Coverage Provided by the Global Protected-Area System: Is It Enough?

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Protected-area targets of 10% of a biome, of a country, or of the planet have often been used in conservation planning. The new World Database on Protected Areas shows that terrestrial protected-area coverage now approaches 12% worldwide. Does this mean that the establishment of new protected areas can cease? This was the core question of the "Building Comprehensive Protected Area Systems" stream of the Fifth World Parks Congress in Durban, South Africa, in 2003. To answer it requires global gap analysis, the subject of the special section of BioScience *for which this article serves as an introduction. We also provide an overview of the extraordinary data sets now available to allow global gap analysis and, based on these, an assessment of the degree to which existing protected-area systems represent biodiversity. Coverage varies geographically, but is less than 2% for some bioregions, and more than 12% of 11,633 bird, mammal, amphibian, and turtle species are wholly unrepresented. The global protected-area systems are far from complete.*

Keywords: protected areas, biodiversity, gap analysis, conservation, World Parks Congress

In 1992, the Fourth World Congress on National Parks and Protected Areas, held in Caracas, Venezuela, established a target for conserving biodiversity by recommending "that protected areas cover at least 10 percent of each biome by the year 2000" (McNeely 1993). Indeed, the roots of this target go back at least a decade earlier, to the Third World Congress on National Parks in Bali, Indonesia, in 1982 (Miller 1984). This target has subsequently been generalized to apply to individual countries and to the entire planet. When the recommendation from the Bali conference was made, the existing protected-area network was reported to cover only 3.5% of the planet's land surface (Harrison et al. 1982). Without any doubt, the 10% target has been influential in encouraging countries to increase the area of their land under protection. Indeed, the global terrestrial coverage of protected areas is now 11.5%—although less than half of this is in IUCN categories I through IV (IUCN 1994), and the increase is largely attributable to better reporting of reserves already existing in 1992. Nevertheless, does the growth of global coverage to more than 10% mean that new protected areas no longer need to be established to safeguard the world's biodiversity?

The answer to this question requires gap analyses. In conservation biology, gap analysis has two interrelated roots. On the one hand, it has focused on measuring the existing coverage of biodiversity in protected areas (Specht and Cleland 1961), institutionalized by the Gap Analysis Program, or GAP, in the United States (Scott et al. 1993). Meanwhile, the field of systematic conservation planning (mainly emerging in Australia, South Africa, and Europe) has concentrated on priority areas for the expansion of reserve systems (Margules and Pressey 2000) and on the identification of regionally comprehensive sets of conservation areas (Groves et al. 2002). To conduct a useful global gap analysis, both elements

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are necessary: We need to know how much biodiversity is currently protected and where new protected areas should be established to move toward complete coverage.

New data are making it possible for scientists to address these questions. The establishment of the World Database on Protected Areas consortium in 2002 has led to the compilation of a properly delineated and georeferenced data set on protected areas, with data of much higher quality than had ever before been collected. Meanwhile, efforts to measure biodiversity systematically have accelerated over the last decade, in particular through the efforts of IUCN (The World Conservation Union). Thus, for example, data sets on the global distribution of entire taxonomic groups—mammals, birds, amphibians—have now been compiled. Ancillary data sets, such as those derived from remote sensing products and from human population censuses, have also improved greatly in resolution and availability. Global gap analyses are now possible, albeit still on a relatively coarse scale.

In September 2003, the global conservation community came together at the Fifth World Parks Congress in Durban, South Africa. One of the seven workshop streams of the congress addressed the question of "Building Comprehensive Protected Area Systems"—that is, global gap analysis. This special section of *BioScience* addresses the core questions tackled in that workshop stream. In this article, we examine the new protected-area and biodiversity data sets that allow scientists to assess the area and biodiversity coverage of existing protected areas. Subsequent articles in the section look at other aspects of building comprehensive protected-area systems. Rodrigues and colleagues (2004a), building on a global gap analysis of the protected area network's representation of terrestrial vertebrate species (2004b), offer a framework for strategically expanding the network to cover mammals, amphibians, freshwater turtles and tortoises, and globally threatened birds. Possible ways of assessing coverage of biodiversity more broadly, and in particular evaluating turnover patterns among plants and invertebrates, are explored by Ferrier and colleagues (2004). Eken and colleagues (2004) investigate the potential for moving gap analysis down to the fine scales necessary for identifying areas as targets for protection on the ground. Finally, Bruner and colleagues (2004) assess the likely costs of management and expansion of the protected-area system. The resilience of protected areas in the face of global climate change was also considered at the workshop; the results of this work have been published elsewhere (Hannah and Lovejoy 2003). Noticeable for its absence is the treatment of freshwater and marine systems, for which the compilation of comprehensive data sets is an urgent priority.

The World Database on Protected Areas

The World Database on Protected Areas (WDPA) is the most comprehensive global catalog of protected areas, assembled by a broad alliance of organizations (including the American Museum of Natural History, BirdLife International, Conservation International [CI], Fauna and Flora International, IUCN, The Nature Conservancy, the United Nations Environment Programme–World Conservation Monitoring Centre, the World Resources Institute, the Wildlife Conservation Society, and the World Wildlife Fund) working in coordination with the IUCN World Commission on Protected Areas. It aims to build and maintain a freely available, accurate, and up-to-date database that is accepted as a global standard by all stakeholders; the 2004 version is available at *http://sea.unep-wcmc.org/wdbpa/.* The 2003 WDPA Consortium was the first version of the global data set, which is under continuing, iterative development.

