Biodiversity and Conservation (2006) 15:3773–3799
DOI 10.1007/s10531-005-5401-1

Biogeography, current knowledge and conservation of threatened vascular plants characteristic of Mexican temperate forests

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Received 28 July 2004; accepted in revised form 31 March 2005

Key words: Cloud forest, Endangered species, Endemism, Mexico, Red Data List, Threatened species

Abstract. The main goal of this study is to document the biogeographical patterns, current status and conservation of 24 species of vascular plants in Mexico, all of them recorded in some risk category in the Mexican official publication named 'Norma Oficial Mexicana 059' (NOM-059) and some of them in the IUCN red lists (the World Conservation Union) and CITES (Convention on International Trade in Endangered Species); many of these species are linked to Mexican cloud forests and other temperate vegetation types. Distribution maps of these 24 species were generated with information obtained from specialized literature, herbarium specimens, institutional databases, and field work; with this information, the patterns of richness and endemism of these species were obtained. For this, the Mexican territory was divided using a grid system based on a chart index (scale 1:50,000 system composed by grids of 15′ × 20′). Also, we up to date the knowledge of these species and their populations and current habitats, and evaluate their geographic distribution in relation to the current Mexican National Parks and Reserves System and Mexican Priority Regions for Conservation. We also discuss some changes of categories in the NOM-059 and suggest the urgent incorporation of some of the species in the recent IUCN Red Data List of Threatened Species (2003). Most of the species studied require special policies for their conservation due to problems that affect their natural populations; also we consider that these taxa are underrepresented in the current Mexican System of Natural Protected Areas, especially those with restricted distributions.

Introduction

The Mexican vascular flora is represented by roughly 22,000 species, 9300 of them endemic to the country; 2500 species inhabit exclusively or are characteristic of Mexican cloud forests (Rzedowski 1991, 1996). These species constitute 10% of the total number of vascular plants estimated for Mexico, representing great species richness in a relatively small area (Rzedowski 1991). Many of these species inhabit this vegetation type, which by itself is diagnosed as threatened and relictual, and with populations composed of very scarce individuals located in few isolated patches.

Approximately 70 of these taxa have been included in some risk category in the more recent version of the Mexican official publication named 'Norma Oficial Mexicana 059' ('NOM-59', Secretaría del Medio Ambiente y Recursos Naturales 2002), which includes native and introduced taxa in some risk category.

Mexican temperate forests are closely associated with mountain chains; ecosystems of this kind are among those most preferred for the establishment of villages and towns, for activities such as agriculture and animal husbandry. This has led to temperate areas being among the habitats that have been most disturbed. For this reason they are considered among the most threatened and, in most of cases, they lack conservation policies.

Mexican cloud forest ('bosque mesófilo de montaña' *sensu* Rzedowski 1978) exhibits a highly fragmented distribution pattern that is exacerbated by heavy deforestation, agriculture, and animal husbandry (Luna et al. 1989, 1994, 2000). This fragmentation, reduction and disturbance has recently increased to an alarming rate. The disturbance and exploitation of cloud forest is well documented in some sites of Central Mexico (Peterson and Peterson 1992; Conserva and Byrne 2002). Human occupation (villages) and deforestation (mainly for agriculture) have produced erosion and decline in soil fertility for thousands of years. The floristic richness of the Mexican cloud forest makes this vegetation type the most diverse per unit area in the country (Rzedowski 1978). Likewise, its archipelagic distribution, habitat fragility, and endemicity make it extremely interesting from biogeographic and conservation view points (Luna et al. 2000).

Unfortunately, in Mexico there is insufficient knowledge about the presence of threatened species in the National Parks and Reserves System. Recently, the Comisión Nacional para el Uso y Conocimiento de la Biodiversidad (CONABIO 2000) has declared 151 Priority Regions for Conservation, that include areas with high biodiversity and endemism rates, but are poorly studied (Arriaga et al. 2000). As Peterson et al. (2000) noted, the Mexican system of natural protected areas is an old one and although it was made taking many factors into consideration, many important areas for biodiversity conservation were not included.

Our aim is to offer current ecological and biogeographic information of some selected species that are frequent elements of the Mexican cloud forests, to make some suggestions for their management and conservation, to evaluate their geographic distribution in relation to the current Mexican National Parks and Reserves System, and to compare these results with those obtained with the Priority Regions for Conservation (CONABIO 2000). We also intend to corroborate and complete the published information about these species. Finally, we suggest that the information for many of the species studied should be also incorporated into the more recent IUCN Red Data List of Threatened Species (2003).

Methods

A set of 24 species of vascular plants was chosen for this study, including 16 angiosperms, seven gymnosperms, and one pteridophyte (Table 1), many of them endemic to Mexico and well represented in the Mexican mountains. Many of these species were selected from previous research (CONABIO project W025) carried out during 2002 and 2003, that summarized the biological information on these threatened taxa in Mexico. All these species are cited as frequent elements of the Mexican temperate forests, and many of them are characteristic of Mexican cloud forests. Also, all of them are recorded in some risk category in the 'Norma Oficial Mexicana 059' (Secretaría del Medio Ambiente y Recursos Naturales 2002). In addition, 13 of them are recorded in the IUCN Red Data List of Threatened Species (2003), whereas seven species are registered in the Appendices I and II of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora, http://www.cites.org/) (Table 2). In these cases, information about the species needs to be corroborated and up brought to date.

Data used in this study were obtained from different sources: specialized literature, vascular plant databases, herbarium specimens, and field work. Based on our Mexican cloud forest general database, which is the result of several floristic projects, we built a database comprising 1,600 records of these 24 species. In addition, information published in regional or state floras of Mexico and revisionary studies were used to assess the geographic and ecological distribution and other characteristics of these species (Standley and Steyermark 1946 – 1979; Meyrán 1962; O'Gorman 1963; Bravo 1978; Rzedowski 1978; Hernández-Cerda 1980; Nee 1981; Pacheco 1981; Vovides 1981, 1985, 1988, 1995, 1997, 1999; Moretti et al. 1982; Sánchez-Mejorada 1982; Vargas 1982; Zanoni 1982; Narave 1983; Vovides et al. 1983; Cabrera 1985; Breedlove 1986; Pattison 1986; Puig and Bracho 1987; Luna et al. 1989, 1994; Angulo and Soto 1990; Malda 1990; Niembro 1990; Soto and Gómez-Pompa 1990; McVaugh 1992; Zamudio 1992, 2002; Gómez 1993; Zulueta and Soto 1993; Cuevas and Nuñez 1994; Dieringer and Espinosa 1994; Martínez and Chacalco 1994; Vázquez 1994; Zamudio and Carranza 1994; Bravo and Sheinvar 1995; Chávez and Rubluo 1995; Osborne 1995; Pérez-Escandón and Villavicencio 1995; Vázquez et al. 1995; Alcántara and Luna 1997, 2001; Arreguín et al. 1997; Gutiérrez and Vovides 1997; Ramírez-Marcial and González-Espinosa 1997; Van der Werff and Lorea 1997; World Conservation Monitoring Centre 1997; González-Espinosa 1998; Mayorga et al. 1998; Sosa et al. 1998; Carranza 2000; García and Castillo 2000; Hilton-Taylor 2000; Pavón and Rico-Gray 2000; Calderón de Rzedowski 2001; Contreras-Medina and Luna 2001; Diego et al. 2001; Fonseca et al. 2001; Cartujano et al. 2002; Cervantes 2002; Godínez-Ibarra and López-Mata 2002; Contreras-Medina et al. 2003; Donaldson 2003; Lozada et al. 2003; Sánchez-González and López-Mata 2003).

Table 1. Geographic distribution of the species studied in America and Mexico (number of states/number of grid-cells). Vegetation types follow Rzedowski (1978) and climate types follow García (1988).

