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Expansion of the global terrestrial protected area system

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ABSTRACT

Under the Convention on Biological Diversity, the world's governments set a goal of protecting 10% of all ecological regions by 2010. We evaluated progress toward that goal for the world's major terrestrial biomes, realms, and ecoregions. Total land area under any legal protection has increased from previous estimates to 12.9%, a notable achievement, although only 5.8% has strict protection for biodiversity. For biomes, protection ranges from 4% to 25%, with six of 14 biomes still below the 10% level. Geographic patterns of protection have a distinct bias, with higher rates of protection in New World realms than Old World realms. Of the world's terrestrial ecoregions, half do not meet the 2010 Target and 76% have less than 10% of their area strictly protected. Approximately 13% of ecoregions have no strict protected areas. Recent years have seen an expansion of the protected area network, with an average of 0.13% of the global land area added per year. Most of the expansion since 2003 though has been in Brazil, particularly the Amazon. Without major investments in conservation, spread across the world's ecosystems, the world will likely miss the 2010 target.

1. Introduction

Formal protected areas (hereafter PAs) are widely considered the first line of defense in the global effort to protect biodiversity (e.g., Rodrigues et al., 2004a,b; Chape et al., 2005; Loucks et al., 2008; UNEP-WCMC, 2008). They exist in many forms and with many titles, but can be thought of broadly as delimited areas having specific restrictions on human activities. In an ideal world, perhaps society would protect a sufficient sample of each of the world's ecosystems to guarantee the widest possible variety of life to be enjoyed by future generations. To an extent, that is the motivation behind the highly lauded 2010 Biodiversity target (Balmford et al., 2005), which contains directions to effectively conserve "at least 10% of each of the world's ecological regions" (CBD, 2004). The continuing question is: How close are we to achieving this noble goal?

We present here a comprehensive assessment of the area protected within the world's terrestrial biomes, biogeographic regions, and ecoregions. This study builds upon a rich history of GAP analyses in and around PAs (Chape et al., 2003, 2005; Brooks et al., 2004; Hoekstra et al., 2005; Soutullo et al., 2008), but takes advantage of recently available and more comprehensive data on PAs. We present results for multiple spatial scales and multiple levels of strictness of PAs, as well as an assessment of where recent expansion of the world's protected area system is occurring.

Previous studies found the geographic distribution of PAs to be uneven, particularly with respect to the areas with the strictest protection levels (Chape et al., 2003, 2005; Brooks et al., 2004; Hoekstra et al., 2005; Soutullo et al., 2008). There exists the hope though that society will try to fill in the gaps, focusing new conservation efforts on those ecosystems currently underrepresented in the global PA system. Support and direction for these efforts requires regular assessments of precisely what the current protected area system contains, and so identifying where the remaining gaps are that need filling. The intent of this study is to provide such input.

There has been a substantial increase in the percentage of land area protected over the past 20 years (Table 1), although the methods of calculating that percentage vary by the particular study, partially obscuring the true trend. When analyzing PA coverage for 1985, Zimmerer et al. (2004) showed that just 3.48% of the world was under formal protection at that time. The number may actually have been higher (some PAs were almost certainly not included in the existing IUCN database used by the authors), or lower (the authors were unable to account for overlapping PAs, possibly inflating the estimate of area protected). Nevertheless, it is clear that very little of the world was formally protected in 1985. Zimmerer et al. (2004) also estimated that by 1997, protected area coverage had increased substantially to almost 9% (Table 1), an average increase of ∼0.45% per year.

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Table 1
Previous assessments of the global terrestrial protected area system and source data used.

Study	Year of data	Global land area protected (%)
Zimmerer et al. (2004)	1985	3.48
Zimmerer et al. (2004)	1997	8.82
Chape et al. (2003)	2003	11.5
Brooks et al. (2004)	2003 WDPA	11.9
Hoekstra et al. (2005)	2004 WDPA	11.9
Chape et al. (2005)	2004 WDPA	12.2
Soutullo et al. (2008)	2005 WDPA	11[a]
UNEP-WCMC (2008)	2008 WDPA[b]	12.2

[a] Excludes non-IUCN categorized areas.
[b] Global dataset not publicly available at time of submission.

Starting in 2003, coincident with the Fifth World Parks Congress in Durban, South Africa, a series of studies analyzed the spatial patterns of PAs. All found the global PA system to cover ~11–12% of the world's land area (Table 1). This suggests that the rate of protection continued to increase at about 0.4% per year since 1997, or perhaps slightly faster depending on the study. Chape et al. (2003) and Brooks et al. (2004) led the way by analyzing how much of the world's major biomes were under protection, with both groups of authors using data for 2003. Hoekstra et al. (2005) went a step further by using the more recent 2004 World Database on Protected Areas (WDPA) to evaluate protection levels at the ecoregion scale. Also using 2004 data, Chape et al. (2005) explored the geopolitical distribution of PAs, in addition to updating an earlier evaluation of protection levels by biomes (Chape et al., 2003).

Recently, Soutullo et al. (2008) used the 2005 WDPA to evaluate protection at the ecoregion scale, finding that most ecoregions are under-protected. While we applaud the effort, we have three criticisms of the methods of Soutullo et al. (2008). One, they ignored protected areas having no formal IUCN category. While we agree with treating such areas separately, one should not simply dismiss them. Two, each protected area was assigned to only a single ecoregion, even though the authors acknowledged that some protected areas overlap multiple ecoregions. Three, the authors did not account for overlapping protected areas, likely inflating their estimates of protection.

