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Effectiveness of protected areas against land development in coastal areas of the Mediterranean global biodiversity hotspot

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ABSTRACT

The Mediterranean Basin is a heavily pressured World biodiversity hotspot. Mediterranean coastal areas are especially threatened due to tourism, inland migration and population growth, jeopardizing the remaining natural habitats. Protected areas (PAs) aim to conserve biodiversity and ecosystem services in the long term. Here, we assessed whether coastal PAs in 16 Mediterranean countries had been effective at conserving natural habitats from land development between 2000 and 2020, using a Before-After-Control-Impact design with covariates and case-control matching in R. Mediterranean coastal PAs were effective in reducing land development, with just one exception: Israel. Legally stringent reserves were generally more effective than legally lenient multiple-use PAs, with few exceptions: Albania, France and Cyprus. In a number of countries, reserves completely prevented coastal land development, which shows that reserves are a useful tool to preserve waning Mediterranean coastal habitats. Institutional, social, economic and geographic explanatory factors were analysed for PA effectiveness at country scale, but no significant results were found, suggesting high specificity of PA effectiveness.

1. Introduction

Loss of natural and semi-natural ecosystems due to land use-land cover (LULC) changes is the major cause of biodiversity loss worldwide (IPBES, 2019). LULC changes threaten world biodiversity hotspots like the Mediterranean Basin in which exceptionally high numbers of endemic species face high rates of habitat transformation (Myers et al., 2000; Olson et al., 2001). Among all LULC processes, land development is considered the most serious to biodiversity, as it usually entails complete and irreversible destruction of existing habitats (McKinney, 2002). Land development is especially impactful in highly singular, ecologically sensitive, and spatially restricted coastal habitats (MEA, 2005). However, coastal habitats are under huge developmental pressure in settings like the Mediterranean Basin as a result of population growth, emigration of local populations to coastal settings, tourism development, and climate change (Dias et al., 2013; UNEP/MAP, 2020).

Protected areas (PAs) are aimed at conserving biodiversity and ecosystem services in the long term (Dudley, 2008). They are the primary conservation tool used to stop the global biodiversity crisis (IPBES, 2019). However, their effectiveness at conserving biodiversity has seldom been proved until recently, with PA coverage often leading national and international PA assessments

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(UNEP-WCMC & IUCN, 2016). The 2030 EU Biodiversity Strategy as well as recent regional policies stress the need to assess the effectiveness of PAs in achieving biodiversity conservation (European Commission, 2020; Hoffmann, 2021). Some factors determining PA effectiveness, such as location, PA regulation stringency and governance have been studied to some extent (Rodrigues and Cazalis, 2020; Rodríguez-Rodríguez and Sinoga, 2022), although a global consensus has not been reached, as PA effectiveness seems to be highly context specific (Rodríguez-Rodríguez and Martínez-Vega, 2022). Studying and attaining PA effectiveness in preventing land development is especially urgent in the coastal areas of the Mediterranean region given the small area of natural and semi-natural habitats remaining and the huge developmental pressure on this extraordinarily important region for global conservation (European Commission, 2018a).

Here, we aimed to test three research hypotheses (RH) on Mediterranean coastal PAs effectiveness: (RH1) Are Mediterranean coastal PAs effective to conserve natural and semi-natural habitats?; (RH2) Does the stringency of protection affect land development?; (RH3) Do institutional, economic, social, or geographic factors have an effect on the probability of land development occurring in PAs?

2. Methods

2.1. Study area

The scope of this study was limited to the Mediterranean biome in the Palearctic realm as defined by the World Wildlife Fund Global 200 Terrestrial Ecoregions (Olson and Dinerstein, 2002), specifically to the coastal area of the basin's surrounding countries. The European Commission's Eurostat's spatial delimitation of coastal areas as 10 km inland areas from the coastline was followed (European Commission, 2018b). Given that climate was shown to affect PA effectiveness through differential land development rates (Martínez-Fernández et al., 2015; Rodríguez-Rodríguez et al., 2019), only coastal areas of similar climate were selected. For this, we used the Global 200 ecoregion for Mediterranean forests, woodlands, and scrub which share a similar climate (Olson and Dinerstein, 2002). Thus, any coastal areas belonging to ecoregions with different climates were removed. These included the Deserts and Xeric Shrublands of parts of Egypt, Libya, and the temperate coniferous forests of Northern Italy (Fig. 1). To create the study area, a number of shapefiles were downloaded and processed using QGIS version 3.16.15: WWF G200 terrestrial ecoregions data was downloaded in vector format (World Wildlife Fund, 2012)); the International Hydrographic Organisation's boundaries of the World's seas (Flanders Marine Institute, 2018) and land mass and country data from the Global ADMinistrative Areas (GADM) database version 3.6, available

