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Cover Page Footnote
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Earth's biodiversity includes all extant species; however, species are not evenly distributed across the planet. Species tend to be clustered in densely populated areas known as "biodiversity hotspots;" species which inhabit only a single area are also termed "endemic," and tend to be highly vulnerable to population-reducing changes in their environment. Biodiversity hotspots are considered priorities for conservation if the area has a high rate of endemism as well as a notable and continual habitat loss (Noss et al., 2015). Preventing biodiversity loss is a complex and multi-level decision-making process about setting priorities and defining clear biodiversity protection areas. Biodiversity loss, or the loss of entire species or sub-populations in an area, can be driven by multiple processes, including land use changes, climate change, and the introduction of invasive species (Plexida et al. 2018).

The Mediterranean Basin is one such hotspot, transecting multiple countries surrounding the Mediterranean Sea, including European, Middle Eastern, and North African countries with different systems of government and cultural perceptions of environmental resources and biodiversity. Furthermore, the basin is one the most species-rich biodiversity hotspots on Earth in terms of endemic vascular plants and has high rates of endemism for amphibians and fish, as well as being an important migration corridor for many bird species (Cuttelod et al., 2008). The hotspot is at high risk for continued biodiversity loss due to several human-driven factors including population increase and government-level environmental policies (Grainger, 2003).

One method of preserving biodiversity hotspots is the legal designation of protected areas (PAs). PA territories are clearly defined geographic boundaries recognized by law or other official means to limit human uses of the land or marine space, enshrined for long-term conservation goals (International Union for Conservation, 2018). PAs are a commonly-employed policy to achieve conservation goals. However, different habitat types and biomes tend to have markedly different proportions of their total area set aside for conservation regardless of the recommendations outlined in the Convention on Biological Diversity treaty of 1992 (Watson et al., 2014). PA effectiveness for biodiversity protection also tends to vary based on a country's domestic policies and where transnational biodiversity hotspots are managed by multiple countries (Clement, Moore, and Lockwood, 2016); establishing PAs is additionally complicated when species-rich regions across international borders and depend upon the decisions of multiple countries (Clement et al., 2016; Zimmer, Galt, and Buck 2004). As hotspot protection and biodiversity loss are issues that cross political borders, a domestic approach to preserving biodiversity through PAs may not be the most effective method of preventing habitat and species loss in hotspot zones.

Previous studies demonstrate that macro-level social and economic factors affect domestic biodiversity protection. A study examining biodiversity changes through forest loss found that both increasing per capita gross domestic product (GDP) and population density had notable effects on decreased forest area in regions considered high-priority for biodiversity protection (Morales-Hidalgo, Oswalt and Somanathan, 2015). Therefore, both increasing economic growth and population holds a potentially negative correlation to a country's terrestrial hotspot protection legislation. Furthermore, national democratic policies have irregular influence on environmental protection effectiveness. A broad literature and empirical analysis by Scruggs (2003) suggests that there is no correlation between democratic policies in a country and its environmental protection record. Other research, however, shows that democracy relates to the effectiveness of a country's PAs only when considered in context with the country's (in)equality, where greater total PA area tends to appear in democratic countries that also have low inequality (Kashwan, 2017). This research follows Boyce's inequality hypothesis, which states that different forms of inequality tend to reduce environmental protection and enhance environmental degradation (Boyce, 1994).

The purpose of this study was to examine the economic, demographic, and political characteristics of countries with the most effective domestic terrestrial PAs within the Mediterranean hotspot. Specifically, we examined the relationships between PA effectiveness in each country and GDP per capita, population density, and democracy and equality ratings. The effectiveness of PAs in each country will be determined by what percent of the total hotspot area in each country was covered by terrestrial PAs.

