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Assessing recent environmental sustainability in the Spanish network of National Parks and their statutory peripheral areas

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ABSTRACT

Land use-land cover (LULC) changes and wildfires in the Spanish Network of terrestrial National Parks (NPs) and their legally designated peripheral areas, including Peripheral Protection Zones (PPZs) and Socioeconomic Influence Zones (SIZs), were assessed as indicators of recent territorial environmental sustainability trends. Level three, Corine Land Cover (CLC) data between 2005 and 2011 were compared. Official wildfire digital data were obtained from the European Commission for the 2005–2011 period. Results show increasing numbers of LULC changes along the protection gradient: NPs < PPZs < SIZs. NPs were, in general, highly stable regarding LULC changes and less affected by wildfires, which suggests high environmental effectiveness of legal and managerial protection afforded to the Spanish NP Network. Three study areas (SAs) were very stable in the analysed period in all their zones: Aigüestortes, Ordesa y Monte Perdido and Caldera de Taburiente. In turn, Teide and Doñana were the SAs where LULC changes were more abundant. Unsustainable LULC changes concentrate in NPs' peripheral areas, chiefly in their SIZs, with wildfires being the most widespread pressure in the analysed period. Teide's SA outstands due to its environmentally unsustainable recent LULC changes, with urbanisation and wildfires affecting natural and semi-natural areas. Sustainable territorial planning and management practices should prioritise this SA.

1. Introduction

Global biodiversity is going through an unprecedented decline due to human activities (Butchart et al., 2010). To revert such decline, almost all countries and territories have designated protected areas (PAs) to conserve important genes, species and ecosystems in the long term under dozens of legal designation categories (Dudley, 2008). As such, PAs can be considered the paradigm of environmental sustainability (Rodríguez-Rodríguez & Martínez-Vega, 2013). The environmental sustainability of peripheral areas of PAs is also an important concern as external pressures resulting from activities developed in surrounding areas are likely to have an impact on protected biodiversity and reduce PA conservation effectiveness (Gimmi et al., 2011; Mcdonald et al., 2009; Radeloff et al., 2010; Xun, Yu, Liu, Hao, & Sun, 2014). As a result, surrounding areas subject to progressively more lenient regulations from PA boundaries aimed at making biodiversity conservation and local socioeconomic development compatible have been proposed (Ahmad, Mohd, Abdullah, & Jaafar, 2012; Geneletti & Van Duren, 2008; Sabatini, Verdiell, Rodríguez-Iglesias, & Vidal, 2007) and implemented, rendering some positive environmental and socioeconomic outcomes (Allendorf & Gurung, 2016). That protection-development gradient is precisely the philosophy behind some worldwide networks of PAs and sustainable areas such as Biosphere Reserves (UNESCO, 2016).

Spain is a biodiversity-rich country of approximately 500,000 km^2 in south-western Europe (Médail & Quézel, 1999; Prieto, 2014). It is located in the Mediterranean global biodiversity hotspot (Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2000) and spans across four biogeographic regions: Alpine, Atlantic, Mediterranean and Macaronesian (EEA, 2015; Spanish Government, 2016a). Spain is also a highly decentralised country, with most environmental policies transferred to the 17 autonomous regions and the 2 autonomous cities in the country. In the case of NPs, the Spanish Government is competent for the designation of new NPs, for making and passing basic legislation on NPs that includes common designation and planning objectives (Spanish Government, 2014) and for producing the Director Plan of the NP Network which establishes common management criteria for the network (Spanish Government, 2016b).

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'National Park' is defined by the Spanish law on NPs as: 'little transformed natural areas of high ecological and cultural value that, because of their landscape beauty, ecosystem representativity, and/or floral, faunal or geological singularity, have ecological, aesthetic, cultural, educational or scientific values whose conservation is of general interest to the State' (Spanish Government, 2014). The main objective of the Spanish Network of NPs is to preserve the integrity of their natural assets and landscapes and, secondarily, to cater for social enjoyment, environmental outreach, scientific research and sustainable development of local populations (Spanish Government, 2014). As such, the Spanish definition of NP aligns closely with the definition of IUCN's PA Management Category II that primarily aims to 'protect natural biodiversity along with its underlying ecological structure and support environmental processes, and to promote education and recreation' (Dudley, 2008).

LULC changes largely result from the development model of societies and have great implications for biodiversity and ecosystem service provision (EEA, 2006; Jiménez, 2012). Sustainability objectives of PAs often collide with unsustainable sectoral policies, such as transport, housing or agricultural policies that insufficiently consider environmental assets through sound territorial planning and result in unsustainable LULC changes (EEA, 2006; Prieto, 2014). Thus, LULC change has been proposed and often used as an essential indicator of environmental sustainability of ecological units (Newbold et al., 2016), territories (EEA, 2006; Jiménez, 2012), PAs (Gaston, Jackson, Cantú-Salazar, & Cruz-Piñón, 2008; Martínez-Fernández, Ruiz-Benito, & Zavala, 2015; Terra, Ferreira, & Cortijo, 2014) and their surrounding areas (Martinuzzi et al., 2015; Radeloff et al., 2010). Actually, differences in biodiversity status between protected and unprotected sites are chiefly related to differences in LULCs (Gray et al., 2016). Massive unsustainable LULC changes occurred across Spain in the 1990–2000 decade and, predominantly, between 2000 and the burst of the housing bubble in 2008, which resulted from enormous investment in real estate through critically exposed credits (Alfonso et al., 2016; Jiménez, 2010). Those LULC changes threatened the natural values for which NPs and other PAs were designated, especially around densely populated areas like Barcelona (Mallarach, 2008), Madrid (Gallardo & Martínez-Vega, 2016; Rodríguez-Rodríguez & Martínez-Vega, 2013; Rodríguez-Rodríguez, 2008) and along the coast (Alfonso et al., 2016; Prieto, 2014).

