Short Communication

How effective is the MERCOSUR's network of protected areas in representing South America's ecoregions?

Alvaro Soutullo and Eduardo Gudynas

Abstract We evaluate the effectiveness of the MERCOSUR's network of protected areas in representing South America's ecoregions. The region contains 1,219 non-overlapping protected areas covering nearly 2,000,000 km^2. Fifty percent of the reserves are $<$100 km^2 and 75% $<$1,000 km^2. Less than a half of the 75 ecoregions in the MERCOSUR have at least 10% of their area within protected areas, and only 13 when just reserves in IUCN categories I–IV are considered. In general, forests are better represented than other biomes. At the national level the network of protected areas in Uruguay is the least developed in the region, with those of Bolivia and Chile the most developed. For 10% of each ecoregion to be protected at least another 500,000 km^2 would have to be incorporated into the network. Such expansion would be more efficient if conservation priorities are identified using a regional approach. This is of particular relevance for the cost-efficient protection of the 20 ecoregions that are shared by two or more countries. While only *c*. 20% of the ecoregions found in Brazil are shared with other countries, $>$75% of the ecoregions in Bolivia, *c*. 70% in Argentina, $>$60% in Chile, and all the ecoregions in Paraguay and Uruguay are shared with other countries. Overall, although it currently covers 14% of the region, the network of protected areas of the MERCOSUR still performs poorly in protecting its ecoregions.

Keywords Continental conservation, ecoregions, effectiveness, gap analysis, MERCOSUR, representation, reserves, South America.

This paper contains supplementary material that can only be found online at http://journals.cambridge.org

The relationships between Latin American countries are changing, with integration and trade agreements generating challenges and opportunities for the design of conservation and development strategies at the continental scale. Within the new generation of agreements the MERCOSUR (Common Market of the South) began in 1991 with Argentina, Brazil, Paraguay and Uruguay, inspired by the EU process. Bolivia, Chile and Peru joined more recently as free trade associates. As Peru joined in January 2004, when the assessment reported here was already underway, MERCOSUR here refers to Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay. The block encompasses an area of *c*. 15,000,000 km^2, including many of the most distinctive bioregions of South America such as the Amazonian rainforest, the Pantanal wetlands, and the Chaco dry forest. The agreement provides a unique opportunity for planning the conservation of southern South America's biodiversity from a regional perspective, as well as for the implementation of a regional network of protected areas.

Assessments of the effectiveness of networks of protected areas in protecting biodiversity are often restricted to analyses of species representation (e.g. Andelman & Willig, 2003; Rodrigues *et al.*, 2004) but only limited information is available about the presence and distribution of most species in the MERCOSUR. An alternative approach is to compare the location of extant protected areas with the distribution of major ecological regions, as biogeographical units can provide an analytical framework for analysis of resource allocation at a regional level (Bibby, 1998; Olson *et al.*, 2001).

Here we evaluate the effectiveness (Rodrigues *et al.*, 1999) of the MERCOSUR's protected areas in representing southern South America's ecoregions. Gap analysis (Scott *et al.*, 1993; Rodrigues *et al.*, 2004) enables the assessment of the comprehensiveness of existing protected areas and identification of gaps in coverage. Although there are many classifications of Latin American biogeographical regions, we follow the WWF hierarchical classification of ecoregions (Dinerstein *et al.*, 1995;

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Olson *et al.*, 2001). This has the advantage of allowing comparisons of the values and status of ecoregions with similar structure and climate (Bibby, 1998). In addition, as this classification is endorsed by both WWF and the World Bank, it has a strong influence on governments and other institutions responsible for the management of natural resources.

The main source of data that we used for protected areas was the World Database on Protected Areas (WDPA; WDPA Consortium, 2004). We only considered areas protected at the national level officially recognized as such by the national governments (irrespective of whether they were administrated by national or local governments or owned privately). To improve accuracy, data in the WDPA were compared and complemented with data from the following sources: Argentina, Administración de Parques Nacionales (APN, 2004); Bolivia, Proyecto MAPZA (SERNAP, 2001); Brazil, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA, 2004); Chile, Corporación Nacional Forestal (I. Benoit & M. Gómez, pers. comm.); Uruguay, data available at Centro Latino Americano de Ecología Social.