METHODS

For this project, we used geographic data from world borders with GDP and population data from 2010, world protected areas, world designated hotspots, and democracy and human development ratings in 2010 (Table 1). First, we identified countries with any portion of their territory covered by the Mediterranean Basin hotspot. Terrestrial PAs of the Mediterranean hotspot were separated from a worldwide data set of marine, terrestrial, and coastal PAs. We selected these target countries based on whether their territory crossed with the boundary of a raster of the hotspot area (cell size: $13000m^2$). A zonal statistics test returned each country's hotspot coverage in square kilometers (km^2). We calculated the total area in km^2 of the terrestrial PAs that covered the hotspot by country using zonal statistics. We then divided the area of the PAs in the hotspot by the total area of the country within the boundary of the designated hotspot. In order to have perspective on the completeness of our PA effectiveness percent, we also compared PA effectiveness by country to the total area of PAs covering

Table 1. Data Sources

Name	**Who Created**	**Time valid for**	**Type**	**Spatial Unit**
World Hotspots	UN Environment Programme, World Conservation Monitoring Center	2004	Shapefile	Polygons
World Designated Protected Areas	UN Environment Programme, World Conservation Monitoring Center	2017	Geodatabase	Polygons
Thematic Mapping World Borders	Bjorn Sandvik, Thematic Mapping	2009	Shapefile	Polygons
Democracy Index	Economist Intelligence Unit	2010	Table	Country
Human Development Index	United Nations Development Programme	2010	Table	Country

km^2. This allowed us to evaluate the percent of hotspot protected and the total area of protected hotspot per country.

We compared the effectiveness value to main three variables: GDP per capita, population density in 2010, and a rating of countries based on democracy-equality index (Table 2). For GDP per capita and population density per kilometer, we calculated the values from GDP in 2010, population in millions in

2010, and country area in km^2 for target countries. For our third variable, the democracy and inequality index rating, we used the EIU "Democracy Index" and the UN Development Programme's "Human Development Report" (Table 1). Creating a unique *Equality Index,* countries above the medians of democracy (6.215) and equality (.7465) were

Table 2. Democracy-development index

Country (ISO3)	**Democracy Index**	**Human Development Index**	**Equality Index** (Ratings above/below medians of Democracy and Human Development Index)	**Country (ISO3)**	**Democracy Index**	**Human Development Index**	**Equality Index**
ALB	5.86	0.454	Negative	LBY	1.94	0.756	Negative
DZA	3.44	0.724	Negative	MLT	8.28	0.826	Positive
BIH	5.32	0.711	Negative	MCO	no data	no data	Positive
BGR	6.84	0.775	Positive	MNE	6.27	0.792	Positive
CPV	7.94	0.632	Negative	MAR	3.79	0.612	Negative
HRV	6.81	0.808	Positive	PSE	5.44	0.669	Negative
CYP	7.21	0.847	Positive	PRT	8.02	0.818	Positive
EGY	3.07	0.671	Negative	SRB	6.33	0.757	Positive
FRA	7.77	0.882	Positive	SVN	7.69	0.876	Positive
GRC	7.92	0.86	Positive	ESP	8.16	0.867	Positive
IQR	4	0.649	Negative	SYR	2.18	0.646	Negative
ISR	7.48	0.883	Positive	MKD	6.16	0.735	Negative
ITA	7.83	0.872	Positive	TUN	2.79	0.714	Negative
JOR	3.74	0.737	Negative	TUR	5.73	0.737	Negative
LBN	5.82	0.758	Negative				

designated as *positively* democratic/equal, and those countries that falling below these two medians were designated *negatively* democratic with low equality (Table 3).

With the values of each variable per country calculated in our target countries layer, we joined the tables containing the zonal statistics output of PA effectiveness and the three variables and saved the new data. From this layer, we developed three scatterplots–one for each variable of GDP per capita, population density and total PA area–in comparison to the effectiveness of the PA in each country. We also generated Tukey's Five Number Summaries for PA effectiveness, total PA area, GDP per capita, and population density. To compare the efficiency of positively and negatively rated countries, we created a box-and-whisker plot according to PA effectiveness to look for an average correlation

Table 3. Results of Tukey's Five Number Summaries of each variable calculated.

