

**Eco-Region Protection Indicator
for the 2009 release of the Natural Resource Management Index of the
Millennium Challenge Corporation**

Data and Methodology

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Note: To understand changes in the way we calculated the ecoregion protection indicator in 2009 that affect the 2006, 2007, 2008, and 2009 results reported in the 2009 release of the Natural Resource Management Index (NRMI) spreadsheet, please read the sections beginning at the bottom of page 2.

What it measures

This indicator measures the degree to which a country achieves the target of protecting at least 10% of each terrestrial biome within its borders. We adopted a target of 10% of each biome protected because that is the target most faithful to the existing international consensus. The Convention on Biological Diversity (CBD), at its 7th Conference of the Parties, set the following target: “At least 10% of each of the world’s ecological regions effectively conserved.” (<http://www.biodiv.org/doc/decisions/COP-07-dec-en.doc>, page 385). We treat protected status as a necessary but not sufficient condition for an ecological region to be “effectively conserved.” How well protected areas are managed, the strength of the legal protections extended to them, and the actual outcomes on the ground, are all vital elements of a comprehensive assessment of effective conservation. Such measures are not available on a widespread basis, though there are efforts underway to fill critical gaps (Chape et al, 2005, 452).

There are some nuances that need to be made clear about this target.

First, the target as expressed by the CBD and the conservation community more generally refers to “ecological regions.” In the 2006 Environmental Performance Index (EPI) we abbreviated this as “ecoregion” (Esty et al 2006). To make this metric concrete we had to choose a specific data set accepted in both scientific and policy-making circles. We used the Olson et al (2001) delineation of “biomes” for this purpose. Biomes are broad terrestrial ecological regions. Nested within the biomes are what the authors call “ecoregions,” which are finer-scale areas sensitive to more specific ecological patterns. These “ecoregions” are probably more appropriate as policy targets, because they identify areas based on factors that affect biodiversity on the ground more precisely than biomes. However, given the scale of the present analysis (global 1-km grids) and the processing time requirements, it was determined that using ecoregions as the unit of analysis would not be possible (see Caveats section below).

Second, the target of 10% is clearly the result of many political considerations. Based purely on the scientific merits, some ecological regions should probably be protected to a

greater extent. One systematic review of the literature concluded that most ecological regions probably require more than 10% protection (Svancara et al 2005). We feel it is incumbent on us to point out that the 10% target probably represents more of a floor than a ceiling, and that over time it is likely that either a) the scientific community will come to a more precise consensus on more ambitious targets, perhaps differentiated by ecoregion, or b) the policy-community will endorse a more ambitious target, also possibly differentiated, or both. Certainly, it would not be prudent to make any assumption about the 10% target being fixed into the future.

Data Set Preparation

We utilized the 2009 World Database of Protected Areas (WDPA) maintained by UNEP's World Conservation Monitoring Centre (WDPA 2009). As with prior versions of the WDPA, the 2009 release includes both points and polygon layers. The protected areas represented by polygons, which provide the actual boundaries, are a subset of the protected areas represented by points.

We excluded protected areas that were listed as historical, archaeological, or cultural sites, or that were listed as proposed but not yet designated. For protected areas that had point and area information but not an explicit polygon identified, we created a circular buffer around the point with a total area equivalent to the area listed in the database.¹ Marine Protected Areas whose points were located offshore were excluded from this step. To avoid over-counting overlapping protected areas, the dissolve command in ArcMap was used to create a consolidated set of polygons that distinguished areas that were under protected status from those that were not.

The biome data were obtained from WWF's Terrestrial Ecoregions of the World (Olson *et al.* 2001). Rather than utilize the 200 ecoregions, many of which are quite small, we utilized 14 terrestrial biomes identified in the data set. Because we are measuring the extent of terrestrial protected areas, biome 98 (water) was excluded.

Important Changes in 2009

For the calculation of the ecoregion protection indicator in 2009 we introduced the following important changes to the input data preparation. These same changes were applied to re-calculate the 2006, 2007, and 2008 ecoregion protection indicators included in the 2009 release of the NRMI.

1. *Exclusion of International Protected Area category.* As of 2009 we no longer include protected areas that are listed as "International" in the World Database on Protected Area (WDPA). The vast majority of such internationally designated protected areas, which include World Heritage, Ramsar, and Biosphere Reserve sites, are contained in either the

¹ Note that for points that are located near a country's land border, in some cases the buffered points cover territory in the neighboring countries. This is a case in which it would be important for the country to provide accurate boundary files to the WCMC for incorporation in the next iteration of the WDPA. For more information visit <http://www.wdpa.org> or contact protectedareas@unep-wcmc.org.