Protected areas in the 2003 WDPA were recorded either as polygons (58,514 records) or points (106,215 records), or as both. (Of those recorded as points, 73,863 had no corresponding polygon information.) Both types of data were provided as ArcView shapefiles (ESRI 2000), with associated attribute tables. Data for each protected area included a unique site code, protected-area name, country, geographical coordinates, designation (e.g., nature reserve, national park), and status (e.g., designated, proposed, degazetted). The database further included information on IUCN protected-area categories; categories I through IV are explicitly designated for biodiversity protection, while categories V and VI are designated for multiple-use management (IUCN 1994). The 2003 WDPA also included data on protected areas with international status (e.g., UNESCO Man and the Biosphere Reserves, World Heritage sites, Ramsar wetlands), but this information was included in our analysis only when the area was also designated at a national level.

For the purpose of this analysis, we eliminated the following records from the WDPA: (a) those with no information on the exact geographical location of the area (19,418 points with latitude and longitude listed as zero) and (b) records that did not seem to correspond to established protected areas, including those with their area name recorded as "area not protected" (2599 polygons), or their status recorded as "degazetted," "proposed," "recommended," "in preparation," or "unset" (1024 polygons and 1751 points). For the remaining records, we kept the maximum level of geographic data provided by the WDPA. Point records with no information on area were kept in a separate point shapefile (11,229 records). Point records with associated area were converted into circular shapes of the same area (centered on the coordinates provided for the point) and merged with the polygon records into a common polygon shapefile (total number of records: 69,794). Antarctica, theoretically a single, huge protected area, was excluded from calculations throughout. Globally, the world's network of protected areas covers 11.9% of all land area. Considering only those protected areas designated explicitly for biodiversity conservation (IUCN categories I through IV) yields a more conservative estimate of 5.1%.

Coverage of biomes and realms by protected areas

Biomes represent global-scale ecological variation in the structure, dynamics, and complexity of biological communities and ecosystems, whereas realms are continent-scale regions

