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Moderate effectiveness of multiple-use protected areas as a policy tool for land conservation in Atlantic Spain in the past 30 years

D. Rodríguez-Rodríguez [a,b,*], J.D. Sinoga [a]

[a] Department of Geography, University of Malaga, Facultad de Filosofía y Letras, Campus Universitario de Teatinos, s/n, 29071 Malaga, Spain
[b] European Topic Centre, University of Malaga, Ada Byron Research Building, C/ Arquitecto Francisco Peñalosa s/n, 29010 Malaga, Spain

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ABSTRACT

Protected areas (PAs) are the main global policy instrument to avert the current biodiversity crisis by conserving important species and habitats on site. Yet important pressures around PAs and in PAs, notably land use-land cover (LULC) changes, jeopardise the conservation role of these tools. In Spain, as well as in most developed countries, land development is the main pressure on its rich biodiversity. Here, we used a semi-experimental Before-After-Control-Impact (BACI) research design with covariates to ascertain whether three categories of multiple-use PAs including Nature Parks, Sites of Community Importance (SCIs) and Special Protection Areas (SPAs) have been effective to prevent land development in Atlantic Spain between 1987 and 2017 using CORINE Land Cover (CLC) data. We split our census sample of PAs according to two geographic zones: coastal zone and inland zone, and four administrative sub-zones (regions with distinctive governance systems): Galicia, Asturias, Cantabria and the Basque Country. We created and tested the validity of three types of controls specific to each PA category: standard 5-km buffer controls, bio-physically adjusted standard controls, and bio-physically adjusted random controls across zones. Multiple-use PAs reduced, though not completely avoided, land development in all zones and sub-zones compared with controls. An effectiveness gradient among PA categories was apparent: NPs $\geq$ SCIs $>$ SPAs. Coastal areas, both protected and unprotected, experienced greater land development rates than inland areas, with coastal SPAs showing poor effectiveness results. The Basque Country was the best-performing region regarding PA effectiveness, with the remaining regions showing similar PA performance results regardless of the prevailing political party in power for most of the study period. Random controls had the greatest bio-physical similarity to their cases and produced larger control areas than standard buffer controls. The limited effectiveness of multiple-use PAs, especially of SPAs, at preventing land development in highly pressured coastal areas suggests the need for enhanced legal protection of these areas if long-term biodiversity conservation is to be ensured. Governance and political factors are likely to have influenced the effectiveness of PAs in Spain and should thus be further considered in environmental studies.

1. Introduction

Protected areas (PAs) are areas on land or sea designated for the long-term conservation of biodiversity and associated ecosystem services and cultural values (Dudley, 2008). PAs are the main global policy instrument to avert the current biodiversity crisis (Butchart et al., 2010; IPBES, 2019c; WWF, 2020c). The main drivers of biodiversity decline include habitat degradation and loss, pollution, overexploitation of wild populations, introduction of alien invasive species and climate change (MEA, 2005). Of these, habitat degradation is the key driver of biodiversity loss, considerably affecting all major terrestrial and marine ecosystems for the past century (Millenium Ecosystem Assessment, 2005; WWF, 2020c). In response to the global biodiversity crisis, states' responses have been chiefly based on establishing PA networks to safeguard the remnants of wilderness (Chape et al., 2008). However, uncertainty remains over if PAs can be a useful tool to prevent all pressures on biodiversity and in all circumstances (Mora and Sale, 2011). Thus, an important scientific focus on PA effectiveness has developed in recent years (Hockings et al., 2006; Leverington et al., 2010; IUCN, 2017). Numerous studies have assessed the effects of PAs

* Corresponding author at: Department of Geography, University of Malaga, Facultad de Filosofía y Letras. Campus Universitario de Teatinos, s/n, 29071 Malaga, Spain.

E-mail addresses: davidrr@uma.es, davidrgrg@yahoo.es (D. Rodríguez-Rodríguez).

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on preventing land use changes, chiefly deforestation, with generally positive outcomes (Andam et al., 2008; Pfeifer et al., 2012; Geldmann et al., 2013; Spracklen et al., 2015). In developed settings such as Europe, land development leading to soil sealing and potentially permanent destruction of natural habitats is the main pressure on biodiversity (EEA, 2015a). Thus, it is suggested that a primary measure of PA effectiveness relates to their capacity to prevent negative land use-land cover (LULC) changes, notably land development (Rodríguez-Rodríguez and Martínez-Vega, 2018).

Spain is a Euro-Mediterranean, biodiversity-rich country that has been experiencing massive land development processes at the expense of semi-natural and natural areas in the past 30 years (Montes et al., 2011), especially around big cities and in coastal areas (Jiménez, 2012; Observatorio de la Sostenibilidad, 2018). At the same time, Spain has made impressive progress in legally protecting many of its most important areas for biodiversity, with its terrestrial PA coverage shifting from 0.4% in 1980 (Mulero, 2002) to 28.1% today (Protected Planet, 2020a). Nevertheless, serious concerns remain over the effective conservation of biodiversity in the country before existing and projected new land developments, both legal and illegal (Málvarez et al., 2003; Jiménez, 2009; Rodríguez-Rodríguez and Martínez-Vega, 2018).