Since the earlier studies, the WDPA itself has improved substantially. In previous versions, many PAs lacked boundary information and were represented as single points. Substantial progress has been made on this deficiency, especially in South America and Australia. Since 2005, there have also been several large PAs created, particularly in the Amazon basin, and many pre-existing PAs have been added to the database.

In addition to providing an updated analysis using the most current, publicly available WDPA, we attempt to address the methodological problems of the earlier studies described above. Some previous studies were also limited or unclear in their analyses, particularly with regard to which categories of protected areas were included. Moreover, at the risk of serious analytical error, different authors dealt differently with overlapping PAs and those PAs represented as points.

The problem of PAs represented as points has been a continuing concern across studies. Generally, the approach is to create a buffer around the point that is equal to the reported area of the PA. This is not an ideal solution, and while other authors have discussed the possible consequences of using buffered points (e.g., Chape et al., 2005), we believe we are the first to quantify the potential error incurred with this method. For very broad-scale analyses, such as assessing the protection levels of entire biomes, the errors are likely insignificant. For finer scales, such as the ecoregion level, they could be more important. Consider the case of the Sungai Serudong Protection Forest Reserve in Malaysia (Fig. 1). The actual

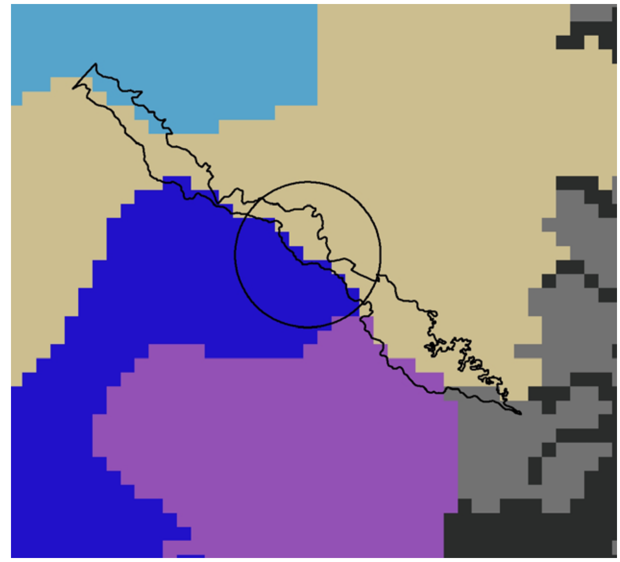

Fig. 1. Sungai Serudong Protection Forest Reserve in Malaysia overlaid on WWF ecoregions. The circle represents how the reserve would appear if represented by a buffered point rather than a polygon.

reserve is almost entirely within one ecoregion (light brown in Fig. 1).[1] Were the reserve to have been represented by a single point, and then buffered to create a circular reserve, the circle would be split roughly halfway between two ecoregions (light brown and blue in Fig. 1). We explore the potential severity of this problem, showing that it can be significant, but likely only in particular parts of the world.

2. Materials and methods

We used the 2009 World Database on Protected Areas as our primary source for PAs (WDPA, 2009), the most recent public version available at the time of submission. We excluded from our analyses all areas designated only by international conventions (i.e., not nationally gazetted). All PAs with a status other than "designated" were also excluded (i.e., Adopted, Degazatted, Inscribed, Not Applicable, Not Known, Proposed, Recommended, Retired, Voluntary). For PAs included only as points in the WDPA, we created a circular buffer around the point equal to the listed area for the PA. Of the point-only PAs, 10,638 had no reported area and so were excluded. The 2009 WDPA does not include the United Kingdom because of unspecified "data restrictions", and so we copied data for the United Kingdom from the 2007 version of the WDPA (2007, 2009). Because of an ongoing change in the data sources for the United States of America, many of its protected areas do not appear in the 2009 WDPA, although they were present in the 2007 WDPA. These include most of the National Forests and Grasslands, as well as many State Parks and Forests. We copied these from the 2007 WDPA.

All PAs in the WDPA are classified either as one of the six IUCN Protected Area Management Categories (IUCN, 1994), or lack an IUCN category altogether. We grouped the PAs into three groups for analysis: (1) all PAs, (2) all IUCN categories, and (3) strictly protected IUCN categories (I–IV). When there were overlaps in protected areas, we classified the area as the highest IUCN category occurring in that location. Areas not designated as an IUCN

[1] For interpretation of color in Figs. 1–7, the reader is referred to the web version of this article.

category were considered the lowest protection level (i.e., below IUCN category VI).

For the spatial analyses, we used the World Wildlife Fund ecoregions database (Olson et al., 2001; WWF, 2008), which is widely used for global conservation planning. We used the revised version of this database, sometimes referred to as "version 2", which includes 825 ecoregions (as opposed to 867 in the original version). The ecoregion database also divides the world into biomes and geographic realms, which we analyze in addition to the ecoregion scale. We excluded the Lakes, Rock and Ice, and Antarctica ecoregions, leaving 821 ecoregions. A minor point to note is the slight change in biome boundaries in South America with the version 2 ecoregions database. This change could slightly affect comparisons with previous studies that used the original ecoregions dataset.

Previous studies have only conjectured about the potential error of drawing circular buffers around PAs represented as points (although Joppa et al. (2008) replicated their analysis with and without point data, finding the results changed significantly depending on the geographic region of interest). There is, however, a way to evaluate objectively the magnitude of the errors incurred. To test the potential effects of point versus polygon representation in the database, we randomly selected 1000 polygons from the WDPA and calculated the centroid position of each. We then placed a point at the centroid and buffered the point to match the original area of the polygon. This allowed us to compare the change in proportional representation of ecoregions within that PA using a spatially explicit polygon and a coarse-scale point.

