Ecoregions of the Northern Mexican Border

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Introduction

Mexico, the United States of America and Canada form the North American Subcontinent, a vast territory (8.2 million mi^2) ,that extends from the intertropical zone to the Arctic (Latitude: 15° N to 85° N). Within the continent,there is a wide latitudinal gradient, with a complex orography and large diversity of environments, constituting a complex ecological mosaic. Many of its ecosystems extend across these countries forming a continuum; so there are many species of organisms that are common throughout their territories.

In the area of contact between the United States and Mexico converge two biogeographic regions, the Neartic, reaching from the North and the Neotropical that stretches from the South. To a great extent, this determines the presence of a great diversity of organisms and ecosystems (Rzedowski 1991), and for this reason, both countries are included among the 17 countries considered as megadiverse at global scale (Mittermeier *et al.* 1999). In this contact zone, the eastern and western mountain ranges meet, and two of North America's great deserts are shared: the Sonoran and the Chihuahuan deserts, which are notable for their high levels of endemism (Rzedowski 1991).

Ecoregions allow us to count geographical units that share the majority of their species and ecological dynamics and comprise similar environmental

conditions where the ecological interactions, on which their long term persistence depends, take place (CEC 1997). These can be defined at various nested scales that group similar units, from biomes (such as deserts and forests) up to units defined by their geomorphological characteristics, vegetation type and species composition. At the subcontinent scale, Level 1 comprises 15 ecoregions at a scale of 1:40-50 million; Level 2 includes 52 ecoregions at a scale of 1:20-30 million; Level 3 consists of 200 units at a scale of 1:2-4 million (CEC 1997). Mexico has made some progress in defining Level 4 (N4), by identifying 96 ecoregions at a scale of 1:1 million (INEGI-Conabio-INE 2007).

Ecoregional units have been used over the past few years to define conservation priorities at the global and regional scale, and to protect as many representative areas with special elements as possible so to ensure the survival of populations and ecological processes (Dinerstein *et al.* 1995; Olson *et al.* 2001, Olson and Dinerstein 2002; Loucks *et al.* 2003; Hoekstra *et al.* 2005; Balmford *et al.* 2005, Burgess 2006). For example, Olson and Dinerstein (2002) selected 200 ecoregions as priorities, from a total of 867 land ecoregions in the world. Among these, 142 are singled out as outstanding on a global, regional, bioregional or local scale; 72 of which are considered critical or endangered, 39 sensitive and 28 relatively stable or intact.

Mexico stands out among the countries in America with the largest priority conservation area, with five out of the six priority ecoregions being singled out: the California Chaparral and Woodlands, the Baja California and Sonoran Deserts, the Pine-Oak Forests of the Sierra Madre Oriental and Sierra Madre Occidental Mountain Ranges, the Dry Forests in Southern Mexico and the Tehuacan and Chihuahuan Deserts (Olson y Dinerstein 2002). These five ecoregions are located mainly in Mexico; nevertheless, they extend beyond the geopolitical borders into U.S. territory.

As a follow up on the Work Agenda for protected areas agreed to in 2004 at the seventh meeting of the parties involved in the Convention on Biological Diversity, the National Commission for the Knowledge and Use of Biodiversity (Conabio), in collaboration with the National Commission for Natural Protected Areas (CONANP), has coordinated the analysis of gaps and omissions in the conservation of N4 ecoregions (details may be seen in Koleff *et al.* under review).

Based on the results of the study on a national scale, the present work has the objective of determining the representativity levels of the sixteen N4 ecoregions that come in contact with the U.S. border region (Table 1, Fig. 1), with regards to the 13 protected areas (PA) (10 under federal jurisdiction and

Table 1. N4 Ecoregions of the northern Mexican Border (in the entire country and within 62 miles of the border), indicating the surface ratio with regards to Mexico and its Natural Protected Areas. (INEGI-CONABIO-INE 2007)