Spain is a highly decentralised country where the central government holds competencies for basic law passing on nature conservation and managerial coordination of the Network of National Parks. In turn, the 17 regional governments have competencies for broadening the basic legislation on nature conservation, passing territorial planning regulations and managing biodiversity and land uses in their territories (Spanish Government, 1978). Moreover, whereas urban development is a local competency of municipalities, regional authorities are charged with overseeing and granting permission to local development plans in their territories. Thus, though biodiversity protection and territorial planning are largely regional policies most likely influencing land development and PA effectiveness in Spain, limited research has yet focused on the effects of regional policies on such variables in a comparable manner(e.g. Jiménez, 2012). Despite the country's diverse environmental and administrative characteristics, most scientific studies on LULC changes in Spain have not differentiated among regional administrative regimes and considered the whole country as a homogeneous normative and managerial unit (Stellmes et al., 2013; Rodríguez-Rodríguez and Martínez-Vega, 2018). Some authors have refined national studies on land use changes and PAs differentiating biomes (Martínez-Fernández et al., 2015) and coastal influence (Rodríguez-Rodríguez et al., 2019). These studies found different land development rates among biomes and coastal and inland areas, further advocating a finer scale study of land development processes in such an environmentally and administratively heterogeneous country like Spain. Both studies found greater land development rates in the Mediterranean biome than in the Atlantic biome, chiefly attributed to climatic differences leading to different residential and tourist developments (Martínez-Fernández et al., 2015; Rodríguez-Rodríguez et al., 2019). However, Rodríguez-Rodríguez et al. (2019) showed a worrisome result that coastal PAs in the Atlantic biogeographic region of Spain had similar or worse land development values that their unprotected controls in the 1990–2006 period, which might compromise their conservation. Here, we aimed to delve on that result by applying a more discriminating legal, spatial and policy research design in order to understand what PA categories, geographic areas and administrative regions might be failing to adequately protect biodiversity in order to come out with specific sustainable policy recommendations to responsible authorities. We also aimed to expand on those results by also analysing PA performance over the most recent period for which consistent land use-land cover data are available: 2006 until 2018.

2. Methods

2.1. Study area

We assessed land development in PAs and controls in the Atlantic biogeographic region of Spain, largely defined on climatic grounds by mild rainy winters and warm, wet summers (European Commission, 2020a). We selected the Atlantic region from the European biogeographical regions' GIS layer (European Environment Agency, 2019a) and clipped it against the official Spain's administrative regions' boundary layer (IGN, 2020a) to select our study regions: Galicia, Asturias, Cantabria and Basque Country. Atlantic administrative regions that could not provide coastal and inland zones were excluded from the study. We then geographically split the Atlantic biogeographical region of Spain in two zones according to their different land development intensities (Rodríguez-Rodríguez et al., 2019) using Arc-GIS v.10.5 (Environmental Systems Resource Institute, 2018a): 1) Coastal Zone, which included a 10 km inland stripe from the coastline (10,652 km^2); and 2) Inland Zone, which included the rest of the Atlantic biogeographical region in the four selected administrative regions (35,858 km^2) to obtain coastal and inland administrative zones for each region or sub-zone (Fig. 1).

2.2. PA data

Official digital boundaries of a census sample of PAs that had been designated in Spain until August of 2000 were downloaded from the Spanish Ministry of Environment's website (Spanish Government, 2020b). That date was selected according to the satellite scenes that were used to produce the LULC data for CORINE Land Cover (CLC) 2006, the first of which was taken in June of 2003, with an average scene date of July of 2005. That way, we could be sure that the PAs that had been designated the latest had been protected for, at least, 3 years to show some effect against land development by 2006. Individual PA layers were then unioned in a single PA layer and resulting protected polygons (PPs) smaller than 100 ha were deleted, as many were layer alignment errors. Designation dates for Natura 2000 sites (SCIs and SPAs) were then included (EEA, 2015b). For SCIs, each site's proposal date was selected as designation date, as since that moment the Habitat Directive's regulations generally start to apply on this site (European Commission, 2019b). We made sure to select only PAs whose designation dates were later than the baseline data (land development at t_1 according to the CLC90 scene dates) from each satellite scene that covered the area of those PAs. Of all the existing legal categories of PAs at that date, three multiple-use PA categories with common legal and managerial characteristics across the country were selected (Rodríguez-Rodríguez and Martínez-Vega, 2018): Nature Parks (moderate legal stringency and active management), Sites of Community Importance (SCIs; moderate legal stringency and no management), and Special Protection Areas (SPAs; moderate legal stringency and no management). SCIs, SPAs and Special Areas of Conservation (SACs) make the European Natura 2000 Network (European Economic Community, 1992). When different legal protection categories of PAs overlapped over the same space, we assigned the oldest designation category to the resulting protected polygon (PP), as it was the date when that area was initially afforded legal protection against land development.

2.3. Land development data

We considered artificial areas the following level-2 CLC subclasses of Class 1 (Artificial areas) that entail severe or complete habitat destruction and/or soil sealing: 1.1 (Urban fabric), 1.2 (Industrial, commercial and transport units) and 1.3 (Mine, dump and constructions sites). Some inconsistencies in artificial areas were detected within periods. Some artificial areas from period 1 *Before* data (CLC1990; t_1) were not present in its *After* data (CLC2006; t_2). Even if some 1.3 artificial LULC (mainly