All results use a cylindrical equal-area projection.

3. Results

Considering all categories of PAs, including those with point data only, 12.9% of the global terrestrial area is formally protected (Table 2). Only 5.8% is within strictly protected areas (IUCN categories I–IV), although this is an increase from the 5.1% found by Brooks et al. (2004) and the 5.7% found by Soutullo et al. (2008). Protected areas are geographically widespread (Fig. 2) but do have a clear bias toward particular biogeographic realms and biomes (Figs. 3 and 4, Table 3).

3.1. Realms

Among the biogeographic realms, the Neotropical realm has the highest percentage (20%) of its area protected (Fig. 3a, Table 3), significantly higher than the 16% coverage previously estimated by Brooks et al. (2004). This appears to be due mainly to increased coverage of the Tropical and Subtropical Moist Broadleaf Forests biome within the realm, although other biomes also show increases. The Australasia realm has also increased to 11% protected from the 8% estimated in Brooks et al. (2004). This mainly reflects increased coverage of the Temperate Broadleaf and Mixed Forests and the Deserts and Xeric Shrublands biomes within the realm. The Oceania realm remains the least protected with only 3% of its land area protected, substantially lower than the 8% previously estimated (Brooks et al., 2004).

When considering only strictly protected areas (IUCN I–IV), all realms have less than 10% of their area protected, with the highest being the Nearctic (9%) and the lowest Oceania (1%) and the Palearctic (4%) (Fig. 3c, Table 3).

Table 2
Global terrestrial area within protected areas.

IUCN category	Area protected (million km^2)	Percent of total area
I	1.78	1.35
II	3.37	2.56
III	0.22	0.17
IV	2.24	1.70
V	2.63	1.99
VI	3.37	2.56
Other	3.33	2.53
IUCN I–IV	7.62	5.77
IUCN I–VI	13.61	10.32
All PAs	16.94	12.85

3.2. Biomes

Among the 14 biomes, the Temperate Conifer Forests biome enjoys the highest level of protection at 25%, closely followed by the Montane Grasslands and Shrublands biome at 24.8% (Table 3). These protection levels are consistent with previous findings (Brooks et al., 2004; Hoekstra et al., 2005). We did find increases of at least 1% in five of the biomes as compared to the recent global assessment by Hoekstra et al. (2005). Mangroves (20.7%) and Tropical and Subtropical Moist Broadleaf Forests (20.7%) have more than 20% of their area protected (Table 3). Both are significant increases from previous findings (Brooks et al., 2004; Hoekstra et al., 2005), mainly due to increased coverage in the Neotropics. We also found notable increases (>5%) from estimates in previous studies in 12 of the 63 bioregions (realm-biome combinations, *sensu* Brooks et al., 2004) and decreases of >5% in five (Table 3).

Considering strictly protected areas only, most biomes are less than 10% protected, with the exceptions being Tundra (13.8%) and Flooded Grasslands and Savannahs (10.3%) (Table 3). The Temperate Grasslands, Savannas and Shrublands biome has the least protection with a mere 2% in strict PAs.

Protection of biomes varies substantially depending on the realm in which the biome occurs. For a given biome, protection levels are usually lower in the Old World realms than in the New World (Fig. 4). For example, large parts of the Amazonian tropical forest are within PAs, leading to a high overall percent protection for that biome (Tropical and Subtropical Moist Broadleaf Forests). This masks the fact that protection rates for this biome in the Neotropics (32%) are more than twice what they are in all other realms.

Our findings for biome level protection are markedly different from those in a recent protected areas report from the World Conservation Monitoring Center (UNEP-WCMC, 2008). They report higher rates of protection than we do for 13 of 14 biomes, even though their reported global protection rate is 12.2%, substantially lower than our finding of a 12.85% global protection rate (Table 3). We were unable to identify a cause for these differences. If one multiplies the reported protection rates for each biome by the area of that biome in UNEP-WCMC (2008), the result is 19.58 million km^2 protected, which yields a global protection rate of ~14.8% rather than the 12.2% reported. It appears that either the global or the biome protection numbers are in error.

3.3. Ecoregions

Biases in protection coverage are more severe at the ecoregion scale (Fig. 5). Of the 821 ecoregions assessed, 4% have no protected areas of any kind and 13% have no strict protected areas (Table 4). Half of the ecoregions fail to reach the 10% protection target of the Convention on Biological Diversity, and more than three-quarters, covering most of the globe, have less than 10% of their area under strict protection (Fig. 5d, Table 4). While this shows a failure to reach the 10% target, it is an improvement over the protection rates found by Soutullo et al. (2008), although their differing methods make direct comparisons uncertain.