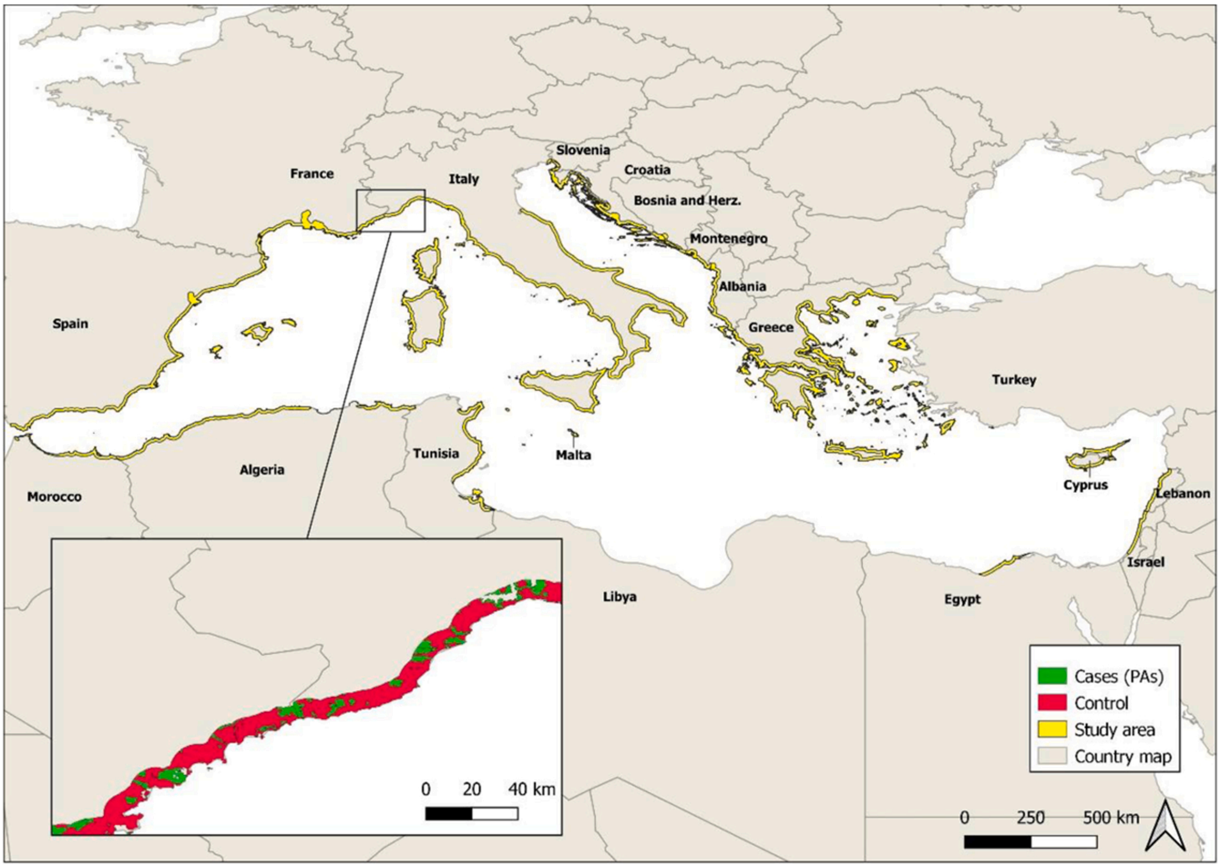

Fig. 1. Study area, including case and control areas (in zoomed map).

at https://gadm.org/, was used to create the 10 km inland coastal buffer.