Species	Distribution	Vegetation type	Climate	Altitudinal range (m)	Habitat	Forest strata
Acer negundo var. *mexicanum*	Mx (19/27)	BMM, BQ, BP-Q	c, d, e	1500–2400	R, Hu	Medium or high arboreal layer
Aporocactus flagelliformis	Mx (5/12)	BMM, BQ	c, e	1600–2450	MoS	Epiphyte
Bernardia mollis	Mx (1/2), N-CA	BMM	d	1550–2430	Hu	Shrub and arboreal layers
Bouvardia xylosteoides	Mx (2/5)	BQ, BTC	a, c, e	1615–2300	Sh	Shrub layer
Carpinus caroliniana	Mx (13/81), N-CA	BCon., BMM, BQ, BP-Q	c, e	1350–2500	Hu	Medium and high arboreal layer
Ceratozamia kuesteriana	Mx (1/2)	BMM, BQ, BP-Q, BTS	c	800–1450	Sh	Herbaceous layer
Ceratozamia mexicana	Mx (7/19), CA	BMM, BP-Q	a, c	800–1800	ShWR	Herbaceous layer
Cupressus lusitanica	Mx (19/75), N-CA	BCon., BMM, BP-Q	d, e	1400–3600	He	Arboreal layer
Cyathea mexicana	Mx (8/27)	BMM, BP-Q, BTP	a, c, e	800–2500	Mo	Low arboreal layer
Diospyros riojae	Mx (4/11)	BMM, BQ, BP-Q	a, c	740–1900	Hu	Medium arboreal layer
Juglans pyriformis	Mx (5/10)	BMM, BP-Q	c, e	1200–1400	Hu	Medium and high arboreal
Litsea glaucescens	Mx (19/46), CA	BCon., BMM, BQ, BP-Q, BTC, MT	a, b, c, d, e	800–2830	To	Low and medium arboreal layer
Magnolia dealbata	Mx (4/11)	BMM, BQ, BP-Q	a, c, e	1500–1820	Hu	Medium and high arboreal layer
Magnolia schiedeana	Mx (5/20)	BMM, BQ, BP-Q, BTP	c, e	1000–2000	Hu	Medium and high arboreal layer
Matudaea trinervia	Mx (7/15)	BMM, BQ, BP-Q	a, c, e	500–2000	Mo	Medium arboreal layer

Nopalxochia phyllanthoides	Mx (3/3)	BQ	c	1000–1850	Mos	Epiphyte
Ostrya virginiana	E-USA, Mx (15/74), N-CA	BCon., BMM, BQ, BP-Q	c, d	1200–2800	MoS	Medium arboreal layer
Podocarpus reichei	Mx (13/32), N-CA	BMM, BQ, BP-Q	a, c, e	800–2300	Mo	Arboreal layer
Symplocos coccinea	Mx (5/22)	BMM, BQ, BP-Q	a, c, d, e	1750–2700	Mo	Low and medium arboreal layers
Taxus globosa	Mx (9/32), CA	BMM, BQ, BP-Q	c, e	1000–2950	Mo	Low and medium arboreal layers
Tilia mexicana	Mx (15/51)	BCon., BMM, BQ, BP-Q	a, c, d, e	1100–2500	Hu	High and medium arboreal layer
Zamia fischeri	Mx (4/6)	BQ, BTC, BTP	c	180 to 950	ShWR	Herbaceous layer
Zamia loddigesii	Mx (7/24), N-CA	BQ, BTC, BTP	c	30–850	ShWR	Herbaceous layer
Zinowiewia concinna	Mx (3/8)	BMM, BQ, BP-Q	a, c	1800–2000	Hu	Medium and high arboreal layers

Abbreviations: Distribution: Mx, Mexico; N-CA, northern Central America; CA, Central America; E-USA, eastern United States. Vegetation types: BCon, conifer forest; BMM, cloud forest; BQ, oak forest; BP-Q, pine-oak forest; BTC, tropical deciduous forest; BTP, tropical evergreen forest; MT, arid tropical scrub. Climate: (a) tropical wet to tropical seasonally wet (Am, Am(f), Aw1, Aw2, Awo); (b) semiarid, mild (BS1kw); (c) humid subtropical to seasonally humid subtropical ((A)C(m), (A)C(w), (A)C(w1), (A)C(w2)); (d) humid cool to seasonally humid cool (Cb′(m)(f) Cb′(w2)); (e) humid mild to seasonally humid mild (C(f) C(m) C(w2) C(m)(f)). Habitat: He, heliophyte species that forms pure stands of small extension; Hu, humid slopes and cliffs; Mo, moisture and shadow ravines of temperate forests; MoS, moisture and shadow slopes; R, riparian; Sh, shadow and ravine conditions and rocky slopes; ShW, shadow and wet sites; ShWR, shadow and wet sites associated to rocky sites; To, tolerant species of substantial ecological amplitude.

Table 2. Comparison among the risk categories of IUCN, CITES and NOM-059 for the species studied and conservation status in Mexico.

Species	NOM risk category	CITES	IUCN risk category	Main problems of the species	Importance for conservation	Conservation status
Acer negundo var. *mexicanum*	Pr		VU B1 + 2c	1	ReT, OI, HbD	A, B
Aporocactus flagelliformis	Pr	Appendix II		1, 3	IlTr, Ts	A, C
Bernardia mollis	A			1	ReD, SmP, Ts, HbD	A
Bouvardia xylosteoides	Pr			1, 7	Ts, ReD, HbD	A
Carpinus caroliniana	A			1, 2	HbD	A
Ceratozamia kuesteriana	Pr	Appendix I	CR B1ab(ii,iii,iv) + 2ab(ii,iii,iv)	1, 3, 8	Ts, ReD, HbD	A
Ceratozamia mexicana	A	Appendix I	VU A2cd; C1	1, 3	Ts, ReD, IlTr	E
Cupressus lusitanica	Pr		LR/nt	1	OI, MI, NbD	A, B, F, G
Cyathea mexicana	P	Appendix II		1, 3	Ra	A
Diospyros riojae	P		EN B1 + 2c	1, 4	ReD, SmP, Ts, HbD	A
Juglans pyriformis	A			1, 2	InT, Ts, HbD	A
Litsea glaucescens	Pr			1, 5	LI	A
Magnolia dealbata	Pr		EN B1 + 2c, C2b	1, 4	ReP, LoR, Ts, HbD	D
Magnolia schiedeana	A		EN B1 + 2c	1, 6, 7	ReD,Ts, LoF, HbD	A
Matudaea trinerva	A		VU B1 + 2c	1	SpSt, HbD	A
Nopalxochia phyllanthoides	A	Appendix II		1	Ts, ReD, HbD, MI, OI	A
Ostrya virginiana	Pr			1, 2	ReT, HbD	A
Podocarpus reichei	Pr		DD	1, 7	SpSt, SHRa, HbD	A

Symplocos coccinea	Pr		VU A1c	1, 7	Ts, ReD, HbD	D
Taxus globosa	Pr		LR/nt	1	Eco	A
Tilia mexicana	P			1, 7	Eco	A
Zamia fischeri	A	Appendix II	EN A2abd	1, 3	Ts, ReD, IlTr	E
Zamia loddigesii	A	Appendix II	NT	1	HbD	A
Zinowiewia concinna	P			1	ReD, Ts	A

Abbreviations: Risk category: NOM: A, threatened; P, endangered; Pr, with special protection. CITES: Appendix I, list of species that are the most endangered among CITES-listed animals and plants; Appendix II, list of species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. UICN: (CR) critically endangered; (EN) endangered; (VU) vulnerable; (NT) near threatened; (DD) data deficient; (LR) lower risk: conservation dependent (cd), near threatened (nt), least concern (lc). Main problem: (1) habitat destruction, due to agricultural, forestry exploitation, and animal husbandry; (2) timber exploitation; (3) illicit extraction from the field and traffic of plants; (4) poor natural regeneration; (5) used for commercial purposes; (6) low fertility which reduced its populations; (7) expansion of human villages; (8) very restricted distribution. Importance for conservation: Eco, economic potential; HbD, habitat destruction, which affects its natural populations; IlTr, illegal trade and extraction of plants from their natural environment for sale; InT, intensive timber exploitation for musical instruments and furniture; LoF, low fertility; LI, relatively low importance; LoR, low regeneration; MI, medicinal importance; OI, ornamental importance; PrW, precious wood; ReT, relatively timber importance; ReP, relictual populations; Ra, reported as rare in its recollection localities; ReD, restricted distribution; SmP, small populations; SpSt, special protection status; SHRa, specific humid and generally ravine conditions; Ts, threatened status. Conservation status: (A) conservation management program absent; (B) frequent in public gardens of some Mexican cities; (C) cultivated in some tropical regions of the American continent; (D) conservation program with *in vitro* propagation in the Botanical Garden of the Instituto de Biología, UNAM; (E) conservation program in the Botanical Garden 'Francisco Javier Clavijero' of the Instituto de Ecología, in Xalapa, Veracruz; (F) frequent in plant nurseries and greenhouses; (G) used for reforestation.

