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Nature protection across countries: Do size and power matter?

Short title: **Conservation and country size and power**

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Highlights

- The extent of the protected area is less in larger and powerful countries
- Protected areas are relatively smaller in larger and powerful countries
- Smaller and less powerful countries comply more with conservation agreements
- Conservation largely depends on the willingness of larger and powerful countries

Abstract

Protected areas are one of the most effective tools for nature conservation. Consequently, almost all countries have agreed to set increasingly demanding goals for the expansion of their protected area systems. However, there is a large disparity among countries, and research on the cultural drivers of differences remains quite unexplored. Here, we explore the relationship between the protected extent and a limited spectrum of socio-economic characteristics, making focus on size and power features. Protected areas under strict conservation categories (I to IV, IUCN) were considered for 195 countries, and relationships were modeled by means of LOESS regressions, violin plots, and a random forest ensemble learning method. Larger and more powerful countries (in terms of land area, gross domestic product, or military expenditure) protect less and in relatively smaller units than smaller and less powerful countries. Out of the twenty most extensive countries of the world, only two exceed 10% of protection. This situation is problematic since an effective growth of the global protected area network depends on the willingness of larger and more powerful countries. We propose different hypotheses *a posteriori* that explain the role of size and power driving protection. These hypotheses involve direct mechanisms (e.g., the persuasive capacity of large countries) or mechanisms that mediate the interactions of some others (e.g., tourism contribution to GDP and insularity). Independently of mechanisms, our results emphasize the conservation responsibilities of large and powerful countries and contribute envisioning conservation scenarios in the face of changes in the number and size of countries.

Keywords: protected areas; country size; country power; Convention on Biological Diversity

1. Introduction

The physical, biological and cultural assets of the planet are unequally divided among more than 200 sovereign countries and dependencies of different legal character. The six largest countries of the world occupy 45% of the land area excluding Antarctica, while the smallest hundred occupy only 2.5% (Gini index, G = 0.80, Table 1; data sources are depicted in Table 2). Moreover, ten countries exceeding 100 M inhabitants, encompass 60% of the world population, while there are 115 countries with less than 1 M (G = 0.81). This conjunction of conditions clearly implies differential access and appropriation of natural resources by humans, which is reflected and magnified in the gross domestic product (G = 0.87) and in the military expenditure (G = 0.90). Perhaps less obvious is that these inequalities together imply different degrees of responsibility on the part of the administrations of countries in the long-term conservation of natural and cultural assets. This makes global sustainability hard to achieve considering that it should be a joint effort which exceeds current and future political borders.

The countries with the highest level of wealth were the first to formalize conservation policies under different agreements. Short after the United States of

America installed the modern concept of protected area in 1872 (Watson, Dudley, Segan, & Hockings, 2014), numerous sovereign or colonial governments quickly established their own parks and reserves (McNeely, Harrison, & Dingwall, 1994; Szafer, 1973; Watson, et al., 2014). The 20th century brought relevant geopolitical changes, such as the independence of colonial territories and the split of former territories after both World-Wars. Since then, new countries actively promoted the creation of protected areas, and conservation was no longer exclusive to powerful countries (Fairbrother, 2012; Frank, Hironaka, & Schofer, 2000). As of July 2018, there are around 240,000 terrestrial protected areas, which occupy a land area of 20.2 M km^2 or 14.9% of the world land surface excluding Antarctica (UNEP-WCMC, IUCN, & NGS, 2018). Furthermore, almost all countries in 2010 negotiated that at least 17% of terrestrial areas needed to be included within protected networks by 2020 (first clause of the Aichi Biodiversity Target 11, SCBD, 2010).

Protected areas arise from a complex interplay of motivations related to perceived societal benefits, like the early preservation of iconic landscape features, or the late widespread agreement on the importance of maintaining nature and biodiversity (Baldi, Texeira, Martin, Grau, & Jobbágy, 2017; Pressey, 1994; Watson, et al., 2014). However, these motivations act as underlying forces, being the process of conforming protected areas driven by direct human-related or cultural drivers (hereafter, cultural drivers). These drivers can be associated with the economic or political context of the country, its social organization, and prevailing moral rules (Baldi, et al., 2017). There is currently a broad consensus about the need to increase the extent under protection to preserve the structure and functioning of nature (Rodrigues, et al., 2004; Watson, et al., 2014). That is why a joint analysis of these drivers would identify the conditions that may facilitate or boost the creation of protected areas, as well as the conservation debts maintained by countries that have favorable conditions, but for which conservation has played a minor role in political agendas.

Research on cultural drivers has not yet been examined or discussed thoroughly, and literature on this topic is mostly based on qualitative analyses focused on a few features. For example, several narratives have evidenced the importance of individual actors (e.g., heads of state, naturalists and scientists) and political actions driving the deployment of protected areas (Castañeda Rincón, 2006; Leal, 2017; Ouyang, Ye, Hockings, Luk, & Huang, 2013; Pauchard & Villarroel, 2002; Wells & Williams, 1998). Quantitative studies are scarcer. For example, Marinaro, Grau, and Aráoz (2012) showed that, in Argentina, the totalitarian administrations of the first half of the 20th century established protected areas of large size. Meanwhile, subsequent democratic administrations made focus on the diversification of the protected network, with the inclusion of many areas of small size only when significant economic surpluses were available.

Studies about cultural drivers become even less at the global level (Table 3). In their seminal assessment, Frank et al. (2000) showed that the links of countries to world society (e.g., the signature of environmental treaties) were strong drivers of the extent of protected areas. Later, Upton et al. (2008) found few significant relationships between poverty indicators and the extent of the protected area. They suggested that inconclusive associations could be attributed to the joint effect of two factors. On the one hand, local society pressures and economic capacity of more affluent countries aimed at setting aside land for conservation. On the other hand, international agendas and foreign investment in less affluent countries contributed to land conservation. McDonald and Boucher (2011) found that more affluent countries achieved a larger extent of protection in the middle of the 20th century, while currently, less affluent/developing and more affluent/developed countries protect their territories at similar rates. Kashwan (2017) found that the protected extent depended mainly on the interaction between democratic strength and economic inequality. Protected areas tended to emerge under undemocratic settings with high inequality, or under democratic settings with low inequality. Finally, Baynham-Herd et al. (2018) assessed the engagement and investment in the environment and pro-environmental behavior and found that governance was the most relevant driver of protection, with a minor contribution of the level of globalization as well.