N4 Key	N4 Ecoregions	Mexico (ha)	PA Mexico (ha)	PA Mexico (%)	Border buffer 100 km (ha)/	Border buffer 100 km (%)/ Mexico (%)	PA Border buffer 100 km (ha)	PA Border buffer 100 km/ Border buffer 100 km (%)
10.2.4.3	Rio Grande basin alluvial plain -La Cochina, with xeric vegetation	355,865	0	0	355,865	100	0	0
11.1.1.2	Hills and mountain ranges with conifer, oak and mixed forests	6,050	0	0	6,050	100	0	0
12.1.2.1	Slopes and plains with grassland, xeric scrub and oak and conifer forests	12,877,393	108,913	0.8	857,423	6.7	0	0
9.6.1.1	Inner Tamaulipan flatlands with xeric scrub	6,590,056	107,770	1.6	4,521,515	68.6	9,254	0.2
11.1.1.3	Hills and Plains with xeric scrub and chaparral	2,277,045	153,228	6.7	881,807	38.7	1,821	0.2
9.5.1.2	Tamaulipan Coastal Plains with xeric vegetation or no aparent vegetation	1,173,783	54,129	4.6	768,724	65.5	7,465	1.0
12.1.1.1	Hills and flatlands with xeric scrub, grasslands and isolated elevations with oak and conifer forests	3,206,424	146,556	4.6	2,229,007	69.5	52,703	2.4
11.1.3.1	Hills and mountain ranges with conifer, oak and mixed forests (of Juarez)	113,798	3,083	2.7	89,111	78.3	3,077	3.5
10.2.4.1	Center flatlands of the Chihuahuan Desert, with xeric microphyll-halophyllous vegetation	15,767,680	545,551	3.5	5,158,231	32.7	179,126	3.5

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13.2.1.1	Mountain ranges with conifer, oak and mixed forests	13,644,674	748,134	5.5	170,741	1.3	16,437	9.6
10.2.4.2	Northern Chihuahuan Desert hills and lower mountain ranges with microphyll rosette-like xeric scrub	5,914,534	762,681	12.9	2,401,397	40.6	232,295	9.7
9.6.1.2	Hills and mountain ranges with xeric scrub and oak forests	2,229,909	332,064	14.9	801,359	35.9	162,796	20.3
10.2.2.6	Upper Gulf Deserts (Altar, El Pinacate, Mexicali-San Felipe corridor, Asuncion, Sonoyta and San Ignacio-Arivaipa basins)	6,465,017	931,161	14.4	4,046,581	62.6	866,868	21.4
10.2.4.4	Major elevations in the Chihuahuan Desert with xeric vegetation, conifer, oak and mixed forests	1,220,104	636,349	52.2	536,231	43.9	237,192	44.2
10.2.2.1	Colorado River Delta wetlands	391,673	238,667	60.9	330,892	84.5	177,891	53.8
9.5.1.1	Laguna Madre wetlands	346,597	237,798	68.6	272,720	78.7	179,708	65.9
	Total	72,580,600	5,006,085	6.9	23,427,654	32.3	2,126,632	9.1