Also, herbarium specimens of the species studied were revised from the following collections: MEXU, ENCB, MO, XAL, IEB, FCME, IBUG, CHAP, and INIF (acronyms sensu Holmgren et al. 1990). Finally, botanical field exploration was carried out in the Mexican states of Hidalgo, Querétaro, estado de México, and Oaxaca in order to obtain field data and to make field observations of natural populations of these species.

Distributional maps of each of the 24 species were obtained using the GIS ArcView software ver. 3.2 (ESRI 1999), and then superimposed on digital 1:1,000,000 scale maps of Mexico (CONABIO 1998). In this way, the Mexican territory was divided using a grid system based on a chart index (scale 1:50,000 system composed of 2313 grids of $15' \times 20'$ and with a spatial resolution of approximately 27.75 km × 36.75 km) produced by the Instituto Nacional de Estadística, Geografía e Informática (INEGI 1992), and digitized by CONABIO (1999). The names of each topographic chart were used to identify the grid-cells.

Using ArcView (ESRI 1999), we intersected the maps of localities of the species with the grid system scale 1:50,000, first including all the species to obtain the richness of each grid-cell, and then, using only the species with restricted distribution (those represented in less than 15 grids), to obtain the areas with high concentration of restricted species. Then we selected those areas with more species richness and/or more concentration of restricted species (more than 10 of them living sympatrically) and drew them on the map of Mexican protected areas system of SEMARNAT (electronic page), and on the map of Mexican Priority Regions for conservation of CONABIO (electronic page), to find out if the areas occupied by these species are under some type of special protection.

Results

The species of vascular plants studied here are distributed mainly in the 'Región Mesoamericana de Montaña' *sensu* Rzedowski (1978) (Sierra Madre Occidental, Sierra Madre Oriental, Serranías Meridionales, and Serranías Transístmicas floristic provinces), characterized by its montane temperate humid conditions, mainly in cloud forest, oak, and pine forests (Figure 1).

The presence of each species in the different Mexican vegetation types is shown in Table 1. These species mainly inhabit temperate forests, such as pine-oak, oak and cloud forests, especially in areas with humid subtropical to humid mild climates, in altitudinal ranges from 30 to 3600 m, but mainly between 800 and 3000 m. A few species inhabit both tropical and temperate forests in different vegetation types, along broad altitudinal and latitudinal ranges (e.g. *Litsea glaucescens*). Most of these taxa inhabit humid slopes, with abundant atmospheric moisture, and protected from direct sun exposure; these species are important elements in the different strata of the forests in which they grow (Table 1).

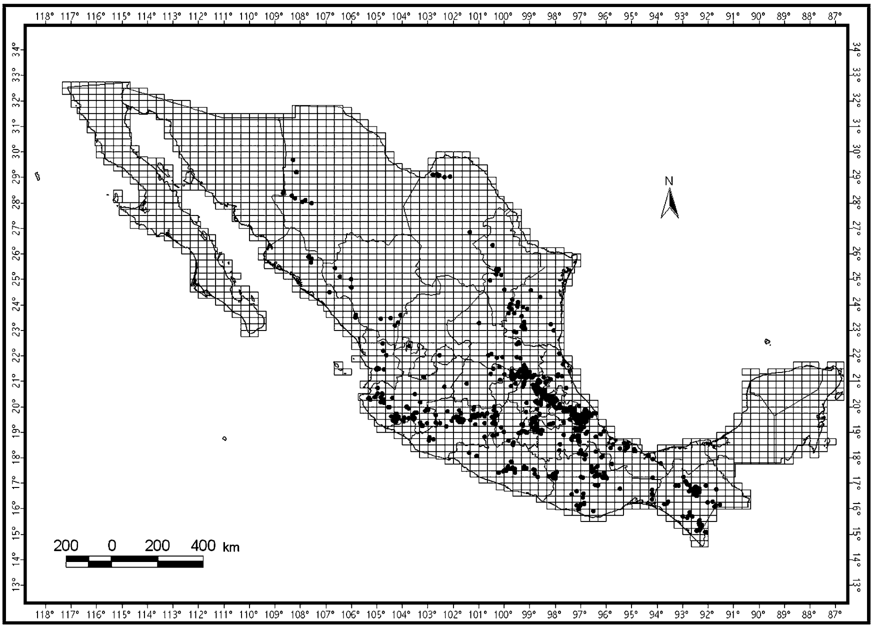


Figure 1. Geographic distribution of the 24 species studied using a grid system of Mexico by INEGI (1992), mainly distributed in the 'Región Mesoamericana de Montaña' of Rzedowski (1978).

A comparison among the risk categories of IUCN, CITES and NOM-059 for the species studied is shown in Table 2, together with the problems that affect their natural populations. The main threat to these species is habitat destruction, mainly due to expansion of human villages and related activities, such as agriculture, clandestine timber exploitation, and animal husbandry. For most of these taxa there is no management program or conservation plan.

Many of these species are well-known to local people, and most of them are recognized by common names (in many cases in local languages as Náhuatl, Purépecha, Mixteco, and Otomí, among others), that can vary from one site to another. These plants are used by local people in folk medicine, in religious festivities, as ornamentals, timber and reforestation (Table 3).

Table 4 offers some data on the biology of the species studied; some of them require specific dispersal agents and pollinators, and the absence of these agents due to habitat disturbance also affects the reproductive biology of these species.

Figure 2 shows that the richest area at species level (14 species) is located in eastern Mexico, in the Zacualtipán area, in the states of Hidalgo-Veracruz. The geographic distribution of the taxa included in this study show different patterns, from wide to narrow ranges assessed by their presence in different Mexican states (Table 1) or grid-cells (Figure 3). *Ceratozamia kuesteriana* is

Table 3. Mexican local names and traditional uses of the species studied.

Species	Local name	Uses
Acer negundo var. *mexicanum*	Amargoso, arce, negundo, zarcillo, ácer, zilozóchitl, acezintle	WO(9)(11), Or, St, WiC
Aporocactus flagelliformis	Junco, flor de látigo, junquillo, floricuerno	TM(3), Or
Bernardia mollis	–	NI
Bouvardia xylosteoides	–	NI
Carpinus caroliniana	Caxin, corriosillo, pipinque	TM(8)
Ceratozamia kuesteriana	–	NI
Ceratozamia mexicana	Chamal, pesma espinosa, teozintle, costilla de león, palma imperial, piña del monte	TM(2), Or, Rf
Cupressus lusitanica	Ciprés, cedro, cedro blanco, tlascal	TM(1), Re, Or
Cyathea mexicana	Paguinqui, palmito	Rf, Or
Diospyros riojae	Zapote de monte, zapote prieto, zapotillo	NI
Juglans pyriformis	Nogal, nogal cimarrón, cedro nogal	WO(9)(10)
Litsea glaucescens	Laurel, laurelillo, laurel chico, canelillo, chico	TM(5), Cu
Magnolia dealbata	Magnolia, yoloxóchitl, elosúchil, guia-lachi, quije-zehe, yo-zaba	TM(4), Or
Magnolia schiedeana	Magnolia, eloxóchitl, palo de cacique, yaga-zaha, yolosúchitl	Or
Matudaea trinerva	Cuencudo, naranjillo, quiebra hacha, palo de barranco	NI
Nopalxochia phyllanthoides	–	Or
Ostrya virginiana	Tzutujté, mora, mora roja, palo blanco moro, guapaque, pipinque, petatillo, guichin	WO
Podocarpus reichei	Cuayapole, sabino, palmillo	NI
Symplocos coccinea	Limoncillo	NI
Taxus globosa	Chuchún, granadillo, mezquitillo, romerillo colorado, tacxi, tlastscal	Ant
Tilia mexicana	Sirimo, tilio, yaca, jonote	WO(9)(10), TM(6), Fc, BaR
Zamia fischeri	Chamal chico, chamalillo, amigo del maíz	NI, Or
Zamia loddigesii	Palmiche, palmilla, tzompollo, palmita, chac-hua	NI
Zinowiewia concinna	Tchcari-cameri, trueno, gloria	NI