From the above studies, only Frank, et al. (2000) and Baynham-Herd et al. (2018) marginally considered the size and power of countries in order to explain cross-national differences in nature conservation. Frank et al. (2000) included population size in models and Baynham-Herd et al. (2018) included economy size (Table 3). At this point, we identify a gap in knowledge. In a broad sense, country size and power (e.g., land area, economic activity, and military power; Arvanitidis & Kollias, 2016; Crowards, 2002b) constitute determining factors in numerous economic, political and social processes, such as market stability or social development (Alesina & Wacziarg, 1998; Prasad, 2009; Spolaore, 2004). Given these circumstances, and returning to the initial question of the unbalanced distribution of assets in the world, this study aims to explore the relationships between the intertwined concepts of size and power and the extent of protected areas. Additionally, we explore the relationship between the land area of a country and the size of the largest protected unit. Along with the size and power metrics, other cultural drivers used in previous research (e.g., education) were included in analyses to contextualize the shape and strength of relationships. Notably, the smallest and less powerful countries in the world are commonly excluded from comparative analyses in different fields, which biases our current knowledge to a partial spectrum of environmental or cultural conditions, therefore excluding extreme and deviant cases (Baldacchino & Milne, 2006; Veenendaal & Corbett, 2014). This study intends to amend these geographic, methodological and –perhaps– ideological biases by encompassing data from a more comprehensive set of countries.

2. Methods

The data about the size of individual protected areas (in km^2) and of the extent of protected areas at a national level (in percentage) were obtained from the World Database on Protected Areas, March 2018 (UNEP-WCMC and IUCN, 2018). We included only protected areas which have been specifically designated for nature protection, i.e., strict nature reserve, wilderness areas, national parks, natural monuments or features, and habitat/species management areas, categorized as I-IV under the IUCN guidelines (1994). In this database, protected areas in many countries (e.g., Bolivia, South Africa, Comoros) are almost exclusively labeled under the IUCN class "Not Reported", which could lead to an underestimation of their national figures. In this sense, for these countries, we considered previous UNEP-WCMC categorizations (e.g., Bolivia or South Africa in 2013 had many protected areas categorized as I to IV) or included areas labeled with the general designations described above (e.g., national parks) and small variations of them. For those polygons that shared land and sea, we only considered the terrestrial area by subtracting the marine area to the overall GIS area from tabular data (Figure A.1, Appendix A). We excluded all protected areas with a "proposed" status. Due to a potential overestimation of national protected extent from overlapping problems (Deguignet, et al., 2017), polygons were dissolved and new individual areas were recalculated using the Mollweide projection. Finally, for countries where polygonal data was partially or completely unavailable (>

50% of the units, e.g., Moldova), we included information from point data. After this data manipulation, the total global protected extent was 9.2 M km^2, which is equivalent to 7.0% of the land surface, divided into approximately 114,000 units.

We included as samples of this study 195 countries members of the United Nations, and the Cook Islands and Niue (both under the Realm of New Zealand and Parties of the Convention on Biological Diversity –CBD). We excluded from the analyses the city states of Monaco and the Vatican City, the State of Palestine, and non-sovereign territories (in where land management policies can be delineated outside their territories).

We related the protected extent at a national level to sixteen independent variables representing cultural drivers (Table 2). The first six variables are associated with the intertwined concepts of size and power of a country. The first variable is Crowards (2002a, 2002b) classification based on non-hierarchical cluster analysis, generated from land area, gross domestic product (GDP) and population. The second, third and fourth variables are the individual land area, GDP and population. We added two more variables to the size and power group, i.e., the military expenditure and the possession of external territories (Arvanitidis & Kollias, 2016; Baldacchino & Milne, 2006). The following ten variables are related to general geographical, conservation and socio-economic characteristics of countries, and are used to contextualize the strength of variables related to size and power. These ten variables are equal or similar to those used in the global studies of Table 3, except for the tourism contribution to GDP (variable #13) and whether the countries are continental or insular (variable #15). These last two variables are included as many local studies highlight the role of tourism as a driver of conservation (e.g., Maekawa, Lanjouw, Rutagarama, & Sharp, 2013), especially on islands (e.g., Sufrauj, 2011). Finally, the governance value (variable #12) of Somalia was excluded by considering it as an outlier. All data is available in Appendix B.

With an exclusively exploratory and descriptive purpose, we regressed the protected extent (in percentage) to continuous variables by means of a Local Regression (LOESS) method. This non-parametric approach identifies patterns and fits a smoothed curve neither assuming any global function nor estimating a statistical significance of relationships (e.g., via a coefficient of determination) (Cleveland, 1979). For categorical variables, we constructed violin plots, which are similar to box plots with a rotated kernel density plot on each side. In violin plot, the density traces graphically show the distributional characteristics of data, allowing quick and insightful comparisons between classes (e.g., to have or not an external possession), and avoiding the use of abstract symbols to depict main features, i.e., center, spread, asymmetry, and outliers (Hintze & Nelson, 1998). We also assessed the correlation between continuous variables through a Kendall's τ non-parametric test (Whittaker, 1987). The number of samples that were used for LOESS models (i.e., countries) varied according to data available (from 145 to 195, see Figure 2).