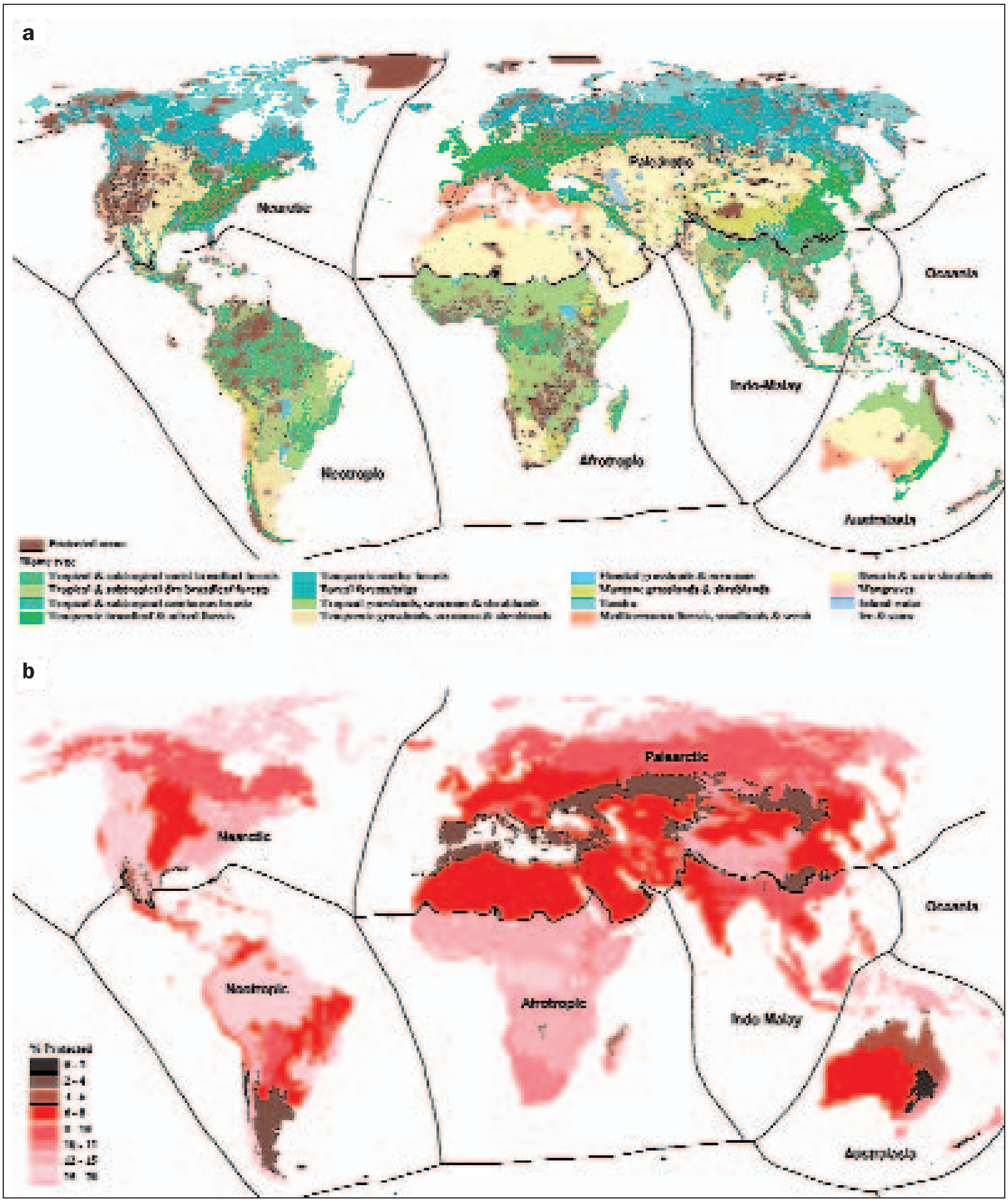

Figure 1. (a) Global network of protected areas overlaid on terrestrial biomes and realms. Data on protected areas are from the World Database on Protected Areas (WDPA Consortium 2003); presumptive boundaries for biomes and realms were delineated according to terrestrial ecoregion classifications (Olson et al. 2001). (b) Protected-area coverage by bioregion (biome–realm combinations). Bioregions are shaded according to the percentage of area protected.

distinguished by characteristic biota that reflect shared evolutionary histories (figure 1a; Olson et al. 2001). We summarized protected-area coverage across each of the terrestrial biomes and biogeographic realms to identify bioregional gaps in the protected-area network (figure 1b, table 1). Temperate conifer forests (25%), flooded grasslands and savannas (18%), and tropical or subtropical moist broadleaf forests (18%) are the most protected biomes, although if only protected areas in IUCN categories I through IV are considered, tundra (12%) emerges as the most protected biome. Temperate grasslands, savannas, and shrublands (5%); mediterranean forests, woodlands, and scrub (6%); and tropical or

Table 1. Estimates of the percentage of area protected (global, by biome, and by biogeographic realm), calculated using all protected areas listed in the 2003 World Database on Protected Areas (WDPA Consortium 2003).

	Global	Australasia	Afrotropic	Indo-Malay	Nearctic	Neotropic	Oceania	Palearctic
Global	12	8	15	10	16	16	8	9
Tropical and subtropical moist broadleaf forests	18	14	16	10	–	24	3	3
Tropical and subtropical dry broadleaf forests	9	11	6	8	0	9	9	–
Tropical and subtropical coniferous forests	6	–	–	6	5	8	–	–
Temperate broadleaf and mixed forests	9	12	–	15	13	25	–	7
Temperate coniferous forests	25	–	–	18	34	–	–	12
Boreal forests and taiga	10	–	–	–	10	–	–	9
Tropical and subtropical grasslands, savannas, and shrublands	13	5	15	10	3	8	43	–
Temperate grasslands, savannas, and shrublands	5	2	–	–	7	3	–	4
Flooded grasslands and savannas	18	–	29	70	–	10	–	7
Montane grasslands and shrublands	15	50	12	29	–	13	–	15
Tundra	15	–	–	–	18	–	–	13
Mediterranean forests, woodlands, and scrub	6	8	12	–	26	1	–	4
Deserts and xeric shrublands	10	8	12	8	23	8	–	8
Mangroves	16	20	10	9	4	26	–	–

subtropical conifer forest (6%) are the least protected biomes, a result that is robust when considering only protected areas in IUCN categories I through IV. Protection also varies among biogeographic realms. In relation to total area, habitat protection has been most substantial in the Neotropical (16%), Nearctic (16%), and Afrotropic (15%) realms, but less so in the Indo-Malay (10%), Palearctic (9%), Australasian (8%), and Oceanian (8%) realms. There is little variation among realms when considering only protected areas in IUCN categories I through IV. The most significant bioregional gaps in protected-area coverage (< 2%) are in the tropical dry forests of Mexico, the mediterranean habitats of Chile, and the temperate grasslands of Southern Africa (figure 1b, table 1).

Global databases on species distribution

The conservation community has a long history of evaluating threats to species, with the IUCN Red List program dating back four decades (Burton 2003), but the importance of systematic assessment has only been realized relatively recently (Mace and Lande 1991). The IUCN Red List (*www.redlist.org*) now provides comprehensive evaluation of ecology and distribution, as well as extinction risk (IUCN 2001, Pollock et al. 2003), providing a framework for assessing the coverage of species in protected areas. To date, approximately 30,000 species have been evaluated, with approximately 10,000 considered threatened (IUCN 2003), although data vary enormously across taxonomic groups (table 2). Many terrestrial vertebrate and plant groups have been comprehensively assessed and are discussed in more detail here. In contrast, remarkably few aquatic species have been assessed in either freshwater or marine environments, and the situation is even more serious for invertebrates, for which fewer than 1% of described species—and hence maybe as few as 0.1% of all species (Novotny et al. 2002)—have been assessed. A massive increase in support to systematic, ecological, and conservation studies of invertebrate species is urgently required, along with the development of surrogate techniques for assessing overall biodiversity (see Ferrier et al. 2004).

Birds. There is better information on birds than on any other comparable taxon. They are easy to observe, being relatively big, attractive, and conspicuous. Most are active by day; they can be identified in the field from a distance; and, although they are diverse, the number of species is manageable (approximately 10,000). For all these reasons, people enjoy watching birds and can provide useful data on them. For example, in 2001, the month-long World Bird Festival attracted well over 300,000 people to cultural and birding events in 88 countries worldwide, with three million bird sightings logged in Europe alone.