2.2. Land use-land cover data and PA data

Raster layers of LULC data were downloaded from the European Space Agency Climate Cover Initiative (ESA-CCI) database of global land cover maps at a 300 m spatial resolution for the years 2000 and 2020 (ESA, 2017) which are divided into 22 LULC classes. For this study, the category used to assess land development was 'urban areas'. It is comprised of a combination of the Global Human Settlement Layer (Pesaresi et al., 2016) and the Global Urban Footprint (Earth Observation, 2016). The comparison between the presence of artificial land cover in 2000 versus 2020 was used to signify changes over a 20-year period and act as a proxy for land development in that particular pixel.

PAs vector data were downloaded from the World Database on Protected Areas (UNEP-WCMC, 2021). The PAs were split into two broad protection categories: strict protection 'reserves' and less strict 'multiple-use' PAs. Each PA was assigned either category according to its IUCN PA Management Category (Dudley, 2008). Categories Ia, Ib and II, which represent strict nature reserves, wilderness areas and national parks, were deemed legally highly restrictive 'reserves', while category IV, V and VI sites were deemed 'multiple-use' because of their greater legal leniency, as they allow the sustainable use of natural resources and even some controlled land development. Previous studies have used the same categorisation technique (Jones et al., 2018; Vimal et al., 2021). Category III: 'Natural Monument or Feature' was excluded from the analysis, primarily due to the large number of point data compared to polygon data available for the category from the WDPA database. Additionally, much of the Category III PAs represented small, individual monuments, caves, or other geological features that are too small in area to be significantly monitored for LULC change or that are unlikely to experience surface modifications e.g. underground caves and caverns. Where there was an overlap between multiple PAs with different IUCN designations, the area was assigned according to the strictest IUCN category present.

For those PAs given as point data, a circular buffer around the point was created representing its area, a usual procedure by WDPA managers and users (Jenkins and Joppa, 2009; UNEP-WCMC, 2019). For point data which did not include its area, an average of the other points within the same IUCN category was used to create a polygon. This method was preferred over excluding all point data. Any PAs smaller than the minimum mapping unit (MMU) of the land cover data of 0.09 km^2 were eliminated.

Some countries for which complete or reliable PA data could not be retrieved were removed from the study. These included Syria, Turkey, and Libya. Ramsar sites were reported by some countries as highly legally stringent 'reserves' to the WDPA. However, that is not generally the case in many Mediterranean countries where Ramsar sites are mostly multiple-use PAs where a broad range of human uses is allowed (Geijzendorffer et al., 2019). Thus, for providing results for RH2, we included Ramsar sites as 'multiple-use PAs', if they did not overlap with other IUCN 'reserve' categories.

2.3. Research design

We used a Before-After-Control-Impact (BACI) research design with covariates whereby land development was compared *before* and *after* the legal designation (*impact*) of a census of PAs (cases; $N = 1907$ totalling 67,198 km^2) inside those PAs and outside them, in bio-physically similar *control* areas comprising 182,369 km^2. Random points ($n_1 = 402{,}772$) within PAs were compared to a pool of control points ($n_2 = 948{,}281$) of similar characteristics in the study area at two dates: t1 (2000) and t2 (2020). All PAs designated before 2000, after 2019 or those without a designation date were removed from the PA sample. Additionally, any marine or freshwater areas were removed for cases and controls, as land development was very unlikely in them. The control group consisted of any non-water terrestrial land within the study area that was not a PA at any point in time, and that was not an urban area before 2000.

In order to account for bias in land development of sites which have a greater or lesser disposition for it, 'matching methods' were used to select control points with similar characteristics to case points, therefore leaving protection as the primary difference to evaluate (Andam et al., 2008). The covariates chosen as potential confounding factors were those related to ease of access and land suitability for development and human use: slope, elevation, distance to nearest city considered as 'urban centre' (European Commission, 2021), and distance to major roads (Anderson and Mammides, 2020).

ArcMap v. 10.5 was used to generate random points within both the PA layer and the control layer based on their areas, for a total of roughly 1 point per 150 m^2 for PAs and over twice as many points in the controls. In QGIS, the plugin "Point Sampling Tool" was used to extract information for each point. The data recorded for each point included: (1) LULC in 2000 (ESA CCI Land Cover, 2000); (2) LULC in 2020 (ESA CCI Land Cover 2020); (3) elevation; (4) slope; (5) distance from the nearest city; (6) distance from the nearest road; (7) whether the point was a reserve or multiple-use; (8) whether the point was within a PA; and (9) the governing country (Andam et al., 2008; Amatulli et al., 2018).