In order to measure the individual effect of the independent variables, we applied a random forest ensemble learning method (Breiman, 2001), which estimates their importance (variable importance, VI) by looking at how much the mean square error (MSE) increases when the out-of-bag data (OOB) for that variable is permuted while all others are left unchanged (Grömping, 2009; Liaw & Wiener, 2002). To include all considered countries in the random forest, we filled missing values with the continental averages (5.4% of the values from the combination of 195 countries * 16 variables). As we included different types of variables (i.e., continuous vs. categorical), we followed Strobl, Boulesteix, Kneib, Augustin, and Zeileis (2008, 2009) methodological suggestions and calculated the VI using the "cforest" function of the "party" package (Hothorn, Hornik, & Zeileis, 2008). As some of these variables vary in their scale of measurement or their number of categories, we selected the subsample without replacement approach; and as some of these variables were highly correlated, we selected the conditional permutation approach. In the cforest procedure, we chose a number of trees to grow, ntree, equal to 2500; a minimum size of the terminal nodes, nodesize, equal to 1; and a number of input variables at each split, mtry, equal to 3. For mtry, the chosen value minimized the OOB-MSE of the model. As VI results differed from run to run, we calculated a mean and standard deviation of VI values by running the model 50 times. The VI values were used here with an explanatory and interpretative rather than predictive aim. Data processing was conducted in RStudio v. 1.1.423 (RStudio Team, 2018) (packages foreign, ggplot2, ggrepel, gridExtra and party).

3. Results

Land area is –perhaps– the most intuitive variable representing the size and power of a country. At a first cartographic glance, some of the largest countries of the world set aside a lower extent of their territories than some of the smallest ones for conservation (Figure 1). Russia and the United States of America, which are examples at the high end of the land area gradient, protect 6.6% and 9.4% of their territories, respectively. In contrast, Liechtenstein and São Tomé and Príncipe, which are examples at the low end of the land area gradient, protect 14.1% and 30.0% of their territories (Appendix B). Figure 2 shows the protected extent along the classes or gradients of independent variables representing cultural drivers for all countries. Following Crowards' classification (2002a, 2002b), we show a high dispersion in the protected extent values within classes, with some "micro" to "large" countries achieving the highest values (up to 40.8% in Bhutan), but only one out of the seven "very large" countries surpassing 10% (Figure 2a). Complementing the cartographic description of Figure 1 regarding the land area, data reveal an inverse U-shaped curve pronounced at the low end of the gradient and with a gentle slope at the high end (Figure 2b). Very small countries protect little (e.g., Nauru, San Marino), but with a small increase in land area, some countries set aside significant portions of their territories to conservation (e.g., Liechtenstein, Niue). The maximum values of protected extent are found in small countries that exceed the ~500 km^2 (e.g., Luxembourg, Sri Lanka). Moving on along the land area gradient, the slope of the LOESS model becomes negative, as many countries have the potential to achieve high values (e.g., Tanzania, Chile), but many more have very low conservation values. Finally, the largest countries do not equate the values of the smallest: Out of the twenty most extensive countries, only two exceed a 10% protected (i.e., Indonesia and Mongolia).

The relationship between the protected extent and other components of size and power also adopts an inverse U-shaped curve (i.e., population size) or negative linear shapes (i.e., military expenditure and gross domestic product –GDP) (Figure 2c-e). These consistent results would obey the strong and positive correlation that exists between the four continuous variables (Figure 3). More affluent countries protect less than less affluent ones: Out of the twenty countries with the largest GDP that account for more than 80.5% of global amounts, none achieve the 17% of protection suggested by the CBD convention. Conversely, out of the twenty countries with the lowest GDP, six does. Countries with higher military expenditure protect less than those with the lower ones: Out of the twenty countries with the largest military budget that accounts for more than 85% of global amounts, only Israel surpasses the 17% of protection. Conversely, out of the twenty countries with the smallest military expenditure, five surpass the 17% of protection. Albeit with a less clear pattern, those countries with external possessions set aside less land for conservation than those without these (Figure 2f).

According to the random forest analysis, the most relevant variable determining the protected extent of a country is income inequality, being ~2.7 times more important than the following two variables, i.e., the military expenditure and the age of the protected area network (VI = 1.62 ± 0.15, 0.61 ± 0.09 and 0.55 ± 0.10, respectively; Figure 4). The strong importance of income inequality obtains suggests the interaction with other variables, given the unclear dependence of the protected extent to this variable according to the LOESS model (Figure 2h). In comparison, other variables related or unrelated to size and power, such as the above-mentioned land area (VI = 0.04 ± 0.06), governance (VI = 0.14 ± 0.10) or even the contribution of tourism to GDP (VI = -0.25 ± 0.09) suggest clearer relationships to protected extent from LOESS models (Figure 2b,l,m). Although none of the studies of Table 3 incorporated the condition of continental/insular among the driving factors, it is interesting to notice the high protected extent achieved by some insular countries (tropical, temperate or cold; Figure 2o). Out of the ten countries with the highest level of protection, eight are insular, and out of the next ten countries, half are insular.

In addition to an apparent effect of land area on the protected extent of a country, the smallest countries also preserve larger protected areas in relation to their particular size, with the Seychelles being at the top of the ranking (Figure 5). As other examples, we can mention the Ôbo Natural Park in the southernmost São Tomé island of São Tomé and Príncipe, which covers 24.4% of the 860 km² of the country (Figure 1), while the Garsaelli Forest Reserve in Liechtenstein covers 6.7% of the national territory. Out of the first twenty countries whose most extensive protected area constitutes a larger fraction of the country, eight of them are "micro", seven are "small" and five are "medium" following Crowards' classification (2002a, 2002b). The first "large" country that appears in the ranking is Venezuela, in the thirteenth position, closely followed by Chile (rank #34) and Algeria (rank #41).