BirdLife International (*www.birdlife.org*) serves as an important global focus for this huge array of bird data (BirdLife International 2004a). As the Red List authority for birds, BirdLife has published four global assessments of the status of the world's birds (Collar and Andrew 1988, Collar et al. 1994, BirdLife International 2000, 2004b). These will be updated comprehensively every 4 years, with partial updates on an annual basis. The "Threatened Bird Discussion Forums" hosted on BirdLife International's Web site facilitate widespread contributions of recent information and debate on the

Table 2. Total numbers of known species for five taxa (birds, mammals, amphibians, reptiles, and plants), numbers and percentages of species in each taxon that were assessed for the IUCN Red List, and numbers and percentages of assessed species that were considered threatened (IUCN 2003).

		Species assessed		Threatened species	
Taxon	Total number of species	Number	Percentage of total species	Number	Percentage of species assessed
Birds	9932	9932	100	1194	12
Mammals	4842	4789	99	1130	24
Amphibians	5743	5743	100	1856	32
Reptiles	8134	473	6	293	62
Plants	287,655	9706	3	6774	70

Note: Data on amphibians are from the IUCN Global Amphibian Assessment.

most appropriate conservation status for bird species. A total of 1211 species are currently considered threatened (plus 4 extinct in the wild), making up 12% of all bird species. BirdLife International is using these data to develop Red List indices to quantify the overall change in threat status of the world's birds over the last 16 years as a result of genuine improvement or deterioration (Butchart et al. 2004). The organization manages its extensive data in a world bird database covering all species, more than 7500 important bird areas (Eken et al. 2004), and 218 endemic bird areas (Stattersfield et al. 1998). Range maps showing the extent of occurrence are currently being prepared for all bird species; they are already available for New World species (figure 2a; Ridgely et al. 2003) and for all globally threatened species (figure 2b; BirdLife International 2000).

Mammals. Many species of large mammals are well known both scientifically and popularly. However, current knowledge about mammals is neither uniform nor complete. About 5000 mammal species are known worldwide (Wilson and Reeder 1993; *www.nmnh.si.edu/msw/*), but the conservation status of more than half is insufficiently known or inadequately documented. To address this knowledge gap, the IUCN Global Mammal Assessment (GMA) has been established through the IUCN/SSC (Species Survival Commission)–CI/CABS (Center for Applied Biodiversity Science) Biodiversity Assessment Unit (*www.iucn.org/themes/ssc/programs/gma/index.htm*). Its main goal is to consolidate available information on the systematics, distribution, habitat requirements, biology, ecology and life history, threats, needed conservation measures, and conservation status of mammals. The GMA process comprises three components: (1) IUCN/SSC specialist group review, (2) workshops, and (3) collaborations with other relevant experts and projects. The existing IUCN/SSC specialist group structure is remarkably strong for some mammal taxa, but is somewhat less developed with regard to some small mammals, and it is in this area that there is the greatest role for review workshops. The activities of the GMA, therefore, are reaching out to mammalogists throughout the world; helping to connect experts within their discipline; and creating opportunities for training, a greater knowledge base, and enhanced scientific integration.

Mammals are a diverse group, found in all biomes of the world. Preliminary work in mapping each species through the GMA illustrates broad distributional patterns for mammals as a group (figure 3a), with a strong latitudinal gradient in species richness. The initial assessment of the conservation status of mammals (Baillie and Groombridge 1996) showed that roughly one-fourth of all mammals—1130 species—were threatened with extinction. Many of these species are found in discrete areas, mainly in tropical montane forests and on islands (figure 3b).

Amphibians and reptiles. Remarkable advances in data compilation for amphibians have taken place over the last few years, though even on the 2003 IUCN Red List, only 401 amphibian species were assessed—revealing 157 threatened species (IUCN 2003)—out of a total amphibian diversity of more than 5500 species (Frost 2004; *http://research.amnh.org/herpetology/amphibia*). However, the results of the comprehensive IUCN Global Amphibian Assessment (GAA) have now been compiled globally and will be incorporated into the 2004 IUCN Red List. The GAA, like the GMA, was conducted through the IUCN/SSC–CI/CABS Biodiversity Assessment Unit. It used a two-stage process: First, an expert on amphibians in each of 33 designated regions collected data on species taxonomy, distribution, population status, habitat preferences, trade status, and major threats and conservation measures for all species in the region. Each regional expert also provided a preliminary threat assessment for each species. Second, all the data collected in this initial stage were reviewed either through expert workshops (for the more speciose regions) or by correspondence. The only exceptions to this process were for the United States and Canada, for which NatureServe provided assessments directly. In total, some 1856 amphibian species are now considered globally threatened, and 34 species have already become extinct within the last few decades.

