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REPORT

The relationship among biodiversity, governance, wealth, and scientific capacity at a country level: Disaggregation and prioritization

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Abstract At a global level, the relationship between biodiversity importance and capacity to manage it is often assumed to be negative, without much differentiation among the more than 200 countries and territories of the world. We examine this relationship using a database including terrestrial biodiversity, wealth and governance indicators for most countries. From these, principal components analysis was used to construct aggregated indicators at global and regional scales. Wealth, governance, and scientific capacity represent different skills and abilities in relation to biodiversity importance. Our results show that the relationship between biodiversity and the different factors is not simple: in most regions wealth and capacity varies positively with biodiversity, while governance vary negatively with biodiversity. However, these trends, to a certain extent, are concentrated in certain groups of nations and outlier countries. We discuss our results in the context of collaboration and joint efforts among biodiversity-rich countries and foreign agencies.

Keywords Biodiversity indicators · Biodiversity assessment · Decision makers · Developing countries

INTRODUCTION

There is an often-repeated view that has now reached the point of uncontested truth, namely, that biodiverse developing countries lack the capacity to study and to manage their biodiversity: "the taxonomic impediment […] is most acute in tropical, developing nations, which contain most of the world's biodiversity" (Geeta et al. 2004); "scientific capacity is not equally shared across the globe, and in particular is concentrated in rich developed countries rather than in the regions that face the most substantial challenges" (Rands et al. 2010). In a very influential paper, Gaston and May (1992) used information about specimen loans in major British taxonomic institutions to reach the conclusion (carefully nuanced) that probably 80 % of the taxonomic expertise in the world is concentrated in the Holarctic biogeographic realm. They quote other studies that support the idea that ecologists are also concentrated at a similar proportion of 80 % in North America (meaning the US and Canada) and Europe (probably sensu lato). More recent work (Martin et al. 2012), based on an analysis of a sample of 8000 papers in leading ecological journals, concluded that 90 % of ecological field work is performed in countries within the 70th–100th percentiles of Gross National Income.

It is not only capacity in taxonomy and ecology that may be lacking in the developing world. Measures of governance are lower in high-biodiversity countries in Africa (Smith et al. 2003): "we show that countries rich in species and identified as containing priority areas for conservation have lower governance scores than other nations."

Clearly governance and scientific capacity differ dramatically across the world's ~ 200 countries, and it is not surprising that Western science is concentrated in Western countries. But the pattern is not without exceptions (de Carvalho et al. 2005; Tancoigne et al. 2011). In the 20 years since Gaston and May (1992) published their paper, the situation appears to have changed. Many developing, high-biodiversity countries have improved quite significantly their capacities to conserve and manage their biodiversity. More importantly, both biodiversity and

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governance are complex concepts (Folke et al. 2005; Maclaurin and Sterelny 2008) and resorting to coarse and aggregated relationships tends to obscure interesting exceptions and outliers to the patterns. Not disaggregating the pattern is another form of the "scale mismatch" fallacy (Ludwig and Stafford Smith 2005), whereby indicators relevant for a certain scale are also expected to be relevant at other scales.

In this paper, we have analyzed the question of whether at global and regional levels there are consistent relationships between terrestrial measures of "biodiversity"—defined below in the Methods section—and three different indicators of conservation capacity: economic wealth, scientific capacity, and governance. Each one of these indicators reveals a different aspect of a country's ability to deal with biodiversity issues. Economic wealth is a general enabler; local scientific capacity may be required for medium-term projects and long-term change and sustainability in good management practices; and good governance is a *sine qua non* for implementation of any policy, mostly in the long-term. Different indicators also highlight different weaknesses and strengths of collaborative work among institutions or partners in different countries.

MATERIALS AND METHODS

In order to rank and relate a country's biodiversity with respect to its governance, scientific capacities, and wealth, we developed five indices—two of biodiversity and one each for governance, scientific capacity and wealth—using principal components analysis (PCA) based on standardized variables pertaining to each country, as described below. Appendix S1 (Electronic Supplementary Material) lists the raw variables and developed indicators. PCA was performed twice, first for a global analysis including all countries, and second for separate regional analyses for seven regions formed by countries that share geographic affinity and dynamics—America; Asia Pacific; Caribbean; Europe, Eastern Europe and Central Asia; Middle East and North Africa; and Sub-Saharan Africa (see Appendix S1). Countries with insufficient data—mostly small territories and islands, were not included in the analysis.