Distance from the nearest road and distance from the nearest city were calculated for every point using the QGIS plugin NNJoin and the GRIP global roads dataset (Meijer et al., 2018) for highways and primary roads, and the global human settlement layer (JRC, 2021). Data for slope and elevation was downloaded from a 250 m digital elevation model GMTED2010 and near-global 90 m SRTM4.1dev (Amatulli et al., 2018).

2.4. Matching Methods

The statistical software R was used to perform matching methods and to analyse the data. The package 'MatchIt' in R performed the matching sequence which chose a matching control point for every case point based on their similarity regarding the inputted covariates. The two sets of points were matched exactly by country to ensure equal controls for each country and the remaining four covariates were matched using nearest neighbour matching. The Mahalanobis distance metric was chosen, along with a caliper of 0.2 indicating the maximum difference allowed between a matched pair thus improving the balance (Andam et al., 2008). Matching with replacement for Slovenia allowed enough Slovenian case points to be included in the study by reusing some control points for multiple case point matches.

Logistic regression was used for RHs 1 and 2 where the outcome variable (artificial land cover increase) was binary (0 for no increase, 1 for an increase). The inputted independent variables were also binary: PA presence (0 for no PA/control, 1 for PA presence) and PA strictness (0 for multiple-use, 1 for reserve). Univariate GLMs were used for research questions 1 and 2 to test for differences in artificial land cover increase within PAs and their controls and to test for differences in artificial land cover increase within reserves of multiple-use PAs. Odds ratios were used as a standardised metric for PA effectiveness. ORs measure the association between land development occurring and the presence of protection against control sites (RH1) or different protection categories (RH2). An OR of 1 means there is an equal likelihood of land development occurring regardless of protection. An OR < 1 implies a negative relationship and therefore a decrease in development when protected, and > 1 implies there is an increase in development when protected. If the OR lies within the range of the confidence interval (CI), it does not reach statistical significance and therefore does not show an association between the control and protection, or an association between strict and multiple-use protection. This makes development equally likely in either scenario. Alternatively, if the OR lies outside the bounds of its confidence interval, it shows there is a statistically significant difference. The CI is also used to estimate the precision of the OR depending on how narrow or broad the interval is.

2.5. Other factors affecting PA effectiveness

Ten institutional, economic, social, and geographic variables from a diversity of sources were chosen as potentially influential factors on PA effectiveness within countries. These included: GDP per capita, unemployment, Human Development Index, Global Peace Index, regulatory enforcement, political corruption, transparent laws with predictable enforcement, representative government, average maximal temperature, and average precipitation per year (Supplementary Material 1). Available annual data for each factor between 2000 and 2020 were collated, the median for each variable and country ($n \leq 21$) was calculated and compared to the odds ratio (OR) of land development occurring within each country. The non-parametric Kendall's rank correlation coefficient was used for RH 3 to test whether the chosen factors influenced the likelihood of artificial land cover increase within PAs, following non-normality of data.

3. Results

3.1. Similarity of the samples

The Mean Standardised Difference (MSD) for each covariate was greatly improved after matching of the cases to the control points was performed. This means that the similarity distance between the two means of each group of points was reduced after matching for all covariates. A balance of MSD ≤ 0.25 was unanimously generated in our samples.

Table 1

Summary statistics for each country, including the odds ratios and their 95% confidence intervals and p-values, and proportions of artificial cover increase in the control and case points from 2000 to 2020. An asterisk (*) represents countries with statistically insignificant results due to no artificial cover increase. (†) denotes countries with unequal point matching.

