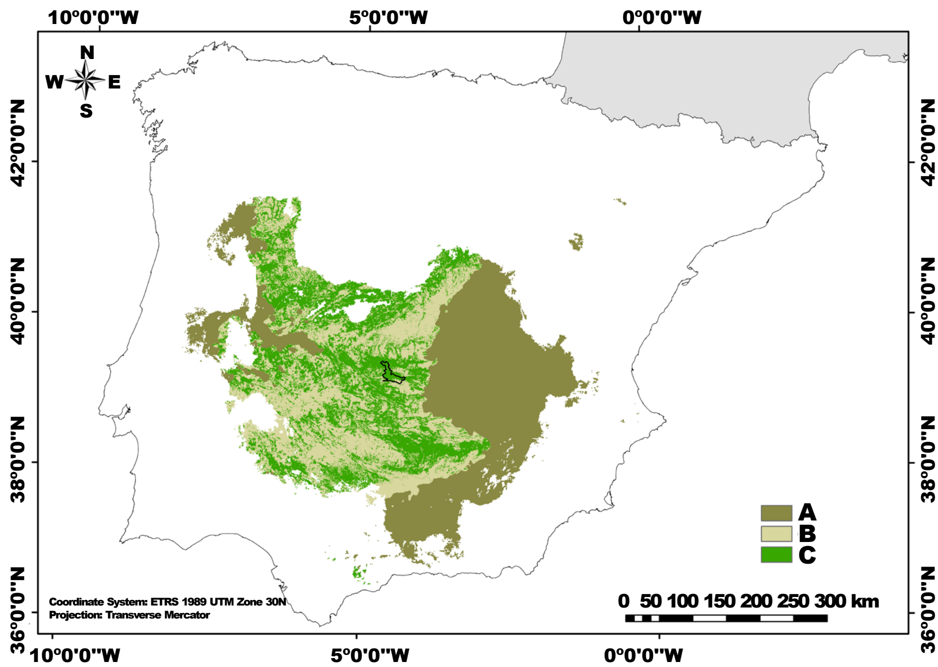

Fig. 2. Regions with climatic (A), climatic and edaphic (B), and climatic–edaphic areas with land cover conditions similar to those currently found in the Cabañeros National Park (C).

Fig. 2. Regiones con condiciones climáticas (A), climático–edáficas (B) y climático–edáficas con una cobertura natural similar a la existente actualmente en el Parque Nacional de Cabañeros (C).

Selection of climatic variables

After standardizing the values of all the considered climatic variables to mean zero and one standard deviation to eliminate the effect of different measurement scales, we conducted a principal components analysis (PCA) to reduce the number of climatic variables that would be used. PCA provided three non–correlated factors with eigenvalues higher than 1, representing 93.5 % of all the climatic variability in the Iberian Peninsula (factor 1 = 53.6 %, factor 2 = 31.7 %, factor 3 = 8.2 %). For each one of these three factors we chose the original variable with the highest factor loading; i.e. the primary variable best correlated with the values of each factor. The values of the first factor were positively correlated with different precipitation variables and negatively correlated with soil acidity (table 1), selecting the precipitation of the wettest month as representative (factor loading = 0.9464). The second factor was positively correlated with different temperature variables and negatively correlated with the precipitation of the driest month (table 1). On this occasion, the annual average temperature was chosen as the most representative variable (factor loading = 0.9800). Finally, the third factor was negatively correlated with temperature seasonality, continentality and thermal contrast (table 1), selecting thermal contrast as the representative variable (factor loading = – 0.8939).

Like isothermality, average monthly maximum temperature and maximum temperature of the warmest month were relatively poorly represented by the selected PCA factors (table 1); the first two were also selected to describe the climatic conditions of Cabañeros (only one of the two temperature variables was selected because both were highly and positively correlated; $r = 0.997$, $p < 0.0001$).