Input data and index construction

It may be surprising to realize that at country level, for most of the world there is very little data on the most common surrogate of 'biodiversity': the number of species. The so-called Linnean and Wallacean shortfalls (Whittaker et al. 2005) mean, respectively, that most species are not even described, and that those that are, have poorly known geographic distributions. To a large extent it is only the terrestrial vertebrates for which there is reliable world-wide information, and only at coarse resolutions (Whittaker et al. 2005). The numbers of species of mammals, amphibians, and reptiles were determined from distributional data derived from NatureServe polygons using spatial queries per country (www.natureserve.org); bird species numbers are from Heywood (1995, Table 13.1). We corrected species number for area of the country using a logarithmic transformation of area and species number. Since the relationship between area and species is not linear, a value of 0.2 for the exponent z in the $S = kA^z$ relationship (Rosenzweig et al. 2011) was assumed and an area-corrected species is $C = S/A^z$. Although z varies with latitude and for islands and continental masses, and finding the best z for each country was beyond the purpose and scope of this study, the value recommended by Rosenzweig et al. (2011) was selected. For both the raw and the area-corrected numbers centered and standardized principal components were determined, with the first component being the biodiversity index (Electronic Supplementary Material, Table S1; Appendix S1). Adding information on centers of plant diversity, number of ecoregions, and number of hotspots per country (see Appendix S1 for details on these variables), made the resulting principal components less clear and more difficult to interpret.

The governance index is the first principal component (Table S1; Appendix S1) of the mean over the last ten years of five variables from the Worldwide Governance Indicators (www.govindicators.org): (i) voice and accountability, (ii) political stability and no violence, (iii) government effectiveness, (iv) rule of law, and (v) control of corruption. These indicators are based on several hundred individual underlying variables, in turn derived from data for over 200 countries and territories that, since 1996, have measured dimensions of governance (see Appendix S1 for details).

Scientific capacity is measured by two indices, Capacity GEF and Capacity no GEF. Capacity GEF index includes: (i) ratio of the number of biodiversity records (including specimens in scientific collections, and observations) about a country that are held in the country's institutions relative to the total number of records of that country (both in national and foreign institutions) obtained from the Global Biodiversity Information Facility (GBIF; www.gbif.org), currently serving more than 400 million voucher and observational records; (ii) number of herbaria per country; (iii) number of specimens held by these herbaria, obtained from *Index Herbariorum*; (iv) number of scientific papers published from 2000 to 2010 by resident country scientists, obtained from the Web of Science; (v) number of ecological sites studied in the countries, as reported by Martin et al. (2012); (vi) Internet penetration at December 31, 2011, using mid-year 2012 population estimates and data from Internet Usage Statistics (www.internetworldstats.com/stats); (vii) number of Global Environment Facility (GEF; www.gefonline.org) grants; and (viii) total co-financing of GEF projects provided by a country from 1991 to 2012 for strictly national biodiversity projects. Regional projects, such as South African National Biodiversity Institute (SANBI) or Inter-American Biodiversity Information Network (IABIN), were not included. The last two variables provide a proxy for the in-country managerial and institutional capacity, which are required to obtain and execute multimillion-dollar GEF grants, but do not apply to developed countries, which are ineligible for GEF support.

Capacity no GEF index includes all the variables of Capacity GEF except for the (vii) and (viii) GEF measures, which enables comparison of all countries, including GEF-ineligible ones. Since countries with large biodiversities tend to attract GEF grants, the second measure maybe less likely to give circular results.

These two capacity indices are designed to capture the state and productivity of a country's strict biodiversity science infrastructure, as opposed to the more general scientific capacity of Wagner et al. (2001), which relies on a more subjective weighting of different variables. Nevertheless, we observed a strong positive relationship (0.715, $p < 0.001$) between Capacity no GEF and the index of Wagner et al. (2001).

Country wealth index is derived from two variables from the World Bank Development Indicators (data.worldbank.org/data-catalog/world-development-indicators): (i) average GDP during 2008–2011; and (ii) GDP *per capita* (US dollars). A second trial index that in addition included the rates of change of GDP variables (i) and (ii) during 2008–2011 and 2000–2011 proved less informative because the percent of variance explained by the first PC of these four variables was lower than when only using (i) GDP and (ii) *per capita* GDP.