Country	Point pairs (n)	Raw Proportion: Controls	Raw Proportion: Cases	Odds Ratio	Confidence Interval (2.5%, 97.5%)	P-value
Albania	5644	0.012	0.00620	0.53	(0.34, 0.78)	0.0018
Algeria	892	0.035	0.0056	0.16	(0.053, 0.37)	1.29E-04
Bosnia & Herzegovina*	20	0	0	1	NA	1
Croatia	61300	0.016	0.0025	0.15	(0.13, 0.18)	< 2.2e-16
Cyprus	12622	0.026	0.0094	0.39	(0.32, 0.48)	< 2.2e-16
France	40000	0.095	0.022	0.22	(0.20, 0.23)	< 2.2e-16
Spain	50927	0.059	0.0077	0.13	(0.11, 0.14)	< 2.2e-16
Greece	147826	0.014	0.0032	0.22	(0.20, 0.25)	< 2.2e-16
Israel	303	0	0.0066	4.2E+ 07	(1.574e-198, NA)	0.995
Italy	69448	0.032	0.015	0.46	(0.43, 0.50)	< 2e-16
Lebanon*	5	0	0	1		1
Morocco	4271	0.0049	0.0030	0.62	(0.30, 1.22)	0.17
Malta	1044	0.035	0.0067	0.18	(0.075, 0.39)	4.35E-05
Montenegro*	122	0	0			1
Slovenia†	915/3400	0.020	0.0053	0.26	(0.14, 0.50)	5.87E-05
Tunisia	2794	0.022	0.0050	0.22	(0.12, 0.39)	4.04E-07
Overall	*402772*	*0.031*	*0.00845*	*0.27*	*(0.26, 0.28)*	*< 2.2e-16*

3.2. Effects of PAs on land development

The hypothesis that PAs reduced land development compared to controls (RH1) was almost unanimously followed. The specific odds ratios (OR) for each country and their 95% significance level and p-values are shown in Table 1. The only exception was Israel, with slightly greater land development in its PAs than in control sites, although the difference was not statistically significant.

3.3. Effectiveness of reserves versus multiple-use PAs

RH2 was met by most Mediterranean countries. There were, however, few exceptions, including countries were reserves performed similarly to multiple-use PAs (Cyprus and France) and one country were multiple-use PAs outperformed reserves (Albania). Three groupings of countries could be made: (1) Countries with statistically different performance between reserves and multiple-use: Spain (meeting RH2) and Albania (opposite to RH2); (2) Countries with statistically similar, moderate performances, such as France and Cyprus; and (3) Countries meeting RH2 with statistically insignificant results due to maximal reserve performance (null land development), including Algeria, Croatia, Greece, Israel, Italy, Morocco, Malta and Tunisia. Bosnia & Hercegovina and Montenegro had no random points in reserves, whereas Lebanon and Slovenia both had less than 10 points inside reserves, so they were excluded from the analysis. The complete results for RH2 are shown in Table 2.

3.4. Explanatory factors for effectiveness

None of the potential explanatory factors selected proved to significantly correlate with land development figures within PAs compared to outside of PAs (Supplementary material 2).

4. Discussion

4.1. Effect of Mediterranean coastal PAs

Coastal PAs around the Mediterranean notably reduced land development in these very pressured and sensitive areas. This result aligns with a number of previous studies around the world, underpinning moderately good performance of PAs at conserving natural and semi-natural habitats (Geldmann et al., 2013; Rodríguez-Rodríguez and Martínez-Vega, 2022). More specifically, PAs have been shown to substantially reduce land development around the Mediterranean Basin, including its coastal areas (Maiorano et al., 2008; Rodríguez-Rodríguez et al., 2019). Nevertheless, these studies reveal that, with some exceptions, PAs tend to reduce, rather than stop, land development. Similarly, our results showed that all the countries in which a relatively high number of case points were analysed experienced some land development, which highlights a worrisome unsustainable development trend across the Basin. Nevertheless, our PA effectiveness results are likely to be slightly underestimated due to the fact that part of the sample of cases was designated during the final years of the assessment period (i.e. 2018, 2019), thus allowing the latest PAs little time to provide protection. Therefore, some land development in those sites may actually have occurred before such sites were designated.

