An Overview of the Floristic Richness and Conservation of the Arid Regions of Northern Mexico

Laura Arriaga
Centro de Investigaciones Biológicas del Noroeste (CIBNOR). Apdo. Postal 128, La Paz, 23000, B.C.S., México, and Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), Av. Liga Periférico-Insurgentes Sur 4903, Col. Parques del Pedregal, Del. Tlalpan, 14010, México, D.F.

Elizabeth Moreno
Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), Av. Liga Periférico-Insurgentes Sur 4903, Col. Parques del Pedregal, Del. Tlalpan, 14010, México, D.F.

Claudia Aguilar
Centro Regional de Investigaciones Multidisciplinarias, Universidad Nacional Autónoma de México (UNAM). Av. Universidad s/n, Circuito 2, Cuernavaca, 62210, Morelos, México

Abstract—*The arid and semiarid regions of Northern Mexico harbor diverse, highly endemic, and geographically complex ecosystems. These share topographic and biogeographic similarities that can be used as an analytical framework to assess biodiversity patterns. This study presents the current status of vascular plant inventories for Mexican Aridamerica. The spatial distribution of floristic records obtained for different vegetation types was analyzed for a 171-year period of field inventories. Floristic curatorial records (96,302) were obtained from the Mexican National Biodiversity Information System, provided by CONABIO, belonging to 10,772 species. Results show sampling efforts are scarce to characterize the vascular plant diversity of the natural ecosystems of Northern Mexico. The lowest sampling efforts were recorded for the central regions of the states of Sonora, Chihuahua, Coahuila, Sinaloa, Durango, Zacatecas, and western San Luis Potosí. The highest species richness was obtained for currently disturbed areas, since most of the analyzed floristic records are historical. The sites where most specimens were collected are now agricultural lands or urban zones.*

Introduction

Arid regions are characterized by relatively fewer species than those found in more humid environments. In the arid and semiarid regions of Northern Mexico, plants have evolved into a moderately rich and distinctive flora with specialized growth forms that are often unique (Rzedowski 1992). Therefore, biodiversity in these regions must be given high priority, since each species lost from an arid region represents a higher percentage loss of the region's biodiversity than in more speciose regions (McNeely 2003).

Biological inventories have traditionally been considered the most extensive means to document species biodiversity. Herbaria harbor vast information of large geographical areas that are quite useful to describe regional floras and to review phytogeographic patterns. Although inventories are the first step in biodiversity assessment and in many other approaches to biological conservation, taxonomically complete inventories are rarely conducted. In Mexico, botanists have carried out biological inventories for almost two centuries (Davis 1936; Ochoterena 1942; Fulton 1944; McVaugh 1956; Rzedowski 1959, 1981, 1997; Miranda 1961; Sousa 1969; Lozoya 1984; Herrera et al. 1998; Bernabéu et al. 2000, among others). The phanerogamic flora of Mexico is estimated at roughly 220 families, 2,410 genera, and 22,000 species. Approximately 10% of the genera and 52% of the species are endemic to Mexico (Rzedowski 1992). Based on previous data, one could think sampling efforts account for most of the plant species diversity distributed in the country.

In this study, we present an overview of the floristic records and conservation of Mexican Aridamerica by addressing the following queries: Are the current biological inventories enough to describe vascular plant diversity of these regions in Northern Mexico? How does a spatial scale of analysis determine an adequate pattern of sampling efforts in the region? What is the correlation between current land use in these regions and floristic curatorial records?

These queries are addressed by analyzing the specimen records and species richness of vascular plants occurring in Mexican Aridamerica over 171 years, as well as their present spatial distribution according to a current land use and vegetation map.

Methods

The boundaries of Mexican Aridamerica were defined according to physiographic (INEGI-IGUNAM 1990), geomorphologic, and climatic criteria (Cervantes-Zamora et al.