Abbreviations: Uses: WiC, As 'windbreak curtain'; NI, not information; Or, ornamental; Rf, religious festivities – the leaves are used; St, shade tree; BaR, bark for rope making; Fc, foliage is used to feed cattle; Cu, leaves are widely used in Mexican cuisine; Ant, pharmaceutic industry importance due to the existence of the taxol, which is an anticancerigen; TM, traditional medicine – (1) reported to treat bone pains, (2) seeds are grinded and used as vermifuge, (3) tea for hearth diseases and vermicide, (4) flowers are used for the treatment of arterial pressure and heart diseases, (5) to treat fevers and cough, (6) to treat nerves, enterocolitis, haemorrhoids, rheumatism, and colics, (8) treatment of eyes irritation; Re, used in reforestation; WO, timber is used – (9) for the manufacture of furniture, (10) for the manufacture of musical instruments, (11) for the manufacture of barrels, paper pulp, and charcoal.

Table 4. Reproductive structures, pollination, dispersal and phenology of the species.

Species	Reproductive organs	Fruit	Pollination	Dispersal	Phenology
Acer negundo var. *mexicanum*	Perfect and imperfect flowers	Samara	Wind	Wind	Staminate flowers: March to April; pistillate flowers and mature fruit: April to May
Aporocactus flagelliformis	Hermaphroditic and solitary flowers	Red berry	Birds	Birds	Flowering: April to May
Bernardia mollis	Dioecious flowers, axillary and staminate spikes	Ligneous capsule	Wind	Autochory	Flowering: December to April; fruit: April to July
Bouvardia xylosteoides	Hermaphroditic flowers	Capsule	–	–	Flowering: June to August; fruit: August to January
Carpinus caroliniana	Monoecious plants, staminate and pistillate flowers in solitary catkins	Ovoid nut fruit	Wind	Birds, wind	Flowering: February to April; fruit: April to June
Ceratozamia kuesteriana	Dioecious plants	Male and female strobila	Weevils	Autochory	Female strobilus: February to August; male strobilus: February to April
Ceratozamia mexicana	Dioecious plants	Male and female strobila	Weevils	Autochory	Strobilus: July to February
Cupressus lusitanica	Monoecious plants	Yellow male strobilous; globose, ligneous and dehiscent female strobilous	Wind	Autochory, wind	Male strobilus: February to April
Cyathea mexicana	Homosporous plant, abaxial sori	–	–	Wind	–
Diospyros riojae	Dioecious plants	Berry		Birds	Flowering: February to April; fruit: May to November
Juglans pyriformis	Monoecious plants	Globose pseudodrupe	Wind	Autochory, mammals	Flowering: February to March

Table 4. (*Continued*).

Species	Reproductive organs	Fruit	Pollination	Dispersal	Phenology
Litsea glaucescens	Dioecious plants	Drupe		Birds	Flowering: February to May; fruit: August to September
Magnolia dealbata	Hermaphroditic flowers	Follicetum	Beetles	Autochory	Flowering: April to June
Magnolia schiedeana	Hermaphroditic flowers	Follicetum	Beetles	Autochory	Flowering: May to June
Matudaea trinervia	Incomplete and hermaphroditic flowers	Capsule	–	Autochory	–
Nopalxochia phyllanthoides	Hermaphroditic and solitary flowers	Red berry	Birds	Birds	Flowering: April to June
Ostrya virginiana	Monoecious plants	Ovoid nut fruit	Wind	Birds	Flowering: March to April; fruit: April to August
Podocarpus reichei	Dioecious plants	Male strobilus and solitary seeds	Wind	Birds	Strobilus: March to April; mature seeds: July to November
Symplocos coccinea	Hermaphroditic flowers	Drupe	Wind	Birds	–
Taxus globosa	Dioecious plants	Male strobilus and solitary seeds	Wind	Birds	Male strobilus: December to February; mature seeds: September to November
Tilia mexicana	Hermaphroditic flowers	Subglobose, dry, hard, indehiscent	Bees, flies	Wind	Flowering: April to June; fruit: July.
Zamia fischeri	Dioecious plants	Male and female strobila	Weevils	Autochory	Strobilus: April to December
Zamia loddigesii	Dioecious plants	Male and female strobila	Weevils	Autochory	Strobilus: May to December
Zinowiewia concinna	Hermaphroditic flowers	Oblong-elliptic sub-falcate fruit		Wind	Flowering: June

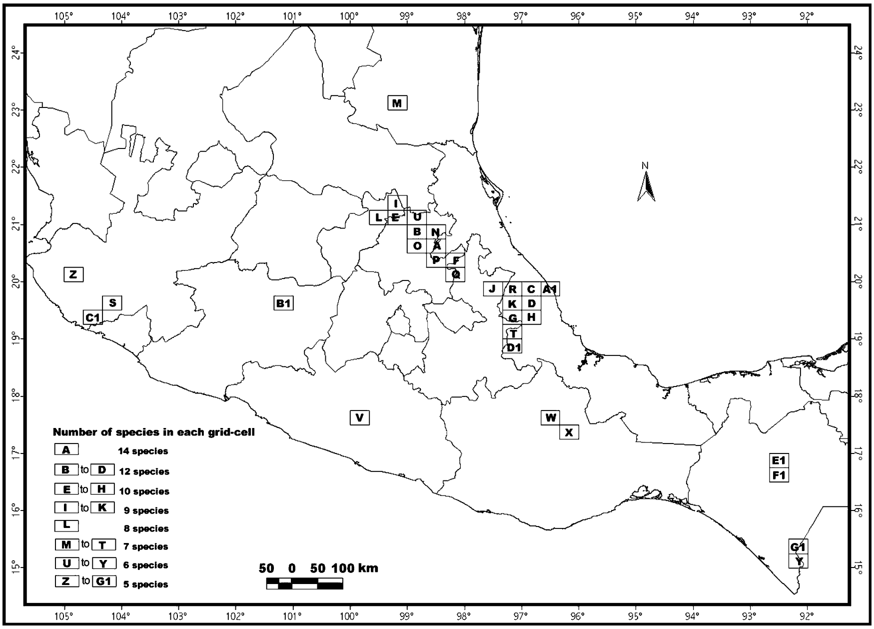


Figure 2. Representation of the Mexican richest grid-cells based on the species studied. A. Zasualtipán, Hgo., Ver.; B. Molango, Hgo.; C. Misantla, Ver.; D. Xalapa, Ver.; E. Jacala, Hgo., Qro.; F. Pahuatlán, Hgo., Ver., Pue.; G. Xico, Pue., Ver.; H. Coatepec, Ver.; I. Ahuacatlán, Qro., S.L.P.; J. Teziutlán, Pue.; K. Perote, Pue., Ver.; L. Jalpan, Qro., Hgo.; M. Gómez Farías, Tamps.; N. Calnali, Hgo., Ver.; O. Metztitlán, Hgo.; P. Carbonera Jacales, Hgo., Ver.; Q. Huachinango, Hgo., Pue.; R. Altotonga, Pue., Ver.; S. El Chante, Jal.; T. Coscomatepec, Pue., Ver.; U. Chapulhuacán, Hgo., S.L.P., Qro.; V. Chichihualco, Gro.; W. San Juan Quiotepec, Oax.; X. San Miguel Talea de Castro, Oax.; Y. Pavincul, Chis.; Z. Llano Grande, Jal.; A1. Villa Emilio Carranza, Ver.; B1. Morelia, Mich.; C1. La Huerta, Col., Jal.; D1. Orizaba, Ver., Pue.; E1. Oxchuc, Chis.; F1. San Cristóbal de las Casas, Chis.; G1. Motozintla, Chis.

restricted to the state of Tamaulipas, and some species are restricted to few states, as *Nopalxochia phyllanthoides* and *Bernardia mollis*, while others are found in more than 12 states, such as *Carpinus caroliniana*, *Cupressus lusitanica*, *Ostrya virginiana*, and *Tilia mexicana*; these species also were recorded in more than 50 grid-cells, whereas *Ceratozamia kuesteriana*, *Bernardia mollis*, *Nopalxochia phyllanthoides*, *Bouvardia xylostoides*, and *Zamia fischeri* were recorded in only five grid-cells or less (Figure 3 and Table 1). *Nopalxochia phyllanthoides* is not included in the IUCN Red Lists (2003), whereas *Bernardia mollis* and *Bouvardia xylostoides* are not included in CITES and IUCN Red Lists (Table 2).