Although the database that we compiled is not exhaustive, it is probably the most comprehensive account of protected areas in the region currently available. For Argentina, Brazil, Paraguay and Uruguay information on some private areas was incorporated, whereas for Bolivia and Chile only areas administrated by the national governments were included. Differences among countries in the exhaustiveness of the data analysed are mostly a consequence of inexactness, incompleteness and fragmentation of the information available.

In order to calculate the area protected within the MERCOSUR we removed redundant areas: when the geographic position of two or more areas overlapped we only considered the largest one; when they had the same area we kept the one with the strictest management category. Areas were then overlaid on a map of terrestrial ecoregions (Olson *et al.*, 2001) using ArcView 3.2 (ESRI, Redmond, California). ArcView shapefiles and associated tables of attributes were obtained from WWF (2005). Areas of ecoregions were calculated using ArcView's Xtools extension.

We then assigned each protected area to an ecoregion using ArcView's spatial join function. Areas not assigned to a terrestrial ecoregion (mostly islands and marine areas) and areas for which area information was not available or calculable were excluded from further analyses. To analyse latitudinal trends in the number of protected areas and the total area protected, we calculated the latitude and longitude of each protected area using points or the centroid of polygons. Latitude was then rounded up to whole degrees, and for each degree of latitude we counted the number of protected areas and summed their areas.

Finally, for each country and for the whole MERCOSUR we calculated the number of terrestrial ecoregions and non-overlapping protected areas present, and the percentage of each terrestrial ecoregion officially protected. Percentages were first calculated considering all areas, and then recalculated after removing areas in different categories: first those with unknown management objectives or not assignable to IUCN categories (e.g. indigenous areas) and then those in IUCN categories V–VI.

Table 1. Protected areas and ecoregions in the MERCOSUR. The number of reserves may be smaller than those officially listed because we do not include overlapping areas, marine reserves and islands that could not be assigned to a terrestrial ecoregion.

	Argentina	Bolivia	Brazil	Chile	Paraguay	Uruguay	MERCOSUR
Total area (km^2)	2,779,238	1,090,132	8,498,754	727,311	399,759	177,722	13,672,916
Area within protected areas (km^2)	179,969	183,526	1,407,207	141,105	16,556	2,901	1,931,264
% within protected areas	6.5	16.8	16.6	19.4	4.1	1.6	14.1
% within protected areas in IUCN categories	6.4	16.8	5.7	19.4	3.5	0.0	7.3
% within protected areas in IUCN categories I–IV	2.2	10.2	2.6	19.4	3.5	0.0	4.0
Number of protected areas	253	26	788	88	49	15	1,219
Median size of protected areas (km^2)	34	4,567	128	124	55	66	100
Mean size of protected areas (km^2)	711	7,059	1,784	1,603	338	264	1,588
Number of ecoregions	22	13	52	11	5	1	75
Number of ecoregions restricted to the country	7	3	41	4	0	0	
Number of ecoregions shared with other countries	15	10	11	7	5	1	

The MERCOSUR extends across 10 biomes and 75 terrestrial ecoregions, and contains 1,219 non-overlapping terrestrial reserves devoted to the conservation or sustainable exploitation of natural resources, including both public and private areas (Table 1). Fifty-five of the ecoregions are represented solely in one of the six countries. Of the remaining, 12 are shared by two countries, seven by three, and the Chaco is the only ecoregion spanning four countries. While only *c*. 20% of the ecoregions found in Brazil are shared with other countries, all ecoregions found in Paraguay and Uruguay are shared with other countries.