Table 1—Floristic specimen records provided by the Mexican National Biodiversity Information System (SNIB-Conabio 2001) collected by different botanists in the arid and semiarid regions of Northern Mexico during 1827-1998.

Class	Species	Records	Sampling period
Cycadopsida	10	61	1962-1997
Dicotyledonae	8,942	69,234	1827-1998
Gnetopsida	11	64	1946-1994
Monocotyledonae	1,712	23,805	1839-1998
Pinopsida	96	3,111	1848-1998
Taxopsida	1	27	1965-1990
Total	10,772	96,302	

1990), as well as to cultural ones (SEDESOL 2000). The study area comprised all the Northern Mexican states and its limits to the south with the physiographic province "Eje Volcánico Transversal," to the southeast with the ethnic region "Huasteca" and physiographic region "Llanuras y lomeríos," and to the southwest with the ethnic region "Huicot" and physiographic regions "Mesetas y cañadas del Sur" and "Pie de la Sierra." The floristic records included information for 17 Mexican States located in these regions. Baja California, Baja California Sur, Sonora, Chihuahua, Coahuila, Nuevo León, Aguascalientes, and San Luis Potosí were fully covered. Sinaloa, Durango, Zacatecas, and Tamaulipas were covered in the majority of their territory, except for their extreme southern parts. Jalisco, Guanajuato, Querétaro, Hidalgo, and Veracruz were partially covered, specifically their northern areas.

For this area, 68 databases of floristic specimens provided by the Mexican National Biodiversity Information System (SNIB-CONABIO 2001) were analyzed. Data included 10,772 species and 96,302 specimen records collected by botanists from 1827 to 1998 (table 1). Specimen records were analyzed according to sampling dates and were grouped by decades. Specimen records were also digitized and projected onto a grid of cartographic cells (4 × 4 km), using the land use and vegetation map generated by INEGI (2002). Subsequently, the cartographic cells containing at least one specimen record were highlighted on a map. Specimen records were projected onto the digitized land use and vegetation map (INEGI 2002), and species richness was obtained for each land use and vegetation class. Only those classes where species richness was higher than 100 species were included in the analysis.

Results and Discussion

Historical and Spatial Analysis of Field Inventories

An historical analysis of the field inventories carried out by botanists in Mexican Aridamerica is shown in figure 1. These data only include the information compiled in the SNIB, and do not necessarily include the specimen records housed in all the Mexican or foreign herbaria. Three statistical modes in the field inventories, grouped by decades, can be distinguished in this logarithmic graph. The first stage shows that only a very few hundred plant specimens were obtained from 1827 to1866, and they were collected only by foreign botanists. A second stage occurred from 1867 to 1925. During this period, although few field inventories were carried out, important collections were obtained by several herbaria, mostly in the U.S.A. The more relevant botanists who collected vascular plants in these regions of Mexico were E. Palmer, T. S. Brandegee, G. Thurber, J. Gregg, K. Hartweg, C. Wright, J. L. Berlandier, J. G. Schaffner, and A. Schott. The third stage (1927-1998) has been the most exhaustive and productive period, since it accounts for more than one hundred thousand specimens collected by numerous botanists. Some of the more relevant ones are H. S. Gentry, E. Y. Dawson, F. Gander, L. R. Stanford, S. White, F. Miranda, E. Hernández X., I. L. Wiggins, I. M. Johnston, F. Shreve, H. Leseur, R. M. Turner, P. S. Martin, R. M. Stewart, V. H. Chase, R. Moran, A. Carter, J. Rzedowski, R. McVaugh, J. R. Reeder, T. R. Van Devender, R. Spellenberg, F. González-Medrano, R. Bye, and R. Vega-Aviña, to list the most prominent individuals. Likewise, a continuous increase in the number of species and curatorial records obtained during this period is shown in figure 1. This tendency was the result of a growing interest of Mexican authorities to promote scientific policies oriented toward biodiversity monitoring during the last decades of the 20th century, as a consequence of a global interest subsequent to the Convention on Biological Diversity. Unfortunately this pattern changed recently, and a marked decrease in the number of specimens is seen in the last two years of the period analyzed.