Data analysis

The five previously selected climatic variables were used to calculate the Mahalanobis distance (MD) from the conditions in the 1 km^2 cells of the National Park of Cabañeros to all remaining Iberian cells. We thus obtained a continuous measure able to represent not only the places with the same conditions to those of Cabañeros, but also the places with relatively similar conditions. The process was repeated both for present and for future climatic data. MD was chosen to measure climate similarity because this multidimensional measure takes into account the correlations of the variables and it is scale–invariant regardless of the units used for each variable (Farber and Kadmon, 2003; Xiang et al., 2008). We used the value corresponding to the 90th percentile of the MD values appearing in Cabañeros as the decision threshold to delimit the areas with a climate highly similar to that in the national park. Subsequently, a similar estimate

Table 2. The Iberian area currently represented by the climatic (C) or the climatic and edaphic (CE) conditions of Cabañeros National Park, and CE areas with natural land cover (CEN). CEN areas currently protected by any type of reserve, CEN areas within the Nature 2000 network (N2000), CEN area covered by large and continuous patches, total number of patches in CEN, and the value of the area–weighted mean shape index (AWMSI). The same values are provided for recipient areas (sites that in the future will have similar environmental conditions to those currently existing in Cabañeros) and emitter areas (that at present have similar conditions to those that Cabañeros will have in the future). C, CE and CEN percentages are computed considering the total area of the Iberian Peninsula, while remaining percentages are calculated on the basis of the CEN area.

Tabla 2. Superficie de la península ibérica que actualmente está representada por las condiciones climáticas (C) o climático–edáficas (CE) del Parque Nacional Cabañeros, y áreas CE con cobertura natural (CEN). Zonas CEN actualmente protegidas por cualquier tipo de reserva, zonas CEN dentro de la Red Natura 2000 (N2000), área CEN cubierta por parches grandes y continuos, número total de parches en CEN y valor del índice medio de forma ponderado por el área (AWMSI). Se proporcionan los mismos datos para el área receptora (sitios que tendrán en el futuro condiciones ambientales similares a las existentes hoy en Cabañeros) y el área emisora (sitios que actualmente tienen condiciones similares a las que tendrá en el futuro Cabañeros). Los porcentajes de C, CE y CEN están calculados sobre la superficie total de la península ibérica, mientras que los restantes están calculados sobre el área CEN.

Current representativeness	km^2	%
C	157,327	27.0
CE	92,280	15.9
CEN	42,030	7.2
Protected	19,355	46.05
N2000	17,419	41.45
Patches > 10.000 km^2	25,509	60.7
Patches 1.000–10.000 km^2	5,442	12.9
Number of patches	6,985	
AWMSI	59.96	

Future recipient areas	km^2	%
C	37,630	6.5
CE	9,048	1.6
CEN	5,023	0.9
Protected	2,218	44.17
N2000	2,002	39.86
Patches > 10.000 km^2	0	0.0
Patches 1.000–10.000 km^2	1,382	27.5
Number of patches	1,505	
AWMSI	10.02	

Future emitter areas	km^2	%
C	48,990	8.4
CE	35,244	6.1
CEN	16,100	2.8
Protected	6,806	42.27
N2000	5,937	36.87
Patches > 10.000 km^2	0	0.0
Patches 1.000–10.000 km^2	11,508	71.5
Number of patches	2,881	
AWMSI	27.84	

was made taking into account both climatic and edaphic variables. For this purpose, we estimated the range of pH values appearing within Cabañeros (from 5 to 6), removing all the areas outside these pH values from the climatically favourable territory. However, considering that species can be relatively tolerant to pH variations (Prentice et al., 1992), pH ranges were modified in ± 0.5 (i.e. from 4.5 to 6.5) in order to include those with relatively similar pH conditions as edaphically favourable regions.