The global species richness of amphibians shows notable differences from that for birds and mammals, with a much steeper latitudinal gradient and very few species occurring on oceanic islands, because of the poor dispersal abilities of the taxon (figure 4a). The richness of threatened amphibian species is hard to discern on a global map (figure 4b) because

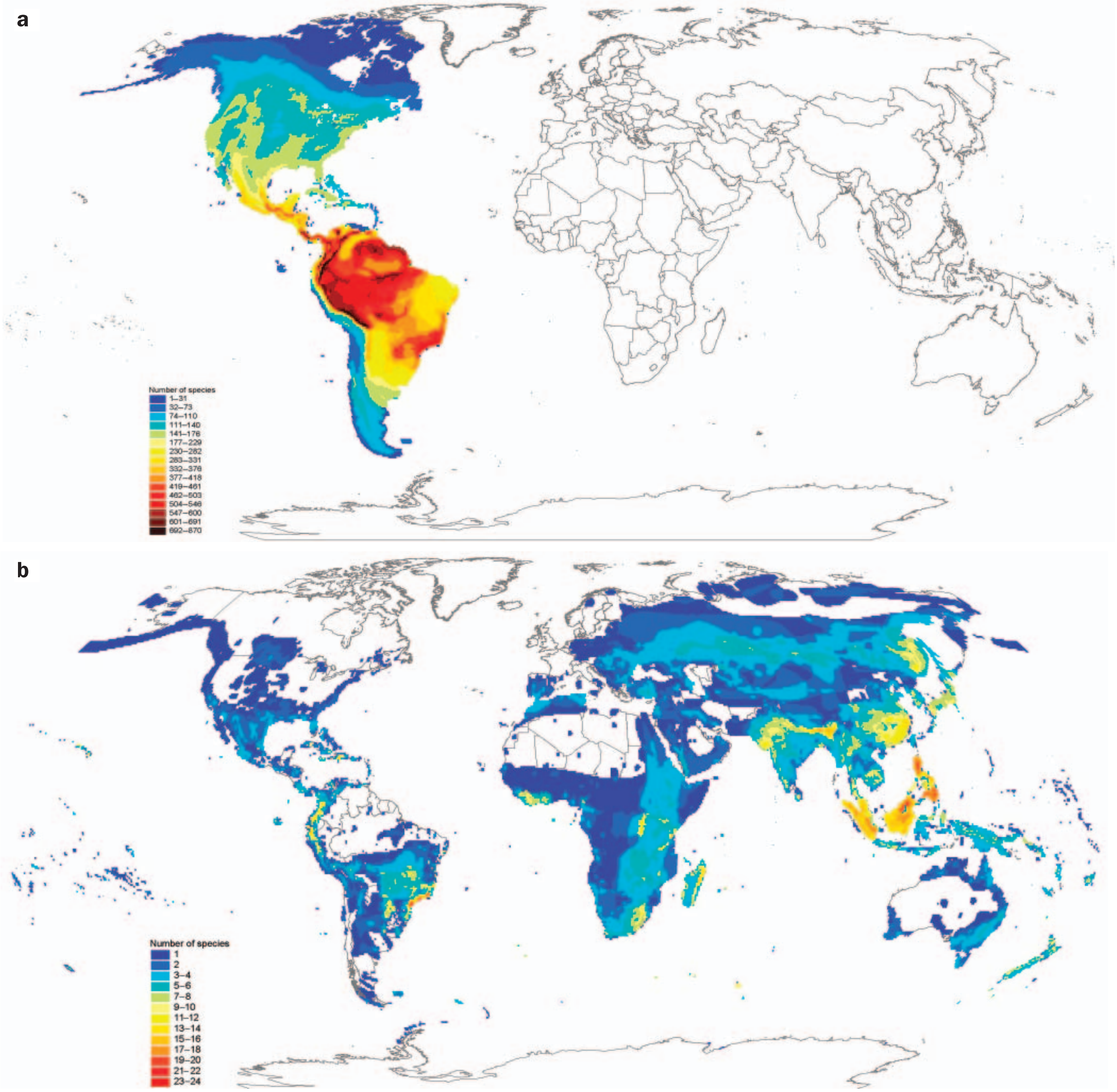

*Figure 2. (a) Species richness of birds across the Americas (*n *= 4340) per half-degree cell (Ridgely et al. 2003). (b) Global patterns of species richness for threatened bird species (*n *= 1186) per half-degree cell (BirdLife International 2000).*

of the tiny distribution of many amphibian species, but it is clear that large numbers of threatened species are confined to tropical mountains. Amphibians appear to be declining (Houlahan et al. 2000) as a result not only of habitat loss but also of numerous other threats, including fungal disease, pesticides, ultraviolet-B radiation, climate change, and synergistic interactions between these and other factors.

Data on reptile species have yet to be assessed comprehensively. There are more than 8000 reptile species worldwide (Uetz and Etzold 1996; *www.reptile-database.org*), but only 473 species were evaluated for the 2003 Red List (IUCN 2003). While coverage of amphisbaenians (worm lizards), snakes, and lizards is patchy, tuataras, crocodilians, and chelonians have been comprehensively assessed (IUCN 2003). Moreover, the latter of these have also been mapped using point data from the EMYSystem World Turtle Database (Iverson et al. 2003; *http://emys.geo.orst.edu*), converted into polygons and preliminarily reviewed by the IUCN Global Turtle Assessment. In total, 273 species were analyzed (a little more than 3% of all reptiles), of which 119 are considered globally threatened (IUCN 2003). The establishment of an overall Global Reptile Assessment, planned to begin in 2005, is a high priority.