A common objective of conservation strategies is the conservation of 10% of the surface covered by an ecological assemblage (Bibby, 1998). If 10% of each ecoregion were to be represented within the MERCOSUR's network of protected areas, at least another 500,000 km^2 would have to be incorporated, and twice as much if only reserves in IUCN categories I–IV are considered. Biomes and ecoregions are not, however, evenly represented within protected areas (Fig. 1; Appendix), and there is no relationship between the size of ecoregions ($R_S = 0.179$, $n = 75$, P = 0.125) or biomes ($R_S = 0.309$, $n = 10$, P = 0.385) and the proportion protected in reserves. While *c*. 60% of the Temperate Forests of southern Argentina and Chile are currently protected, the average for the whole set of biomes is 13.1% (median = 5.5%). For ecoregions, only 35 have at

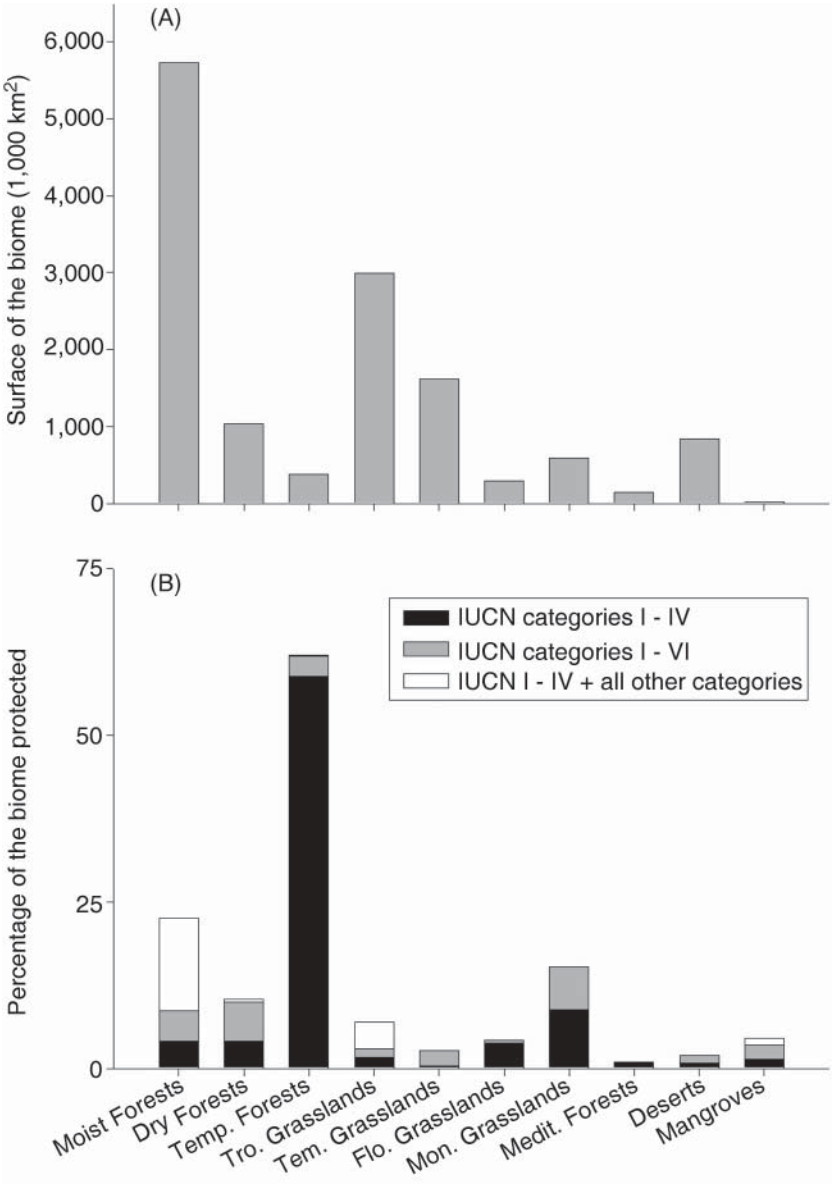

Fig. 1. Area of the MERCOSUR covered by each biome (A), and proportion of each biome protected under different management categories (B). From left to right biomes are: Tropical and Subtropical Moist Broadleaf Forests; Tropical and Subtropical Dry Broadleaf Forests; Temperate Broadleaf and Mixed Forests; Tropical and Subtropical Grasslands, Savannas and Shrublands; Temperate Grasslands, Savannas and Shrublands; Flooded Grasslands and Savannas; Montane Grasslands and Shrublands; Mediterranean Forests, Woodlands and Scrub; Deserts and Xeric Shrublands; Mangroves. The figure shows, for example, that while the Tropical and Subtropical Moist Forests cover *c*. 42% of the MERCOSUR's surface (A), only *c*. 22% of the biome is actually protected, with <10% managed according to IUCN categories, and only 4% protected in IUCN categories I–IV (B).

least 10% of their surface within protected areas. The number decreases to 13 when only the areas in IUCN categories I–IV are considered (Appendix).

Fifty percent of all protected areas are <100 km^2 and 75% $<1{,}000$ km^2, with Bolivia's being significantly larger than those of the other countries ($\chi^2_5 = 77.156$, $P < 0.0001$). The area protected tends to decrease from the equator (Fig. 2), approximately corresponding to the decrease in continental surface with latitude. Nevertheless, while the number of protected areas shows a similar pattern ($R_S = 0.443$, $n = 62$, $P < 0.001$), it reaches its maximum at 20–30° latitude south (Fig. 2).