Principal component analysis loadings and biplot outputs using the R package 'BiplotGUI' (la Grange et al. 2009) were used to interpret the relationships of variables forming each index (Electronic Supplementary Material, Tables S2, S3, S4, S5, S6, S7), and in all cases we selected the first principal component as the final indicator used in these analyses (Table S1; Appendix S1). We corrected an index's direction by multiplying it by minus one (-1) when the principal component sign behaved in a direction opposite from the natural (e.g., if Brazil appeared as the least diverse country). Variables with very large values (GDP and number of GBIF records) were transformed logarithmically.

Statistical analyses

To understand the relationship between indices, we calculated Pearson correlation coefficients for the five indicators globally (i.e., using the principal components obtained for the entire world) and regionally (i.e., on the indices created separately for each region). Regression models were obtained using the 'scatterplotMatrix' function of the 'car' package in R (Fox and Weisberg 2011) and displayed using the ggplot2 package in R. We identified the influence of outlier and extreme countries in these relationships, i.e., countries falling above or below the 0.05 confidence interval in the regression models using the 'spm' function of the car package in R (Fox and Weisberg 2011), or countries far to the end of predictor variables. All analyses were performed using the R environment (R Development Core Team 2013).

RESULTS

Global analysis

At the global level the relationship between biodiversity indices and the three indicators departs somewhat from the conventional wisdom (Table 1) because global Biodiversity is significantly and positively correlated with both indices of capacity (with or without GEF contributions), and positively (although not significantly; $p > 0.05$) with Wealth. In accord with conventional wisdom, the relationship between Biodiversity and Governance is weakly negative ($p > 0.05$; Table 1; Fig. 1). The inclusion of GEF grants and co-financing in the Capacity GEF index and its exclusion from the Capacity no GEF index reveals significant contrasting national capacities for implementing biodiversity projects (Fig. 1). The main difference is created by China, which benefits from the largest and most GEF grants in the world. These results change when the Area-Corrected Biodiversity index is used: now Biodiversity has a lower (still significant) correlation with Capacity including GEF grants, and it is no longer significantly related to Capacity without GEF. This is because the density-correction reduces the effect of China (Fig. 2).

These global results can be disaggregated into a regional view of country performance (Table 2). Again, the results do not confirm unequivocally the widespread assumption. The Biodiversity index correlates positively ($p < 0.05$) with both indices of capacity in every region of the world with the exception of Europe, the Caribbean, and the Middle East and North Africa, and with Wealth in the Americas, Eastern Europe and the Middle East. However, Governance is now negatively and significantly associated with Biodiversity indices in the Caribbean region, in a very clear relation not apparently due to outliers or extremes (Fig. 2).

Regional analysis

A regional analysis also produces mixed results, not consistently supporting the preconceived notion of large-biodiversity-little-capacity. Indeed, the correlations of the

Table 1 Pearson correlation for the global first principal components ($n = 137$). Asterisk denotes significance at $p < 0.05$

	Biodiversity	AC Biodiversity	Capacity GEF	Capacity no GEF	Governance
Biodiversity	1				
AC biodiversity	0.887*	1			
Capacity GEF	0.536*	0.374*	1		
Capacity no GEF	0.171*	0.108	0.697*	1	
Governance	−0.147	−0.124	0.197*	0.594*	1
Wealth	0.187	0.025	0.432*	0.705*	0.564*