Tukey's 5 Number Summary	PA effectiveness (%)	PA total (km2) in hotspot area	GDP per capita	Populations Density	Positive Democracy -Equality Index Rating	Negative Democracy -Equality Index Rating
Min	0	0	2076	3.73	0	0
Q1	0	0	4094	74.62	6.9	1.25
Median	6.98	0.065	6631	92.48	24.5	6.4
Q3	28.31	0.312	22878	119.25	31.57	9.8

Max	100.0	10.1	145,541	2846.15	100	41.192
Upper outliers	100.0	1.287 2.184 2.44 3.042 8.892 10.1	145,541	1148.65 2846.15	68.48	22.62
Lower outliers	NA	NA	NA	3.73	NA	NA

between the positive and negative democracy/inequality indexes (Figure 1). We calculated average results without outliers.

RESULTS

Overall, PA effectiveness analysis showed that Greece, Macedonia, Croatia, Morocco, France, Slovenia, and Bulgaria had notably high effective hotspot protected areas within their territories being over 30% effective and falling above the third quartile (Figure 2). Countries to the south and east of the Mediterranean hotspot showed the lowest PA effectiveness, with Egypt, Libya, Monaco, Palestine, Western Sahara, and Serbia having no PA in their territory at all. PAs in Montenegro, Malta, and Iraq did not overlap with a hotspot area in these countries, and thus also had low PA effectiveness. There was a weak positive relationship between GDP per capita and PA effectiveness on a log scale (Figure 3). Countries above the third quartile for GDP per capita, often larger European countries (Figure 4), were above the median of PA effectiveness (median PA effectiveness = 6.98% [Israel], Table 3), with the singular exception of Monaco, which has no PAs in its territory at all (Figure 4). Countries in the median GDP per capita ($6,631, Montenegro, Table 3) also fell mostly above the median PA effectiveness. Bulgaria, with a lower GDP per capita of $6,459, is a notable exception, as it holds the highest PA effectiveness with a GDP per capita below the median (Figure 2).

Based on PA effectiveness, there appeared to be an "ideal" population density of 100 people per km^2 (Figure 5). The countries with the highest PA effectiveness were clustered around 100 people per km^2, and countries of higher and lower population density above and

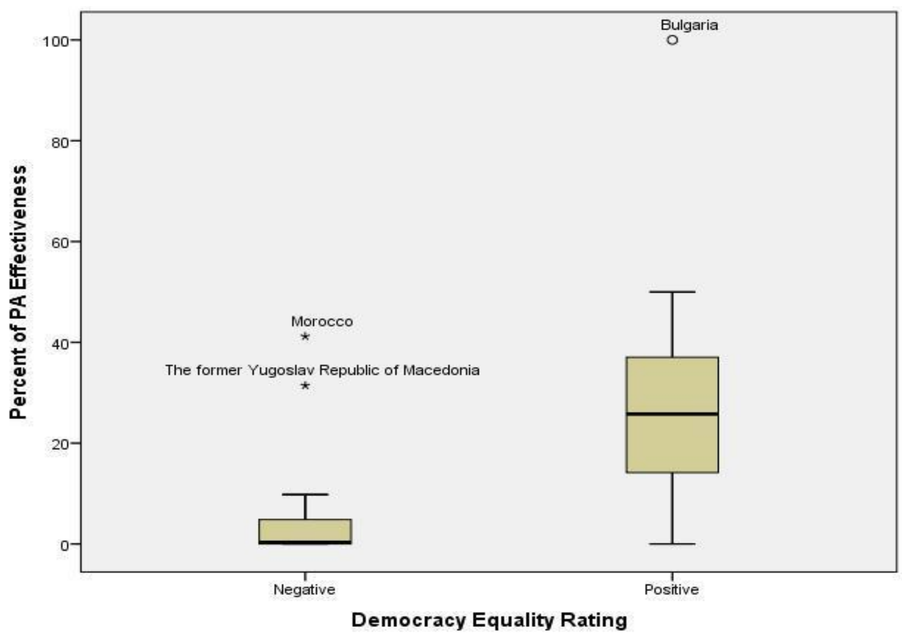


Figure 1. Comparison of positively rated and negatively rated countries on the democracy-equality index based on percent PA effectiveness.