4. Discussion

There is a broad consensus in society that protected areas are one of the most effective tools in the conservation of nature, and that it is necessary to extend their current surface and connect all biophysical systems (Rodrigues, et al., 2004; Saura, et al., 2018; Watson, et al., 2014). However, this globalized discourse contrasts with our results for the more developed or powerful countries, as it is argued in section 4.1. A key to forecast scenarios and eventually balance efforts across countries lies in the comprehension of the cultural drivers of conservation, as it is argued in section 4.2.

4.1. Size and power

The largest and most powerful countries (in terms of land area) maintain a conservation debt regarding protected extent in comparison with micro- to medium-size countries (Figure 2b). Large to very large countries are also mostly affluent, populated and powerful (Figure 3), a conjunction of factors that make them fundamentally responsible for the conservation of nature. As a matter of fact, these countries manage a remarkable amount of natural resources and biodiversity, occupy multiple continents or hemispheres, possess the material resources to maintain and promote conservation programs, and shape and determine their own and others' economic and political actions with the greatest independence (Beckley, 2018; Neumann & Gstöhl, 2004). Certainly, every country should make a similar attempt to conserve a fraction of their natural resources (SCBD, 2010), as the fulfillment of common goals by small countries ensures the protection of their geographical or biological singularities. However, this legal equality has a political and –essentially– ecological counterpart, since an effective growth of the global protected area network depends on larger countries which have the actual capacity to generate radical changes at that spatial level.

More than two decades ago, Wells and Williams (1998) pointed out that, with the demise of communism in Russia, the economic resources allocated to conservation sharply declined, with a consequent weakening of law enforcement and an increase in illegal activities in protected areas. Confirming and extending these findings, Watson, et al. (2014) suggested that there was significant evidence that more affluent and extensive countries were cutting financial and human resources for the conservation sector, and were even overlooking existing conservation policies and legislation. This has occurred in spite of the strong discourse in these countries towards increasing the size and effectiveness of protected area networks. Several studies endorse our findings by considering the level of anthropization of protected areas (Jones, et al., 2018; Leroux, et al., 2010), the specific efforts in the conservation of a taxon (Lindsey, et al., 2017), or even the attitudes of the population. By means of social surveys, Nawrotzki (2012) stated that the strongest opposition toward environmental protection was observed in conservative people of most powerful, capitalist countries.

This differential effort emerges so markedly that it is interesting to return to a selective and meaningful comparison between extreme cases. If Russia and the United States of America sought to repeat the examples of Liechtenstein and São Tomé and Príncipe, their protected area networks would need to incorporate millions of square kilometers, and their largest protected areas would need to be significantly larger. Comparisons can be considered at some point unlikely due to the deep economic and social implications that these and other large countries would have to face in light of a different territorial order. However, comparisons stress that some small to medium-sized countries have decided to follow a conservation-prone spatial planning without many –at least financial– apparent difficulties. Renowned Bhutan's conservation efforts exceed protected areas, as its constitution mandates that at least 60% of the country must remain with its natural forest cover (Lham, Wangchuk, Stolton, & Dudley, 2019; Wangchuk, 2007).

Turning back to the Aichi agreements, the debt held by the largest or most powerful countries is enlarged by considering the second clause of Target 11 (SCBD, 2010), which sets that conservation networks have to sample all natural conditions and all levels of life organization with the same effort. According to Barr, et al. (2011), the very large countries protect in a divergent way: Russia's network equitably encompasses most ecoregions of the country, while Brazil, the United States of America, Indonesia, India, Mexico, and China networks are biased towards a few ecoregions. To reinforce this idea, we deliberately excluded the non-contiguous states of Alaska and Hawaii of the United States of America, as well as their external possessions in Figure 1. Protected areas are frequently established on territories that face little human interventions and have comparatively low opportunity-costs (Baldi, et al., 2019; Baldi, et al., 2017; Joppa & Pfaff, 2009). One possibility to overcome these problems of imbalances among and within countries is that international representation goals are not established at the country level but at the level of ecoregion or physical environments (Aksenov, Kuhmonen, Mikkola, & Sobolev, 2015; Baldi, et al., 2019). In this way, all countries should agree on multilateral strategies of conservation of their natural conditions regardless of the protected national extent.

4.2. Size and power in context

None of the individual relationships explored in Figure 2 was particularly strong. This fact does not detract what was expressed in section 4.1 but rather indicates that there are multiple interactions not identified in the analyses. Interactions would explain why income inequality has prevailed in the random forest ranking (Figure 4). In fact, Kashwan (2017) found a strong interplay between income inequality and the system of government: When democracy prevailed, inequality led to less protection, whereas when totalitarianism did, inequality led to more protection.

Including income inequality and other variables in these analyses was aimed at contextualizing the importance of size and power drivers. From these, the one that reached the greatest importance turned out to be military expenditure (second position), followed by population size, GDP, land area and external possessions in decreasing order (Figure 4). Regardless of the position in the ranking, the question about which mechanisms explain the effect of size and power remain unanswered. Having stated this, the empirical knowledge generated in this and previous studies (see Table 3) provides evidence to propose the following *a posteriori* hypotheses:

(#1) The *per capita* costs of public goods and services are determined by the number of taxpayers (Alesina, 2003; Spolaore, 2004). In this regard, the larger and more powerful the country is (in population terms), the more economically viable it would be to maintain and expand a network of protected areas.

(#2) The integration to world society is commonly related to economic wealth in the smallest or less powerful countries (Pelling & Uitto, 2001; Prasad, 2009). In this regard, and as opposed to the previous hypothesis, conservation would be internally boosted by accomplishing multilateral or international treaties, regulations, or agreements (like the CBD, Woodley, et al., 2012), or by attending transnational social movements (T. Lewis, 2000). In addition to this integration, conservation projects in smaller countries frequently obtain financial assistance from international non-governmental organizations (NGOs) (Frank, et al., 2000; Kashwan, 2017). This can eventually be associated with a green grabbing process (Fairhead, Leach, & Scoones,

2012) or a sign of soft power (i.e., the ability to attract and co-opt others) that larger countries exert over smaller ones (Arvanitidis & Kollias, 2016; Beckley, 2018).