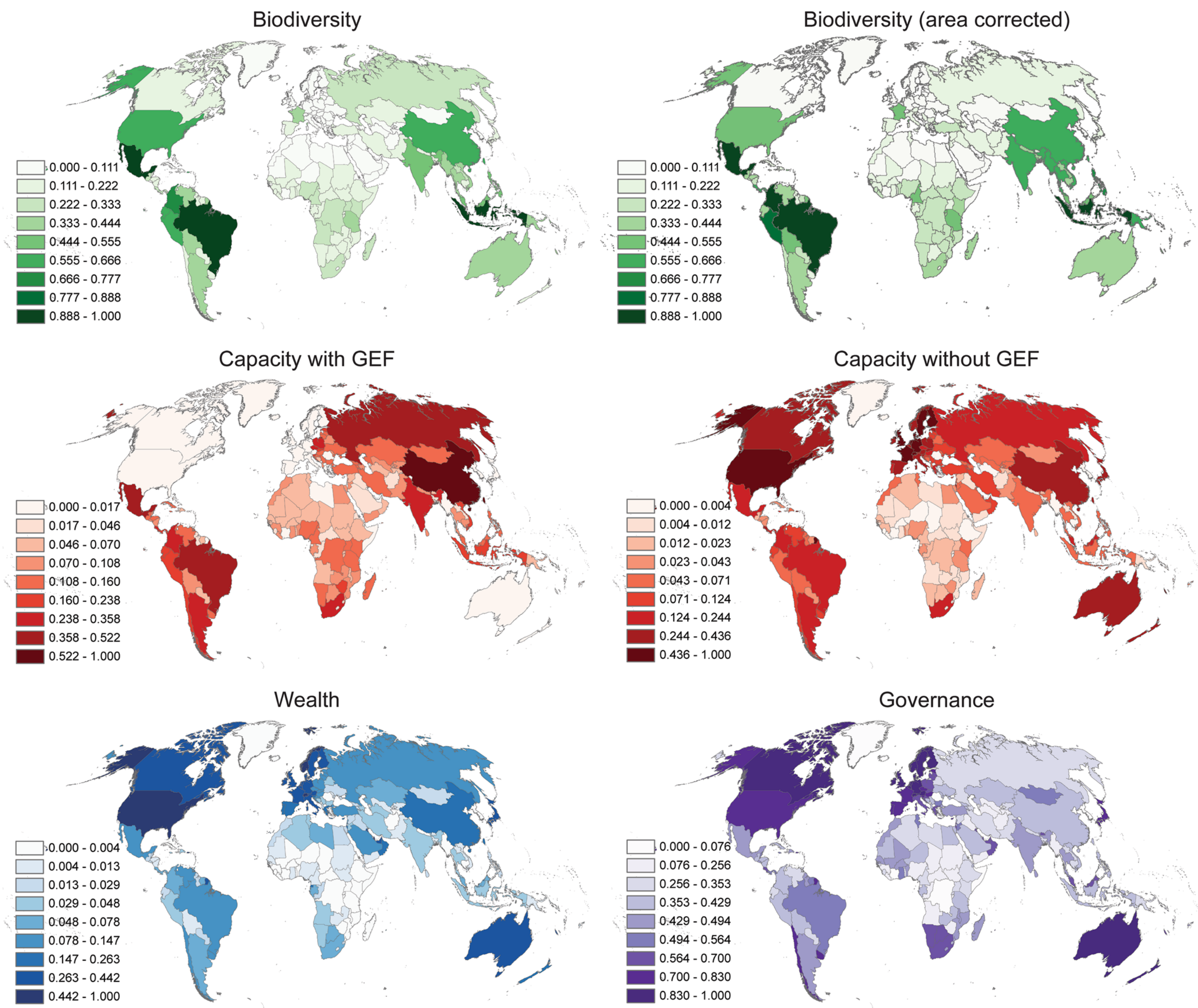

Fig. 1 Distribution of indices worldwide. Each index was scaled to show values between 0 and 1

indices for each region (Table 3) indicate that Biodiversity has: (i) a significant and positive correlation with Capacity GEF in the Americas (without Canada and the United States), Asia–Pacific, Eastern Europe and Central Asia and Sub Saharan Africa; significant ($p < 0.05$) relationships with Capacity no GEF only in Asia Pacific and Eastern Europe and Central Asia; but no negative relationship between Biodiversity and Capacity no GEF was significant; (ii) a positive relationship with Wealth ($p < 0.05$) for the Americas (without Canada and the United States); and (iii) many negative correlations existed between the Biodiversity and Governance indices (sometimes significant;