IUCN I-VI or the “no category” national protected area databases of the WDPA, meaning that they have some national legal status. Where they have no national legal status, such protected areas cannot be considered to be adequately protected. This decision is supported by the common practice of many studies that utilize the WDPA to assess the protected status of a nation’s territory.

2. *Use of a new global coastline data.* We replaced CIESIN’s coastline data (CIESIN 2005) with a much higher resolution and spatially accurate dataset developed by ISciences L.L.C (ISciences 2009). The ISciences coastline data has higher resolution (3 arc-second, or approximately 90m) compared to CIESIN’s 2.5 minute (5 km) resolution. The use of the ISciences dataset has affected area calculations in countries differently. Some countries saw an increase in land area while others saw a decrease.

3. *Extension of WWF Terrestrial Biome Data.* We manually extended the WWF Terrestrial biome data to match the new coastline data eliminating areas with no biome in all countries. This has also altered the individual biome areas and total land area, two important variables used in calculating the ecoregion protection indicator.

Methods

In order to compute what proportion of each biome in a country is protected, we first created a composite layer consisting of country boundaries (ISciences 2009), WWF’s terrestrial biomes layer and the consolidated global protected area polygon layer. The combined country boundary-biome-protected area map was projected using Mollweide equal area projection and the area for each unique polygon was computed. The attribute table of the projected layer was exported into tabular data for import into statistical packages.

The tabular data set quantifies, for each country, the total area of each biome and the total protected area of each biome. The percentage of each biome that is protected was calculated. The percentage was capped at 10%, so that additional “credit” does not accrue where protection exceeds 10%. The countries overall score is a weighted average of the protection score for each biome. The weights are derived by calculating the biome area as a fraction of a country’s overall land area. Greater weights are applied to larger biomes.

Caveats

Spatial errors are always a possibility when combining multiple global, 1:1m scale data sets for analytical purposes. Uncertainty about the exact location of boundaries of some protected areas, especially those represented by creating circles around points, and the potential spatial mismatch between the protected areas layer and the biome-country layer represent potential sources of error. Also worth mentioning is that the WDPA database has been a work in progress since 2006. Over the years, as relatively accurate boundary data becomes available, point protected areas are replaced with boundary delineations that often result in a decrease in total area under protection. The 2009 WDPA saw the

largest such replacement of the versions used to date to calculate the ecoregion protection indicator, which has resulted in a decrease in the area protected in many countries (see Table 1).

Table 1. Countries with decrease in ecoregion protection indicator value from 2008 to 2009 due to changes in the underlying data from the WDPA

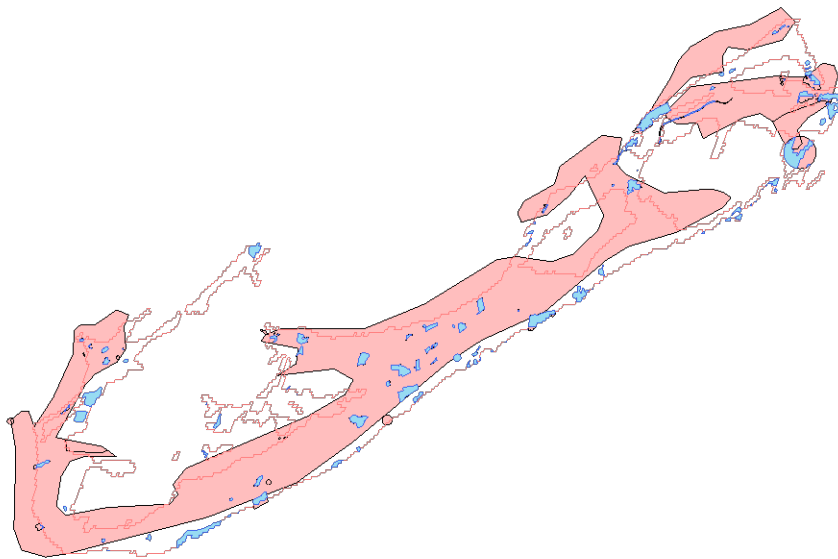
Country	ISO3	Change in value	Remarks
United Kingdom	GBR	-10.0	PA data was unavailable for UK in 2008.
United States	USA	-2.1	National Forest area removed in 2008
Denmark	DNK	-1.4	Replacement of point PAs
Congo	COG	-1.1	Replacement of point PAs and declassification
Bulgaria	BGR	-1.1	Replacement of point PAs
Cuba	CUB	-0.9	Category change from designated to proposed
French Polynesia	PYF	-0.8	Category change from designated to proposed
Gambia	GMB	-0.7	Category change from designated to proposed
Bermuda	BMU	-0.7	Category change from inter-tidal to marine
Australia	AUS	-0.5	Replacement of point PAs
Albania	ALB	-0.4	Replacement of point PAs
South Korea	KOR	-0.2	Replacement of point PAs
Brazil	BRA	-0.1	Replacement of point PAs