Of the least protected ecoregions (<1% protected), we found no consistent pattern in the location or broad type of ecosystems (Fig. 5). The most protected ecoregions (>10% protection) tend to

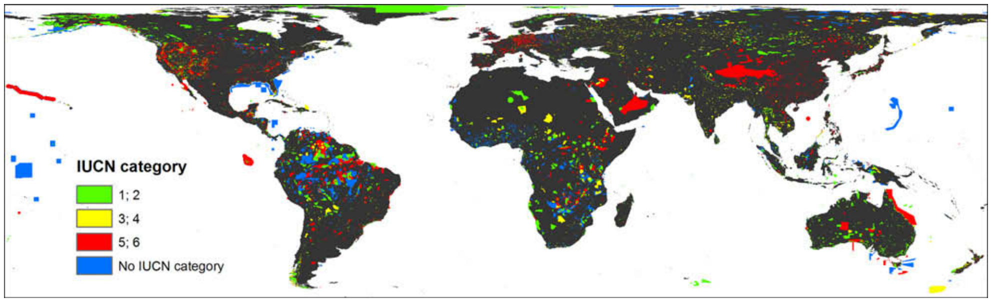

Fig. 2. Protected areas of the world colored by IUCN category. Data represent holdings of the 2009 WDPA plus additional PAs for the United Kingdom and the United States of America, described in Section 2.

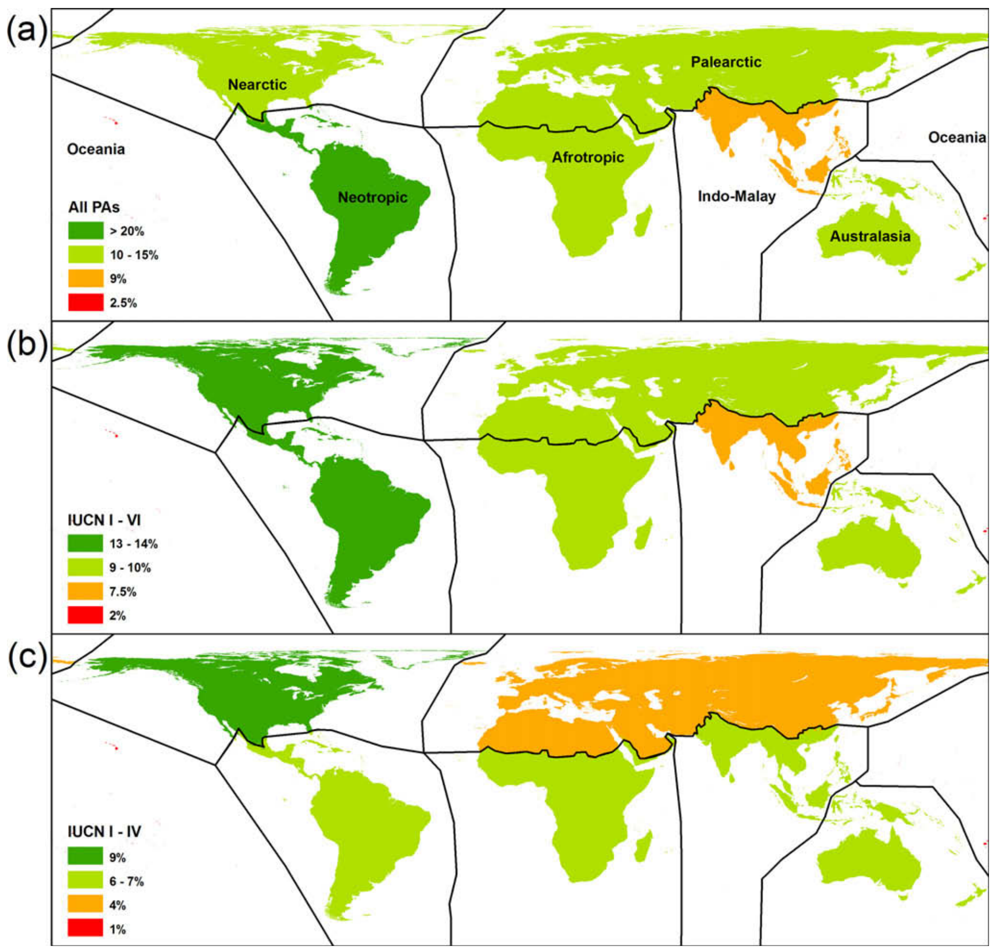

Fig. 3. Percent of each realm protected by (a) any type of PA, (b) IUCN listed PAs, and (c) strict IUCN PAs.

be the large tropical forests, some boreal forests, and some dryland ecoregions, although there is substantial variation (Fig. 5).

When considering only strict protected areas, few obvious patterns emerge (Fig. 5d). Many Amazonian ecoregions are above 10% protection, as are many of the southern African woodlands, parts of Australia, and parts of the western United States and Alaska. Notably low coverage is apparent for the ecoregions in China, the eastern and Midwestern United States, Mexico, and northern Africa.

3.4. Growth of the protected area system

While the total amount of land protected has certainly increased in recent years, we found that the rate of increase is slower than at first appearance and there is an extreme spatial bias. Using the dates of establishment listed for each PA in the WDPA, we calculated the area of PAs established annually starting in 2003 (Table 5). The total area (703,864 km^2) represents an expansion of roughly 0.53% of the world's land area. This equates to ~0.13% per year, if one excludes 2007–2009 as data for those years are likely incomplete. This new protected area is not enough to account for the apparent increase in global protection since previous global estimates (Table 1). Using the 2003 and 2004 WDPA, respectively, Brooks et al. (2004) and Hoekstra et al. (2005) both estimated global protection at 11.9%, giving a difference of ~1% between their estimates and ours. If only 0.53% of this is due to PAs established since 2003 (Table 5), then either PAs older than