For more than a decade one of the main global conservation goals has been the consolidation of an international network of protected areas covering 10% of the world's surface (IUCN, 1993). This was achieved in 2003, with the network currently covering 11.5% of the planet's land surface (Chape *et al*., 2003). However, despite being attractive for its simplicity, the logic and conservation value of such fixed targets have been questioned (Soulé & Sanjayan, 1998; Rodrigues & Gaston, 2001; Pressey *et al*., 2003; Rodrigues *et al*., 2004) because land surface is not necessarily a good proxy for biodiversity. A fixed percentage-based target does not ensure proper representation, regardless of whether biodiversity is measured at the species, ecoregion or other level, and area representation is not necessarily the most meaningful way of assessing conservation needs.

The MERCOSUR is an opportunity for the incorporation of national reserves into regional networks, and a regional approach is more cost efficient because what may be rare and costly to protect in one country may be well represented and comparatively easier to protect in another. For example, not all ecoregions in each country need to be protected for all the ecoregions in the MERCOSUR to be represented in the network of reserves. International efforts do not preclude national responsibilities, however. In the case of Brazil, with almost 80% of its ecoregions restricted within national boundaries, the country faces the challenge of incorporating a regional context when identifying national priorities. Conversely, countries of the MERCOSUR other than Brazil share more than 60% of their ecoregions and thus efficient planning will largely depend on transboundary cooperation.

A regional approach requires not only the identification of regional priorities, a unified strategy and coordinated actions, but also shared responsibility. This involves such matters as sharing costs, allocation of funding to fulfil agreed regional priorities, exchange of management experiences, and coordinated training. Unfortunately, the environmental directives of the MERCOSUR only provide vague references to the protection of natural areas. The new integration process, however, provides a unique opportunity for a leap forward in the conservation of South American biodiversity, although parochialism (*sensu* Hunter & Hutchinson, 1994) would need to be avoided. Paraguay and Uruguay, with less developed reserve networks, will need to engage in proportionally larger commitments. Regrettably, despite isolated initiatives to improve national networks, no actual steps are yet being taken towards the development of an integrated network for the MERCOSUR.