The results of the digitization of specimen records and their projection onto a 4- x 4-km grid, using the land use and vegetation map are shown in figure 2. Although the analyzed specimen records are very numerous (96,302), their spatial distribution is heterogeneous and clustered within a few geographical areas. Most of the records come from the northern and southern parts of the Baja California Peninsula, while other areas showing high concentrations of sampled specimens occur in some parts of the States of Nuevo León, Tamaulipas, and eastern San Luis Potosí. Likewise, the northern portions of the States of Guanajuato, Querétaro, and Hidalgo also show areas where plant specimens have been collected more thoroughly. Specimens collected in the central parts of Sonora, Chihuahua, Coahuila, Sinaloa, Durango, Zacatecas, and western San Luis Potosí are completely skewed and incomplete. These were obtained following the highways and road networks and do not represent the flora of broad landscape units. Few interpretations and inferences concerning species richness, distribution, and biodiversity patterns can be derived from these data, since sampling efforts have neither been exhaustive nor intensive in the arid and semiarid regions of Northern Mexico.

Specimen Records, Land Use, and Biodiversity Loss

Changes in land use have been considered one of the greatest threats to biodiversity, globally. This analysis for Northern Mexico illustrated this same issue at a local approach. The highest species richness of vascular plants in this study was recorded in disturbed habitats (figure 3) including areas of seasonal (3,979 species) and irrigated (2,476) agriculture, urban zones (3,100), and induced (1,661) and cultivated grasslands (787). These records account only as historical.

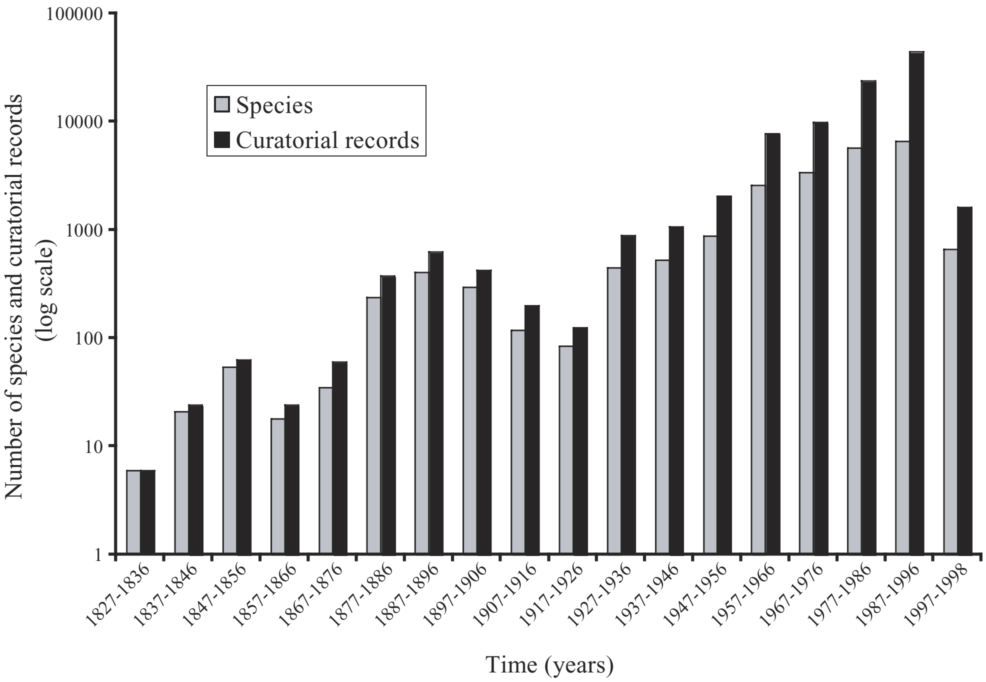

Figure 1—Field inventories of vascular plants for a time interval comprised from 1827 to 1998. Specimen records were provided by the taxonomic databases of the Mexican National Biodiversity Information System (SNIB-Conabio 2001).