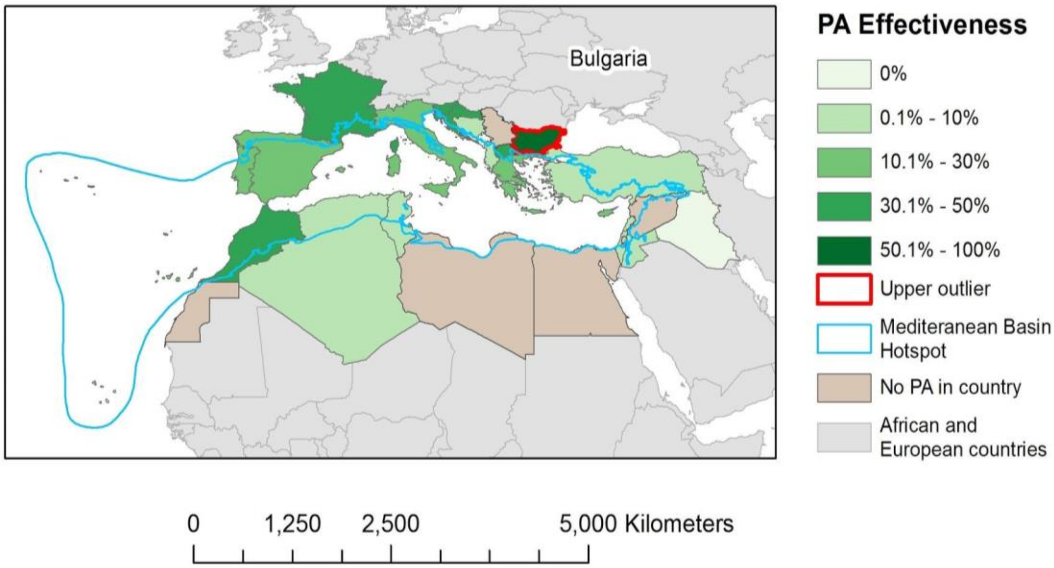


Figure 2. PA effectiveness in countries of the Mediterranean Basin hotspot

below this mark tended to have lower PA effectiveness the farther the population density was from 100 people per km^2 (Figure 5).

Positive and negative democracy/equality index ratings of the test countries are listed in Table 2. Ignoring PA effectiveness outliers for each group, the mean effectiveness of positive countries was calculated to be about 21%, while the effectiveness of negative countries was around 1.3%. The results of the average PA effectiveness according to the positive and negative indexes are compared with a box-plot (Figure 1). Geographically, the countries with high PA effectiveness and positive index rating were predominantly European countries on the northern border of the hotspot, and negative index countries largely overlapped with low PA effectiveness -rated countries in the south and east of the hotspot (Figure 6).