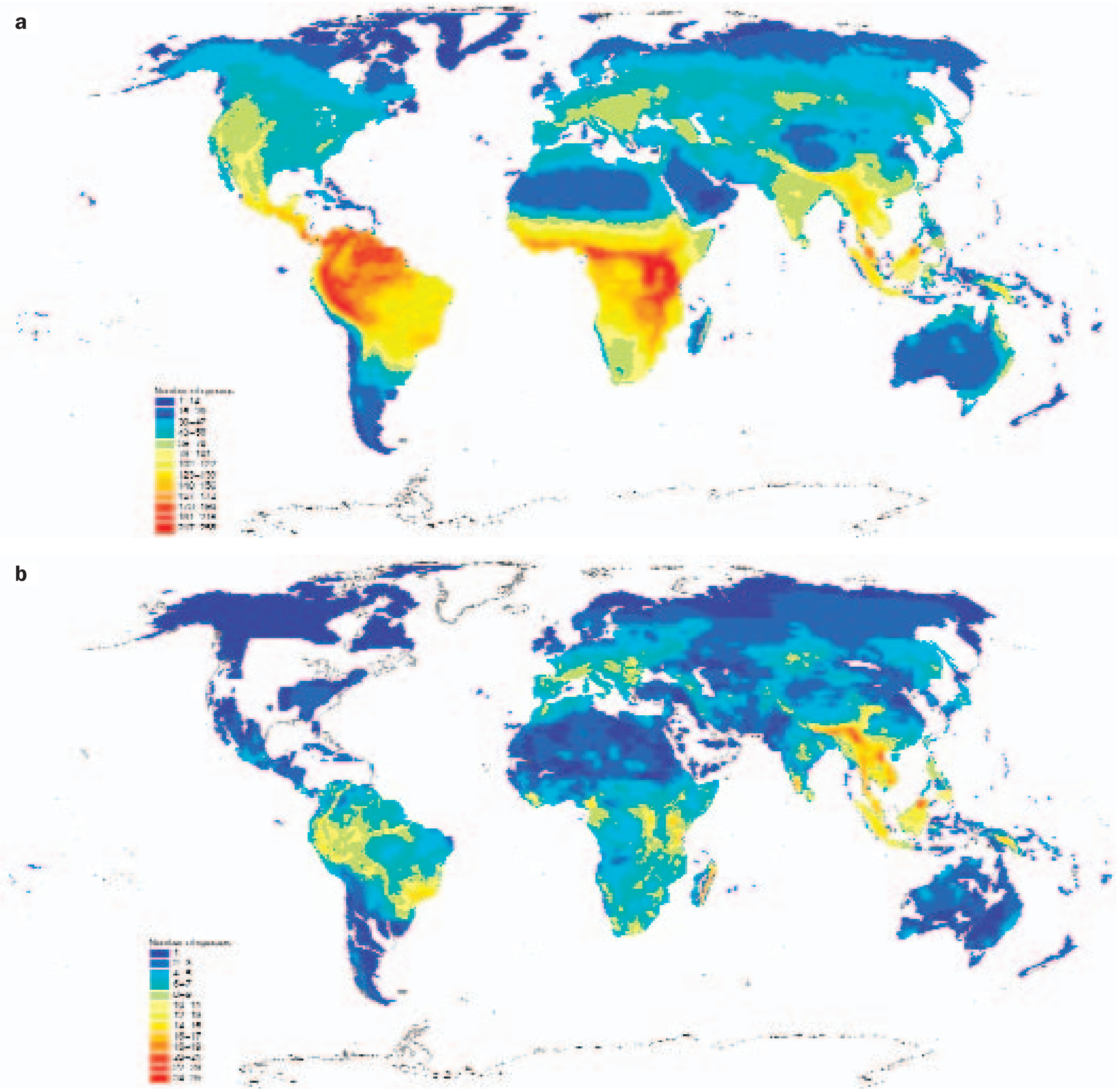

Figure 3. (a) Global species richness of mammals (n = 4734) per half-degree cell. Data were compiled under the IUCN/SSC (Species Survival Commission)–CI (Conservation International)/CABS (Center for Applied Biodiversity Science) Global Mammal Assessment. (b) Global patterns of species richness for threatened mammals (n = 1130) per half-degree cell. Data were compiled under the IUCN/SSC–CI/CABS Global Mammal Assessment.

Plants. In April 2002, the Convention on Biological Diversity (CBD) adopted a "global strategy for plant conservation." This strategy brought together many sectors involved in plant conservation to provide an umbrella of essential plant conservation efforts and adopt a target of "60 per cent of the world's threatened species conserved in situ" by the year 2010. While it is not yet possible to measure the global coverage of plant species by protected areas, 15 other targets were included in the strategy. Target 5, for example, requires "protection of 50 per cent of the most important areas for plant diversity assured," which necessitates the identification of important plant areas (Eken et al. 2004).

Two other targets are particularly relevant to a global gap analysis of plant species. The first of these targets calls for "a widely accessible working list of known plant species, as a step towards a complete world flora." This task is enormous, since the estimated number of described vascular species (i.e., all flowering plants, plus ferns and fern allies) varies from 270,000