The two most effective PAs were in countries belonging to the European Union: Spain and Croatia. In turn, the least effective PAs were all located outside the EU, in Israel, Morocco and Albania. The fact that the majority of PAs in the most effective countries are part of the EU-regulated Natura 2000 Network, a pan-European PA network whose objective is to conserve natural habitats and species (EEC, 1992), is likely to provide additional effectiveness to national PA designations through supra-national requirements and legally binding commitments (Fauchald et al., 2014). However, national PA designation categories have been shown more effective than Natura 2000 sites when considered separately (Martínez-Fernández et al., 2015; Rodríguez-Rodríguez et al., 2019). Kallimanis et al. (2015) found that Natura 2000 sites exhibit lower rates of land development than outside areas, but this effect decreased with newer EU member states, the majority of which are in Eastern Europe. However, this and other European-wide studies coincide in reporting

Table 2
Summary statistics for each country including the odds ratios and their 95% confidence intervals (CI) and p-values for a comparison of land development within reserves and multiple-use, and proportions of artificial cover increase in the reserves and multiple-use points from 2000 to 2020. Countries with an asterisk (*) are those with no land development in reserves and therefore a comparison could not be generated.

Country	Points in Multiple-use; Reserve (n)	Raw proportion Multiple-use	Raw proportion Reserves	Odds Ratio	CI (2.5%, 97.5%)	P-value
Albania	3641; 2003	0.00055	0.016	30.48	(9.26, 188.08)	2.75e-06
Algeria*	854; 38	0.0059	0	~0		
Croatia*	60845; 455	0.0025	0	~0		0.97
Cyprus	11876; 746	0.0093	0.011	1.16	(0.52, 2.24)	0.69
France	37980; 2020	0.022	0.025	1.15	(0.86, 1.52)	0.34
Spain	48234; 2693	0.0081	0.0019	0.23	(0.082, 0.50)	0.0011
Greece*	147462; 364	0.0032	0	~0		0.96
Israel*	63; 240	0.027	0	~0		
Italy*	69016; 432	0.015	0	~0		
Morocco*	2734; 1537	0.0048	0	~0		
Malta*	1027; 17	0.0069	0	~0		
Tunisia*	2585; 209	0.0054	0	~0		

some urban development in Natura 2000 sites in recent years (Kubacka and Smaga, 2019), even more so than in control areas, especially in Special Protection Areas deriving from the Birds Directive (Concepción, 2020).

4.2. Effect of protection regulations

We found a general but less consistent pattern of greater effectiveness of reserves when compared to multiple-use PAs, even though the fewer number of points inside reserves made them less likely to undergo land development (Ferraro et al., 2013). Nevertheless, reserves in eight countries totaling over 3000 assessment points experienced null land development in the 20-year assessment period compared to some land development in multiple-use PAs. Moreover, reserves in an additional country experienced significantly lower land development than multiple-use PAs.

The very high effectiveness of reserves in coastal Mediterranean areas suggest reserves to be the most effective on-site tool to stop natural habitat destruction in this heavily pressured environment (Rodríguez-Rodríguez et al., 2019). A number of Mediterranean countries could substantially increase the effectiveness and coverage of their PA networks (UNEP-WCMC, 2021). according to the oncoming global protection targets (CBD, 2021) by following a reserve-based protection strategy for their most concerning ecosystems. Similarly, most previous studies found reserves to be more effective than multiple-use PAs at preventing LULC changes in different settings (Pfeifer et al., 2012; Ferraro et al., 2013; Jones et al., 2018), although some studies did not find differences in maintaining naturalness between both categories (Elleason et al., 2021). Albania was the only country with significantly negative results that contradicted the hypothesis. The two Albanian reserves showed clear land development in 2020 compared to 2000. Butrinti National Park is a reserve reported by Albania to the WDPA as an IUCN category II site (Dudley, 2008). However, a new, highly developed zone within the reserve can be identified as the town of Ksamil in the municipality of Sarandë . The town has become an increasingly popular beach destination for tourists and was named the Guardian's best bargain beach holidays for 2013 (Batten, 2013). Similarly, Divjake-Karavasta National Park, which is also IUCN category II, experienced pockets of new land development from 2000 to 2020. This is equally likely due to construction for tourism as this has been identified as a key threat to the national park (Çollaku et al., 2017). The French results for 'reserves' were largely driven by one French reserve where land development was evident: Calanques National Park, an IUCN category II, lying on the outskirts of Marseille. Urban sprawl in the Mediterranean as a whole is affecting previously untouched Mediterranean coastal areas and threatening further PAs with land development (García-Ayllón, 2018; Lagarias and Stratigea, 2021). Given the high dependency of Mediterranean societies on coastal resources (UNEP/MAP and Plan Bleu, 2020), greater consideration must be taken to account for sustainable development which can strengthen natural integrity and benefit local communities alike (García-Frapolli et al., 2007).