Once identified and mapped, the areas with favourable climatic and edaphic conditions (i.e. those with MD values lower than the 90th percentile value calculated for Cabañeros) were overlapped with the current natural areas according to CORINE land cover as well as with the polygons representing Natura

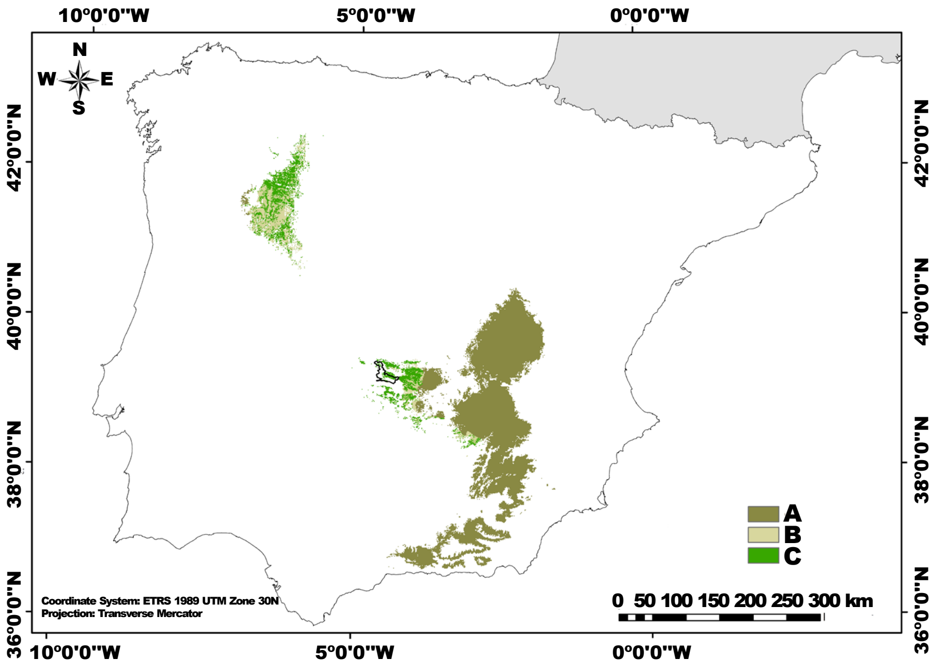

Fig. 3. Regions with climatic (A), climatic and edaphic (B), and climatic–edaphic areas currently harbouring natural land cover conditions that, in the future, will have similar conditions to those currently existing at Cabañeros National Park (C). Climatic data come from the IPSL–CM5A–LR scenario of the fifth assessment report (AR5) (2060–2080).

Fig. 3. Regiones con condiciones climáticas (A), climático–edáficas (B) y climático–edáficas con una cobertura natural que, en el futuro, serán similares a las existentes actualmente en el Parque Nacional Cabañeros (C). Los datos climáticos provienen del escenario IPSL–CM5A–LR del quinto informe de evaluación (AR5) (2060–2080).

2000 PAs. Finally, considering that fragmentation is one of the biggest threats to biodiversity conservation (Fahrig, 2003), we calculated the area, number and location of the groups of localities connected or adjacent (touching each other), assuming that a high fragmentation diminishes the conservation value of recipient and emitter areas. To do this, we used only those areas that are suitable from the climatic and edaphic point of view and, also have natural land uses. We also measured fragmentation using the area–weighted mean shape index (AWMSI). This index measures the average perimeter–to–area ratio, weighted by the size of the patches so that larger patches weigh more than smaller ones (McGarigal et al., 2012). This index is equal to 1 when all patches are circular, increasing in value without limit as patch shapes become more irregular.

Results

Current representativeness

The climatic conditions of Cabañeros are found in a large area of the Iberian Peninsula (fig. 2), accounting for 27 % (157,327 km^2) of its total area (table 2). Part of the northern sub–plateau just above Serra da Estrela, almost all of the southern sub–plateau to the Guadalquivir valley, and the Subbaetic mountains are climatically similar areas to those of Cabañeros. However, the region with similar climatic and edaphic conditions covers a considerably smaller area as the result of the elimination of eastern calcareous areas, totalling around 16 % (92,280 km^2) of the Iberian Peninsula (fig. 2). That is a decrease of 41 % in the representative area (65,047 km^2 less). Within the National Park, only 12 % of the territory is dedicated to anthropic land uses. In contrast, the representative Iberian climatic and edaphic area is highly anthropized (34.5 %) and only 45.5 % of it harbours natural landscapes (around 42,030 km^2; see fig. 2 and table 2).