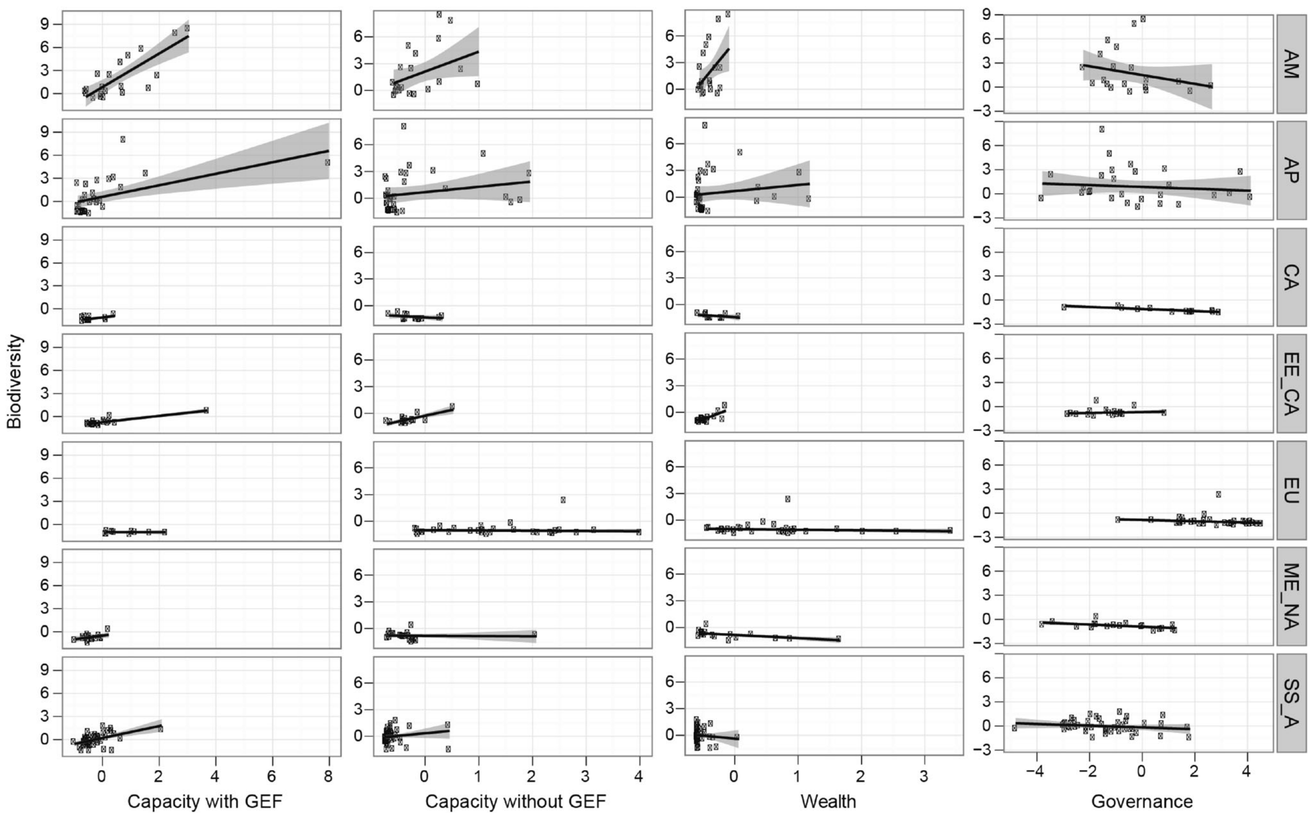

Fig. 2 *Scatterplot* of global Biodiversity and four indices, presented by region. *AM* Americas, *AP* Asia Pacific, *CA* Caribbean, *EU_CA* Eastern Europe and Central Asia, *EU* Europe, *ME_NA* Middle East and North Africa, *SS_A* Sub Saharan Africa

$p < 0.05$ for the Caribbean region). Results change a little when the Area-Corrected Biodiversity index is used, but not qualitatively (Table 3; Fig. S1).

In some regions there are a few extreme or outlier countries that are primarily responsible for the positive correlations between biodiversity and the capacity indices (Table 4). Positive outliers, i.e., those countries pulling the slopes into the positive, are Brazil, Mexico, China, Russia, Indonesia, and South Africa. Posterior removal of Brazil and Mexico changes the significance ($p = 0.0012$ to 0.094) in the Americas, but removal of outlier countries in Africa, Eastern Europe & Central Asia, and Asia Pacific did not affect the significance ($p < 0.05$). Table 4 summarizes the outliers in the relationships between biodiversity and the other indices. In all cases, outlier countries in the lower bound coincide with small territories or islands with lower biodiversity values, whereas outliers in the upper bound correspond usually to large and more biodiverse countries.

