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Global development and the future of the protected area strategy

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ABSTRACT

Land protection has become increasingly common, and global land protection is now greater than 12%. Prediction of future protected area expansion are uncertain, and depend on understanding the factors that have to date explained the historical pattern and geographic variation in protected area (PA) establishment. We test four major perspectives on factors limiting or facilitating PA creation, differentiating between strict PAs and multiple-use PAs where some resource extraction is permitted. Richer countries had a greater amount of land protection and were more likely to create strict PAs, supporting the view of land protection as an economic amenity, although the magnitude of this effect declines in recent decades. There are also significant differences in amount of protection by political structure, with independent countries tending to protect more land, and education, with countries with high levels of primary education tending to protect more. However, countries with substantial previous protection tend to do less protection and create proportionally fewer strict and more multiple-use PAs. Scenarios of future socio-economic and political conditions suggest that on balance the amount of protection should increase in many countries, driven by economic prosperity, and by 2030 global land protection is forecast to reach 15–29%. The limiting factor in land protection varies among countries, and sub-Saharan African countries in particular will remain a very hard place for land protection because of low per-capita GDP. Overall, however, more land protection may occur in the next 20 years than has occurred in the previous 20 years.

1. Introduction

Protecting land by created parks and other protected areas has become increasingly common, with land protection globally now greater than 12% (Brooks et al., 2004; Chape et al., 2005; Jenkins and Joppa, 2009; Naughton-Treves et al., 2005; Pyke, 2007; Rodrigues et al., 2004). The motivation for this protection has varied widely, from preserving biodiversity to maintaining hunting to protecting scenic beauty to ensuring the sustainable extraction of natural resources (Runte, 1997; Sellars, 1997). Moreover, the timing and extent of land protection has been very uneven among and within countries (Coad et al., 2009; Hoekstra et al., 2005; Soutullo et al., 2008). In this study, we seek to answer a simple question: How much more land is likely to be protected in the next few decades, given demographic, agricultural, and economic growth?

We analyze data for terrestrial protection from 1950 onwards, build statistical models of past trends, and then use our statistical model to make projections of future land protection. We categorize the range of motivations for protected area (PA) creation into two broad categories: "strict" PAs (IUCN categories I–IV), where there is a focus on preserving the natural ecosystem and little resource extraction, and "multiple-use" PAs (IUCN categories V–VI), where there is a focus on the sustainable extraction of natural resources. Input data on the amount and strictness of protection in 5-year intervals is analyzed as a function of time-varying covariates such as population, agricultural land, urbanization, per-capita GDP, political context, and education. In order to sharpen our work, we structure our analysis around four distinct perspectives that seek to explain what drives patterns of PA expansion, each of which implies a different future for the PA strategy. By comparing the observed correlations between a set of explanatory variables and land protection with those predicted by one of our four perspectives, we can evaluate the overall utility of a perspective in explaining the observed pattern. We stress, however, that these perspectives are not mutually exclusive, and more than one of them may be of importance in explaining what drives patterns of PA expansion.

One perspective suggests that PAs are most frequently established in sites that are "worthless" to people, or at least less economically useful (Joppa and Pfaff, 2009; Runte, 1997; Sellars, 1983). For instance, steep slopes, barren soils, or harsh climates might make a site unsuitable for agriculture, and hence more likely to be protected. Regions with a low population density might find

Abbreviations: IPCC, intergovernmental panel on climate change; GDP, gross domestic product; PA, protected area; SRES, special report on emissions scenario.

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it easier to establish PAs because relatively little of the landscape is put to human use. Strict PAs may be more common because these lands have relatively little productive value. Conversely, protection has been limited in places with significant economic value to people, such as areas of agricultural production or high population density. Multiple-use PAs may be more common because it allows the continued use of at least part of the productive value of the land. This hypothesis implies that in the future land protection may get harder, either because the most worthless sites have already been protected or because the demands of housing and feeding another three billion people forces (UNPD, 2007) much more land to be put to productive use.

Another perspective suggests that environmental protection is an amenity that becomes of greater importance to people once they have satisfied other more basic economic desires (Dinda, 2004; Mikkelson et al., 2007; Pandit and Laband, 2009; Torras and Boyce, 1998). In this view, the correlation between the rapid rise in land protection in the past half century and the contemporaneous increase in economic development are indicative of a causal relationship. Note that while economic theory might tie the decision to protect land to specific variables such as land price, the economic value of alternate use forgone with protection and the willingness to pay for the benefits of protection (Dixon and Sherman, 1991; McNeely, 1988), this detailed data is simply not available for all countries globally since 1950. Instead we, like many econometric studies, use per-capita GDP as a proxy for the overall process of development. This perspective predicts that countries with a greater per-capita GDP will set aside more land for protection. Similarly, they may be able to afford more "strict" protection, and have proportionally more of this type of protection. Barring major global disruptions, continued economic development seems assured, increasing fastest in percentage terms in what are today the less developed countries. This perspective implies that this continued economic development might make land protection easier, as nations would have more resources to invest in this amenity.