(#3) The diversity and abundance of natural resources are generally determined by the land area of a country through a sampling effect (except those occupying extreme deserts) (Freudenberger, Hobson, Schluck, & Ibisch, 2012). In this regard, the larger the country is (in terms of land area), the greater the redundancy of diverse resources will be. Given this redundancy, larger countries would allocate a small fraction of their territories to conservation to achieve representation goals. Complementarily, smaller countries would allocate a large fraction of their territories to maintain their natural system, ensuring the provision of varied resources or services and the achievement of representation goals.

(#4) Given the interaction between the aspects associated with an economy of scale (hypothesis #1) and a limited diversity of resources (hypothesis #3), the economic viability of the smallest and less powerful countries (in terms of land area, population, GDP) would be conditioned by non-extractive or unconventional industries, such as tourism in tropical islands (Croes, 2013). In this regard, the smallest and less powerful is the country, the tourism industry would be boosted by the maintenance of landscape quality and biological diversity in protected areas.

Considering the results depicted in Figures 1 and 2a-f, the mechanism that supports the first hypotheses would not prevail, since even countries with a very low population maintain extensive protected area systems (e.g., Iceland, Mongolia, Namibia) (Figure 2d,j). The other three hypotheses could advocate mechanisms that have effective implications for conservation, although these have received mixed support from our results. As an example, we found that the highly correlated governance-globalization drivers (Figure 3), which achieved an intermediate to low position in the importance ranking (Figure 4), showed an inconclusive relationship with the protected extent (Figure 2k,l). This questions the interactions or mediations of hypothesis #2 and the findings of Frank, et al. (2000) and Baynham-Herd, et al. (2018), who emphasized the positive role of cultural processes that promote the links to world society (i.e., globalization) directing conservation efforts.

Other less explored factors, such as the closeness to natural environments, the social sense of belonging, cohesion or self-sufficiency, as well as the degradation, scarcity or finitude of natural resources in resource-constrained environments, could support the thesis of a greater conservation effort in smaller or less powerful countries (Aguilera-Klink, Pérez-Moriana, & Sánchez-García, 2000; McNeely, 2015). Oceanic islands could be used to test these ideas, as they frequently maintain well-organized strategies of land management due to their high environmental, demographic, and economic vulnerabilities (Christensen & Mertz, 2010; Pelling & Uitto, 2001).

Our results could be used to unfold conservation scenarios in the face of geopolitical changes, specifically in relation to the number and size of countries. Two opposite phenomena occur in this regard. On the one hand, new countries will probably emerge as there are still subnational regions and stateless nations asserting for full sovereignty and recognition (e.g., New Caledonia, Kurdistan) (Baldacchino & Hepburn, 2012; Veenendaal & Corbett, 2014). On the other hand, the pursuit of sovereignty has sharply declined in the last decades (e.g., Basque Country, Scotland) (Baldacchino & Hepburn, 2012; Baldacchino & Milne, 2006), some once sovereign and recognized countries have been (re)united (e.g., Germany, Yemen) and political blocks have been formed with different levels of supranational unification (e.g., Turkic Council, European Union). If small territories gained sovereignty, we wonder whether the creation of protected areas would slow down (hypothesis #1) or accelerate (hypotheses #2 to #4). And *vice versa*, if unions consolidate, it would be interesting to question whether the creation of protected areas would accelerate (hypothesis #1) or slow down (hypotheses #2 to #4).

Finally, we highlight some caveats of the paper. First, the land area could be intuitively considered a geographical –more than a cultural– trait. However, as stated by Alesina (2003), the land area would not be necessarily a factor external to a country's culture, as the same culture could determine this merely geographical feature. Second, we have exclusively evaluated the relationships of each cultural driver and the current protected extent. Yet, in the historical process of growth of protected area networks, these relationships have varied (McDonald & Boucher, 2011; Radeloff, et al., 2013). Third, the described relationships came from the comparison between countries, but these relationships can have different shapes or intensities at other spatial levels. For example, the populational or scenic characteristics of a territory –traits of low explanatory power according to our approach– have been identified as drivers of the establishment of protected areas within countries (Baldi, et al., 2019; Baldi, et al., 2017;

Joppa & Pfaff, 2009). Fourth, we did not evaluate the effectiveness of the protection networks in terms of their ability to limit interventions such as infrastructure development or resource extraction, an aspect that can distinguish countries with different cultural and institutional qualities (Abman, 2018). At last, the role of unconsidered IUCN conservation categories could modify the messages from this study. Nevertheless, we left aside these categories (and other such as wilderness areas, Dietz, Belote, Aplet, & Aycrigg, 2015) as their governance and tenure potentially lack formal protection and management, they have uncertain conservation objectives and long-term capabilities, and their enforcement of law is compromised (Shafer, 2015, 2019).

5. Conclusions

The commitment of countries to nature conservation, specifically through the deployment of protected areas, showed to be greatly uneven among countries, from those which completely devoid of this legal figure to those in which nearly half of the territory is strictly protected. These differences would obey to the interaction of several underlying and direct cultural drivers. Previous studies that observe these relationships excluded countries of small size, sparsely populated, recently conformed or of insular character, omitting thus extreme and deviant geographical or cultural cases. Meanwhile, until now the size and power of a country as a driver of the protected extent of a country had not been explored. We intended to amend both situations, finding that the largest or most powerful countries have made a lower conservation effort than the smaller or less powerful ones. Size and power would mediate individual or joint effects of other drivers or would act directly as a mechanism by allowing, for example, stronger countries to impose policies over weaker countries or by abstaining to participate (the stronger) countries in international agreements.