Taking into account the climatic and edaphic conditions with natural land cover, around 19,355 km^2 (46 % of this area) is included under some type of protection category, with 90 % corresponding to the Natura 2000 Network (table 2). Connectivity between the climatic and edaphic favourable area and natural land cover is high and its fragmentation low. Only two patches have more than 10,000 km^2, representing 60.7 % of this total area, and another four patches

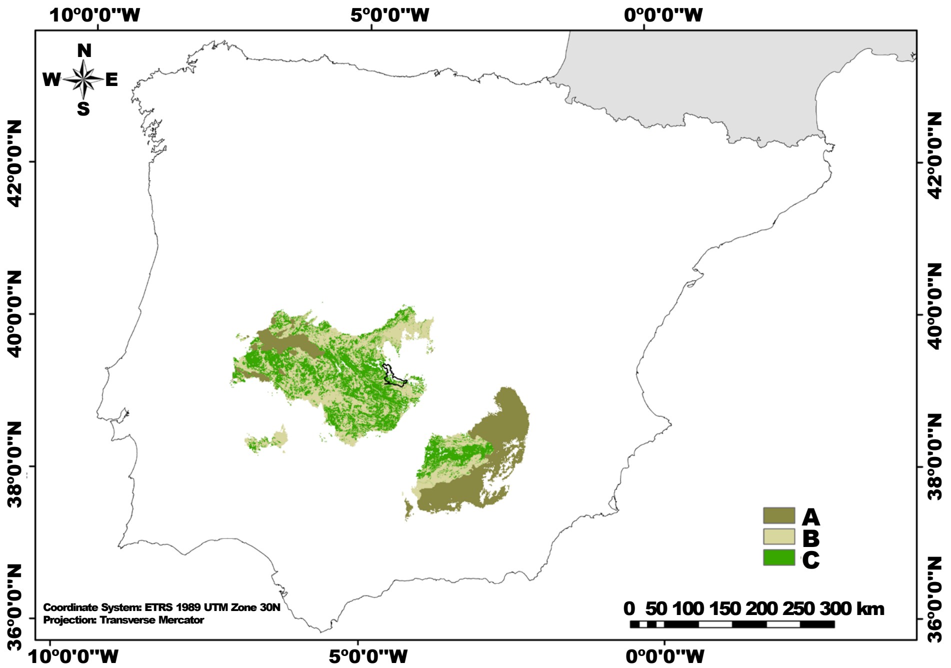

Fig. 4. Regions with climatic (A), climatic and edaphic (B), and climatic–edaphic areas harbouring natural land cover conditions that currently have similar conditions to those that Cabañeros National Park will have in the future (C). Climatic data come from the IPSL–CM5A–LR scenario of the fifth assessment report (AR5) (2060–2080).

Fig. 4. Regiones con condiciones climáticas (A), climático–edáficas (B) y climático–edáficas con una cobertura natural que, actualmente, son similares a las que el Parque Nacional de Cabañeros tendrá en el futuro (C). Los datos climáticos provienen del escenario IPSL–CM5A–LR del quinto informe de evaluación (AR5) (2060–2080).

embody 13 %. In total, there are 6,985 patches and the AWMSI index is 59.96 (table 2).