Figure 4 shows that when we superimpose the localities of the species with restricted distribution on the grid system, those grid-cells with a high number of restricted species are located at Jacala and adjacent areas, in the limits of the states of Querétaro and Hidalgo, with four species.

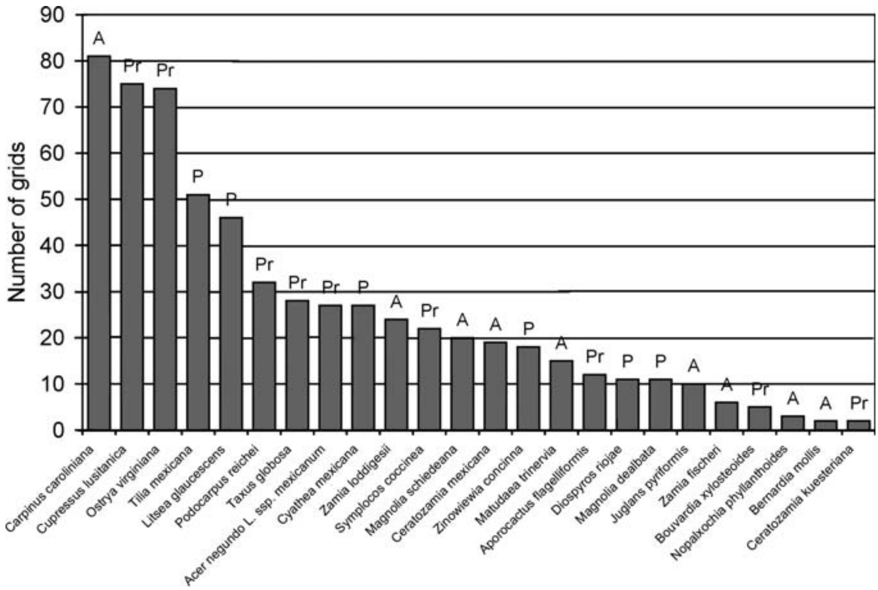


Figure 3. Risk category in the NOM-059 and relation with the number of grid-cells ocuppied by each species.

Based on the above analyses, we detected the following types of areas to be conserved based on these plants: (a) areas with high taxonomic richness: the most important areas are Zacualtipán, Hidalgo-Veracruz, that contain 14 of the 24 species considered; Molango, Hidalgo and Misantla and Xalapa, Veracruz, with 12 species each; and Jacala, Querétaro-Hidalgo, Pahuatlán, Hidalgo-Veracruz-Puebla, and Coatepec and Xico, Veracruz, with 10 species each. The area occupied by all these grid-cells conforms to the largest and most continuous fragment of cloud forest in eastern Mexico (Figure 2); (b) areas with a high concentration of restricted species; in this case, the richest grid-cells are Jacala, Querétaro-Hidalgo with four restricted species, and Molango, Hidalgo, Zacualtipán, Hidalgo-Veracruz, and Misantla and Xalapa, Veracruz, with three species each (Figure 4).

Finally, when we combined both results on the map of the Mexican National System of Protected Areas (ANP) of SEMARNAT (electronic page), we detected that many of these grid-cells are not included in any protected area (Figures 5a and 6a). When we followed the same procedure on the map of the Mexican Priority Regions for conservation (RTP) of CONABIO (2000), we observed that many of these grid-cells are included in these regions (Figures 5b and 6b). Table 5 offers the mexican National System of Protected Areas and the Priority Regions for Conservation where these species mostly occur. Nevertheless, many of these grid-cells are not included in any of these systems. We found that among the current Mexican National Protected Areas, the

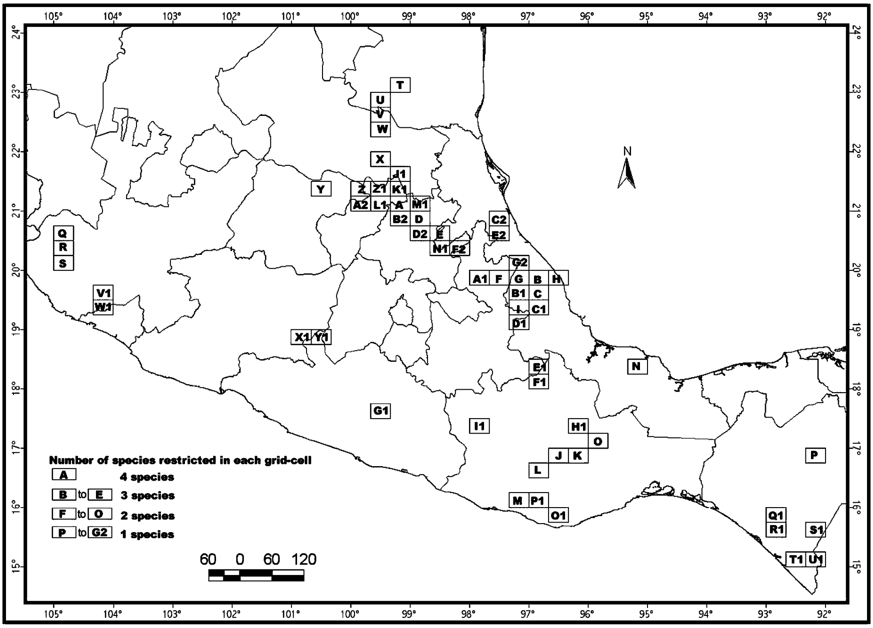


Figure 4. Grid-cells containing more restricted species. A. Jacala, Hgo., Qro.; B. Misantla, Ver.; C. Xalapa, Ver.; D. Molango, Hgo.; E. Zacualtipán, Hgo., Ver.; F. Teziutlán, Pue.; G. Altotonga, Pue., Ver.; H. Villa Emilio Carranza, Ver.; I. Xico, Pue., Ver.; J. Tlacolula de Matamoros, Oax.; K. San Pedro Quiantón, Oax.; L. Ejutla de Crespo, Oax.; M. Santa Catarina Juquila, Oax.; N. San Andrés Tuxtla, Ver.; O. San Juan Cotzocón, Oax.; P. Ocosingo, Chis.; Q. Mascota, Jal; R. Talpa de Allende, Jal.; S. Llano Grande, Jal.; T. Gómez Farías, Tamps.; U. Ocampo, Tamps.; V. Salto del Agua, S.L.P., Tamps.; W. Cd. del Maíz, S.L.P.; X. Tamasopo, S.L.P.; Y. San Luis de la Paz, Gto.; Z. El Carricillo, Gto., Qro., S.L.P.; A1. Zacatlán, Pue.; B1. Perote, Pue., Ver.; C1. Coatepec, Ver.; D1. Coscomatepec, Pue., Ver.; E1. Coyomeapan, Pue., Oax.; F1. Huautla, Pue., Oax.; G1. Chilpancingo, Gro.; H1. San Miguel Talea de Castro, Oax.; I1. Tlaxiaco, Oax.; J1. Aquismón, S.L.P., Qro.; K1. Ahuacatlán, Qro., S.L.P.; L1. Jalpan, Qro., Hgo.; M1. Chapulhuacán, Hgo., S.L.P., Qro.; N1. Carbonera Jacales, Hgo., Ver.; O1. San José Chacalapa, Oax.; P1. San Baltasar Loxicha, Oax.; Q1. Angel Albino Corzo, Chis.; R1. Samule León Brindis, Chis.; S1. Chicomuselo, Chis.; T1. Huixtla, Chis.; U1. Pavincul, Chis.; V1. El Chante, Jal.; W1. Minatitlán, Jal., Col.; X1. Tiquicheo, Mich.; Y1. Bejucos, Méx., Mich.; Z1. Conca, Qro., S.L.P.; A2. Peña Miller, Gto., Qro.; B2. San Nicolás, Hgo.; C2. Tuxpan, Ver.; D2. Metztitlán, Hgo.; E2. Poza Rica, Ver., Pue.; F2. Pahuatlán, Hgo., Ver., Pue.; G2. Martínez de la Torre, Pue., Ver.

known records are located within the limits of 15 National Parks and seven Biosphere Reserves (Table 5).