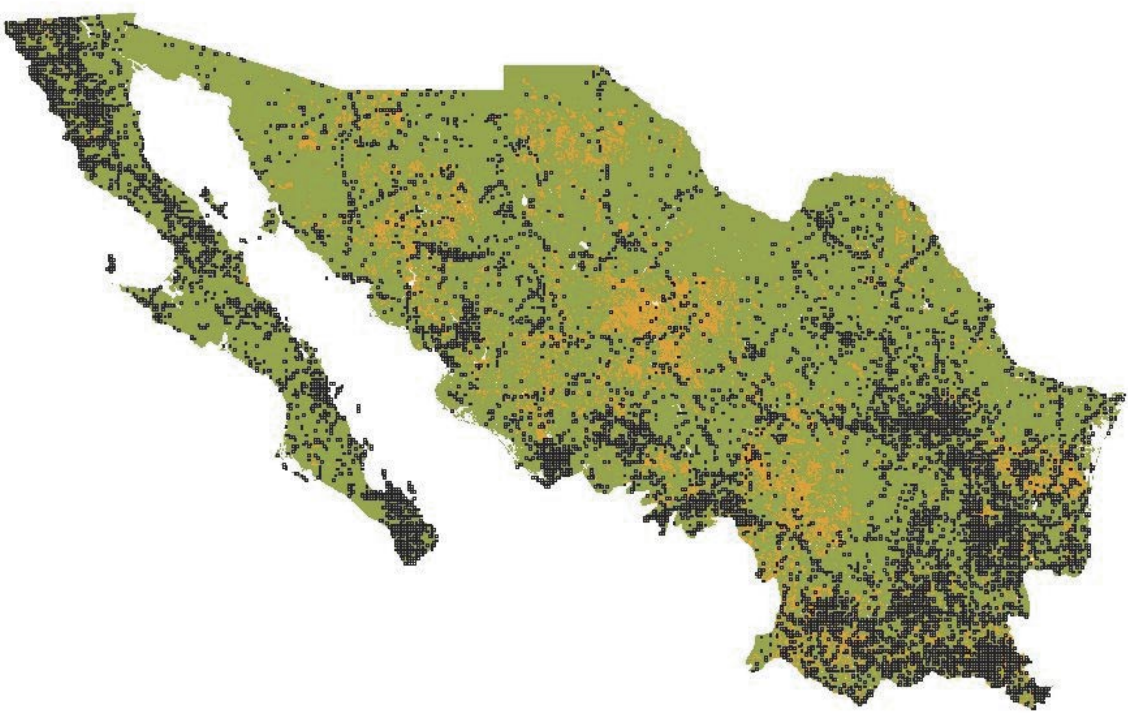

Figure 2—Spatial distribution of the field records of vascular plants in Northern Mexico for a sampling period comprised from 1827 to 1998. Specimen records are projected onto a 4 x 4 km grid. Black color stands for those areas where at least one specimen record was collected. The green color represents all the natural vegetation classes grouped, while the yellow color groups the secondary vegetation according to INEGI (2002).

The natural vegetation classes recording the highest species richness are oak forests (2,522 species), deciduous seasonal forest (2,405), pine (1,988) and pine-oak forests (1,924), submontane scrub (1,824), chaparral (1,562), and microphyllous desertscrub (1,525). Other vegetation types such as sarcocaulescent desertscrub, oak-pine forest, rosetophyllous desertscrub, and natural grasslands also have more than 1,000 species, while the remainder of vegetation classes are less rich (figure 3).