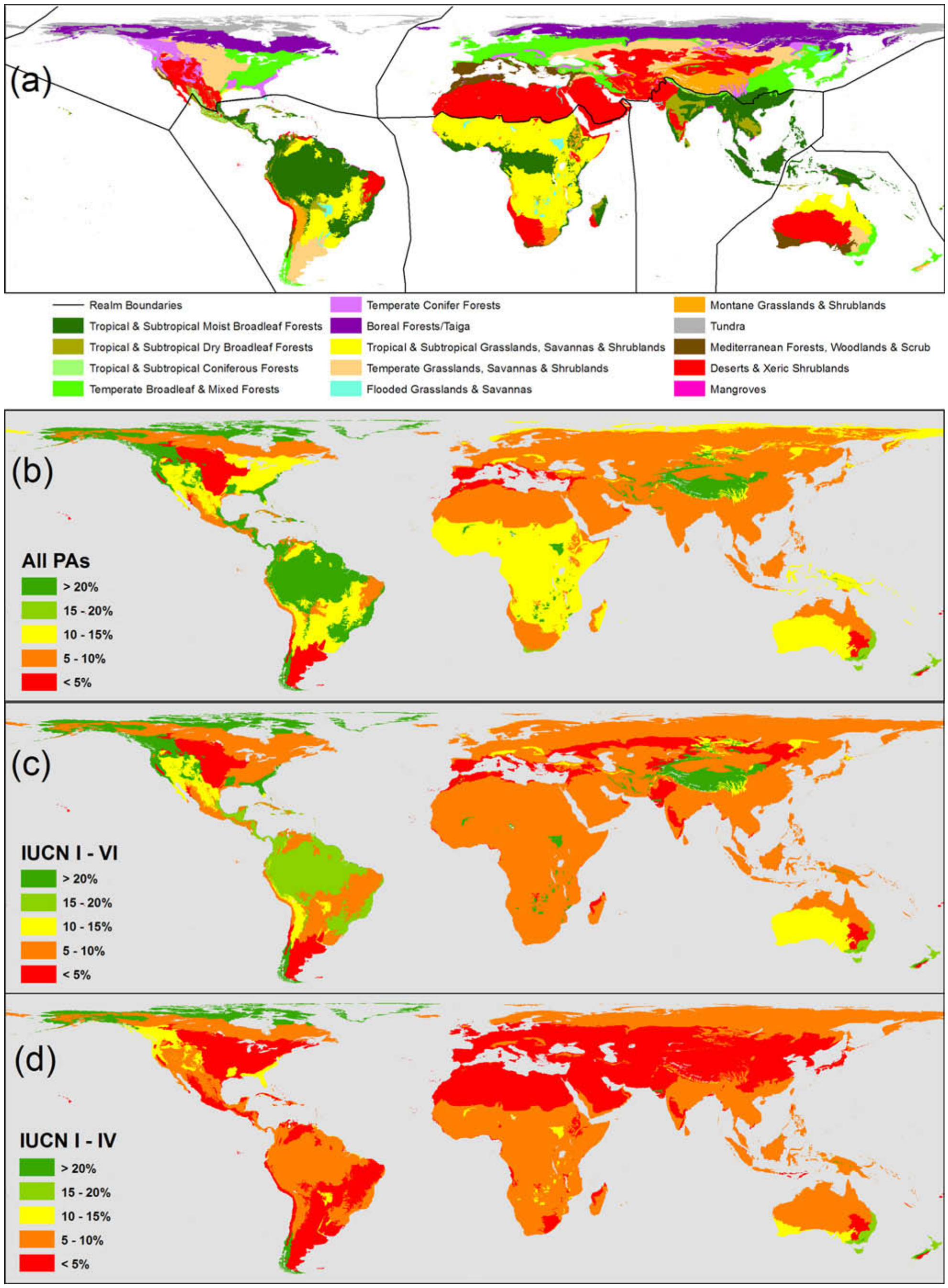

Fig. 4. Percent of each biome protected within each realm. (a) Global distribution of biomes. Percent of each biome protected within each realm (i.e., biogeographic realm) in (b) all PAs, (c) IUCN PAs, and (d) strict PAs.

2003 have been added to the WDPA since the 2003/2004 version (database expansion), or many PAs established since 2003 do not yet have establishment dates listed in the current WDPA (true protected area expansion).

Our analysis also revealed that 74% of the area protected since 2003 is in Brazil, an overwhelming bias toward a single country (Fig. 6). Our conclusion is that outside Brazil, protected area has increased at a paltry rate since 2003.

3.5. Effects of point data

Most studies of the global protected area system include both the polygon and point data from the WDPA, usually by creating a circular buffer around the points equal to the reported area of that PA. The geographic distribution of those point data, and their influence on analyses, is not random (see Fig. 1 in electronic Supplementary material). Inclusion of the point data results in substantial new IUCN classified protected area in eastern Asia, central Africa, and northern South America, as well as other scattered locations. A notable amount of area is also reclassified to a higher IUCN category because of the point data, particularly in northern South America. These up-rankings result from overlaps between buffered points and nearby polygons where the point represents a PA with a higher IUCN category than the underlying polygon.

Inclusion of the point data strongly influences the apparent protection level of specific ecoregions (Fig. 7). In considering only

Table 3
Percent of area protected globally, by biome, and by biogeographic realm. Bold numbers in Global protection are increases of 1+% from Hoekstra et al. (2005). Biome protection levels from UNEP-WCMC (2008) are provided for reference, although their numbers vary substantially from ours and other studies.