Regardless of these points, the largest and most powerful countries are the ones that have the greatest responsibility in nature protection, given that internal changes in their conservation policies aimed at increasing the extension and financing their protected areas imply the success of the global conservation of nature. Perhaps a more plausible conclusion about the differences among countries is that the larger and more powerful ones protect less, not because they cannot do better, but because it is not part of their political agendas. Paraphrasing Lewis and Wigen (1997), an increasingly integrated world demands a more modest, honest, and accurate geographical depiction of the distribution of protected areas to understand the needs, debts, and opportunities in the conservation of nature.

Declaration of interests

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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Figures

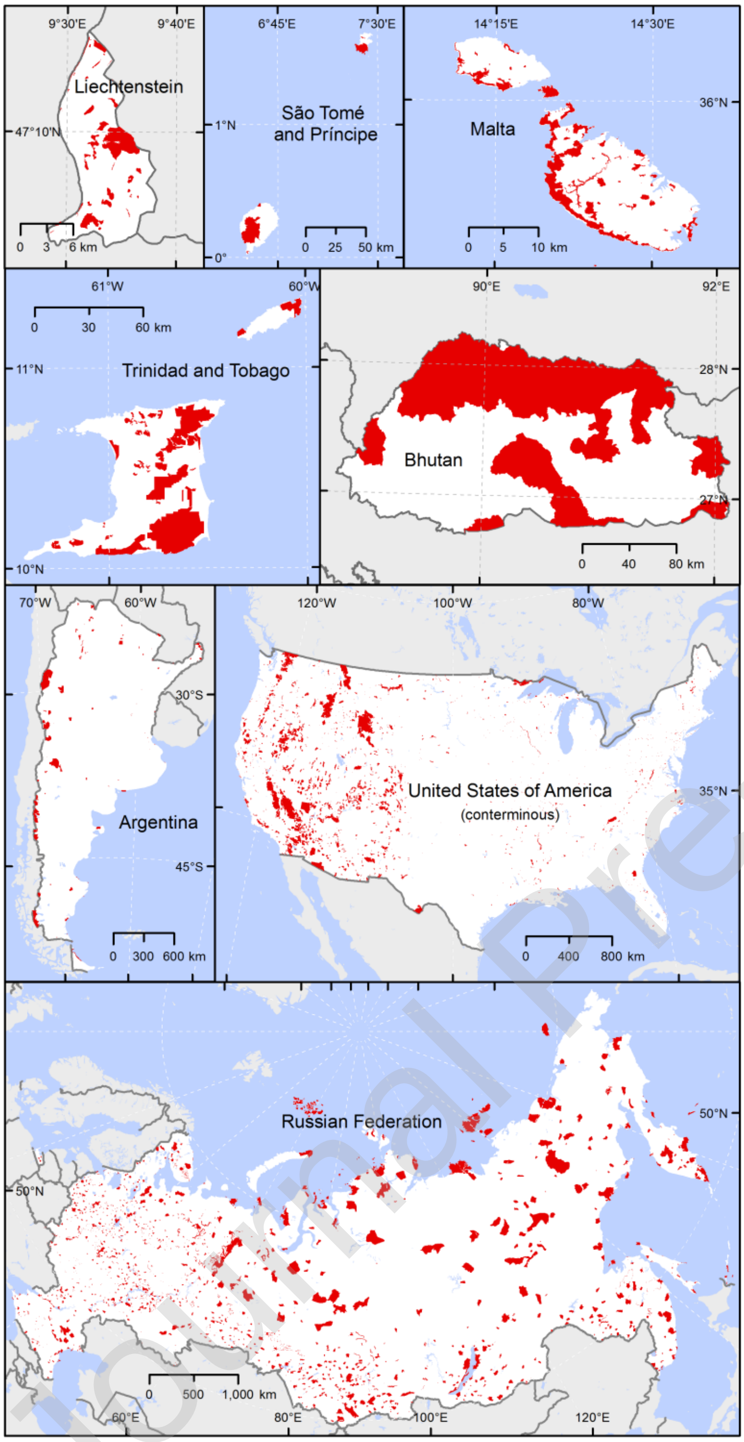

Figure 1. Protected areas categorized as I-IV under the International Union for Conservation of Nature guidelines (IUCN, 1994) in eight countries with contrasting geographies and human contexts. Alaska and Hawaii in the United States of America are not depicted.