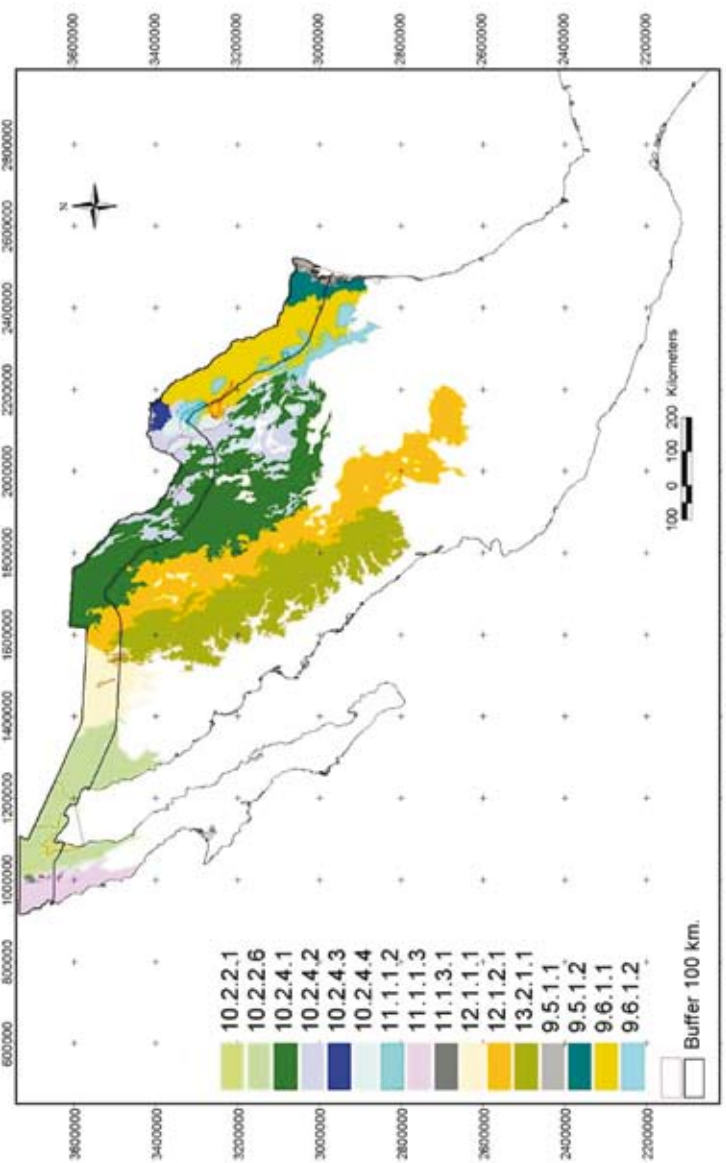

Figure 1. N4 Ecoregions and Natural Areas in Mexico's northern border zone (INEGI-CONABIO-INE 2007). + See Table 1 for the names of each code number

3 under state jurisdiction) and the types of primary natural vegetation cover (Table 2, Fig. 2) that exist in these border ecoregions.

Methods

The method applied was the one developed in the Gap Analysis Program (GAP; Scott *et al.* 1993) for identifying gaps and omissions in conservation, which consists of determining the level of representativity of the NPAs in the ecoregions that come in contact with Mexico's northern border. An area within 62 miles (100 km) from the border in Mexican territory was established as a maximum limit for the analysis, which included only NPAs larger than 247.1 acres (100 hectares) (Conanp- Conabio, unpublished). Also, the representativity level was evaluated taking into account the vegetation cover, based on the most recent land use and vegetation cover data (Series III, INEGI, 2005). This is a variable of great importance when evaluating the representativity bias in the NPA systems and identifying conservation priorities. All of the digital covers were combined and analyzed with the ArcView™ program, version 3.2.

For the purposes of the present study, the current ratio of national territory protected (11.4%) was adopted as a threshold for the conservation goal; any amount below that is considered a conservation omission. That is, the ecoregions or types of vegetation with values under 11.4% of their surface area declared PAs are considered omissions; while those that are not covered by any PAs are considered gaps.

Results and Discussion

Within the 62 mile border zone there is a total of sixteen N4 ecoregions, of the 96 registered in Mexico, that come into contact with U.S. territory. The sum of these ecoregions' entire surface area totals 179,350,568.5 acres (72,580,600 hectares), which represents 32.3% of the entire country. The ecoregions that stand out for their size are: 10.2.4.1, the Center Flatlands in the Chihuahuan Desert, with xeric microphyll-halophilous vegetation; 13.2.1.1, Hills and Mountain Ranges with conifer, oak and mixed forests; and 12.1.2.1, foothills and plains with grasslands, xerophytic scrub and conifer oak forests. These ecoregions are included within the North American Great Plains and Deserts, the California Mediterranean and the Semiarid Southern Elevations, extending across the U.S. and Mexico, so they share the distribution area of a great number of species, many of which are endangered due to the strong challenges

Table 2. Primary vegetation in the border zone ecoregions in northern Mexico (in the entire country and in the 62 mile border zone), indicating the surface ratio with regards to Mexico and Natural Protected Areas (INEGI 2005)

Series III Primary Vegetation (INEGI 2005)	Mexico (ha)	PA Mexico (ha)	PA Mexico (%)	Border buffer 100 km (ha)	Border buffer 100 km/ Mexico (%)	PA Border buffer 100 km (ha)	PA Border buffer 100 km/ Border buffer 100 km (%)
Rosette-like coastal scrub	439,068	139,433	31.8	2,046	0.5	0	0
Natural palm trees	11,449	1,508	13.2	54	0.5	0	0
Tamaulipan thorn scrub	2,555,497	95,810	3.7	1,973,337	77.2	11,822	0.6
Mezquital	2,516,180	36,204	1.4	428,946	17.0	4,573	1.1
Halophilous grassland	1,823,487	96,881	5.3	618,824	33.9	17,298	2.8
Gallery vegetation	136,639	29,095	21.3	26,201	19.2	982	3.7
Natural grassland	6,323,740	227,357	3.6	1,674,936	26.5	88,855	5.3
Juniper forests	158,903	9,523	6.0	21,102	13.3	1,269	6.0
Microphyll desert scrub	19,588,232	1,190,273	6.1	6,714,246	34.3	529,951	7.9
Rosette-like desert scrub	10,210,408	1,382,033	13.5	2,012,713	19.7	184,925	9.2
Pine forests	5,219,836	371,205	7.1	111,921	2.1	11,351	10.1
Oak forests	6,879,257	857,566	12.5	561,064	8.2	64,983	11.6
Gallery forests	20,624	1,324	6.4	6,404	31.1	803	12.5
Submontane scrub	2,389,509	538,487	22.5	393,919	16.5	72,207	18.3
Halophilous vegetation	2,765,285	990,979	35.8	597,976	21.6	124,395	20.8
Sarcocaule scrub	5,208,915	1,230,711	23.6	271,104	5.2	58,226	21.5