Forest fires form part of the ecological dynamics in Mediterranean ecosystems (Moreno, 1989; Pausas & Vallejo, 1999). However, human activities often modify natural fire regimes resulting in shifting fire frequency, intensity and seasonality. This may overcome ecosystems' resilience and permanently turn them to different stages of their succession processes, with serious consequences for biodiversity (Pausas, 1999; Pérez-Cabello & De la Riva, 2001). In Spain, both the number of wildfires and their extent notably decreased between 1991-2000 and 2001–2010 as a result of increased and more effective prevention and extinction means (Enríquez & del Moral, 2012). However, wildfires are still the main factor reducing forest cover, maturity and quality in Spain (Prieto, 2014; Pérez-Cabello & De la Riva, 2001). They cause biomass loss, forest rejuvenation, reduced ecological and productive value and increased soil erosion (Prieto, 2014). Thus, it is advisable to analyse the environmental sustainability of recent LULC changes and wildfire extent in the Spanish Network of National Parks and in their peripheral areas in order to detect positive trends towards 'naturalness' or, inversely, negative trends towards 'anthropisation' of those natural assets of the utmost importance.

2. Methods

2.1. Study scope

The Spanish law on NPs (Spanish Government, 2014) defines three general statutory zones that can be applied to NPs: 1) Socioeconomic Influence Zones (SIZs); 2) Peripheral Protection Zones (PPZs); and 3) NPs. We will refer to the three statutory zones of each site as 'study area' (SA). SIZs are made of the entire territory of the municipalities whose areas are totally or partially included in the NP. These municipalities are entitled to state subsidies to offset land management limitations as a result of NP's regulations. PPZs are terrestrial or marine areas external and contiguous to NPs that are subject to some regulations aimed at buffering the external impacts on NPs. NPs include the perimeters of the actual PAs which must be (and are normally) also zoned according to planning and managerial needs (Spanish Government, 2012a). By September of 2017, all the fifteen NPs of the Spanish NP Network had SIZs and ten of them had PPZs.

Twelve of the 15 NPs that made the Spanish NP Network were selected for this study on the grounds of designation dates and main realm of protected ecosystems. They represent 85% of the whole NP network area, 83% of the PPZ area in the network, and 87% of the SIZ of the network by September of 2017. These 12 NPs are scattered across the four biogeographical regions in the Spanish terrestrial territory (EEA, 2015; Fig. 1). Appendix 1 summarises the main characteristics of the selected NPs.

2.2. Spatial-statistical analysis

The official digital layers of the different statutory zones of the terrestrial NPs (Spanish Government, 2016c) were intersected with Corine Land Cover (CLC)-2006 and CLC-2012 level-3 data. Versions 18.5 of CLC 2006 and 2012 (Copernicus, 2016a,b) were used for being the most updated consistent and comparable repository of LULC data at European scale (Hewitt, Pera, & Escobar, 2016; Maucha & Büttner, 2005). From the current 15 Spanish NPs by September of 2017, only those terrestrial NPs designated until the median CLC-2006 scene dates (July 2005) were selected to be sure that they had been NPs for the whole analysed period (n = 11). Monfragüe NP, designated in March of 2007, was also included in the set of analysed NPs, as it had been previously designated as Nature Park (so no major LULC changes were expected between July 2005 and March 2007) and was designated as NP for the most part of the analysed period (July 2005 till June 2011 on average).

LULC change (C) was calculated subtracting the percentage of each CLC level 3 LULC in 2005 from that percentage in 2011 by each SA and statutory zone of the whole network of sites: $C = LUx,i_{(2011)} - LUx,i_{(2005)}$, where LU is the percentage of coverage of LULC x in SA or zone i. The LULC change thresholds we used are quite modest: we considered 'noticeable' change those LULC changes that affected $\geq \pm 0.1\%$ of the area of the analysed SA or zone, and 'relevant' change, all LULC changes affecting $\geq \pm 1\%$ of that area in the considered period. Pearson correlation analysis between the number of 'noticeable' LULC changes and each SA's area and NP's age was performed to assess whether LULC changes might be driven by the amount of area assessed or by social recognition of the site, respectively, after checking the normality of variables. As official SIZs included the whole area covered by NPs and PPZs (when these exist), the area of both zones was subtracted from SIZ area values for each site, so the three zones were spatially mutually exclusive and legally ranked in decreasing degree of protection (Spanish Government, 2014).

The aim of any PA should be to conserve biodiversity and associated ecosystem services and cultural values in the long term while maintaining or increasing the naturalness of the ecosystems being protected (Dudley, 2008). Therefore, LULC changes or processes towards more natural, less intensive ecosystems (e.g. natural succession; ecological restoration; agricultural extensification) were considered as environmentally sustainable whereas changes that reduce naturalness or increase LULC intensity (e.g. artificialisation; degradation of vegetation; agricultural intensification) were considered as environmentally unsustainable (Kuemmerle et al., 2016). The sustainability of stable LULCs was not analysed. We however assessed initial LULCs around NPs (in their SIZs) by 2005 (Copernicus, 2016a) as a proxy of the degree of starting human pressure on them.