These results show that sampling efforts do not account for most of the plant species diversity distributed in Mexican Aridamerica, and that most of the available specimen records

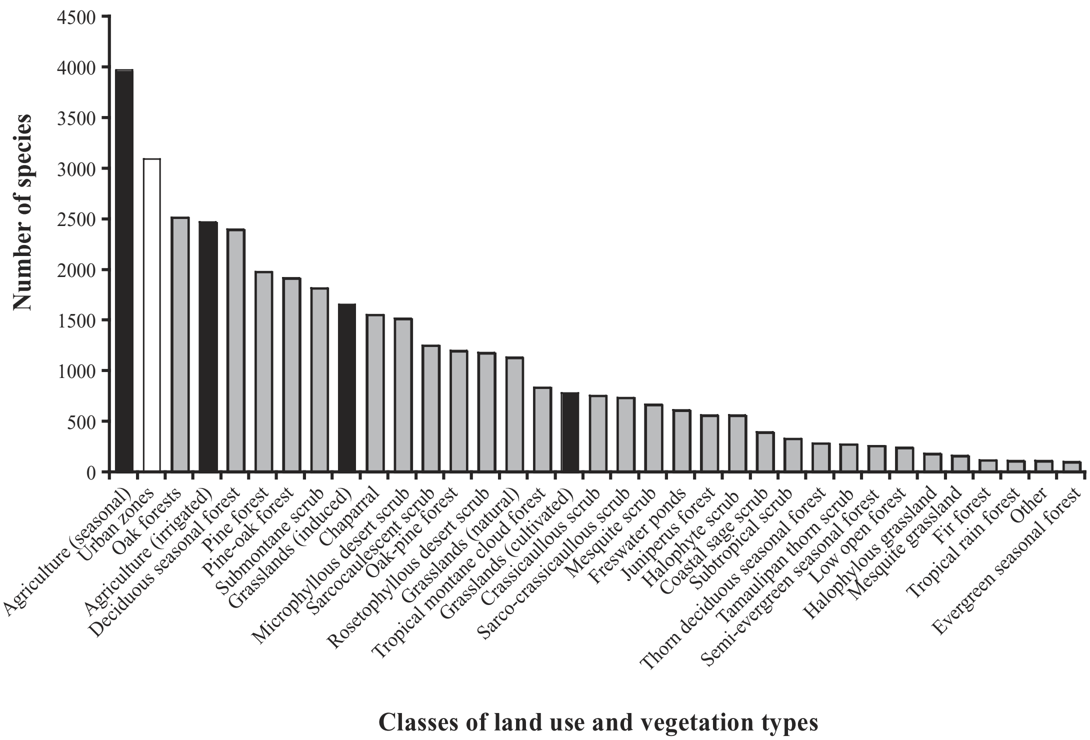

Figure 3—Species richness associated to land use and vegetation classes. Species richness was obtained from plant inventories compiled in the SNIB, and land use and vegetation classes are based in INEGI (2002). Black and white bars stand for disturbed habitats. Only land use and vegetation classes with more than 100 species were considered

in Mexican and foreign herbaria are now historical records that no longer occur in natural habitats, because of changes in land use.

Concluding Remarks

We believe that considerable efforts need to be made to document vascular plants biodiversity in these regions. Taxonomically current species inventories are essential components of regional and global conservation efforts, and although the decade of the 1990s promoted the inventory of biodiversity as never before (figure 1), these efforts do not appear to be enough to describe regional floras or landscape units. It is widely recognized that taxonomic information is a prerequisite to understanding biodiversity. Unfortunately, this discipline is not currently being fully supported in the universities and research institutions. The taxonomic impediment to progress in the study of biodiversity is linked to a worldwide shortage of taxonomists (Simpson and Cracraft 1995). The lack of enough taxonomists and the rapid changes in land use could, in the short term, prevent documentation of the distinctive flora of the unique desert habitats of Northern Mexico. Better collaboration between United States and Mexican botanists need to be promoted to integrate and complete floristic studies in Aridamerica.