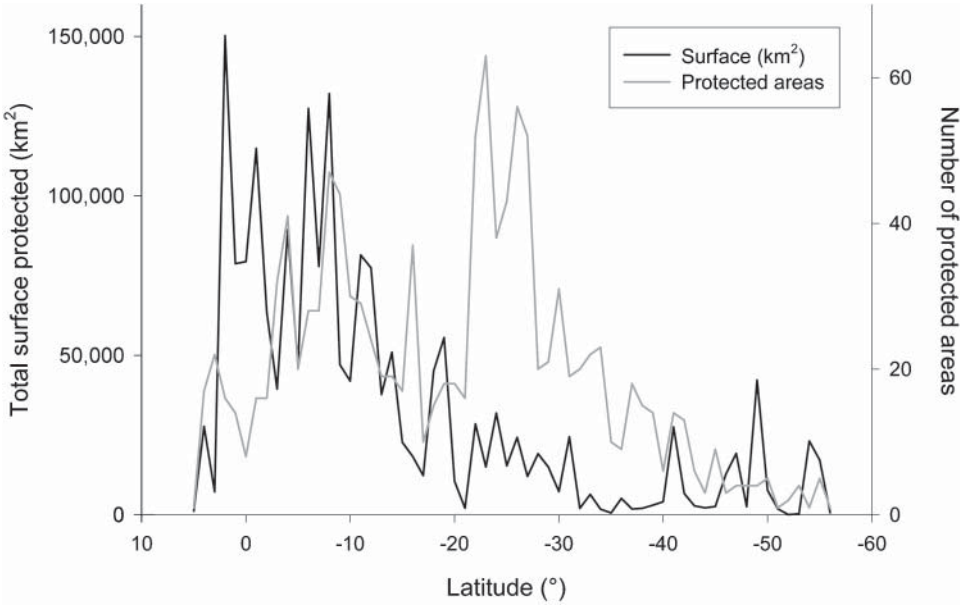

Fig. 2. Latitudinal trends in the number of reserves in the MERCOSUR and total area protected (negative values indicate southern latitudes).

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Appendix

The appendix for this article is available online at http://journals.cambridge.org

Biographical sketches

Alvaro Soutullo is a keen conservationist with broad biological interests. He has conducted research in subjects ranging from evolutionary ecology to applied conservation science, including the identification of conservation priorities and research on the conservation of phylogenetic diversity.

Eduardo Gudynas is director of the Latin American Centre of Social Ecology. For more than 20 years he has conducted research, given courses, written textbooks and advised governments and international organizations on social ecology, sustainable development, globalization and trade.

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Appendix

Southern South American ecoregions within the MERCOSUR and proportion of each ecoregion officially protected. Note that when only the areas in IUCN categories I–IV are considered the proportion of ecoregions protected decreases dramatically.