The representation of these species in the Mexican National Parks and Reserves System shows that some of them (*Bernardia mollis*, *Bouvardia xylosteoides*, *Ceratozamia kuesteriana*, *Juglans pyriformis*, and *Nopalxochia phyllanthoides*) are not included in any protected area, whereas other species with a wide geographic distribution in the country (e.g. *Carpinus caroliniana*, *Cupressus lusitanica*, *Ostrya virginiana*, and *Tilia mexicana*) are represented in six or more protected areas (Table 5).

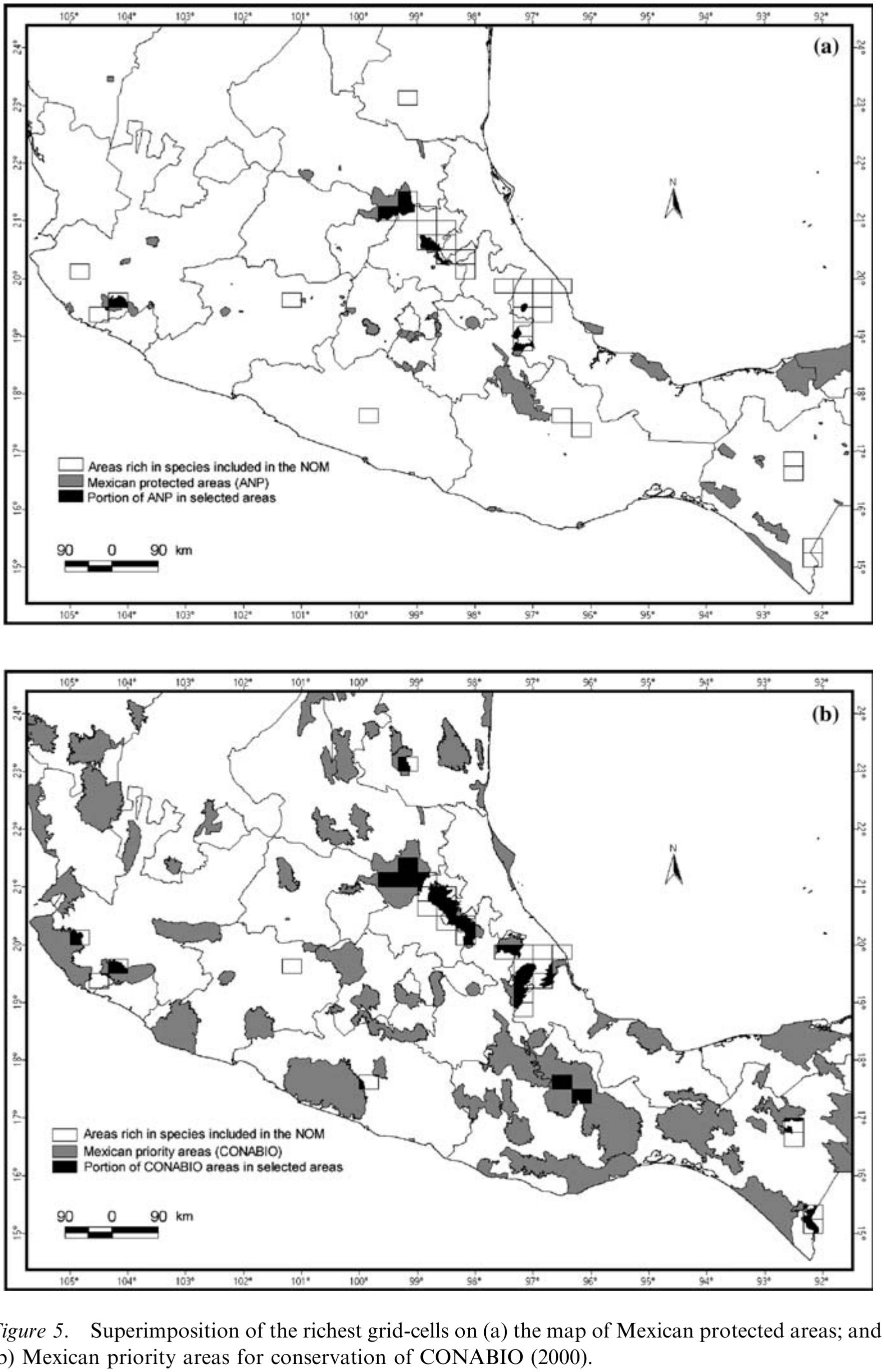
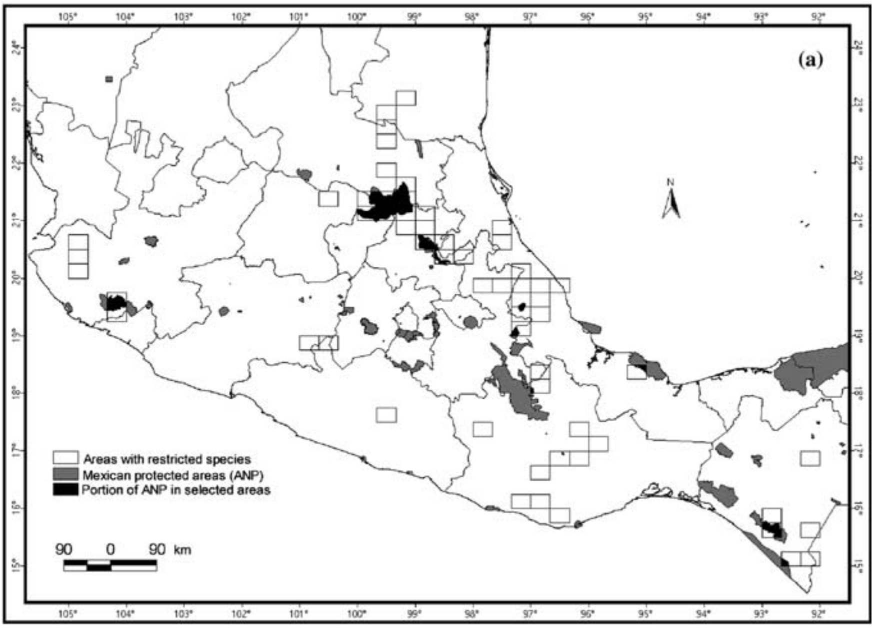


Figure 5. Superimposition of the richest grid-cells on (a) the map of Mexican protected areas; and (b) Mexican priority areas for conservation of CONABIO (2000).



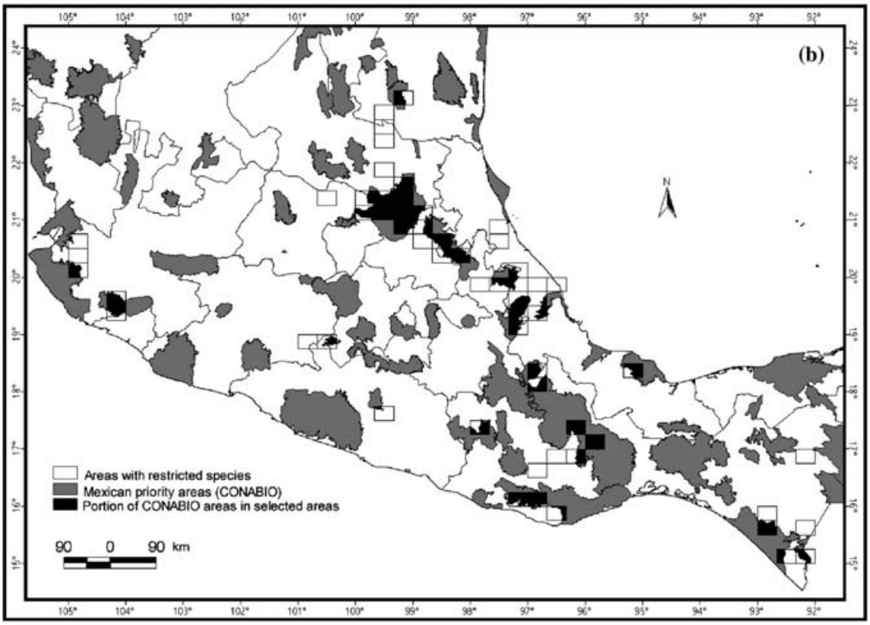


Figure 6. Superimposition of the grid-cells with more restricted species on (a) the map of Mexican protected areas; and (b) Mexican priority areas of CONABIO (2000).