BIOME	Area (million km^2)	Global					REALM						
		Hoekstra et al. (2005)[b]	UNEP, 2008	All PAs	IUCN I–VI	IUCN I–IV	AA	AT	IM	NA	NT	OC	PA
Tropical and subtropical moist broadleaf forests	19.78	16.0	23	**20.7**	13.0	6.9	11[e]	14	10		32[d]	3	8[d]
Tropical and subtropical dry broadleaf forests	3.01	7.6	10	8.1	7.0	5.2	10	6	8	0	9	2[f]	
Tropical and subtropical coniferous forests	0.71	6.7	9	7.0	5.8	2.7			6	7	8		
Temperate broadleaf and mixed forests	12.83	9.8	14	**11.3**	10.0	4.4	20[d]		9[f]	12	29[c]		9
Temperate conifer forests	4.09	26.3	27	25.0	24.3	9.4			15[e]	33			15[c]
Boreal forests/taiga	15.13	8.9	10	8.9	7.0	6.1				10			8
Tropical and subtropical grasslands, savannas and shrublands	20.18	11.9	16	12.5	8.5	5.9	6	14	10	8[d]	11[c]	4[f]	
Temperate grasslands, savannas and shrublands	10.10	4.6	5	3.9	3.6	2.0	2	0		3[e]	2		5
Flooded grasslands and savannas	1.09	18.1	42	**19.5**	16.2	10.3		28	73[c]		15[d]		8
Montane grasslands and shrublands	5.19	24.7	28	24.8	24.1	4.1	46[e]	8[e]	34[d]		14		32[d]
Tundra	8.35	16.0	13	17.3	14.9	13.8	74[d]			22[d]			12
Mediterranean forests, woodlands and scrub	3.22	5.0	11	7.3	6.4	4.3	12[c]	19[d]		21[f]	1		5
Deserts and xeric shrublands	27.89	9.9	11	9.3	8.8	4.2	13[d]	9[e]	7	14[f]	9		8
Mangroves[a]	0.35	–	29	20.7[d]	13.4	7.8	19	12	10		37[d]		
Global	131.9			12.8	10.3	5.8	11[c]	13	9	15	20[c]	3[f]	10
IUCN I–VI							10	9	7	14	13	2	9
IUCN I–IV							7	6	6	9	7	1	4

[a] Estimates for mangroves are less certain because of the generally small size of these ecosystems and thus higher potential for spatial mismatches with protected areas data.
[b] Hoekstra et al. (2005) did not include mangroves in their assessment.
[c] Increase of 3+% from Brooks et al. (2004).
[d] Increase of 5+% from Brooks et al. (2004).
[e] Decrease of 3+% from Brooks et al. (2004).
[f] Decrease of 5+% from Brooks et al. (2004).

strict protected areas, select ecoregions in Africa, the Guianan Highlands, Hispaniola, and various island ecoregions are strongly affected. Patterns of influence are similar when considering all IUCN category PAs, although the effect is more widespread.

Analysis of the error potential when using point data suggests that it is a relatively minor problem at the ecoregion scale, but it could induce serious inaccuracies at finer resolutions (see electronic Supporting material for further discussion and analyses). When converting existing polygons to buffered points, the number of ecoregions present within a protected area decreases by an average of 0.045 ecoregions, a negligible amount. When looking at the proportional changes of ecoregions present within a PA, in 703 of 1000 cases the largest proportional change was 0.01 or less. In 95% of protected areas, the largest change was less than 0.17 (see Fig. 2 in Supplementary materials). That said, at the individual PA level buffered point data could produce serious inaccuracies, as we show in Fig. 1.

4. Discussion

Our finding that 12.85% of the global land area has protection, and 5.8% has strict protection, is higher than previous estimates (Chape et al., 2003, 2005; Brooks et al., 2004; Hoekstra et al., 2005; Soutullo et al., 2008; UNEP-WCMC, 2008). The estimate by Soutullo et al. (2008) of 5.7% having strict protection is close to ours, although they used an older version of the WDPA (2005) and did not account for overlapping protected areas, possibly inflating their estimate.

The increased protection that we found appears to be only partially due to a genuine increase in the area protected. Approximately half may be due to a more complete accounting by the WDPA itself of previously established PAs. The true expansions of the global protected area system are encouraging, for they suggest the world's governments are setting aside more land for environmental protection. Of the truly new protected area though, the vast majority is concentrated in a single country, Brazil.

Protection across the world is geographically very uneven. Many realms and biomes still have less than 10% of their area within formal protected areas, while every realm has less than 10% strictly protected. The Oceania realm lags behind all others by a notable margin, having only 3% under any form of protection. The differences between realms are striking. New World realms have a higher percent of their area protected than all other realms, regardless of the strictness of protection assessed. The difference is particularly prominent for the Tropical and Subtropical Moist Broadleaf Forests biome, where a 32% protection rate in the Neotropics, primarily the Amazon, is more than double the protection rate within any other realm.

Among the biomes, protection has increased to more than 20% of the Tropical and Subtropical Moist Broadleaf Forests, a notable advance for biodiversity conservation given the exceptional diversity of this biome. The Mediterranean Forests, Woodlands, and Scrub biome also appears to be increasing in protection, having reached 7% coverage from earlier estimates of 5% to 6% (Brooks et al., 2004; Hoekstra et al., 2005). Most of this increase appears to be within the Australasia and Afrotropic realms. Many biomes continue to have less than 10% of their area protected with many having less than 5% under strict protection. The Temperate Grasslands, Savannahs, and Shrublands biome lags behind all others with a paltry 2% under strict protection.