Comparing the Ecoregion Protection Indicator in the 2008 and 2009 releases of the NRMI

The 2009 release of the NRMI has benefitted greatly from the use of IScience's global coastline dataset, the modified biome data which now covers the entire global land area, and the adoption of a more streamlined geospatial processing methodology. The new coastline data has improved spatial coincidence between the protected area data and the country-biome data, particularly for small island nations. In some of these countries the ecoregion protection indicator values increased even though international PAs were removed.

Table 2. Differences in the 2008 values for ecoregion protection between the 2008 and 2009 NRMIs

Country	ISO3	2008 value for 2008 NRMIs	2008 value for 2009 NRMIs	Increase (2009 NRMIs-2008 NRMIs)
Bermuda	BMU	2.7	6.2	3.4
Tokelau	TKL	0.0	7.0	7.0
East Timor	TLS	0.0	1.3	1.3
Tonga	TON	0.8	10.0	9.2
Tuvalu	TUV	0.0	0.1	0.1
St. Vincent and the Grenadines	VCT	0.0	4.2	4.2
Vanuatu	VUT	3.8	4.1	0.3
Samoa	WSM	1.7	2.7	1.1

Figure 1. Spatial coincidence between old CIESIN country-biome data (red filled), IScience land-biome data (red line), and protected areas (blue filled) for Bermuda**Legend**

- Old CIESIN boundary
- IScience Boundary
- Protected New

To streamline the processing steps we performed geospatial processing such as point PA buffering and country-biome-PA separately for each country before importing areas into the ecoregion protection indicator calculator. A major benefit of this change is

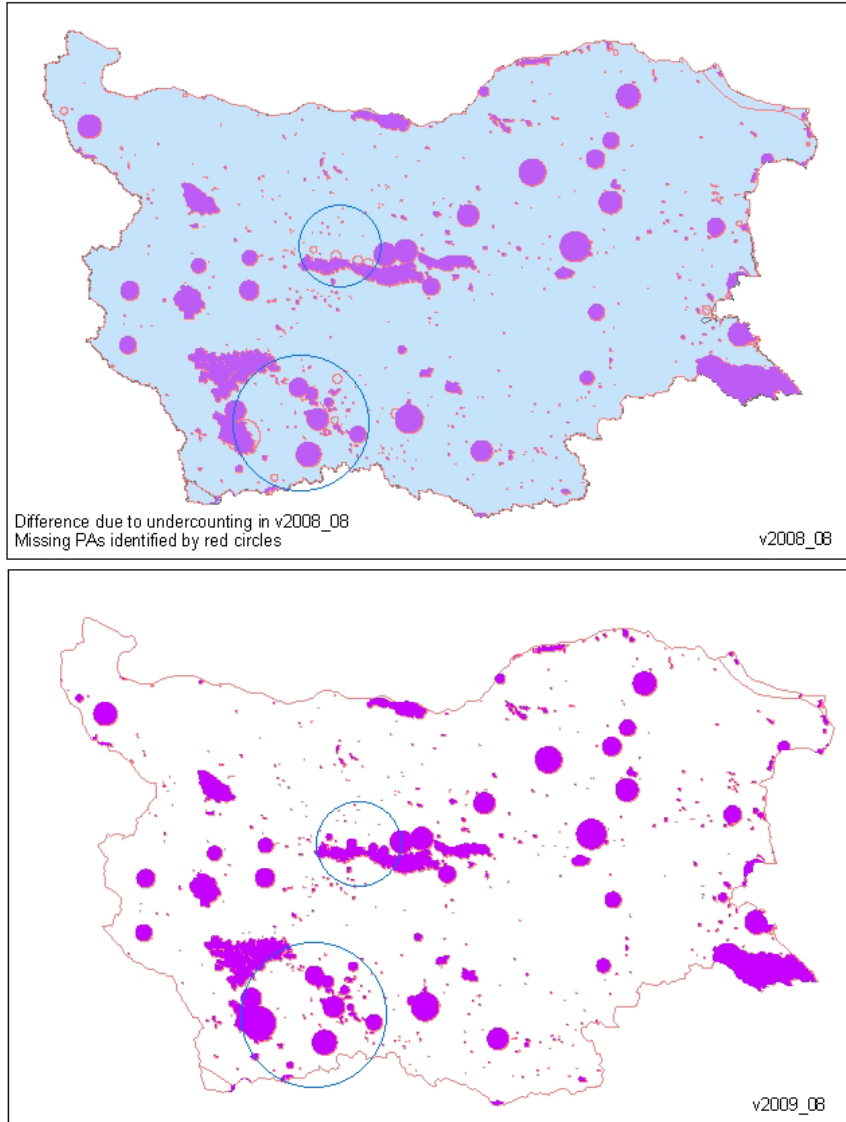
eliminating over-estimation of PAs as a result of point buffers in adjacent countries from spilling over into neighboring countries thereby inflating the overall ecoregion protection score. For the 2008 and prior NRMIs there was “spillage” of buffered points across international borders that led to over estimation of protection in neighboring countries and underestimation in the target country.