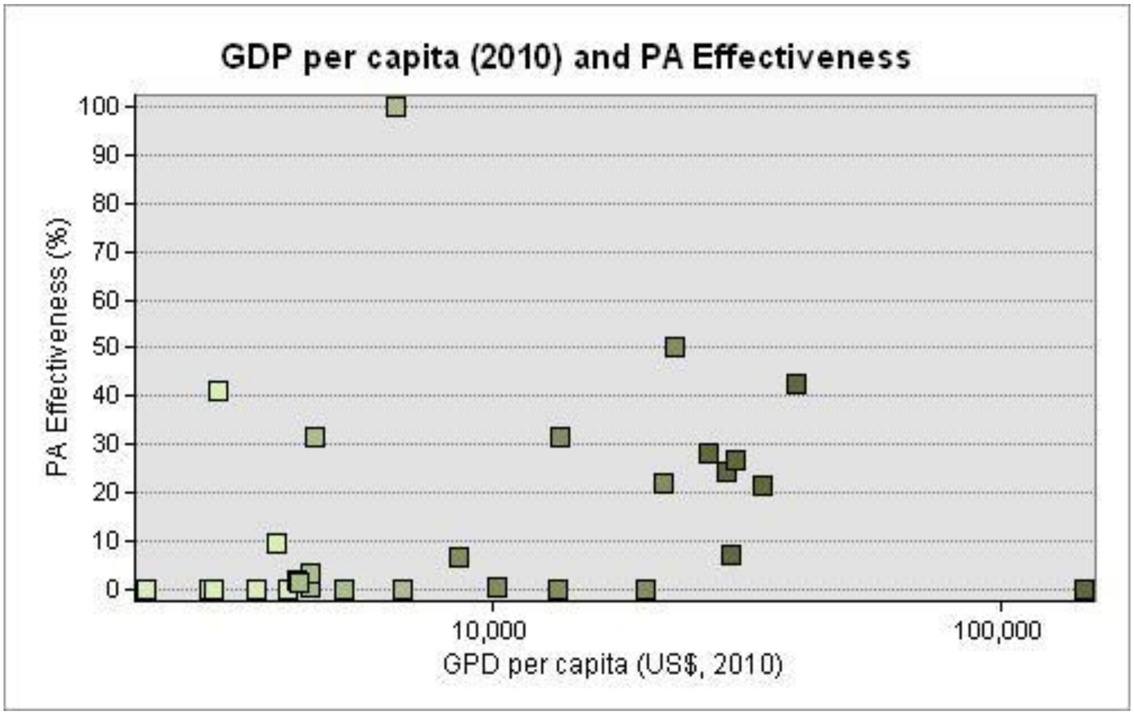


Figure 3. GDP per capita (in US $, 2010) compared to PA effectiveness by country in the Mediterranean Basin hotspot.

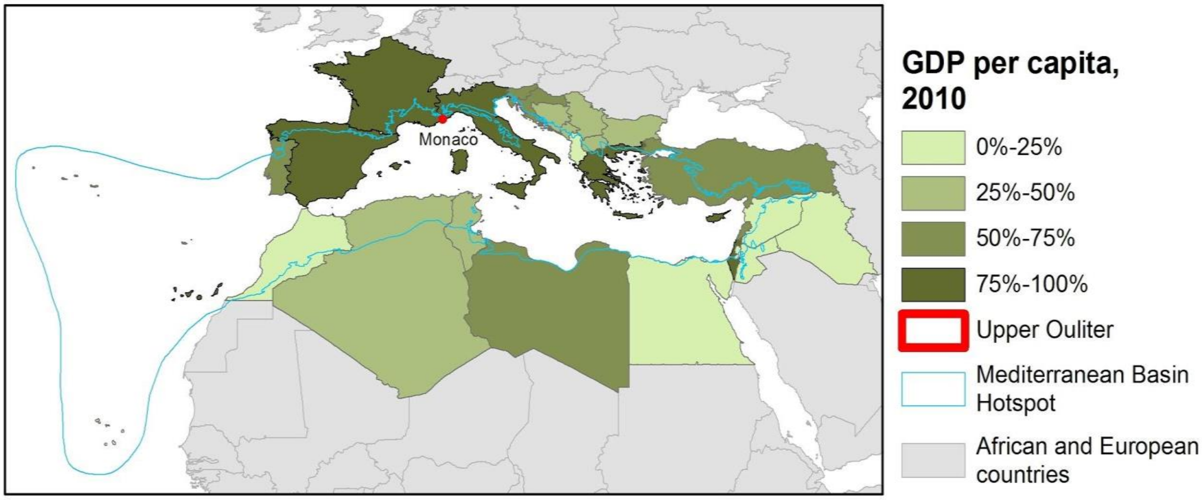


Figure 4. Distribution of countries by GDP per capita in the Mediterranean Basin hotspot.