Table 5. Presence of the studied species in the Mexican National Parks and Reserves System (ANP and RTP).

Species	ANP[a]	RTP[b]
Acer negundo L. var. *mexicanum* (DC.) Wesm.	8, 14	5, 6, 11, 20, 25, 32, 48, 49, and 50
Aporocactus flagelliformis (L.) Lem.	16, 22	5, 25, 40, 47, and 49
Bernardia mollis Lundell	–	–
Bouvardia xylosteoides Hook. et Arn.	–	–
Carpinus caroliniana Walter	3, 10, 13, 17, 18, 19, 21, and 22	5, 6, 11, 12, 14, 17, 18, 23, 25, 30, 32, 33, 34, 36, 40, 42, 43, 46, 47, 48, and 49
Ceratozamia kuesteriana Regel	–	12
Ceratozamia mexicana Brongn.	22	5 and 40
Cupressus lusitanica Mill.	1, 3, 6, 8, 11,12, 15, 17, 20, 21, and 22	1, 4, 5, 10, 11, 12, 17, 19, 23, 25, 27, 29, 30, 32, 33, 39, 40, 44, and 47
Cyathea mexicana Schltdl. et Cham.	18 and 19	5, 6, 11, 13, 22, 30, 34, 40, 42, 47, and 49
Diospyros riojae Gómez Pompa	22	11, 34, and 40
Juglans pyriformis Liebm.	–	4, 5, and 40
Litsea glaucescens Kunth	4, 9, 18, 21, and 22	1, 5, 9, 10, 12, 13, 19, 20, 21, 23, 25, 29, 35, 40, 45, 47, 48, 49, and 51
Magnolia dealbata Zucc.	22	5, 40, and 47
Magnolia schiedeana Schltdl.	22	5, 18, 25, 40, 42, and 47
Matudaea trinervia Lundell	17 and 21	9, 11, 17, 23, 43, and 45
Nopalxochia phyllanthoides (DC.) Britton et Rose	–	5 and 11
Ostrya virginiana (Mill.) K. Koch	2, 3, 7, 19, 21, and 22	3, 5, 7, 8, 11, 13, 15, 16, 20, 23, 25, 27, 30, 31, 34, 38, 40, 41, 42, 47, 48, and 49
Podocarpus reichei Buchholz et Gray	21 and 22	5, 9, 11, 12, 23, 25, 33, 40, 45, and 47
Symplocos coccinea Bonpl.	16	5, 6, 11, 16, 25, 34, and 47
Taxus globosa Schltdl.	7, 8, and 22	5, 12, 15, 25, 26, 28, 35, 40, and 47
Tilia mexicana Schltdl.	2, 5, 7, 16, 21, and 22	2, 3, 5, 12, 15, 23, 25, 38, 40, 41, and 47
Zamia fischeri Miq.	22	40

Zamia loddigesii Miq.	22	11, 18, 34, 37, and 40
Zinowiewia concinna Lundell	9 and 21	1, 23, 24, 46, 47, and 48

[a]ANP: Flora and fauna protected areas: 1. Corredor Biológico Chichinautzin (Morelos); 2. Maderas del Carmen (Coahuila). National parks: 3. Cañón del Río Blanco (Veracruz); 4. Cañón del Sumidero (Chiapas); 5. Cascada de Bassaseachic (Chihuahua); 6. Cofre de Perote (Veracruz); 7. Cumbres de Monterrey (Nuevo León); 8. El Chico (Hidalgo); 9. El Tepozteco (Morelos-Distrito Federal); 10. Insurg. José María Morelos (Michoacán); 11. Iztaccíhuatl-Popocatépetl (México-Morelos-Puebla); 12. Lagunas de Zempoala (Morelos-México); 13. Volcán Nevado de Colima (Jalisco); 14. Xicoténcatl (Tlaxcala); 15. Zoquiapan and vicinities (México-Puebla). Biosphere reserves: 16. Barranca de Metztitlán (Hidalgo); 17. El Triunfo (Chiapas); 18. La Sepultura (Chiapas); 19. Los Tuxtlas (Veracruz); 20. Mariposa Monarca (Michoacán-México); 21. Sierra de Manantlán (Jalisco-Colima); 22. Sierra Gorda (Querétaro-Hidalgo).

[b]RTP: 1. Ajusco-Chichinautzin (Distrito Federal-México-Morelos); 2. Alta Tarahumara-Barrancas del Cobre (Chihuahua); 3. Bassaseachic (Chihuahua); 4. Bavispe-El Tigre (Chihuahua-Sonora); 5. bosques mesófilos de la Sierra Madre Oriental (Hidalgo-Puebla-Veracruz); 6. bosques mesófilos de los Altos de Chiapas (Chiapas); 7. Cañón del Zopilote (Guerrero); 8. Cerro Viejo-Sierras de Chapala (Jalisco-Michoacán); 9. Chamela-Cabo Corrientes (Jalisco); 10. Cuenca del río Jesús María (Durango-Jalisco-Nayarit-Zacatecas); 11. Cuetzalan (Puebla-Veracruz); 12. El Cielo (Tamaulipas); 13. El Momón-Margaritas-Montebello (Chiapas); 14. El Mozotal (Chiapas); 15. El Potosí-Cumbres de Monterrey (Coahuila-Nuevo León); 16. El Tlacuache (Oaxaca); 17. El Triunfo-La Encrucijada-Palo Blanco (Chiapas); 18. encinares tropicales de la planicie costera veracruzana (Veracruz); 19. Guacamayita (Durango); 20. Huitepec-Tzontehuitz (Chiapas); 21. La Chacona-Cañón del Sumidero (Chiapas); 22. Lacandona (Chiapas-Tabasco); 23. Manantlán-Volcán de Colima (Colima-Jalisco); 24. Nevado de Toluca (México); 25. Pico de Orizaba-Cofre de Perote (Puebla-Veracruz); 26. Puerto Purificación (Nuevo León-Tamaulipas); 27. Río Presidio (Durango-Sinaloa); 28. San Antonio-Peña Nevada (Nuevo León-Tamaulipas); 29. San Juan de Camarones (Durango-Sinaloa); 30. Selva Zoque-La Sepultura (Chiapas-Oaxaca-Veracruz), 31. Sierra Bustamante (Coahuila-Nuevo León); 32. Sierra de Chincua (México-Guanajuato-Michoacán); 33. Sierra de Coalcomán (Jalisco-Michoacán); 34. Sierra de los Tuxtlas-Laguna del Ostión (Veracruz); 35. Sierra de álvarez (San Luis Potosí); 36. Sierra de San Carlos (Nuevo León- Tamaulipas); 37. Sierra de Tamaulipas (Tamaulipas); 38. Sierra El Burro-río San Rodrigo (Coahuila); 39. Sierra Fría (Aguascalientes-Zacatecas); 40. Sierra Gorda-Río Moctezuma (Guanajuato-Hidalgo-Querétaro-San Luis Potosí); 41. Sierra Maderas del Carmen (Coahuila); 42. Sierra Madre del Sur de Guerrero (Guerrero); 43. Sierra Nanchititla (México-Guerrero); 44. Sierra Nevada (México-Morelos-Puebla-Tlaxcala); 45. Sierra sur y costa de Oaxaca (Oaxaca); 46. Sierras de Taxco-Huautla (México-Guerrero-Morelos-Puebla); 47. Sierras del norte de Oaxaca-Mixe (Oaxaca-Puebla-Veracruz); 48. Sierras Triqui-Mixteca (Guerrero-Oaxaca); 49. Tacaná-Boquerón (Chiapas); 50. Tokio (Coahuila-Nuevo León-San Luis Potosí-Zacatecas); 51. Valle de Jaumave (Tamaulipas).