A calculation error in the 2008 release of the NRMI resulted in protected areas in biome 3, tropical and sub-tropical coniferous forests, being omitted from the weighted average for a small number of countries with this biome type. This problem was corrected in the 2009 release of the NRMI, and results are found in Table 3. Also for the 2008 release of the NRMI, PA undercounting stemmed from encoding problems during geospatial processing. In Figure 2, using the example of Bulgaria, the top image shows point PA buffers excluded from protected area tabulation (shown as hollow red circles) during NRMI processing for the 2008 release. The problem was caught and rectified thanks to the streamlined methodology for the 2009 release of the NRMI.

Table 3. Causes of differences in 2008 values for ecoregion protection between the 2008 and 2009 NRMIs

Country	2008 value for 2008 NRMI	2008 value for 2009 NRMI	Increase (2009 NRMI-2008 NRMI)	Reason for the difference
Albania	2.7	10.0	7.3	Tabulation error
Bulgaria	8.9	10.0	1.1	Tabulation error
Belize	9.2	10.0	0.8	Undercounting of biome 3 PAs
Bahamas	5.6	10.0	4.4	Undercounting of biome 3 PAs
Bhutan	9.9	10.0	0.1	Undercounting of biome 3 PAs
Honduras	6.2	9.7	3.6	Undercounting of biome 3 PAs

Figure 2. Bulgaria: in the upper image hollow red circles representing point PAs were inadvertently omitted from the ecoregion protection indicator in the 2008 NRMI



References

Chape, S., J. Harrison, M. Spalding and I. Lysenko, 2005. "Measuring the Extent and Effectiveness of Protected Areas as an Indicator for Meeting Global Biodiversity Targets," *Philosophical Transactions of the Royal Society* 360: 443-455.

Center for International Earth Science Information Network (CIESIN), Columbia University; and Centro Internacional de Agricultura Tropical (CIAT). 2005. Gridded Population of the World Version 3 (GPWv3): National Boundaries. Palisades, NY: Socioeconomic Data and Applications Center (SEDAC), Columbia University. Available at <http://sedac.ciesin.columbia.edu/gpw>.

Esty, D. C., M. A. Levy, T. Srebotnjak, A. de Sherbinin, C. H. Kim and B. Anderson. 2006. *Pilot 2006 Environmental Performance Index*. New Haven: Yale Center for Environmental Law & Policy.

Ferrier, Simon and others, 2004. "Mapping More of Terrestrial Biodiversity for Global Conservation Assessment," *BioScience* 54,12: 1101-1109.

Hoekstra, Jonathan M., Timothy M. Boucher, Taylor H. Ricketts, Carter Roberts 2005. "Confronting a Biome Crisis: Global Disparities of Habitat Loss and Protection," *Ecology Letters* 8: 23-29.

ISciences, LLC. 2009. Global Coastline v1. Ann Arbor, MI. Available at: <http://www.terraviva.net> (received August 2009).

Olson, D.M., E. Dinerstein, E.D. Wikramanayake, *et al.* 2001. Terrestrial Ecoregions of the World: A New Map of Life on Earth, *Bioscience* 51(11): 933-938.

Rodrigues, A.S.L., *et al.* 2004. "Effectiveness of the Global Protected Area Network in Representing Species Diversity," *Nature* 428, 640-643.

Svancara, Leona K., Ree Brannon, J. Michael Scout, Craig R. Groves, Reed F. Noss, Robert L. Pressey. 2005. "Policy-Driven Versus Evidence-Based Conservation: A Review of Policy Targets and Biological Needs" *BioScience* 55,11: 989-995.

World Database on Protected Areas (WDPA) Annual Release 2009 [Downloaded: 16 April 2009]. The WDPA is a joint product of UNEP and IUCN, prepared by UNEP-WCMC, supported by IUCN WCPA and working with Governments, the Secretariats of MEAs and collaborating NGOs. For further information: protectedareas@unep-wcmc.org or <http://www.wdpa.org>.