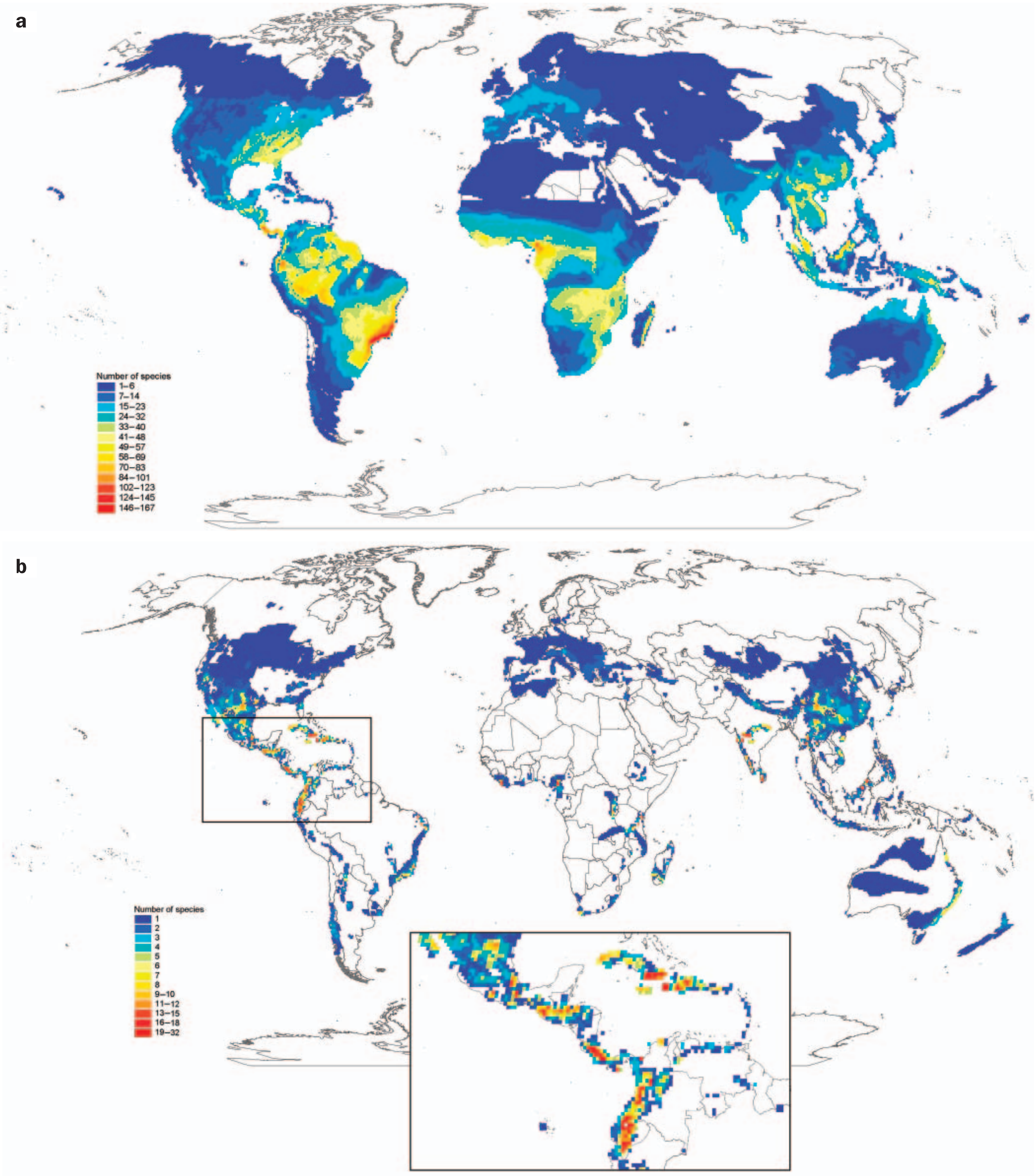

*Figure 4. (a) Global species richness of amphibians (*n = 5247*) per half-degree cell. Data were compiled under the IUCN/SSC (Species Survival Commission)–CI (Conservation International)/CABS (Center for Applied Biodiversity Science) Global Amphibian Assessment. (b) Global patterns of species richness for threatened amphibians (*n = 1560*) per half-degree cell. Data were compiled under the IUCN/SSC–CI/CABS Global Amphibian Assessment. The inset shows the Caribbean, Mesoamerica, and the tropical Andes, which hold large numbers of threatened amphibian species with tiny ranges, hard to discern at a global scale.*

(Thorne 2002) to 422,000 (Govaerts 2001). Even these figures exclude the estimated 15,000 species of bryophytes (mosses, liverworts, and hornworts; Hallingbäck and Hodgetts 2000) and 16,000 species of lichens (Christoph Scheidegger, chair, IUCN/SSC Lichen Specialist Group, personal communication, August 2003).

The other key target for enabling gap analysis through the CBD's global strategy for plant conservation calls for "a preliminary assessment of the conservation status of all known plant species, at national, regional and international levels." The first analysis of the conservation status of the world's vascular plants was published in 1997, summarizing 20 years of work and compilation of several major regional conservation assessments in the United States, Australia, Europe, and South Africa, and covering 35,291 taxa (Walter and Gillett 1998). Subsequently, many tree species have been evaluated (Oldfield et al. 1998) and these data incorporated into the 2003 Red List, in which 6774 plant species out of 9706 evaluated are considered threatened (IUCN 2003). Most species have yet to be mapped in more detail than by country. The Red List does, however, include comprehensive evaluations of all conifer (Farjon and Page 1999) and cycad (Donaldson 2003) species. In addition to these evaluations, a literature review and a stakeholder consultation show that about 60% of countries have undertaken some sort of national Red List evaluation for plants, although these evaluations have used many different systems. All country endemics, once assessed with the IUCN criteria (IUCN 2001), will be included in the global IUCN Red List.

The incorporation of plant data into comprehensive global gap analysis faces major challenges. These include not only the need for a complete global list of species, and for distribution maps and threat assessments for each species, but also the need to standardize plant assessments to the usual Red List criteria, between national and global scales, and from infraspecific scales to species-level assessments. Nevertheless, the very fact that the CBD endorsed these ambitious global targets for plant conservation at least suggests that a framework for resolving these issues may be in place in the not too distant future.