Future recipient areas

The places with the climatic conditions currently represented by Cabañeros are greatly reduced in the future scenario, and their geographical location also shifts (fig. 3). The climatically favourable area would be divided into two fragments, a smaller area located in the South of the 'Montes de León', in the Portuguese region of Tras–Os–Montes and Spanish territories bordering with Portugal, and a larger area located in a strip from the eastern part of the southern plateau below the Iberian System to Sierra Nevada. As a consequence, between 2060 and 2080 around 120,000 km^2 of climatically representative area will have disappeared (table 2). This change could establish a new climatically favourable region equivalent to approximately 6.5 % (37,630 km^2) of the total Iberian Peninsula area. When edaphic conditions are also considered, representative areas would cover a much smaller area (9,048 km^2; 1.6 % of total Iberian area). About half of this future climatically and edaphically favourable territory currently has natural land cover (5,023 km^2), being 44 % currently protected (2,218 km^2) (fig. 3, table 2). In this case, no patch has more than 10,000 km^2 and only one patch has more than 1,000 km^2 representing 27.5 % of the total. Taken together, there are 1,505 patches and the value of the AWMSI index decreases to 10.2 (table 2).

Future emitter areas

The areas that currently have similar climatic conditions to those that Cabañeros will have in the future occupy 48,990 km^2, which is equivalent to 8.4 % of the total area of the Iberian Peninsula (fig. 4, table 2). These areas are located in two main parts of the southern plateau: one between the Guadiana and Tajo valleys (Montes de Toledo, Villuercas, etc.), and another in the southeast around the Subbaetic mountain chain. Furthermore, there are also 643 km^2 very close to the Tajo International Natural Park, located in the boundary between Spain and Portugal. When both the climatic and edaphic conditions are considered this area is reduced to 35,244 km^2. Around 34 % of these favourable climatic and edaphic territories cu-

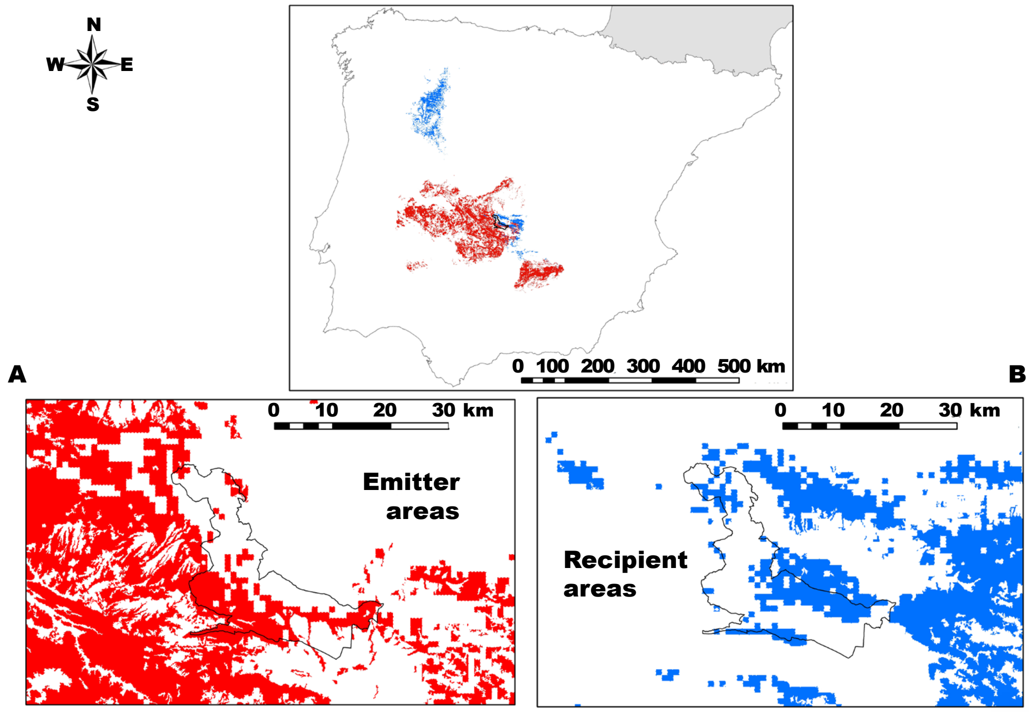

Fig. 5. Regions that will act as emitter (A) or recipient areas (B) for the Cabañeros National Park in the future.