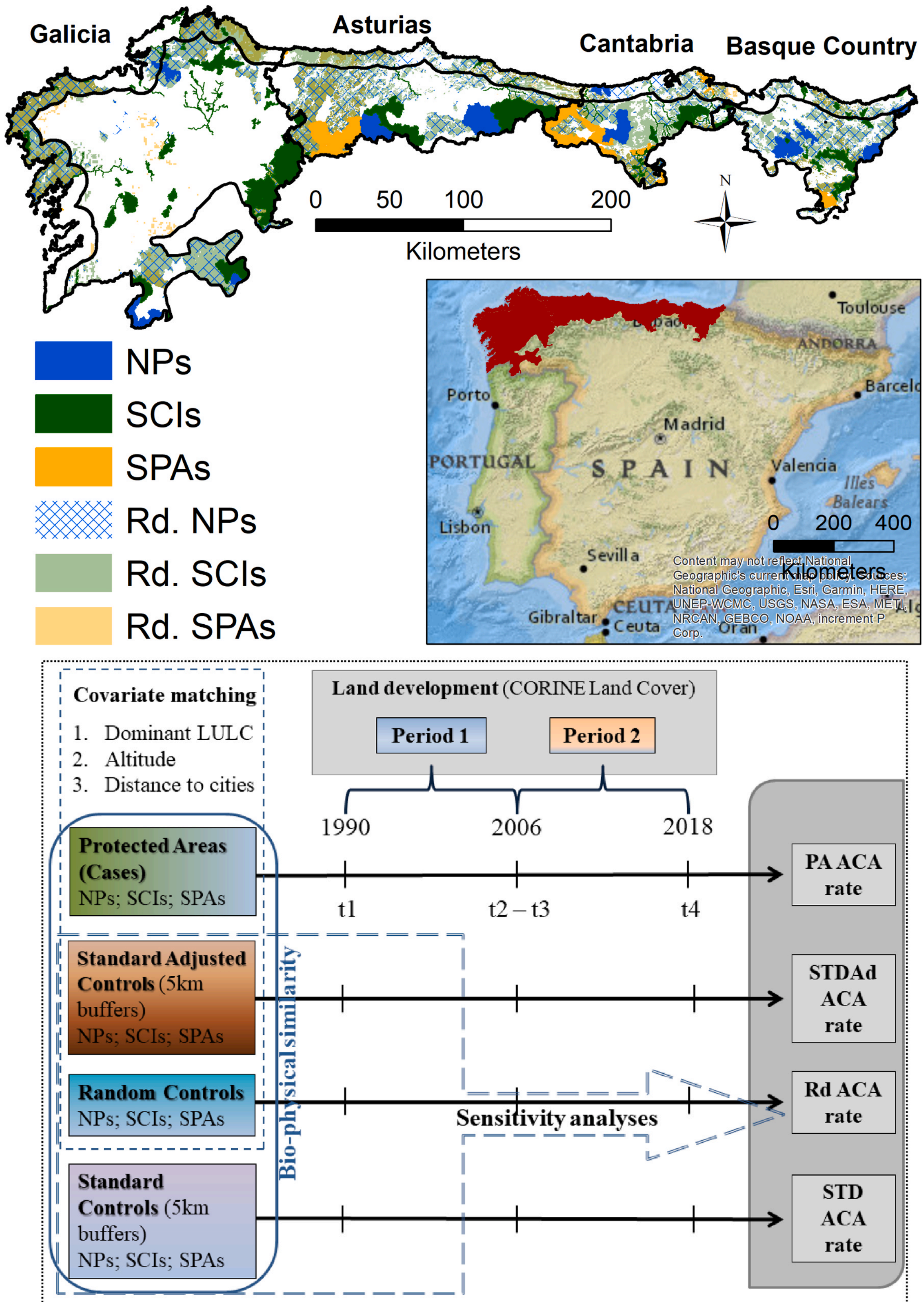

Fig. 1. Study outline NP: Nature Park; SCI: Site of Community Importance; SPA: Special Protection Area; Rd: Random control; ACA: Proportional Absolute Change in Artificial area.

mine sites and dumps) may to some extent change to non-artificial LULC through ecological restoration (Martínez-Fernández et al., 2015), their amount should be quite limited region-wise, so we added all previously existing artificial areas to their *After* data in period 1, as the probability of other artificial LULC to change to non artificial LULC is minimal. Thus, some excess in artificial area is likely to be showing in our period 1 *After* data, but as those 'extra' artificial areas could affect either PPs or their controls, that bias should be small and consistent across comparisons.

The land development indicator used was the Rate of Proportional Absolute Change in Artificial area (ACA rate):

$$\text{ACA rate } x = \frac{1}{t}\sum\left(\frac{\text{ARTx(t2)} - \text{ARTx(t1)}}{\text{AREAx}}\right) \text{x } 10^2$$

Where $\text{ART}x_{(t1)}$ is the sum of artificial areas in PP or buffer network x around 1987, and $\text{ART}x_{(t2)}$ is that sum around 2005 (for period 1); for period 2, $\text{ART}x_{(t1)}$ is the sum of artificial areas in PP or buffer network x around 2005 and $\text{ART}x_{(t2)}$, is that sum around 2017. AREAx is the total area of the PP or buffer network x and t is the period's length in years. ACA rate shows the proportion of each PP or control network that has become artificial each year in a given period.

2.4. Study design

We used a multiple BACI research design (Smith, 2002) that assessed the *Impact* of PA designation on land development by comparing land development values across PP (cases) and control networks across zones and subzones in two time periods: 1987–2006 (period 1, of 19 years) and 2006–2018 (period 2, of 12 years). Due to methodological changes to the production of CLC data in Spain since 2006 (Martínez-Fernández et al., 2019), we had to split our analysis in two data-consistent periods: 1990 (t_1)−2006(t_2) and 2006(t_3)−2018(t_4). Artificial LULC data from CLC 1990 (t_1) was our *Before* data (baseline data) in period 1, and artificial LULC data from our CLC 2006 'improved' version (IGN, 2016) our *After* data in that period (t_2). The most recent, official artificial CLC 2006 LULC data was used as our *Before* data for period 2 (t_3) whereas artificial LULC from CLC 2018 was used as our *After* data for that period (t_4; IGN, 2020b).

Controls are deemed essential to ascertain causality in BACI designs (Smith, 2002; Addison, 2011). However, as PAs are not distributed randomly across the territory and tend to be located in remote areas less affected by human activities, substantial bias is expected by selecting 'standard' buffers around PAs as controls, as they may not share the same bio-physical or legal characteristics as their cases, thus reducing the validity of comparisons (Mas, 2005; Andam et al., 2008; Pfeifer et al., 2012). Thus, we used three types of controls for each of the three PA networks (NPs, SCIs & SPAs): 1) Standard controls, created by applying a default 5 km-radius buffer around each PP and assigning them the corresponding PA network category and subtracting all overlapping protected area (all PAs of any legal category) that existed in both periods (designated until 2006 –post period 1(t_2)- and until 2019 –post period 2 (t_4)-, respectively; Rodríguez-Rodríguez et al. (2019)); 2) Standard, bio-physically 'adjusted' controls, produced by statistically 'adjusting' standard controls' areas in each zone according to the ranges of their PA networks for three variables (covariates) that are known to affect land development: dominant land covers around 1990; Altitude; and distance to main cities in 1991 (Rodríguez-Rodríguez and Martínez-Vega, 2018); and 3) Random 'adjusted' controls, produced by identifying control areas within the same covariate ranges of their PA networks anywhere across the territory in each zone, as proximal controls are not necessarily more bio-physically similar to their cases than more distant ones (Rodríguez-Rodríguez and Martínez-Vega, 2018). Further details on the creation of controls can be found in Appendix 1.