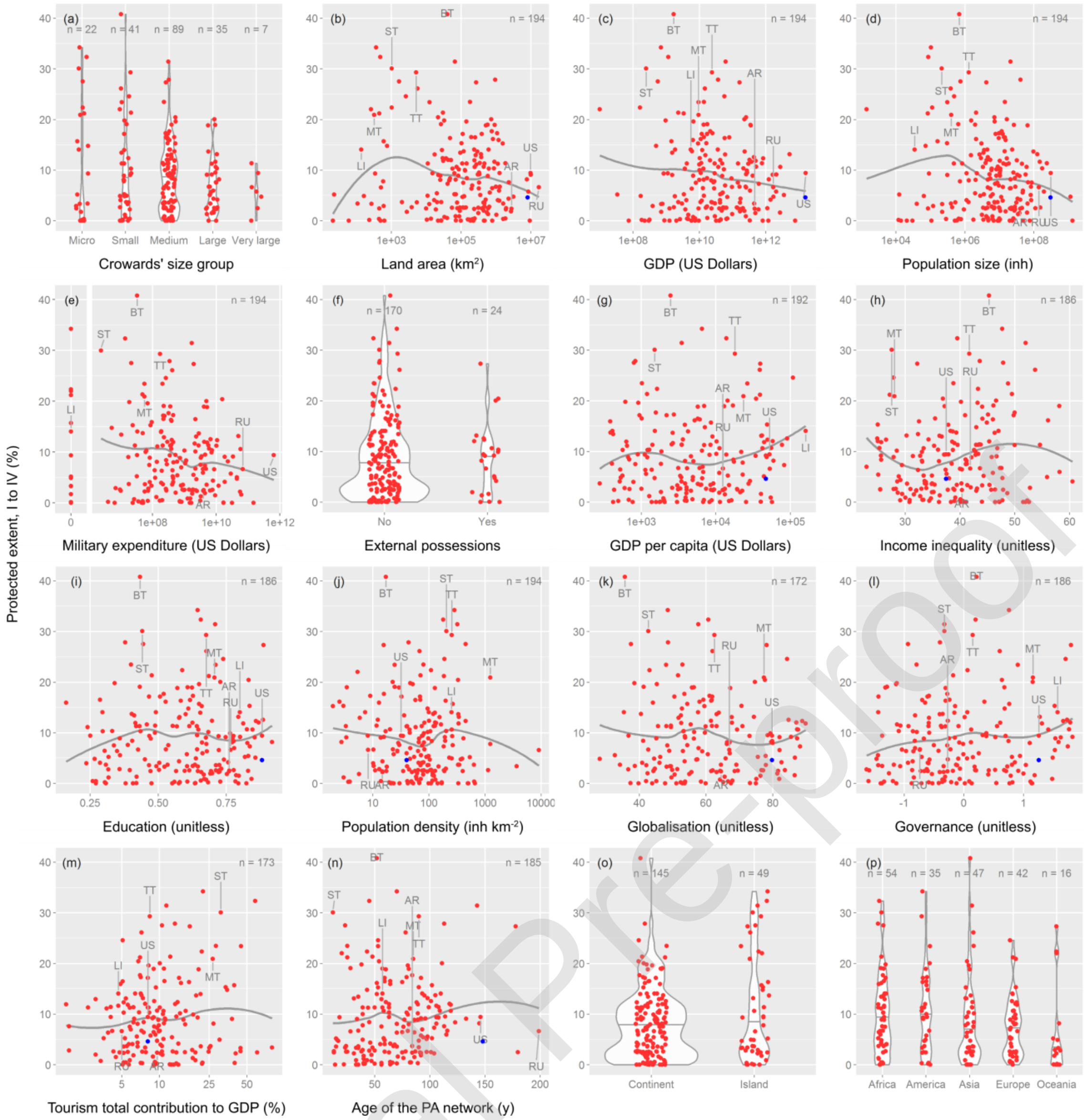

Figure 2. Extent and LOESS models of the networks of protected areas along socio-economical, conservation and geographical gradients. Panels (a) to (f) are related to the size and power of countries. In violin plots (a, f, o and p panels), horizontal lines represent the 0.5 quantiles. The number of samples is depicted on each panel. The eight countries of Figure 1 are labeled with the following acronyms: Argentina (AR), Bhutan (BT), Liechtenstein (LI), Malta (MT), Russia (RU), São Tomé and Príncipe (ST), Trinidad and Tobago (TT) and United States of America (US). Blue points represent the US conterminous states (these data do not feed LOESS models).

Figure 3. Kendall's τ correlation coefficients between continuous variables (n = 194). Colours represent strength and sign (from positive red, to white, to negative blue).

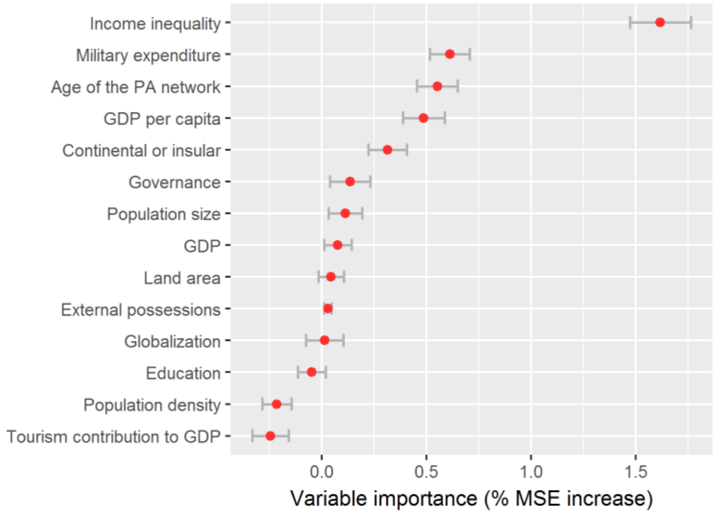

Figure 4. Relative importance of fourteen variables related to socio-economical, conservation and geographical contexts according to the random forest (RF). The variable importance is depicted by the increase in the mean square error when the out-of-bag data for a variable is permuted while all others are left unchanged. Variables #1 and #16 were excluded from the analysis.

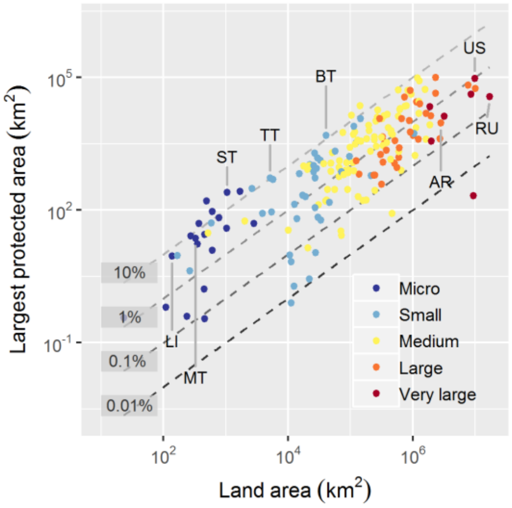

Figure 5. Relationship between the largest protected area of the country and its land area. The four lineal models represent isolines of this relationship (e.g., the 10% isoline represents a single protected area that occupies a tenth of the land area). Different colors represent the size classes of Crowards (2002a, 2002b) which consider, besides land area, population and GDP. See country acronyms in Figure 2.

Table 1. Inequality in the distribution of variables related to the size and power of a country, following Crowards (2002a, 2002b) and Arvanitidis and Kollias (2016).