DISCUSSION AND CONCLUSIONS

Although there are significant relationships, both globally and per region, between our terrestrial biodiversity indicators and several social, economic or political indicators (Smith et al. 2003; Rands et al. 2010; Amano and Sutherland 2013), the results indicate that they are far from simple: the Governance index tends to fit to conventional expectations, but the Wealth and Capacity indicators show a more complicated pattern, with several cases showing positive relationships, although with a few outlier countries significantly influencing the trends. The conventional wisdom is fraught with critical exceptions, both globally and regionally (Table 4), and with significant variation in the requisite capacities that may be lacking. For example, some of the most biodiverse nations in the Mittermeier et al. (1997) list of 'megadiverse countries' are fully developed, like the United States, Australia, and France (France courtesy of its *outremer* possessions), or developing very quickly (Brazil, China, India, Malaysia, Mexico, Colombia, Peru and South Africa, among others), and cumulatively encompassing a significant proportion of global biodiversity.

The relationship of biodiversity with our indicators of scientific capacity, governance and wealth revealed two kinds of outliers: a group of large, biodiverse countries with high-biodiversity indices, roughly corresponding to the developed or fast developing nations cited above; and small temperate or arid countries, or territories and islands with low indices, which although less interesting from the

Table 2 Pearson correlations for the global indices, disaggregated by region. Asterisk denotes significance at $p < 0.05$

Region	Biodiversity	AC biodiversity	Capacity GEF	Capacity no GEF	Governance
Americas ($n = 20$)					
Biodiversity	1				
AC biodiversity	0.875*	1			
Capacity GEF	0.793*	0.751*	1		
Capacity no GEF	0.426	0.498*	0.818*	1	
Governance	−0.22	−0.141	0.209	0.433	1
Wealth	0.475*	0.314	0.673*	0.587*	0.464*
Asia Pacific ($n = 21$)					
Biodiversity	1				
AC biodiversity	0.851*	1			
Capacity GEF	0.548*	0.289	1		
Capacity no GEF	0.507*	0.423	0.814*	1	
Governance	−0.110	0.118	0.045	0.392	1
Wealth	0.306	0.296	0.515*	0.871*	0.479*
Caribbean ($n = 11$)					
Biodiversity	1				
AC biodiversity	0.888*	1			
Capacity GEF	−0.014	1.000	1		
Capacity no GEF	−0.292	−0.247	0.866*	1	
Governance	−0.869*	−0.787*	0.215	0.541	1
Wealth	−0.288	−0.269	0.337	0.490	0.651*
Europe ($n = 10$)					
Biodiversity	1				
AC biodiversity	0.725*	1			
Capacity no GEF	−0.043	−0.099		1	
Governance	−0.504	−0.205		0.667*	1
Wealth	−0.177	0.091		0.816*	0.825*
Eastern Europe and Central Asia ($n = 17$)					
Biodiversity	1				
AC biodiversity	0.490*	1			
Capacity GEF	0.851*	0.207	1		
Capacity no GEF	0.760*	0.231	0.881*	1	
Governance	0.137	0.218	0.069	0.042	1
Wealth	0.755*	0.163	0.649*	0.751*	0.477
Middle East and Northern Africa ($n = 15$)					
Biodiversity	1				
AC biodiversity	0.536*	1			
Capacity GEF	0.494	0.604*	1		
Capacity no GEF	−0.045	0.195	0.444	1	
Governance	−0.457	−0.075	0.235	0.799*	1
Wealth	−0.527*	−0.362	−0.349	0.600*	0.599*
Sub Saharan Africa ($n = 43$)					
Biodiversity	1				
AC biodiversity	0.681*	1			
Capacity GEF	0.466*	0.250	1		
Capacity no GEF	0.018	−0.032	0.725*	1	
Governance	−0.222	−0.224	0.419*	0.485*	1
Wealth	−0.139	0.045	−0.013	0.214	0.078

Table 3 Pearson correlations for the indices within-region. Asterisk denotes significance at $p < 0.05$