We compared the bio-physical similarity of the three PA controls with their cases (each PA network) in each zone to check the validity of comparisons. For bio-physical similarity calculations, and similar to previous studies (Rodríguez-Rodríguez et al., 2019), we used the normalised Manhattan Similarity Coefficient, according to the following formula:

$$D(X, X') = 1 - \frac{\sum_{i=1}^{k}|X_i - X_i'| \quad /Range \quad (Xi)}{K}$$

Where, X_i is the median value of group X for variable i; Range is the amplitude of measurement X_i in the study area; and K is the number of variables used to assess groups X and X′. The Manhattan Similarity Coefficient ranges between 0 (complete difference between compared group values) and 1 (complete similarity).

Once 'adjusted' controls were made bio-physically similar to their cases for each PA network and zone, the artificial layers for period 1 and period 2 were intersected with PPs and control types, and ACA rates for each PA and control network for each zone (coastal vs inland) and subzone (administrative region) were computed for each period. Fig. 1 depicts a methodological outline of the study.

2.5. Hypothesis testing

We aimed at testing eight research hypotheses (RHs) and two methodological hypotheses(MHs; Table 1).

3. Results

3.1. Bio-physical similarity of cases and controls

Initial similarity between cases and the three types of controls in both zones was overly high, ranging from 0.75 to 0.96 (Appendix 2).

3.2. Land development in PAs and controls

Table 2 shows land development figures in Atlantic Spain by PA category, zone, sub-zone, control type and period.

Table 1
Research hypotheses (RH) and methodological hypotheses (MH) tested in this study and supporting references.

Hypothesis type	Hypothesis	References
RH1	PAs experienced less land development than controls areas	Martínez-Fernández et al. (2015)
RH2	Actively managed PAs experienced less land development than unmanaged PAs	Hockings et al. (2006)
RH3	Coastal PAs experienced greater land development than inland PAs	Rodríguez-Rodríguez et al. (2019)
RH4	Coastal controls experienced greater land development than inland controls	Rodríguez-Rodríguez et al. (2019)
RH5	Land development rates were greater in period 1 (1987–2005) than in period 2 (2006–2017)	Spanish Government (2019d)
RH6	There were differences in PA effectiveness against land development among regions	Jiménez (2012)
RH7	There were differences in unprotected land development rates among regions	Jiménez (2012)
RH8	Differences in PA effectiveness among regions are influenced by the political sign of governments	Esteban and Altuzarra (2016)
MH1	Near controls are more bio-physically similar than distant controls	Oudin et al. (2008)
MH2	Adjusted controls are more bio-physically similar to cases than standard controls	Mas (2005)

Table 2
Land development results across protected area categories, zones, sub-zones and periods.