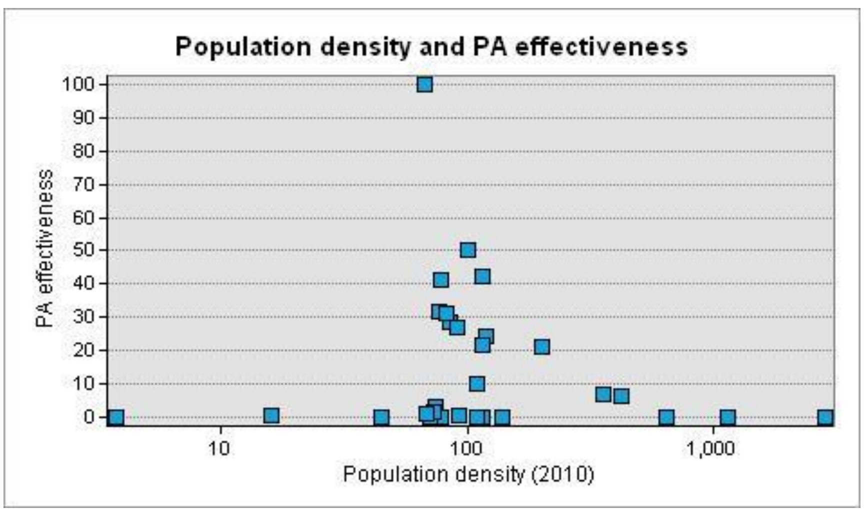


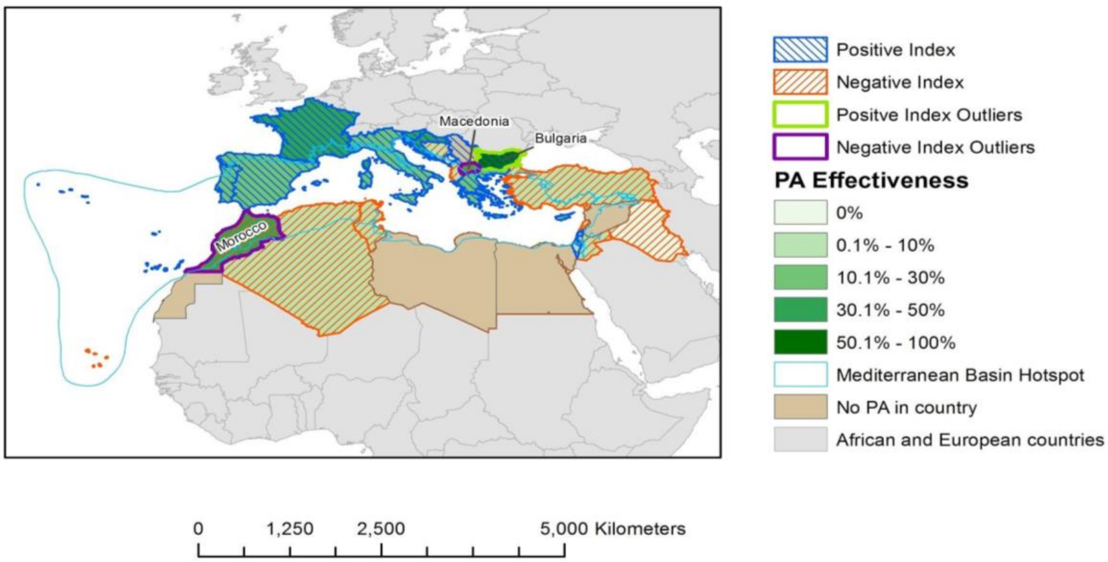
Figure 5. Comparison of population density (2010, people per m^2) by PA effectiveness by country in the Mediterranean Basin hotspot.

DISCUSSION

The data demonstrated a weakness in domestic biodiversity responsibility: nations of lesser economic standing and political equality tended to cover less of the Mediterranean Basin hotspot with PAs. Our study reported that countries with more developed economies—such as European countries and countries on the western border of the Mediterranean Basin hotspot—showed a high total area of PAs covering a hotspot, as well as scoring at least above the 75% percentile in PA effectiveness. We also found that high PA effectiveness was centered on what appeared to be an “ideal” population density for countries of 100 people per square meter. These results seem to contradict previous research, which states that increases in economic growth and population density tended to result in net loss in area of protected forests in high-priority protection areas by country (Morales-Hidalgo et al., 2015). Therefore, our data potentially indicate a discrepancy between the designation of protected areas and actual protection of habitats: even as the area of PAs in a country increases, or at least remains higher than average at higher GDP levels, there is still potential damage occurring within those protected areas.