Variable	Minimum	Median	Maximum	Inequality (Gini index)
Land area (k km^2)	0.01×10^{-3}	566	16,953	0.80
Gross domestic product (M US Dollars)	10	2.7×10^{4}	1.6×10^{7}	0.87
Population size (M inh)	8×10^{-4}	7.2	1,338	0.81
Military expenditure (M US Dollars)	0	412	6.5×10^{5}	0.90

Table 2. List of independent variables associated with the extent of the protected area by country. Variables #1 to #6 are related to the two intertwined concepts of size and power following Crowards (2002b) and Arvanitidis and Kollias (2016). Variables #7 to #16 are used to contextualize size and power results.

#	Variable	Units	Description
1	**Crowards' country size**	categorical	Crowards (2002a, 2002b) classification of 179 independent countries into five categories, according to their area, GDP and population. The categorization of unclassified countries (e.g., Australia, Canada) were completed following his classification scheme
2	**Land area**	km^2	Abundance and diversity of natural assets. From Natural Earth (2017)
3	**Gross domestic product (GDP)**	US Dollars	Economic size or development of a country and, therefore, political strength. From the World Bank (2018) average values 2007-2016
4	**Population size**	inh	Stock of human capital and size of the domestic market. From Natural Earth (2017)
5	**Military expenditure**	US Dollars	Capability to dissuade and/or coerce external entities/policies to either protect and/or advance national interests at national to global levels. Average values 2007-2016. From the World Bank (2018). Missing cases (e.g., Comoros), from the GlobalSecurity.org (2011). Other measures of military power has been proposed (Beckley, 2018; Singer, 1988), but due to redundancies in results, they are only presented on Figure A.2, Appendix A
6	**External possessions**	categorical	Similar to #5, but enabling countries to influence policies abroad. Included countries (†) posses overseas military bases or govern overseas territories, territories with ethnic minorities and listed as "Non Self Governing Territories" according to the 2018 Session of the United Nations (e.g., American Samoa), "Special member state territories" of the European Union (e.g., Canary Is.) or other categories (e.g., Easter Is.)
7	**GDP *per capita***	US Dollars * inh^{-1}	Affluence of population. From the World Bank (2018) average values 2007-2016
8	**Income inequality**	unitless	Estimate of inequality in equivalized (square root scale) household disposable income (post-tax, post-transfer) from Solt (2016). Average Gini index 2007-2016. For Andorra, The Bahamas, Cuba, North Korea, Saudi Arabia, and Singapore, from the IMUNA country profiles (2018)
9	**Education**	unitless	From the Human Development Index ranks. Calculated using mean years of schooling and expected years of schooling. Average values 2005-2015 (UNDP, 2015)
10	**Population density**	inh * km^{-2}	Pressure of population per area for natural resources and space. From Natural Earth (2017)
11	**Globalization**	unitless	Economic, social and political globalization, which includes data on economic flows and restrictions, information flow, and cultural proximity. From the KOF Swiss Economic Institute average values 2006-2015, overall values (Gygli, Haelg, & Sturm, 2018)
12	**Governance**	unitless	Considering voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption (Kaufmann,

			Kraay, & Mastruzzi, 2010). From the World Bank (2018) average values 2007-2016 considering the average of the six governance components
13	**Tourism contribution to GDP**	%	Relative importance of this economic activity, given that nature protection attracts visitors interested in remarkable natural or cultural landscapes, and tourism drive protection to preserve this quality. From the WTTC (2017) data base. 2017 values.
14	**Age of the PA network**	y	Number of years since the creation of the first protected area. From UNEP-WCMC, et al. (2018)
15	**Continental or insular**	categorical	If the country is mostly continental or insular (e.g., Malaysia is considered an insular country, as 60% of its territory is in Borneo Is.)
16	**Continent**	categorical	Following the six fold model (Lewis & Wigen, 1997)‡

† Australia, Chile, China, Denmark, Finland, France, Israel, Morocco, Norway, New Zealand, Portugal, Russia, Spain, The Netherlands, Turkey, United Kingdom of Great Britain and Northern Ireland, and United States of America.

‡ Russia is included in Europe.

Table 3. Non-exhaustive list of global studies about the cultural drivers of protected areas extent at a national level. Physical variables were excluded from the field of drivers (e.g., terrain slope). Acronyms: GDP Gross Domestic Product, GNI Gross National Income, IGOs intergovernmental organizations, INGOs international nongovernmental organizations, IUCN International Union for Conservation of Nature, PA protected areas, sd standard deviation, Spp. species, UN United Nations.

Reference	Focus problem	IUCN categories	Drivers of PA extent	Countries
Frank, et al. (2000)	Institutionalization, globalization and environmentalism relationships	Undefined, PA larger than 10 km^2	International treaties' signature, UN Environment staff, UN conferences' attendance†, INGOs and IGOs membership, ecological and natural science organizations, iron and steel production *per capita*, population size‡	Unknown number, but excluding those of small land are (< 10 k km^2)
Upton et al. (2008)	Poverty-PA relationships	Individual categories, I-II, I-IV	Human Development Index, population living on US Dollars 1 per day, World Bank income†, GNI *per capita*	136, excluding those of low population (< 1.5 M) or small islands
McDonald and Boucher (2011)	Strength of conservation motivations	I–IV, V-VI	Region†, country†, primary education†, political structure†, previous protection, GDP *per capita*, population density, urbanization, agricultural land, spp. richness, IUCN Red List spp.	160, excluding those of small land are or recent conformation
Kashwan (2017)	Inequality and democracy-PA relationships	I-VI	Continent†, democracy, income inequality, rural electrification, development†, GDP *per capita*, population density, life expectancy, forest area, spp. richness,	Variable number (167 to 32), but main results considered 137
Baynham-Herd et al. (2018)	Roots of environmentalism	Undefined	Post-materialism, development, globalization, governance, country age, GDP‡, GDP *per*	Unknown number, but excluding those of small land are or recently created

capita

† categorical variables.

‡ size variables.