Nature Parks													
Sub-zone	Zone	Area (ha)				ACA rate							
						Period 1				Period 2			
		NPs	STD	STDAj	RD	NPs	STD	STDAj	RD	NPs	STD	STDAj	RD
Asturias	Coast												
	Inland	66,476	22,908	20,825	265,598	0.00	0.01	0.00	0.02	0.01	0.02	0.00	0.02
Cantabria	Coast	5655	15,704	8208	61,426	0.05	0.09	0.05	0.12	0.04	0.11	0.09	0.29
	Inland	23,949	35,207	25,213	111,759	0.00	0.07	0.03	0.00	0.00	0.07	0.01	0.01
Galicia	Coast	2620	17,997	14,314	219,781	0.00	0.03	0.04	0.01	0.01	0.24	0.16	0.12
	Inland	31,763	23,057	17,294	231,597	0.00	0.04	0.05	0.04	0.00	0.02	0.02	0.04
Basque Country	Coast	1965	11,949	3796	44,616	0.00	0.17	0.09	0.03	0.00	0.54	0.09	0.15
	Inland	40,962	82,544	47,700	170,897	0.00	0.03	0.01	0.01	0.01	0.23	0.04	0.05
Coastal zone		**10,240**	**45,650**	**26,318**	**396,882**	**0.03**	**0.09**	**0.05**	**0.03**	**0.02**	**0.27**	**0.13**	**0.15**
Inland zone		**163,149**	**163,717**	**111,031**	**779,851**	**0.00**	**0.04**	**0.02**	**0.02**	**0.00**	**0.13**	**0.03**	**0.03**
TOTAL		**173,390**	**209,367**	**137,349**	**1176,733**	**0.00**	**0.05**	**0.02**	**0.02**	**0.01**	**0.16**	**0.05**	**0.07**
Sites of Community Importance													
Sub-zone	**Zone**	**Area (ha)**				**ACA rate**							
						Period 1				**Period 2**			
		SCIs	**STD**	**STDAj**	**RD**	**SCIs**	**STD**	**STDAj**	**RD**	**SCIs**	**STD**	**STDAj**	**RD**
Asturias	Coast	1202	34,319	23,607	126,718	0.00	0.05	0.02	0.01	0.05	0.09	0.08	0.12
	Inland	94,323	123,066	70,033	266,618	0.00	0.04	0.03	0.02	0.00	0.11	0.02	0.02
Cantabria	Coast	346,000	31,911	17,682	48,915	0.04	0.10	0.11	0.08	0.01	0.28	0.29	0.19
	Inland	33,289	159,673	107,849	167,367	0.00	0.02	0.01	0.01	0.01	0.04	0.01	0.01
Galicia	Coast	21,647	195,272	178,126	270,452	0.01	0.02	0.02	0.01	0.05	0.19	0.17	0.12
	Inland	199,753	361,551	296,909	265,643	0.00	0.03	0.03	0.05	0.00	0.10	0.07	0.10
Basque Country	Coast	7630	39,835	20,035	47,027	0.00	0.05	0.01	0.03	0.01	0.31	0.10	0.14
	Inland	37,465	123,326	64,357	180,340	0.00	0.03	0.01	0.01	0.00	0.17	0.06	0.05
Coastal zone		**30,824**	**301,337**	**239,450**	**493,111**	**0.01**	**0.04**	**0.02**	**0.02**	**0.04**	**0.20**	**0.17**	**0.13**
Inland zone		**364,830**	**767,616**	**539,148**	**879,968**	**0.00**	**0.03**	**0.02**	**0.02**	**0.00**	**0.10**	**0.05**	**0.05**
Total		**395,654**	**1068,953**	**778,598**	**1373,079**	**0.00**	**0.03**	**0.02**	**0.02**	**0.01**	**0.13**	**0.09**	**0.08**
Special Protection Areas													
Sub-zone	**Zone**	**Area (ha)**				**ACA rate**							
						Period 1				**Period 2**			
		SPAs	**STD**	**STDAj**	**RD**	**SPAs**	**STD**	**STDAj**	**RD**	**SPAs**	**STD**	**STDAj**	**RD**
Asturias	Coast	1487	1277		52,614	0.00	0.00		0.02	0.28	0.15		0.20
	Inland	56,337	37,819	17,478	117,661	0.00	0.06	0.01	0.02	0.01	0.03	0.00	0.01
Cantabria	Coast	4582	21,722	10,508	20,576	0.09	0.08	0.09	0.08	0.15	0.18	0.20	0.23
	Inland	60,310	66,650	42,269	53,375	0.00	0.02	0.01	0.01	0.00	0.02	0.01	0.02
Galicia	Coast	2077	29,465	14,199	186,786	0.00	0.02	0.01	0.01	0.18	0.29	0.23	0.17
	Inland												
Basque Country	Coast												
	Inland	8430	16,508	3718	35,561	0.00	0.02	0.00	0.02	0.00	0.08	0.04	0.06
Coastal zone		**8146**	**52,464**	**24,706**	**275,819**	**0.05**	**0.04**	**0.05**	**0.02**	**0.18**	**0.24**	**0.22**	**0.18**
Inland zone		**125,077**	**120,977**	**63,465**	**264,428**	**0.00**	**0.03**	**0.01**	**0.03**	**0.00**	**0.03**	**0.01**	**0.03**
Total		**133,223**	**173,441**	**88,172**	**540,247**	**0.00**	**0.04**	**0.02**	**0.03**	**0.02**	**0.09**	**0.07**	**0.11**

ST: Standard control; STAd: Adjusted standard control; RD: Random control; ACA: Proportional Absolute Change in Artificial area

3.2.1. Research hypothesis 1: PAs experienced less land development than control areas

This hypothesis is largely supported by evidence. Mean ACA rate of the three PA networks in both zones was much smaller (0.01) than that of their controls: 0.08 (standard controls), 0.04 (adjusted standard controls) and 0.05 (random controls). Few exceptions to this trend existed involving mostly coastal SPAs, which experienced equal or even more ACA than their controls, especially in period 1.

3.3. Research hypothesis 2: Actively managed PAs experienced less land development than unmanaged PAs

This hypothesis is largely unsupported by evidence. Globally (both zones included), NPs experienced the same ACA than SCIs in both periods. NPs only showed better global ACA values than SPAs for Period 2. In the inland zone, the three PA categories showed the same ACA figures, whereas in the coastal zone, NPs performed better than SCIs and SPAs in Period 2, but worse than SCIs in Period 1. Moreover, coastal SCIs experienced substantially less ACA rate in Period 1 (0.01) than in Period 2 (0.04), when many of them had most likely been designated as SACs and provided with active management.

3.4. Research hypothesis 3: Coastal PAs experienced greater land development than inland PAs

This hypothesis is supported by evidence. ACA rate was systematically greater in protected coastal zones than in protected inland zones. Zonal ACA rate difference was exceptionally stark in SPAs. Coastal SPAs experienced nearly 49 times more ACA rate than inland SPAs (Table 3).

Table 3
Mean Proportional Absolute Change in Artificial area (ACA) rates between coastal and inland PAs and controls across regions in both periods. Controls' figures are the means of the three control types for each PA category.

	Cases		Controls	
	Coast	Inland	Coast	Inland
Nature Parks	0.02	0.00	0.12	0.04
SCIs	0.02	0.00	0.10	0.04
SPAs	0.12	0.00	0.12	0.02

3.5. Research hypothesis 4: Coastal controls experienced greater land development than inland controls

This hypothesis is supported by evidence. ACA rate differences between coastal and inland controls were marked, especially for SPAs' controls. Table 3 summarises mean ACA rate values among coastal and inland cases and controls in all regions and in both periods.

3.6. Research hypothesis 5: Land development rates were greater in period 1 than in period 2

This hypothesis is unsupported by evidence. Rather, the opposite occurred. Mean ACA figures in PAs and controls were greater in period 2 than in period 1 by 3.73 times and 3 times, respectively (Table 4).

3.7. Research hypothesis 6: There were differences in PA effectiveness against land development among regions

This hypothesis is supported by evidence. PAs in the Basque Country largely outperformed all the other regions. Its PAs had almost null mean ACA rate in both zones and periods. In contrast, PAs in Asturias showed the worst performance, with a mean ACA rate of 0.04 for the three PA networks in both zones and periods.