Fig. 5. Regiones que en el futuro se comportarían como zonas emisoras (A) o receptoras (B) para el Parque Nacional de Cabañeros.

rrently have an anthropic land use, while 46 % have natural land cover (table 2). These favourable and natural areas are divided in two main patches (fig. 4), and they include part of the current territory of the Cabañeros National Park. About 43 % of this climatic and edaphic area is currently protected (6,806 km^2), mainly by the Natura 2000 network (87 %). This area would be composed of 2,881 patches with an AWMSI value of 27.84 (table 2).

Discussion

The Iberian reserve selected in this exercise has a key role in terms of climate representativeness as it represents Mediterranean forest conditions better than other National Parks (Sánchez–Fernández et al., 2013), such as those in mountain areas (Lobo, 2011), which barely represent a few hectares beyond their protected area boundaries. Even when both climatic and edaphic conditions are considered together, this Iberian reserve remained representative of a large part of the Iberian territory (around 16 %). If the Iberian territory represented by Cabañeros in regard to climatic and edaphic conditions is large, rather than non–fragmented, with little human impact and many protected areas, we can assume that the species inhabiting this reserve and environmentally similar areas have great potential to maintain their connected and conserved populations. Indeed, almost half of this territory currently possesses a high degree of wilderness, three–quarters is protected, and the general degree of fragmentation is very low; large and continuous patches cover 73 % of the suitable natural conditions. Thus, the potential environmental niche of many of the species sheltered in Cabañeros would also, a priori, appear in these other protected and natural areas, and vice versa.

Remarkably, it appears that the size of the areas representing the current environmental conditions of this reserve will be drastically reduced and fragmented in the future (future recipient areas). Climatic and edaphic future suitable areas that currently have natural land cover may be ten times smaller and only a quarter of them would be located in continuous and large patches. In addition, we should stress that only a small part of the territory that could act as a recipient area is located close to the examined reserve (fig. 5); the conservation of these localities should be given priority because they may ensure the maintenance of some of the organisms currently protected by this reserve. In this specific case, the most important area with optimal conditions to act as a recipient area is the Special Protection Area of Montes de Toledo because the species currently inhabiting lowlands will find suitable climatic conditions in highland areas even when these are located within the park. This whole set of results suggests a strong reduction in the environmental conditions currently represented by Cabañeros, thus probably diminishing the climatic–edaphic niche of many of the species that currently inhabit Cabañeros. This could result in the export of faunistic and floristic elements to areas in which these conditions will appear in the future and, in general, to a drastic reduction of the Mediterranean conditions that motivated the creation of this national park.

According to our results, between 2060 and 2080, Cabañeros National Park will undergo changes in climatic conditions similar to those currently appearing in other areas. These probable emitter areas seem to be larger, currently protected, and not very fragmented (fig. 5). Around 16,000 km^2 of natural land cover currently have climatic and edaphic conditions similar to those that Cabañeros will have in the future. A large part of this area is currently protected and located under continuous and larger patches that encompass the park itself. The International Tajo Natural Park, located on the border between Badajoz province and Portugal, will constitute the main protected emitter area, together with Sierra de las Villuercas, Tajo River, and Monfragüe National Park. These reserves can be important areas from which populations and species will eventually reach Cabañeros, but even the lower elevation parts of the National Park itself can act as emitter areas. It is necessary to promote the connectivity of these areas to facilitate the long–term stability of biodiversity (Haddad et al., 2015).

Taken together, these results suggest that the import of new populations and species in Cabañeros is more probable than the export of species. If climatic and edaphic conditions determine the fauna and flora of this National Park, climate change will generate a deep alteration of its biotic elements (Bestion et al., 2015), basically due to the entry of new elements. These changes could increase the populations of some colonizing species and largely decrease those of other native species. As such changes could lead to various conservation and management problems (Thomas and Gillingham, 2015), it is necessary to anticipate possible alterations and solutions, such as avoiding the isolation of the park and facilitating flow to and from the areas indicated in this study.

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