Cyprus had 4 reserves in the study, one of which is Larnaca Salt Lake (IUCN category Ia) which had evidence of new land development surrounding the edges of the lake within the reserve in 2020 compared to 2000. An important feature to note is that Larnaca Salt Lake is also a Ramsar site. While many countries consider Ramsar sites to be multiple-use or even question the status of Ramsar sites as PAs due to their lack of strict managerial criteria and legal designation (Pliscoff and Fuentes-Castillo, 2011), Cyprus have reported their Ramsar sites to the WDPA as IUCN category Ia, otherwise considered a strict nature reserve "where human visitation, use and impacts are strictly controlled and limited" (Dudley, 2008). The result found for Cyprus may be explained by the fact that the categorisation of Ramsar sites as Ia is misleading and they should instead be considered multiple-use. In that case, Cypriot reserves would actually show far less land development.

4.3. Effectiveness factors

In addition to foremost legal and managerial factors (Dudley, 2008; Rodríguez-Rodríguez and Martínez-Vega, 2022), some institutional factors such as the control of corruption, granted property rights and public participation in public affairs have been proposed to enhance PA effectiveness (Abman, 2018). Nevertheless, in contrast to some studies that found that factors such as increased GDP/capita, PA size or human density around PAs influence PA effectiveness globally (Geldmann et al., 2015) and in tropical areas (Spracklen et al., 2015), no consistent geographic, institutional, economic or historic patterns were found to explain different PA performance at country scale around the Mediterranean Sea. Though not explicitly assessed here, PA size was suggested to be an important factor for PA effectiveness against land development by a number of studies (Maiorano et al., 2008; Leroux and Kerr, 2013; Spracklen et al., 2015). The spatially restricted nature of coastal ecosystems (Tomaselli et al., 2012) and the very high competition for land between conservation and other human uses (Sayer et al., 2013; Rodríguez-Rodríguez et al., 2019) make it challenging to designate very large PAs on the Mediterranean coast (Maiorano et al., 2008).

4.4. Methodological remarks

A regional study such as this one faced some methodological challenges. Firstly, absent or incomplete PA data in the WDPA for some large countries with long coastlines like Turkey, Libya or Syria (UNEP-WCMC, 2021) prevented a comprehensive assessment of the whole Basin. Nevertheless, we managed to assess over three-quarters of Mediterranean countries and study area across the Basin. Secondly, a limited number of points were obtained for comparison for some small countries with restricted coastline in the study area, like Bosnia & Herzegovina or Lebanon. For such spatially restricted areas, land development censuses encompassing their whole study areas are likely to be more methodologically advisable than point sampling. Finally, the IUCN's PA management category system (Dudley, 2008) has become an important step in planning, regulating and establishing new PAs in many countries (Lausche, 2011). However, it is the individual country that dictates the category assigned to the PAs that are reported to the WDPA, so there is often variation between countries in how they interpret the IUCN definitions for each category and how they report them to the WDPA (UNEP-WCMC, 2019), such as for Ramsar sites, which can pose consistency challenges to studies like this one. In turn, an acceptable balance of MSD equal or less than 0.25 for all the considered covariates was achieved, which ensured a valid comparison of our samples of cases and controls (Austin, 2009; Stuart et al., 2013).

5. Conclusions

Coastal Mediterranean PAs were almost unanimously effective at reducing land development across the Basin. PAs in Spain, Croatia and Algeria were the most effective ones, whereas PAs in Israel, Morocco and Albania were the least effective, respectively. Legally stringent reserves were generally more effective than multiple-use PAs, with reserves in eight countries experiencing no land development during the study period. Albania was the only deviant case to this regulation stringency pattern due to substantial tourism development in two coastal national parks. No consistent explanatory factors for PA effectiveness were found at country scale, which suggests high specificity of PA effectiveness across the Mediterranean basin.

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 A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.gecco.2022.e02223.

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