3.8. Research hypothesis 7: There were differences in unprotected land development rates among regions

This hypothesis is supported by evidence. ACA figures outside PAs were best in Asturias (mean ACA rate of 0.04 in the three control types in both zones and periods). In turn, the Basque Country showed the worst mean ACA rate control figures (0.09).

3.9. Research hypothesis 8: Differences in PA effectiveness among regions are influenced by the political sign of governments

This hypothesis is largely unsupported by evidence. Each region had a prevailing political party in power of distinct theoretical ideology during most of the time of the study. Nevertheless, both Asturias, with social-democrat governments in both periods, and Galicia, with conservative governments in both periods, had similar mean ACA rates in PAs in each period: 0.00 and 0.07 for Asturias, and 0.00 and 0.05 for Galicia, respectively. Moreover, thirty yearlong mean regional ACA rates in PAs were similar among Asturian social-democrats (0.04), Galician conservatives (0.03) and Cantabrian conservative-regionalists (0.03), the only exception being Basque Country's nationalists, with consistent exceptionally good PA effectiveness figures (almost null ACA rate) in both periods (Appendix 3).

3.10. Methodological hypothesis 1: Near controls are more bio-physically similar to cases than distant controls

This hypothesis is largely unsupported by evidence. Mean similarity by zone and PA category for random controls was generally greater than for standard adjusted controls (Table 4).

Table 4
Mean Proportional Absolute Change in Artificial area (ACA) rate figures in protected areas (cases, all categories) and controls (all controls) in both periods.

	Period 1	Period 2
Cases	0.00	0.01
Controls	0.03	0.09

3.11. Methodological hypothesis 2: Adjusted controls are more biophysically similar to cases than standard controls

This hypothesis is largely supported by evidence. Mean similarity was equal or greater in both biophysically adjusted controls than in the standard controls (Table 5).

4. Discussion

4.1. PA effectiveness

Multiple-use PAs were an effective territorial policy instrument in Atlantic Spain to reduce land development between 1987 and 2018. With few exceptions, the three PA categories showed lesser land development figures than their controls, as shown previously for the whole country (Martínez-Fernández et al., 2015; Rodríguez-Rodríguez and Martínez-Vega, 2018). Nevertheless, land development has occurred in the three PA networks to a moderate or even large extent, especially in the coastal zone and in period 2. These results point to the same direction as a recent study showing average relative increases of 21.1% in artificial areas in Natura 2000 sites across Europe between 1990 and 2012 (Kubacka and Smaga, 2019). In their study, these authors stated a worrisome 82% relative increase in artificial areas in Natura 2000 sites in Spain in that period, the fourth largest such increase of 21 European countries. Large urbanisation rates in Mediterranean Spanish regions were reported for the 1987–2006 period, with substantially less land development figures for the four Atlantic regions of this study (Jiménez, 2012; Martínez-Fernández et al., 2015; Rodríguez-Rodríguez et al., 2019). Construction rates in Spain peaked in 2006 and showed a stark decrease with the beginning of the global financial crisis and the internal housing crisis in 2008 (Esteban and Altuzarra, 2016). Since then, new residential constructions have remained stable at a much lower rate of 5–10% of the 2006's rate until 2018 (Spanish Government, 2019d). Moreover, the total resident population decreased in Galicia and Asturias between 2007 and 2018, only increasing in Cantabria and the Basque Country in that period (Instituto Nacional de Estadística, 2020b). Given that the bulk of new artificial land uses in Spanish PAs in the 1987–2006 period were residential (Rodríguez-Rodríguez and Martínez-Vega, 2018) and the huge reduction in new residential developments in the country from 2008 (Spanish Government, 2019d), the large difference in land development figures that occurred in Atlantic Spain in period 2 with regard to period 1 is most likely not real entirely. Martínez-Fernández et al. (2019) found substantial underestimation of artificial areas in the period 1 versions of CLC compared to post-2006 versions due to CLC production from finer scale generalisation methods leading to more valid results since 2006. Therefore, relatively greater ACA rates in period 2 should be attributed partly to methodological improvements and partly to real LULC changes.

Increases in artificial areas largely concentrated on the coast chiefly affecting SPAs in Asturias, Galicia and Cantabria as well as control areas in the Basque Country, which suggests either internal residential migration from inland zones to coastal zones and/or substantial contributions to land development figures by other artificial land uses,

Table 5
Mean cross-zone and cross-PA network biophysical similarity values between cases and controls for the three covariates.

	STD	STAd	RD
Altitude	0.92	0.91	0.91
Distance to cities	0.87	0.87	0.89
Size	0.85	0.87	0.95
Mean	**0.88**	**0.88**	**0.92**

STD: Standard controls; STAd: Adjusted standard controls; RD: Random controls.

including industries, infrastructures and mining sites in Atlantic Spain between 2006 and 2018. The fact that 14 of the 19 major cities of Atlantic Spain were in the coastal zone back in 1991 most likely contributed to coastal development figures, especially of control areas mostly closer to urban centres (Esteban and Altuzarra, 2016). Similar to other south-European and Latin-American countries (Dias et al., 2013), land development pressure along the Spanish coastal ecosystems is one of the country's most serious, long-lasting environmental issues (Jiménez, 2005; Montes et al., 2011). It is also a complex, multi-factorial one that involves economic development, substantial employment provision, local councils' budgetary availability, ineffective territorial planning and supervision, little social opposition, and political corruption (Jiménez, 2009).