Ecoregion	% of MERCOSUR	% of areas officially protected	% of areas in categories I–VI	% of areas in categories I–IV
Alta Parana Atlantic forests	3.5	3.6	3.2	1.7
Amapa mangroves	0.0	0.0	0.0	0.0
Araucaria moist forests	1.6	2.3	2.3	0.8
Argentine Espinal	0.8	0.1	0.1	0.0
Argentine Monte	3.0	4.4	4.4	1.0
Arid Chaco	0.7	1.8	1.8	1.6
Atacama desert	0.8	1.0	1.0	1.0
Atlantic Coast restingas	0.1	2.2	2.2	2.1
Atlantic dry forests	0.8	4.6	4.6	4.6
Bahia coastal forests	0.8	1.8	1.3	1.2
Bahia interior forests	1.7	1.6	1.6	1.1
Bahia mangroves	0.0	10.9	0.0	0.0
Beni savannah	0.9	0.0	0.0	0.0
Bolivian montane dry forests	0.6	1.1	1.1	0.2
Bolivian Yungas	0.6	50.6	50.6	27.4
Cordoba montane savannah	0.4	1.2	1.2	0.8
Caatinga	5.4	2.1	2.1	0.8
Caatinga Enclaves moist forests	0.0	7.0	7.0	0.2
Campos Rupestres montane savannah	0.2	19.5	19.5	2.5
Caqueta moist forests	0.1	91.3	1.4	0.0
Central Andean dry puna	2.2	13.6	13.6	6.0
Central Andean puna	0.7	22.8	22.8	6.3
Central Andean wet puna	0.1	3.7	3.7	3.7
Cerrado	14.0	6.6	2.8	2.3
Chaco	4.5	10.6	10.5	5.7
Chilean matorral	1.1	0.9	0.9	0.9
Chiquitano dry forests	1.7	16.2	14.7	0.6
Guayanan Highlands moist forests	0.8	82.8	0.9	0.9
Guianan mangroves	0.0	0.0	0.0	0.0
Guianan moist forests	0.5	40.3	2.3	2.3
Gurupa varzea	0.1	0.0	0.0	0.0
Guyanan savannah	0.6	56.5	0.3	0.0
Humid Chaco	2.4	6.5	6.4	0.6
Humid Pampas	1.8	0.2	0.2	0.1
Ilha Grande mangroves	0.0	11.5	11.5	11
Iquitos varzea	0.2	29	1.5	0.0
Japura-Solimoes-Negro moist forests	1.7	43.7	16.0	11.2
Jurua-Purus moist forests	1.8	18.2	4.3	1.2
Madeira-Tapajos moist forests	5.3	23.5	11.7	5.1
Magellanic subpolar forests	1.0	71.0	71.0	68.5
Marajo Varzea forests	0.6	73.9	73.4	12.7
Maranhao Babacu forests	1.0	5.8	2.8	0.0
Maranhao mangroves	0.1	0.5	0.5	0.3
Mato Grosso seasonal forests	3.0	16.2	0.0	0.0

Ecoregion	% of MERCOSUR	% of areas officially protected	% of areas in categories I–VI	% of areas in categories I–IV
Monte Alegre varzea	0.5	13.5	9.3	0.1
Negro-Branco moist forests	0.4	46.3	45.2	45.2
Northeastern Brazil restingas	0.1	16.4	16.4	15.9
Pantanal	1.3	6.8	6.7	6.1
Para mangroves	0.0	11.3	11.3	0.0
Parana flooded savannah	0.3	0.9	0.9	0.2
Patagonian grasslands	0.4	0.1	0.1	0.1
Patagonian steppe	3.6	4.7	4.7	0.5
Pernambuco coastal forests	0.1	2.0	1.9	0.7
Pernambuco interior forests	0.2	4.0	4.0	0.9
Purus varzea	1.1	26.5	18	9.9
Purus-Madeira moist forests	1.3	5.6	5.6	0.0
Rapa Nui-Sala-y-Gomez subtropical broadleaf forest	0.0	42.7	42.7	42.7
Rio Negro campinarana	0.6	28.7	16.9	11.7
Rio Pirañas mangroves	0.0	4.4	4.4	1.3
Rio Sao Francisco mangroves	0.0	0.2	0.2	0.2
Sechura desert	0.0	0.0	0.0	0.0
Semi-arid Pampas	2.4	0.5	0.5	0.1
Serra do Mar coastal forests	0.8	20.9	20.7	11.5
Solimoes-Japura moist forest	0.3	20.5	20.5	20.5
Southern Andean steppe	1.3	15.5	15.5	15.2
Southern Andean Yungas	0.4	8.6	8.2	7.7
Southern Cone Mesopotamian savannah	0.6	0.4	0.4	0.4
Southwest Amazon moist forests	3.6	31.3	9.6	5.6
Tapajos-Xingu moist forests	2.5	35.1	6.7	0.0
Tepuis	0.0	0.0	0.0	0.0
Tocantins/Pindare moist forests	1.4	10.0	1.9	1.8
Uatuma-Trombetas moist forests	3.4	23.1	6.4	2.6
Uruguayan savannah	2.6	2.0	1.2	0.3
Valdivian temperate forests	1.8	25.2	24.9	22.7
Xingu-Tocantins-Araguaia moist forests	1.9	33.5	2.3	0.4
Mean	1.3	16.0	9.1	5.5
Median	0.8	6.8	3.2	0.9