Half of the world's ecoregions have less than 10% of their area protected, with three-quarters having less than 10% strictly protected. More positively, the protection rates we found are slightly higher than found by Soutullo et al. (2008). How much of this difference is due to our differing methods or by genuine increases in protection is uncertain. Without a rapid, massive increase in the area of land protected though, it seems unlikely that the world will meet the 2010 Biodiversity Target (Balmford et al., 2005; UNEP-WCMC, 2008). This seems particularly true given that most of the ~0.13% of the global land area added annually to the protected area system is in Brazil, mostly in the Amazon.

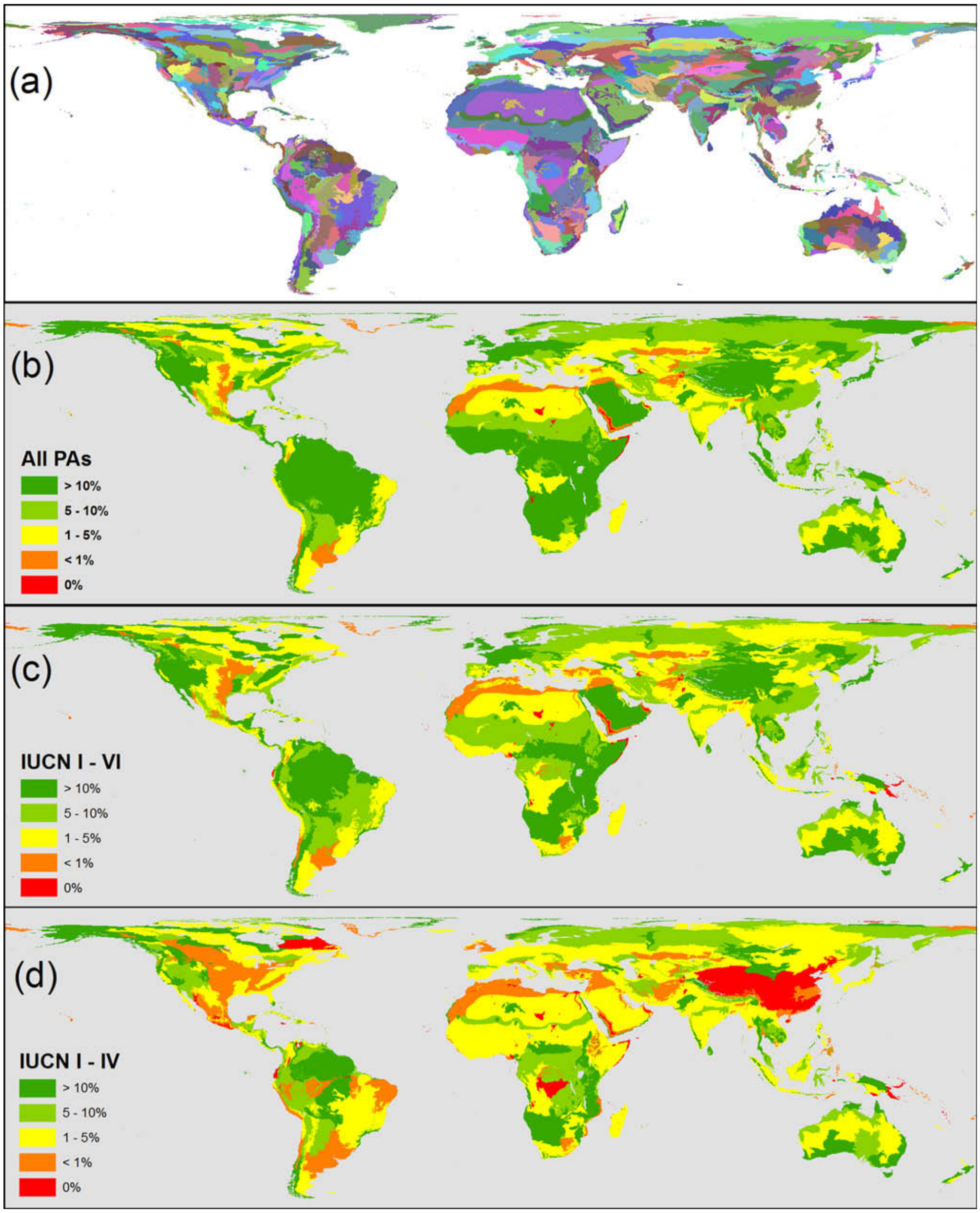

Fig. 5. Percent of each ecoregion protected. (a) Global distribution of ecoregions. Percent of each ecoregion protected within (b) all PAs, (c) IUCN PAs, and (d) strict PAs.

Table 4
Protected area coverage of 821 ecoregions (percent of 821 ecoregions).

	IUCN I–IV	IUCN I–VI	All PAs
0% Coverage	106 (13%)	51 (6%)	33 (4%)
<1% Coverage	236 (29%)	121 (15%)	83 (10%)
<10% Coverage	624 (76%)	485 (59%)	411 (50%)

Building the WDPA has required tremendous effort and the database is steadily becoming more comprehensive (UNEP-WCMC, 2008). The recent "Proteus" effort to rebuild the WDPA into a more user-friendly and interactive form continued these advances and culminated with the release of a new interactive interface (http://wdpa.org, description of Proteus effort available at: http://proteus.unep-wcmc.org). We did identify some gaps in coverage that we suggest as focal areas for improvement. Coverage of the non-Brazilian Amazonian countries appears to be incomplete, with few if any titled indigenous areas included in the database. As well, certain regions of the world have only point data representing

Table 5
Protected areas listed in the WDPA as having been established since 2003. Protected areas in Brazil account for 74% of the global increase since 2003.