Akin to previous studies (Martínez-Fernández et al., 2015; Rodríguez-Rodríguez and Martínez-Vega, 2018; Rodríguez-Rodríguez, 2019), a PA effectiveness gradient was suggested from NPs $\geq$ SCIs $>$ SPAs, and adds to evidence against equal consideration of Natura 2000 sites's categories for conservation (Davis et al., 2014; Martínez-Fernández et al., 2015; Kubacka and Smaga, 2019). Our results align with the limited effectiveness values of SPAs across Spain between 1987 and 2006 shown by Rodríguez-Rodríguez and Martínez-Vega (2018) but contrast with the good effectiveness values shown by coastal SPAs in the whole country also between 1987 and 2006 (Rodríguez-Rodríguez et al., 2019). These authors speculated about the very differential performance of coastal versus inland SPAs in Spain as possibly due to: the predominantly agrarian character of inland SPAs, which are subject to more than double land development pressure than natural land covers (Martínez-Fernández et al., 2015); SPA's long-lasting absence of active management; or to greater legal protection of coastal SPAs. Although legal overlap was not studied here and the proportion of agrarian land covers in coastal SPAs was relatively small at 13%, Atlantic coastal SPAs were actually the PA category with the largest agrarian land cover, more than doubling the rest of PA categories in both zones, including inland SPAs. In light of these worrisome results, ascertaining and addressing the causes of the limited effectiveness of Atlantic coastal SPAs in Spain outstands as a priority of this study. Designating some of these PAs as legally stringent Nature Reserves or National Parks might help avoid further ecosystem destruction in them (Rodríguez-Rodríguez and Martínez-Vega, 2018).

Active site management did not seem to substantially influence land development in PAs, as previously suggested (Rodríguez-Rodríguez and Martínez-Vega, 2018). Not only were average land development results similar between NPs and SCIs, but also coastal SCIs experienced notably more land development in period 2, when many of them had most likely been designated as SACs and provided with management plans and active management, as European regulations require (European Economic Community, 1992). The deadline to do so for SCIs in the Atlantic biogeographical region was December of 2010 (Europarc-España, 2020a), although delays and other infringements in the application and transposition of the European Union's environmental legislation are common in Spain (European Commission, 2020b). Even though NPs showed the same global and zonal mean land development values as SCIs, land development in NPs were mostly restricted to coastal NPs in Cantabria, whereas it was more widespread across regions in chiefly coastal SCIs. Thus, NPs' overall effectiveness seems to be more conditioned by regional policy than by its legal or managerial characteristics.

Social-democratic, conservative or regionalist-driven policies rendered similarly limited outcomes regarding PA effectiveness, in contrast to some claims that left-wing parties might promote unnecessary or speculative residential developments to a lesser extent than right-wing parties in local governments in Spain (Esteban and Altuzarra, 2016). This might have been true for non-protected areas, which experienced notably less land development in social-democrat Asturias than in conservative Galicia, both loosing residents in the second period of the study (INE, 2020). Though political factors are seldom specifically addressed in conservation studies, a number of studies around the World have noted the key influence of political decisions in protecting biodiversity (Chhatre and Saberwal, 2005; Bernard et al., 2014; Mascia et al., 2014; Qin et al., 2019). Land development plans are developed and approved in a long, multifaceted process by local governments in Spain, with regional governments having territorial planning competencies by which local plans must abide as well as oversight competencies over passing local development plans, including compulsory environmental impact assessments (Iberley, 2018). Regional governments are also responsible for PA designation and management in their regions. Thus, regional governments are co-responsible with local governments of land development processes in their territories and fully responsible of conservation of biodiversity in their PAs, except in National Parks, for which some central government's guidelines must be abided by. Only the nationalist, ideologically pragmatic PNV put in place a truly effective regional policy for in-situ conservation of biodiversity in the Basque Country. This is illustrative, as the Basque Country is the most urban region hosting six of the 19 major cities in Atlantic Spain in 1991 and the region with the greatest population density in all the study period, nearly tripling the other regions in 2018 (Instituto Nacional de Estadística, 2020b). These characteristics may help explain the largest regional land development figures in unprotected areas and would also suggest greater pressure on its PAs. Thus, demographic and urban factors being less favourable than those in the other regions and climatic, protection and geographic factors being similar, substantial regional differences in PA effectiveness may be attributed to other factors such as the region's governance and related environmental and housing policies (Jiménez, 2009). Thus, political factors determining policies and policy instruments through governance processes seem to be relevant in the effectiveness of nature conservation in Spain and should be considered in environmental studies (Jacob et al., 2019).

4.2. Methodological considerations

Biophysical similarity between cases and controls was generally greater than in previous studies using the same indicator (Rodríguez-Rodríguez et al., 2019). This may be due to the more restricted spatial scale of this study (Martínez-Fernández et al., 2019) and/or to better biophysical adjustment of controls. Random controls generally had greater similarity to their cases and thus produced more valid results than standard controls and adjusted standard controls. They also usually provided larger control areas (in 19 of 20 pair-wise comparisons) which minimises the risk of running out of control area when adjusting standard buffers and likely includes a broader range of covariate classes that match those of cases, thus further reducing the loss of study area. Thus, the use of random adjusted controls generated across the territory is suggested from this analysis. Inter-period result comparisons should be interpreted with care given relevant changes to methodological accurateness from the 2006 version of CLC in Spain and other European countries, with an overall underestimation of land development in period 1 that was partially offset by our 'improved' CLC 2006 artificial layer (Martínez-Fernández et al., 2019).

5. Conclusions

Multiple-use PAs reduced land development in Atlantic Spain for the past three decades, both inland and on the coast, proving to be a useful biodiversity conservation policy instrument. However, their use to counter the huge land development pressure on the country's coastal environment is sub-optimal, leading to some artificial developments inside PAs. A closer look at the causes of the limited effectiveness of the region's coastal SPAs is urgently needed if important bird biodiversity is to be healthily maintained. The nationalist Basque Country's government has been most successful at its onsite biodiversity conservation policy in the study period, with all the other regions showing improvable figures. In this sense, including governance and politics in the effectiveness equation will most likely entail a number of advantages in environmental assessments, including: more explaining results, showcasing successful governance, greater accountability, and more tailored recommendations. Finally, the use of adjusted, randomly generated controls across the territory was shown to be preferable to traditional standard buffer controls in terms of biophysical similarity and area availability.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1

Creation of bio-physically adjusted controls.