Coverage of species by protected areas

The extent of the global protected-area system is most meaningfully measured by its coverage of biodiversity, of which species diversity is a widely used measure. However, a global gap analysis of species coverage requires systematic information on the spatial distribution of individual species, which is currently available for only a fraction of all species. A recent article (Rodrigues et al. 2004b) provided a first assessment of coverage of species by the global network of protected areas for the four groups of terrestrial vertebrates for which global assessments are currently available: mammals, amphibians, turtles and freshwater tortoises, and threatened birds. Out of 11,633 species analyzed, at least 1424 species (12.2%) are gap species, not covered by any protected area. The coarse nature of the species data means that this figure is likely to be a gross underestimate of the true number of gap species (Rodrigues et al. 2004b). Considering only the protected areas larger than 1000 hectares that are classified in IUCN categories I through IV, this number increases to 2847 (24.5% of all species). These gap species include 232 threatened bird species (19.8%); 258 species of mammals (5.5%), including 149 threatened species (14.0% of all threatened mammals); 913 amphibian species (16.7%), with 411 threatened species (26.6% of all threatened amphibians); and 21 species of turtles (7.7%), including 12 globally threatened species (10.1% of all threatened turtles).

Conclusions

Comprehensive global assessment of coverage by protected areas has never before been possible, and so the results of the "Building Comprehensive Protected Area Systems" stream of the Fifth World Parks Congress represent a major advance for conservation biology. Overall, a number of important themes can be seen emerging from this work, regarding both its limitations and its implications.

Most immediately, the critical importance of large, georeferenced databases on the distribution of both protected areas and species is quite clear. Further, while remarkable steps have been taken toward the production of these databases in the last few years, neither their structure nor their content is yet sufficient for the task at hand. In terms of structure, these data systems face numerous institutional obstacles to achieving broad, Web-based, open-access distribution in a way that credits primary data providers appropriately. This has led to the proliferation of smaller online data systems on biodiversity, covering a single taxonomic group, region, or theme, with resulting problems of interoperability. In terms of content, the need for expansion to cover aquatic, plant, and invertebrate groups comprehensively is obvious, and this expansion will require a serious investment in the systematics and ecology of these groups. Initiatives such as the Global Biodiversity Information Facility (Bisby et al. 2002) and the All Species Initiative (Lawler 2001) are encouraging steps in the direction of eliminating these problems, but they have yet to deliver substantive results. In addition, IUCN has launched a major effort to consolidate the species data collected by its network into a Species Information Service (*www.iucn.org/themes/ssc/programs/sisindex.htm*). These data compilations also allow the incorporation of environmental data (Ferrier et al. 2004) to develop shortcut measures of biodiversity surrogacy.

While these data limitations are a serious problem facing the assessment of protected-area coverage and biodiversity representation, the prediction of the persistence and viability of biodiversity in protected areas is considerably harder. Measures of the ecological processes necessary to allow the persistence of biodiversity are sparse, although some advances are under way (Pressey et al. 2003). Moreover, it is likely that many of these processes are less well maintained by site-scale conservation in protected areas than by landscape-scale interventions (Sanderson et al. 2003). Biodiversity loss at the population level is probably orders of magnitude greater than species loss (Hughes et al. 1997), and species losses from given areas often have far-reaching ecological and evolutionary consequences—for example, through the loss of top-level carnivores (Crooks and Soulé 1999). Furthermore, although it has been shown that any protected areas can confer conservation benefits in comparison with adjacent unprotected areas (Bruner et al. 2001), it is clear that the effectiveness of any given protected area will depend on its management, with many protected areas little more than "paper parks" (Brandon et al. 1998). Bruner and colleagues (2004) provide insight into the costs of effective management of the global protected-area system.

A related issue is one of scale. Assessments such as those presented here give a global framework, which is extremely important for audiences operating at the same scale. Examples include bilateral and multilateral organizations such as the World Bank, international policies such as the CBD, and nongovernmental organizations with global scope. However, this kind of global assessment is far from providing an accurate picture of even the coverage, let alone the viability and effectiveness, of protected areas on a country-by-country or region-by-region scale. Such assessment needs to be driven from subglobal scales to incorporate the complexities of fine-scale data, but it also needs to follow international standards and criteria if it is to be comparable globally. The concept of key biodiversity areas is a tool for achieving this (Eken et al. 2004). Site-by-site assessment of the management effectiveness of such areas in safeguarding the biodiversity for which they are important will be necessary to produce a truly accurate global gap analysis. Thus, the important issues are not what percentage of the planet or its biomes' protected areas should cover, but where exactly these sites should be and how they should be managed; the former can emerge from the latter, but not vice versa. The policy implication is clearly that conservation goals should be measured by biodiversity, not by area.

Finally, and most important, the core conclusion emerging from this work is that the global protected-area system is far from complete. Addressing the issue of which areas should be priorities for expansion requires the application of systematic conservation planning procedures (Margules and Pressey 2000) but, critically, cannot be done without completing assessments of existing coverage, as outlined here. Beginning to fill the gaps in the existing protected-area system—starting with those that require the most urgent attention—should be the highest priority for conservation over the coming decade, so that the next World Parks Congress will be able to report dramatic progress from the current situation.

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