Table 2. Primary vegetation in the border zone ecoregions in northern Mexico (in the entire country and in the 62 mile border zone), indicating the surface ratio with regards to Mexico and Natural Protected Areas (INEGI 2005) (continued)

Series III Primary Vegetation (INEGI 2005)	Mexico (ha)	PA Mexico (ha)	PA Mexico (%)	Border buffer 100 km (ha)	Border buffer 100 km/ Mexico (%)	PA Border buffer 100 km (ha)	PA Border buffer 100 km/ Border buffer 100 km. (%)
Sandy desert vegetation	2,158,605	827,724	38.3	1,515,457	70.2	401,954	26.5
Pine-oak forests	5,733,148	689,430	12.0	62,588	1.1	19,859	31.7
Crasicaule scrub	1,205,357	123,931	10.3	1,732	0.1	642	37.1
Oak-pine forests	3,048,387	481,868	15.8	106,481	3.5	42,612	40.0
Coastal dune vegetation	146,421	34,762	23.7	7,987	5.5	5,148	64.5
Fir forests	26,386	3,613	13.7	843	3.2	843	100
Low deciduous thorn forests	242,919	13,876	5.7	25	0.0	25	100
Total	78,808,254	9,373,591	11.9	17,109,906	21.7	1,642,723	9.6

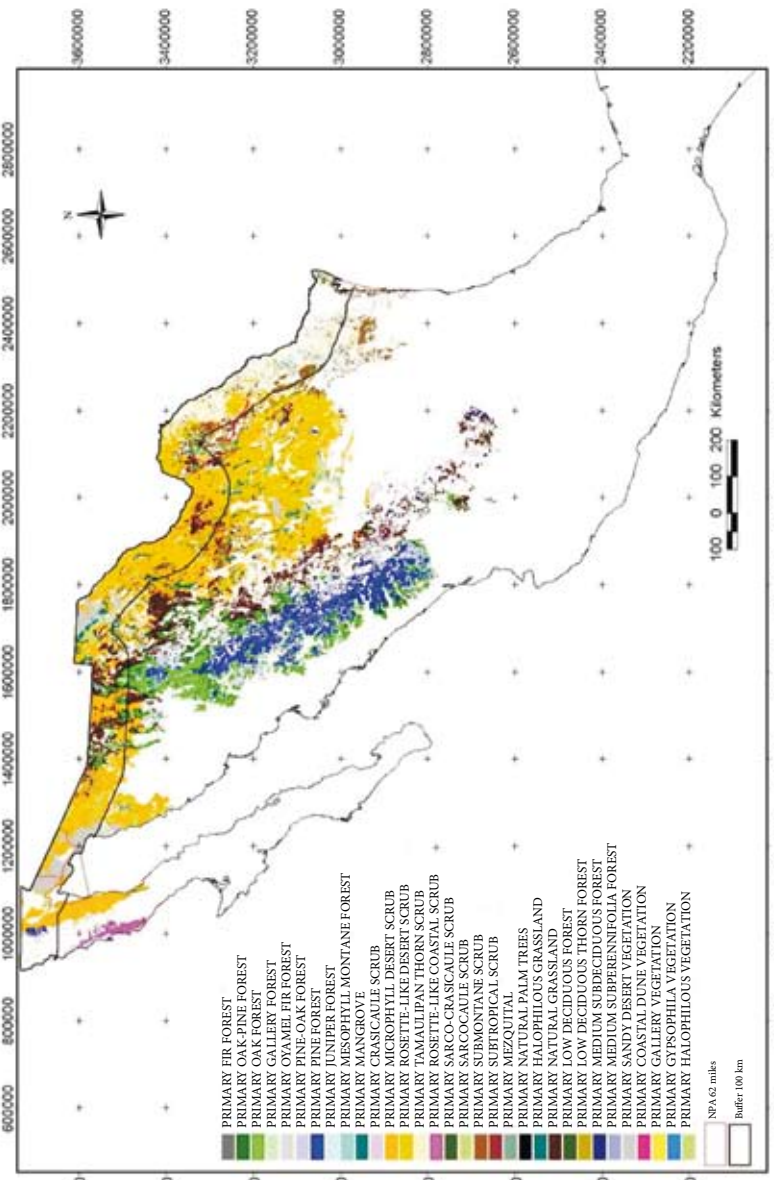

Figure 2. Types of primary vegetation in the ecoregions and Natural Protected Areas in Mexico's northern border zone. (INEGI 2005)