Region	Biodiversity	AC Biodiversity	Capacity GEF	Capacity no GEF	Governance
Americas ($n = 20$)					
Biodiversity	1				
AC biodiversity	0.876*	1			
Capacity GEF	0.793*	0.751*	1		
Capacity no GEF	0.426	0.498*	0.818*	1	
Governance	−0.220	−0.141	0.674*	0.587*	1
Wealth	0.475*	0.314	0.209*	0.433	0.465*
Asia Pacific ($n = 21$)					
Biodiversity	1				
AC biodiversity	0.851*	1			
Capacity GEF	0.548*	0.289	1		
Capacity no GEF	0.507*	0.423	0.814*	1	
Governance	0.047	0.118	0.045	0.392	1
Wealth	0.295	0.389	0.515*	0.871*	0.479*
Caribbean ($n = 14$)					
Biodiversity	1				
AC biodiversity	0.888*	1			
Capacity GEF	−0.014	−0.247	1		
Capacity no GEF	−0.293	−0.364	0.866*	1	
Governance	−0.869*	−0.787*	0.215	0.542	1
Wealth	−0.288	−0.269	0.337	0.490	0.651*
Europe ($n = 30$)					
Biodiversity	1				
AC biodiversity	0.829*	1			
Capacity no GEF	0.140	−0.112		1	
Governance	−0.144	−0.146		0.696*	1
Wealth	−0.052	0.195		0.409*	0.692*
Eastern Europe and Central Asia					
Biodiversity	1				
AC biodiversity	0.490*	1			
Capacity GEF	0.852*	0.206	1		
Capacity no GEF	0.76*	0.231	0.881*	1	
Governance	0.755*	0.163	0.649*	0.751*	1
Wealth	0.137	0.218	0.069	0.42	0.477
Middle East and Northern Africa ($n = 15$)					
Biodiversity	1				
AC biodiversity	0.536*	1			
Capacity GEF	0.494	0.604*	1		
Capacity no GEF	−0.045	0.196	0.444	1	
Governance	−0.457	−0.075	0.235	0.799*	1
Wealth	−0.536*	−0.362	−0.349	0.601*	0.599*
Sub Saharan Africa ($n = 29$)					
Biodiversity	1				
AC biodiversity	0.100	1			
Capacity GEF	0.461*	0.233	1		
Capacity no GEF	−0.196	0.122	0.570*	1	
Governance	−0.269	−0.100	0.419*	0.485*	1
Wealth	−0.109	0.027	−0.013	0.214	0.078

Table 4 Outlier countries from the intra-regional relationship between biodiversity index against all other indices

Region	Variables	Outlier above	Outlier below
Asia Pacific	Biodiversity Capacity(GEF)	Indonesia, India, Myanmar, Papua New Guinea, Thailand	Fiji, Mongolia, Maldives
Sub Saharan Africa	Biodiversity, Capacity (GEF)	Tanzania, Angola, Mozambique, Ethiopia	Comoros, Sao Tome and Principe, Seychelles, Mauritius
Americas	Biodiversity, Capacity (GEF)	Bolivia, Colombia, Ecuador	Chile, Costa Rica, El Salvador, Uruguay
	Biodiversity, Wealth	Bolivia, Brazil, Colombia, Ecuador, Mexico	CostaRica, Chile, Suriname, Uruguay
	AC Biodiversity Capacity (GEF)	Bolivia, Colombia, Panama, Peru	Argentina, Chile, Ecuador, Uruguay
Caribe	Biodiversity Governance	Bahamas, Cuba, Trinidad & Tobago	Grenada
	AC biodiversity Governance	Trinidad & Tobago	Grenada
Middle East and Northern Africa (Negative slope)	Biodiversity Wealth	Iran, Sudan	Bahrain, Libya, Yemen
Eastern Europe & Central Asia	Biodiversity Capacity (GEF)	Azerbaijan, Kazakhstan, Turkey	Moldova, Belarus, Ukraine
	Biodiversity Capacity (−GEF)	Azerbaijan, Georgia, Kazakhstan, Turkey, Turkmenistan	Belarus, Bosnia-Herzegovina, Macedonia, Moldova, Ukraine
	Biodiversity Wealth	Georgia, Russia, Turkey	Belarus, Bosnia-Herzegovina

numerical terrestrial biodiversity standpoint, could still be critical for reasons not captured in our indices, such as species uniqueness and endemism, migratory or large species with very large home-ranges or countries with large marine biodiversity.