Clement et al. (2016) provides a potential explanation for this discrepancy: in an examination of biodiversity protection in the Alps, cultural perception and support of biodiversity protection was the main determining factor of a PA successfully maintaining biodiversity and habitat. Therefore, total area of protection, GDP, or population density must be considered in tandem with the motivation of management and the community supporting hotspots in the country overall. Our data supports the argument that democracy must be accompanied with high equality ratings. Previous research disagrees as to whether a democratic government structure alone indicated a country's effectiveness in protecting environmental resources, with a recent study suggesting that democracy is only significant when a country is a democracy with high equality (Kashwan, 2017). Our study shows that a highly democratic and equal country provides more effective PA protection on average, with the exception of the outliers: Morocco and the former Yugoslav Republic of Macedonia (Figure 6). The spatial distribution of more effective PA protection follows this trend (Figure 6). Our study thus demonstrates that a country's environmental protection effectiveness has a notable relation to both governing style and equality of a country.

However, evaluating countries based simply on total area (km^2) of PAs covering a hotspot produced different results than the evaluation based on percent effectiveness. Based on total area, western and European countries feature prominently, with Morocco, Portugal, Spain, France, Italy, and Greece as upper outliers in this category (Figure 7). While these countries had scores closer to the median in PA effectiveness (Figure 1), they are all above the third quartile in total domestic PA area (km^2) covering hotspot area (Figure 7). Generally, there is a weak positive relationship between total PA area on a hotspot and PA effectiveness (Figure 8). However, countries with extremely low total hotspot area



also tended to fall into the higher

Figure 6. Distribution of countries in the Mediterranean Basin hotspot by PA effectiveness (%) and democracy-equality index rating.

percentiles of PA effectiveness (Figure 1). This discrepancy between highest effectiveness and highest total area of PAs of hotspot underscores incompleteness for domestic PA efficiency. Dividing by the total area of the hotspot in the country to create the percent effectiveness rating favored countries such as Bulgaria, which only had a small amount of hotspot in its territory and happened to be protecting that small area with 0.013 km^2 of PAs, and disadvantaged larger countries that had more territory covered by the hotspot as well as a total of more km^2 of domestic PAs.

The economic development of countries towards greater parity with their neighbors should assist transnational biodiversity protection in light of international standard and policy limitations. Whereas Watson et. al (2014) advocates for individual nations to double-down PA efforts, the inefficiency of domestic PAs for negative index countries suggests that international treaties and agreements cannot overcome regional or national differences in socioeconomic status. Zimmerer et al. (2004) noted the inefficacy of international institutions such as the United

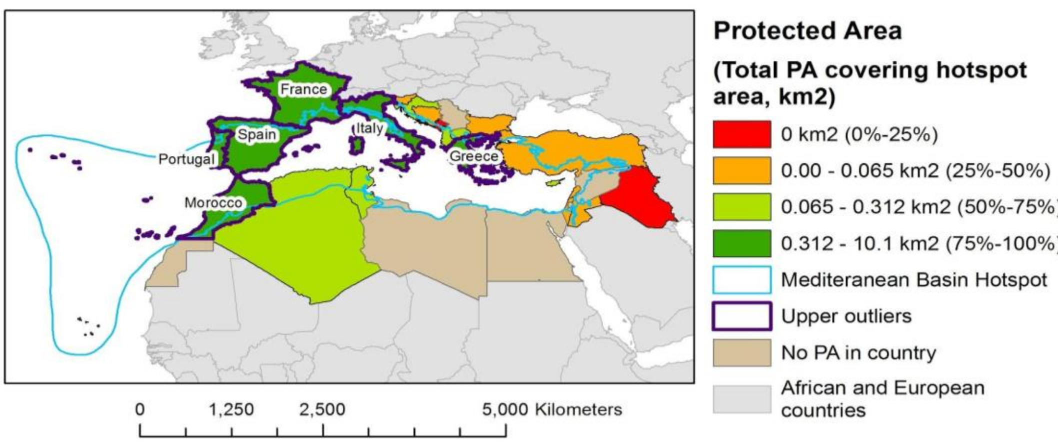


Figure 7. Total PA area (km^2) by country in the Mediterranean Basin hotspot.

Nations, the International Union for the Conservation of Nature (IUCN), and the World Wildlife Fund. These organizations launched new conservation initiatives through 1980-2000, resulting in a boom in global PA coverage. However, the effectiveness of these PAs were predominantly determined by national and even regional differences in conservation priorities, such as development and management style.