that they face (U.S. EPA-Semarnap 2001). There are two ecoregions which are exclusive to the border region: 11.1.1.2, Hills and Mountain Ranges with conifer, oak and mixed forests; and 10.2.4.3, the Rio Grande Basin Alluvial Plain – La Cochina, with xeric vegetation; these two, therefore, are endemic to this region. (Table 1, Fig. 1).

Two great regions that cover a large portion of the Mexican territory along the country's northern border have been identified as 'Hotspots' on a global scale. These are sites with the most biological wealth in the world that are also the most threatened (Mittermier *et al*., 1999), and have an insufficient level of protection with regards to the biodiversity they harbor. That is the case of the California Floristic Province, which extends to the northernmost part of the Baja California peninsula and the Madrean Pine-Oak Woodlands, which includes the Sierra Madre Oriental and the Sierra Madre Occidental and its extensions within U.S. territory.

As far as biodiversity protection in Mexico, there are currently 382 PAs (123 are federal, 247 are state and 12 are municipal) covering 11.4% of the country. Out of these protected areas, 13 (10 federal and 3 state) are located within the ecoregions that extend up to the border zone covering a total of 5,255,197.6 acres (2,126,703 hectares), that is 9% of the region being studied, which is below the protected national median (11.4%) (Fig. 1). These data stress the importance of increasing conservation efforts, as well as considering cross border efforts, since despite the relatively large PAs found in the region, (e.g. the upper Gulf of California and the Colorado Delta; and the Rio Alamo Basin), there are three ecoregions that represent conservation gaps: 10.2.4.3, Rio Grande Basin Alluvial Plain – La Cochina with xeric vegetation; 11.1.1.2, Hills and Mountain Ranges with conifer, oak and mixed forests; and 12.1.2.1, foothills and plains with grasslands, xerophytic scrub and conifer oak forests. These ecoregions represent 5.2% of the entire surface area for the 16 ecoregions. Also, there are eight ecoregions which are conservation omissions, which represent 69% of the entire border ecoregions area (Table 1, Fig. 1).

The digital Land Use and Vegetation cover of the Series III (INEGI 2005) for the Mexican Republic registers a total of 239,616,576.1 acres (96,969,388 hectares) of primary vegetation; that is, 48% of the country's surface area, of which 17.6% is found within the northern border ecoregions (Fig. 2). Nevertheless, the primary vegetation cover accounts for 73% of the surface area if you consider the 57,890,993.8 acres (23,427,654 hectares) that cover the 16 ecoregions under study. This means that this region of the country has a

higher degree of conservation when compared to the rest of Mexico, since at the national level, the primary vegetation cover in the country's entire territory located within PAs is 5.7%, while in the northern border ecoregions it is 9.6% (Table 2, Fig. 2).

On the other hand, two of the primary vegetation types (rosette-like coastal scrub and natural palm trees) are not included in the PAs of the ecoregions under study. These plant communities inhabit a total of 5,189 acres (2,100 hectares), representing less than 0.1% of the border ecoregions' total surface. While nine of the plant communities are conservation omissions, with a surface area of 33,562,411.4 acres (13,582,226 hectares) which represent 79.4% of the northern border ecoregions' territory (Table 2, Fig. 2).

Conclusions

The continuity of the ecological systems across the U.S. and Mexico is a natural condition which goes beyond the artificial geopolitical boundaries that have been established. The fragmentation of the ecoregions that extend across both countries, which share common biological communities and environments, is a threat that endangers their ecological stability. In fact, protected areas such as Big Bend National Park seek conservation beyond borders. In this sense, it is important to identify cross border cooperation efforts, which point to the need to support biodiversity conservation in the boundary zone between the U.S. and Mexico (US EPA-Semarnap 2001).

Fundamental biological processes (dispersion, migration, reproduction, etc.) for many of those species with criss-border distribution will be disturbed by the presence of the fence that is expected to be built. The interruption of the ecoregions that share territories between the U.S. and Mexico is a powerful disruptive agent that will alter the region's ecological stability leaving no possibility of mitigation. The ecological impacts of this project threaten the region's biodiversity and consequently, the natural heritage not only of Mexicans or Americans, but of humanity as a whole.

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