Disaggregating the relationship between biodiversity and several types of capacities (governance, wealth and scientific and technical indices) has important practical and policy implications. It can bear on the kinds of activities that implementing or funding agencies, or local institutional partners, will deem feasible for a particular country. A lower governance index may hinder confidence in long-term projects but less so in short-term ones. Similarly, lower capacities might be overcome through the involvement of advanced local partners or skilled external teams. Developing countries that are positive outliers are particularly interesting—many are examples of megadiverse regions that are becoming much more capable of dealing with biodiversity challenges locally, and thus they can become useful partners to those less-developed countries still developing their management capacities.

Fundamentally, biodiversity assessment is scale-dependent (Soberón and Sarukhán 2009). The relationships between biodiversity and various indicators change with a focus that is global, regional, national, or local. The specific combination of a country's scientific capacity, governance and wealth necessary to achieve particular biodiversity goals will vary according to the spatial and temporal dimensions of the problem it faces (Fig. 3). A rapid local assessment of biodiversity at the level of a few hundred hectares or a municipality will require a different investment in economic resources, professional expertise, governance and technology than a long-term, country-wide monitoring program. Consequently, indicators—ours or others—should be adjusted for particular scales of activity by funding agencies, research organizations or NGOs contemplating projects in a high-biodiversity country. A funding agency's priority for long-term commitments to a country, for instance, may benefit from analyzing the correlation between specific regional biodiversity and the governance and/or the science capacity index because these measures have practical implications with regard to securing long-term research permits, suitable field sites, and local scientific partners. On the other hand, if the project is a rapid, short-term, regional biodiversity survey conducted by an external team, the same agency may proceed regardless of the local governance and capacities.

Our analysis can be improved either by changing the composition of the indices at the same scale, or increasing the scale resolution. Despite the relative availability of statistics on the roughly static, national patterns of

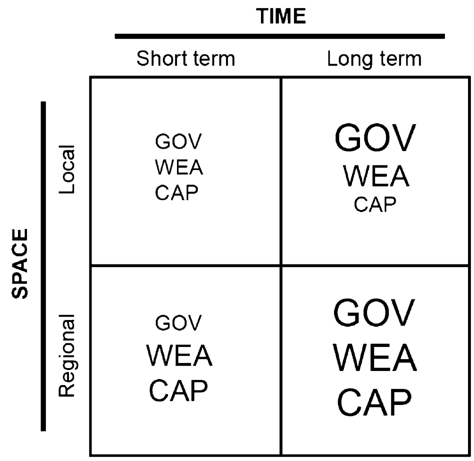

Fig. 3 A possible organization of governance (*GOV*), wealth (*WEA*) and scientific capacity (*CAP*) skills that are required (as indicated by the *letter size*) depending on the spatio-temporal scale of projects

biodiversity, [see also Heywood (1995), Groombridge and Jenkins (2002), and others], the data are mostly reliable for terrestrial vertebrates. Plants or invertebrates, or different spatial and temporal resolutions, pose serious challenges (Balmford et al. 2005). Greater scalar resolution would require biodiversity and governance data for states or provinces or other entities within countries is lacking for many nations. Where the data are available, like in the United States, for instance, state-level results show significant variance: a weighted biodiversity index estimated by The Nature Conservancy is highest for California and southern Appalachia (Stein et al. 2000), two regions that could not differ more economically and infrastructurally, contradicting again the simplistic common-place.

Our analysis is constrained to terrestrial biodiversity. Marine biodiversity is less well known than terrestrial, and the factors influencing their management may be somewhat different. In a recent comprehensive study (Mora et al. 2009) the authors developed a complex management index, based on the answers of 1188 experts to a questionnaire, and a model of sustainability. They found that at a world level, better implementation capability to manage fisheries was more frequent among high-income countries. This finding, although not necessarily related to "biodiversity" as such, tends to support the premise we wished to criticize. However, their results also suggest the need for good indicators and use of scientific information according to the scale in which they are being required and generated to achieve better management practices, as we already highlighted.

Finally, although at certain scales there are rich sources of publicly accessible biodiversity data, exemplified by GBIF (primary data), and IUCN, WWF and others (secondary data in the form of distribution maps, etc.), there are vast amounts of primary biodiversity data, both digitized and not, currently held by the major biodiversity institutions in Europe and the United States but not yet available for analysis, biodiversity science in general, and for informing policy. We urge that the making this data available should be one of the priorities of international initiatives seeking to inform policy, most prominently the recently formed Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

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