A third perspective argues that the conservation movement in general, and land protection in particular is a historical and political process (Gorenflo and Brandon, 2006; Nash, 2001; Smith et al., 2003). The idea of land protection originated in a particular time period and over time gained support in many countries throughout the globe (Nash, 2001). This implies that calendar year will be a significant explanatory variable in a regression analysis, even after accounting for other explanatory variables. Moreover, the political and social context of a country may modify its adoption of the idea of land protection, leading to differences among countries in the extent of protection (Zimmerer et al., 2004). For instance, some have argued the spread of democracy in the past several decades is in part responsible for the rapid land protection (Wells and Williams, 1998), although others have argued that the legacy of colonialism also profoundly shaped the PA networks in many countries (Fabricius et al., 2001). Education is another potentially important variable, because many studies have associated greater education levels with increased activism about environmental issues (e.g., Gillham, 2008; White and Hunter, 2009), presumably including land conservation.

Finally, a fourth perspective argues that international conservation organizations have played a significant role in advocating for land protection, and have concentrated their efforts in places of greater biodiversity significance. For instance, there is some evidence that there is greater land protection in ecoregions with more vertebrate biodiversity (Loucks et al., 2008). This perspective predicts that countries of biodiversity significance, either because of greater species richness or imperilment, will have more area protected and will have relatively more strict PAs.

Our scenarios of the future are based on the four scenarios in the IPCC *Special Report on Emissions Scenarios* (SRES). The A1 and B1 scenarios assume global population growth to around nine billion by 2050 and rapid economic growth leading to convergence in countries' income. In contrast, the A2 and B2 scenario assume greater population growth and greater disparities in economic growth among regions. Relative to the A1 and A2 scenarios, the B1 and B2 scenarios place a greater emphasis on sustainable technology and the environment (IPCC, 2000). Our overall goal in making projections is to define the factors limiting PA creation, and describe how much land could be protected by 2030 if current patterns continue.

2. Materials and methods

2.1. Protected area data

Our information on PAs came from the World Database on Protected Areas (WDPA), as released in 2009, which generally contains information on the date of protection of a parcel as well as its spatial boundary. All IUCN categories of protection (I–VI) are contained in the database, with degree of land protection ranging from, for example, wilderness areas to national forest areas for timber production (but see Leroux et al., 2010). Where the WDPA 2009 dataset seemed to be missing information (e.g., United Kingdom), we used information from the 2007 release of the WDPA or (for the United States) the current Protected Areas Database (DellaSala et al., 2001). We categorized the world's protected areas in two broad categories. First, "strict" PAs were defined as IUCN categories I–IV, which encompasses strict nature reserves, wilderness areas, national parks, national monuments, and habitat/species management areas. Second, "multiple-use" PAs were defined as IUCN categories V–VI, where there is a focus on the sustainable extraction of natural resources, including protected landscapes/seascapes and managed resource PAs such as the national forests in the United States (IUCN-WCMC, 1994). Note that while the WDPA is the best available global data on protected areas, there are data quality issues. We lump the IUCN categories to two broad groups, "strict" and "multiple-use," in part because other papers have recently questioned how accurate and meaningful the IUCN categories are (Brooks et al., 2009; Joppa et al., 2008; Leroux et al., 2010; Nagendra, 2008; Selman, 2009).

Not all PAs had information on date of establishment or PA category, and we conducted a literature search to find information for these parcels, focusing especially on the biggest. Ultimately only 13% and 3% of the area protected was for PAs where we could not assign a date or category, respectively. For each parcel with missing information we have randomly filled in the field, drawing from the distribution of values in the larger dataset. This kind of imputation is common with missing values, and is less likely to change the distribution of values in the dataset or bias the regression coefficients than simply dropping missing values (Little and Rubin, 2002). Preliminary tests with the subset of data with complete information yield qualitatively similar regression results. We projected the WDPA data and all the other spatial layers used in our analysis to a Mollweide equal-area projection at a 1 km resolution.

As most of the potentially explanatory variables occur at the country level (Table S1), we calculated area and percent protected for the countries of the world at 5-year intervals from 1950 to 2005. Five-year intervals were used to match the temporal grain of the potential explanatory dataset. Data from 2005 on were excluded from our analysis out of a concern that there are often a few years of lag between protection and its recording in the WDPA, implying that information over the period 2005–2010 was not