While international conservation institutions have low efficacy, economic-development institutions potentially re-prioritize conservation policies for developed and developing countries alike (Watson et. al, 2014; Clement et. al, 2016). The economic and social factors determined to influence domestic PA effectiveness are driven by international commerce and trade have been highlighted by other studies (Zimmerer et al. 2004). Thus, economic development institutions could improve both political and environmental agency and protections by enhancing popular financial security. If environmental activists have acknowledged the interconnectedness of the global environment, their solutions must take an international approach that considers economic and social inequality between nations a barrier to biodiversity protection that transcends state boundaries.

A few data inconsistencies are worth noting for PA size. Our WDPA shapefile was created from hotspot data that was self-reported by each individual country, and manipulation of PA size by regimes with incentives for top-down manipulation of environmental protection is possible. A second source of error in relation to PA effectiveness is that our Mediterranean hotspot shapefile is dated to 2004. It is possible that hotspot size has changed between 2004 and 2018. Finally, GDP and population data also dated to 2010, which carries the same source of time-sensitive inaccuracy.

Future research should test the relationships between democracy, equality, and environmental protection supported in this study through other means. A larger—if not global—sample can provide a more robust examination of the inequality hypothesis supported by this study. Also, Clement et al. (2016) identified that the culture surrounding PA management was a notable determinant of PAs' successes in biodiversity protection. The positive relationship between democracy and high equality could be related to research conducted by Clement et al.

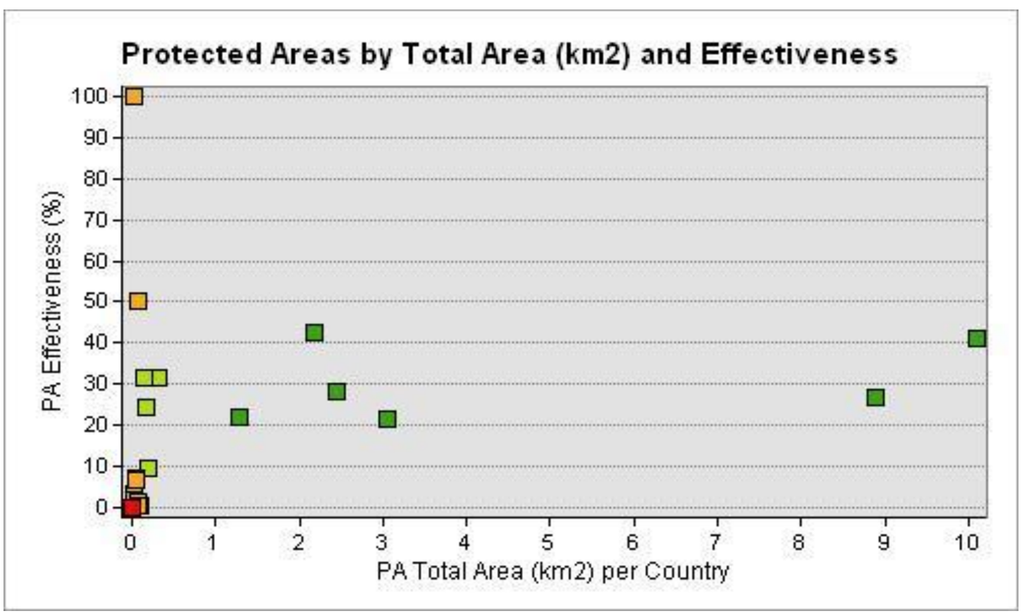


Figure 8. PA total area (km^2) compared to PA effectiveness in protected hotspot territory by country in the Mediterranean Basin hotspot.

(2016) who noted that cultural support increases PA effectiveness, which would support Boyce's inequality and biodiversity protection hypothesis (1994). Alternatively, a grassroots analysis of PA management techniques could account for the discrepancy in our findings for higher GDP per capita countries and the established body of evidence on PA effectiveness and economic and population growth, as well as the macro-level factors determining cultural and management differences (Zimmerer et al., 2004). Therefore, future investigation should establish an index of public support for biodiversity conservation in comparison to scales of PA effectiveness and total PA area in a country to determine the influence of public opinion on biodiversity legislation and vice-versa.

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