'Adjusted' controls were selected by sequentially identifying those areas in each zone (coastal or inland zone) that had similar biophysical values to their corresponding PA network for a number of covariates that have been found to influence land development:

331) Dominant land covers around 1990.
   We reclassified CORINE Land Cover 1990′s (CLC90; IGN, 2020a) LULCs using the following land cover classification: Agrarian land use (CLC90′s subclasses 2.1, 2.2 & 2.3); Semi-natural land use (CLC90′s subclasses 2.4, 3.2 & 3.3); & Forest land use: CLC90′s subclass 3.1. Land cover classes covering less than 15% of each PA network in each zone (e.g. agrarian covers in Nature Parks in the coastal zone) were deleted from their controls. Only agrarian land covers were deleted, as they just covered between 3.05% and 12.72% of the PAs' network's areas. As a result, only forest and semi-natural land covers were retained for controls.
332) Altitude.
   We interpolated altitude isolines to a discrete 1 km^2 raster, 100 m interval model of the Spanish land territory (IGN, 2020b) with the PP's layer to ascertain altitude ranges among PA networks and zones. The proportions of each altitude class in each PA network and zone were computed. Altitude classes representing less than 1% of each PA network in every zone were deleted from their controls.
333) Distance to main cities.

The Near function of Arc-GIS v.10.5 (Environmental Systems Resource Institute, 2018a) was used to calculate the straight distances between each individual PP and the centroid of a city of ≥ 50.000 inhabitants in 1991; Instituto Nacional de Estadística (2020b). Then, the shortest and largest distances to those cities from PPs of each PA network and zone were identified and control areas outside those ranges were excluded.

This way, we made sure to compare climatically (the Atlantic region), geographically (the same zone) and bio-physically similar cases and controls (regarding LULCs, altitude and distance to main cities). Thus, adjusted controls included forest and seminatural areas that were within representative altitude ranges and the same distance ranges from major cities as their cases in each zone (e.g. Nature Parks of the coastal zone). For standard adjusted controls, those characteristics existed just in a 5 km radius around PPs, whereas random controls mimicked an experimental research design by selecting any areas in the territory that met similar bio-physical requirements to their cases, irrespective of their location.

The year 1990 (t_1) was selected as the baseline year for bio-physically matching cases and controls in both periods, as later divergences may be attributed to protection.

Appendix 2

Bio-physical similarity between cases and controls.

Zone	Network	Altitude (m)	Distance to cities (km)	Size (ha)	Similarity PA-Control
Coastal	NP	250	14.35	1824	
	NP-ST	300	22.4	8955	0.75
	NP-STAd	200	7.17	50	0.83
	NP-RD	200	9.9	59	0.91
	SCI	450	25.16	533	
	SCI-ST	400	35.4	34	0.92
	SCI_STAd	250	19.58	53	0.89
	SCI-RD	250	12.98	58	0.85
	SPA	100	32.99	693	
	SPA-ST	250	27.33	34	0.86
	SPA-STAd	100	24.08	149	0.92
	SPA-RD	100	27.65	72	0.96
Inland	NP	1000	17.59	15180	
	NP-ST	1000	30.12	611	0.87
	NP-STAd	1050	29.34	103	0.81
	NP-RD	1050	28.25	72	0.92
	SCI	1250	32.73	1142	
	SCI-ST	1200	45.56	554	0.95
	SCI_STAd	950	28.22	81	0.94
	SCI-RD	950	25.79	75	0.93

(*continued on next page*)

(*continued*)

Zone	Network	Altitude (m)	Distance to cities (km)	Size (ha)	Similarity PA-Control
	SPA	1250	45.91	6849	
	SPA-ST	1150	49.98	1794	0.93
	SPA-STAd	1100	48.07	169	0.89
	SPA-RD	1100	46.03	100	0.93

Median covariate values in each zone and network and biophysical similarity between cases and controls.

NP: Nature park; SCI: Site of Community Importance; SPA: Special Protection Area; ST: Standard control; STAd: Adjusted standard control; RD: Random control.

Appendix 3

Political parties in power and mean ACA rates in PAs in each region.

Period	Term period	Region (sub-zone)			
		Asturias	Cantabria	Galicia	Basque Country
Period 1	1987–1991	PSOE	PP	PP	PNV
	1991–1995	PSOE	PSOE	PP	PNV
	1995–1999	PP	PP	PP	PNV
	1999–2003	PSOE	PP	PP	PNV
	2003–2007	PSOE	PRC	PP	PNV
	Prevailing party	**PSOE**	**PP**	**PP**	**PNV**
	Ideology	**Social-democrat**	**Conservative**	**Conservative**	**Nationalist**
	Mean ACA rate	**0.00**	**0.03**	**0.00**	**0.00**
Period 2	2007–2011	PSOE	PRC	PSOE	PSOE
	2011–2015	PSOE	PP	PP	PNV
	2015–2019	PSOE	PRC	PP	PNV
	Prevailing party	**PSOE**	**PRC**	**PP**	**PNV**
	Ideology	**Social-democrat**	**Regionalist**	**Conservative**	**Nationalist**
	Mean ACA rate	**0.07**	**0.03**	**0.05**	**0.00**
All study	**Prevailing party**	**PSOE**	**PP; PRC**	**PP**	**PNV**
	Ideology	**Social-democrat**	**Conservative; Regionalist**	**Conservative**	**Nationalist**
	Mean ACA rate	**0.04**	**0.03**	**0.03**	**0.00**

Note: PSOE: Spanish Socialist Worker's Party; PP: People's Party; PRC: Cantabrian Regionalist Party; PNV: Basque Nationalist Party.

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