Acknowledgments

The authors are grateful to numerous institutions and herbaria that have provided the data compiled in the Mexican National Biodiversity Information System of CONABIO. The editor at CIBNOR and Tom Van Devender critically reviewed a previous version of this manuscript. This study was partially financed by the Mexican Council for Science and Technology (CONACYT Project No. DAJ-J002/0728/99 and DAJ-J002/798/2000).

References

Bernabéu, S.; Blanco, P. 2000. El águila y el nopal, la expedición de Sessé y Mociño a Nueva España (1787-1803). Catálogo de los fondos documentales del Real Jardín Botánico de Madrid. Lunwerg Editores. Madrid, España. 229 p.

Cervantes-Zamora, Y.; Cornejo-Olguín, S. L.; Lucero-Márquez, R.; Espinoza-Rodríguez, J. M.; Miranda-Víquez, E.; Pineda-Velázquez, A. 1990. Clasificación de Regiones Naturales de México II. Atlas Nacional de México. Vol. II. Escala 1:4,000,000. Instituto de Geografía, Universidad Nacional Autónoma de México, México.

Davis, H. B. 1936. Life and work of Cyrus Guernsey Pringle. University of Vermont, Burlington, VT. 756 p.

Fulton, M.G. 1944. Diary and letters of Josiah Gregg. Excursions in Mexico and California 1847-1850. University of Oklahoma Press, Norman. 396 p.

Herrera, T.; Ortega, M.; Godínez, J. L.; Butanda, A. 1998. Breve historia de la botánica en México. Fondo de Cultura Económica. México. 168 p.

INEGI. 2002. Conjunto de datos vectoriales de la carta de uso de suelo y vegetación 1993-1996. Serie II. Escala 1:250,000. Continuo Nacional. Instituto Nacional de Estadística Geografía e Informática. México.

INEGI-IGUNAM. 1990. Provincias Fisiográficas. Atlas Nacional de México. Vol. II. Escala 1:6,000,000. Instituto de Geografía, Universidad Nacional Autónoma de México. México.

Lozoya, L. J. 1984. Plantas y luces en México: la real expedición científica a Nueva España, 1787-1803. Ed. Serbal. Barcelona, España. 224 p.

McNeely, J. A. 2003. Biodiversity in arid regions: Values and perceptions. Journal of Arid Environments 54 (1): 61-70.

McVaugh, R. 1956. Edward Palmer. Plant explorer of the American West. University of Oklahoma Press, Norman. 429 p.

Miranda, F. 1961. La botánica en México en el último cuarto de siglo. Sociedad Botánica de Historia Natural 22: 85-111.

Ochoterena, I. 1942. Francisco Hernández. Historia de las plantas de la Nueva España, 1517-1587. Instituto de Biología. Universidad Nacional Autónoma de México. México.

Rzedowski, J. 1959. Las colecciones botánicas de Wilhelm (José Guillermo) Schaffner en San Luis Potosí. I. Acta Científica Potosina. 3(1): 99-121.

Rzedowski, J. 1981. Un siglo de la botánica en México. Boletín de la Sociedad Botánica de México. 40: 1-14.

Rzedowski, J. 1992. Diversity and origins of phanerogamic flora in Mexico. Acta Zoologica Mexicana Nueva (Special Volume): 313-335.

Rzedowski, J. 1997. Los principales colectores botánicos de Guanajuato, Querétaro y norte de Michoacán. Flora del Bajío y regiones adyacentes. Fascículo 17. México. 30 p.

SEDESOL. 2000. Regiones Indígenas de México. Secretaría de Desarrollo Social. México.

Simpson, B. B.; Cracraft, J. 1995. Systematics: The science of biodiversity. BioScience 45: 670-672.

Sousa, S. M. 1969. Las colecciones botánicas de C. A. Purpus en México, período 1898-1925. University of California Press, Berkeley. 27 p.