Type of PA entry	Area protected (km^2)							
	2003	2004	2005	2006	2007	2008/2009	Total	Brazil (% of total)
IUCN Category	57,239	54,376	108,526	117,744	5193	40	359,331	295,718 (86%)
No IUCN Category	56,825	149,205	113,197	12,817	28,635	68	375,375	227,874 (63%)
Total	114,064	203,582	221,724	130,561	33,827	108	703,864	523,592 (74%)
Percent of global land area	0.09%	0.15%	0.17%	0.10%	0.03%	0.00%	0.53%	0.40%

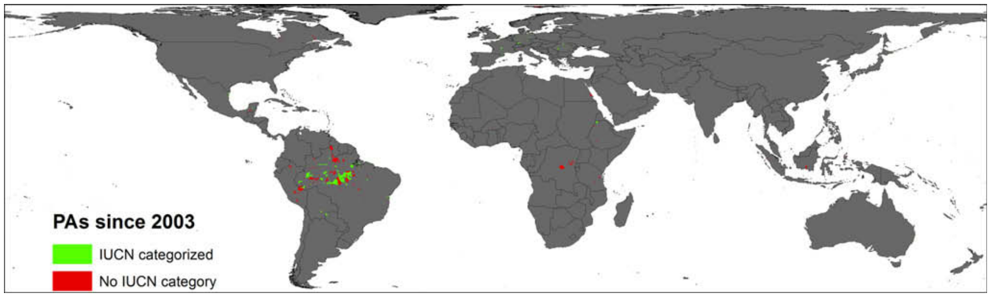

Fig. 6. Protected areas established since 2003. PAs recorded only as points in the WDPA are scaled in size according to their area listed in the WDPA attributes.

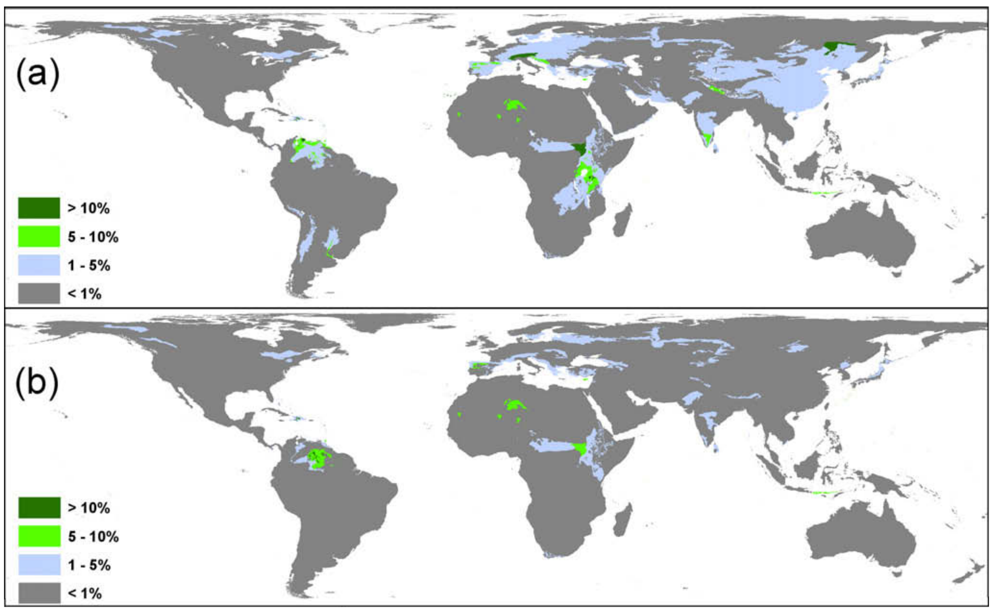

Fig. 7. Increase in the percent of an ecoregion within PAs due to point data. (a) IUCN I–VI and (b) IUCN I–IV.

significant protected areas. Inclusion of polygon boundaries for the largest of the point-only areas should be a priority.

Because the current point data have a bias toward particular regions, we recommend that researchers continue to include them for full assessments of global protection. However, for large protected areas, simple buffering to create a circular area may produce imprecise results at ecoregion or finer scales. Large circular boundaries may incorrectly extend across ecoregions and even country boundaries, distorting results. For coarse scale analyses though, smaller protected areas appear unlikely to cause problems when represented as circles.

Protection of yet more land may not always be the best conservation strategy for some regions. Many parts of the world now have substantial fractions of their land area under formal protection. In those areas, we suggest that shifting efforts toward implementation and enforcement of protection in already declared protected areas may best serve conservation. In some parts of the world though, there is still a distinct lack of protected areas. In those cases, there is still a need to set aside more land for protection. We are certainly not the first to make this call to action (e.g., Brooks et al., 2004; Rodrigues et al., 2004a,b).

With the recent growth rate and geographic pattern of new protected areas, we predict the world will not meet the 2010 target of protecting 10% of all the world's major ecosystems. There is progress though and the conservation community should not despair if a somewhat arbitrary target date is missed. A hope is that society today is better informed about the biodiversity crisis than when the 2010 target was set. Through efforts such as the WDPA, conservationists can identify precisely where the gaps are in the protected area system and continue to fill them. To monitor progress, we suggest continued studies similar to ours and other authors (Chape et al., 2003, 2005; Brooks et al., 2004; Hoekstra et al., 2005; Soutullo et al., 2008; UNEP-WCMC, 2008) as new data become available and to improve upon the almost certain limitations of our own analyses.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.biocon.2009.04.016.

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