Conclusions

Habitat loss is a serious problem in Mexico, mainly due to agriculture and deforestation practices. If these activities continue in the Mexican cloud forests, a permanent loss of many species, mainly those scarcely represented, will occur in the near future. Many actions have been taken to avoid mass extinctions due to habitat loss in Neotropical montane ecosystems (Churchill et al. 1995) and in the worldwide cloud forests (Hamilton et al. 1994), that should be strictly followed in the case of Mexican forests. The scientific knowledge of Mexican montane ecosystems is fragmentary, so it is necessary to promote the preservation of this fragile habitat and to study its diversity, characterized by the existence of species with relictual distribution, in small restricted range populations.

In the last decades, the value of temperate habitats due to the products generated in them and the ambiental services that they produce has been emphasized. These ecosystems are highly associated with water capture and timber production, making them their conservation essential (Luna and Llorente 1993). Also, they represent the only habitat of many taxa (Peters 2003).

Gaston (1994) argued that most of the species that have small range sizes have increased probability of extinction due to chance alone. This is especially true for the 'highly restricted' endemic species, such as those that inhabit the Mexican cloud forest ecosystems, e.g. species of *Magnolia*, *Ceratozamia*, *Clethra*, *Styrax*, *Symplocos*, *Cleyera*, *Ternstroemia*, and *Meliosma*, among plants; *Sorex stizodon* (Insectivora), and *Megadontomys thomasi*, *Habromys chinanteco*, *H. lepturus*, *H. ixtlani*, *H. simulatus*, and *H. delicatulus* (Rodentia) among mammals (*Habromys* and *Megadontomys* are genera restricted to Mesoamerican cloud forests, Livia León, personal communication); *Pharomachrus mocinno*, *Oreophasis derbianus*, *Aspatha gularis*, *Tangara cabanisi*, and *Cyanolyca nana*, among birds (Adolfo Navarro, personal communication); some lizards of the *Anolis schiedii* group (*A. naufragus*, *A. schiedii*, *A. cymbops*, *A. polyrhachis*, *A. cuprinus*, *A. hobartsmithi*, *A. matudai*), and some of the genus *Xenosaurus* (*X. grandis*, *X. newmanorum*, and an undescribed species of the Sierra de Juárez of Oaxaca), and several frogs of the *Hyla bistincta* group among reptiles and amphibians (Adrián Nieto, personal communication); all of these taxa are examples of species with small ranges that are mostly represented by relatively few individuals within those ranges. In this sense, Mexican cloud forests act as centers of endemism, zones characterized by the co-occurrence of species with small ranges, so their conservation is very important.

The Mexican cloud forest is a highly fragmented vegetation type and it has great importance for the survival of many of the species studied. Since many of the patches of this vegetation type are not protected by any reserve system, their case becomes critical since agriculture and animal husbandry expansion are constant threats.

For many of the species studied herein there are no detailed population genetics and demographic studies, so we cannot say much about their population regeneration and other issues; these processes depend strongly on habitat maintenance. This is especially true in cloud forest habitats, where several species are restricted to canyons and shadow and humid microhabitats. Mexican montane forests have high species turnover from one site to another within a vegetational zone, mainly due to habitat heterogeneity and also to the adjacent vegetation types, mainly with the tropical deciduous forest and pine and oak forests, that increase strongly their overall richness.

In the case of cycads, habitat destruction and illicit trade are the main facts that have reduced their populations. Another biological problem is related to their pollination, as in the case of both species of *Zamia*. Sosa et al. (1998) suggested that their slow seed production was due to inadequate pollination. This is not a general rule in Mexican Zamiaceae; our observations in the wild of female cones and seeds of *Ceratozamia mexicana* in Hidalgo and Querétaro suggest that this species has an adequate seed production. Some additional suggestions for the collection of cycad specimens include only the collection of one or few leaves and, if necessary, just one strobilus, avoiding the collection of stems. It is also important to prevent frequent and exhaustive collections in a single population as was suggested by Stevenson (2001).

Some of the species studied here inhabit inaccessible sites with rough topography, and have high probabilities of becoming extinct in the near future, due to their small population size and poor regeneration. Large areas of cloud forests are now converted into plantations, mainly of coffee, bananas, oranges, beans, and corn. In Mexico, as in other countries, the conversion of cloud forests into pastures has stimulated the modification of the forest structure, resulting in a smaller biomass and lower diversity.

Most of the collection localities of these species are not included in any Mexican protected area. Available data show that restricted species inhabit one or two protected areas, and just in these cases we can suppose that their populations are protected. We conclude that, in a general sense the species studied, mainly those with restricted distributions, are underrepresented in the current Mexican System of Natural Protected Areas. In addition, the majority of these species have several problems that affect their natural populations, and for these reasons require special policies and programs for their conservation.

We consider that both type of areas (with a great concentration of species and with a high concentration of restricted species) should be proposed as potential areas for conservation, and therefore must be implemented and considered in future national conservation plans, based on the restricted and relictual areas of distribution of many species. This is important, because many of these species occur in areas not currently protected, which is an important reason to maintain and protect the areas where these species are grouped.

Some of the areas inhabited by these species, mainly Misantla and Villa Emiliano Carranza, in the state of Veracruz, and Morelia, in the state of Michoacán are not protected by any Reserve System, so the populations that inhabit those areas are in constant danger of extinction. In addition, many of them are located in very disturbed sites and are submitted to edge effects in the sense of Murcia (1995). The high richness of these species is concentrated in eastern Mexico, in the Sierra Madre Oriental floristic province *sensu* Rzedowski (1978), mainly in the Zacualtipán area, where 14 of the 24 species studied in this work occur. The next richest areas also located in eastern Mexico, are Molango, Misantla and Xalapa, with 12 species each.

Based on the information obtained, we propose the next conservation strategies for these species: (1) to promote demographic and ecological studies in order to determine if their risk category in the 'Norma Oficial Mexicana 059' agree with recent observations at the field; (2) collection of seeds and vegetative propagation strategies for *ex-situ* conservation in botanical gardens, in order to maintain the germplasm of these plants for further reintroduction; (3) detection and proposal of other areas where these species inhabit can be included in a future conservation plan in the Mexican National Parks and Reserves System.

Many of the species studied here have very restricted distribution areas (Figure 3 and Table 1). The grid-cells where these species are concentrated are also important for conservation (e.g. Jacala, Misantla, Xalapa, Molango, and Zacualtipán). These findings allow the evaluation of the relation between the size of the area of each species studied (number of grid-cells where they are found) with the NOM-059 category in which they are included; for example, species as *Tilia mexicana* and *Litsea glaucescens* with a relatively "large" distributional areas are categorized as P (endangered), whereas other species as *Juglans pyriformis*, *Zamia fischeri*, *Bouvardia xylosteoides*, *Nopalxochia phyllanthoides*, *Bernardia mollis*, and *Ceratozamia kuesteriana*, all of them with very restricted distribution areas are included in the NOM-059 as Pr and A categories (with special protection and threatened respectively). With the information obtained in this work, we suggest a change of category based in their very restricted geographic distributions and their low representation in the current Mexican National Parks and Reserves System.

In this paper we suggest that it is more informative and operative to use small geographic units instead of using the Mexican states, in order to detect areas with high values of richness and endemicity, especially in the case of threatened taxa. The division of Mexico made by INEGI (1992) is an important matrix on which to make biogeographic analyses, because this system offers a standard format and minimal area units, which enable us to recognize better areas for conservation *in situ*. Analyses of this type are a foundation for other detailed studies in biogeography, applying other methods such as parsimony analysis of endemicity (PAE), track analyses, and cladistic biogeography.

The number of individuals and geographic distribution of the species studied must also be considered for designing conservation strategies. Shaffer (1987) affirmed that optimum survival of a species depends on both population size and time. Many of the species are represented by several hundred individuals, and few of these species apparently are producing seeds, whereas some of them probably regenerate by vegetative propagation (slips and cuttings); both strategies must be considered to be implemented in botanical gardens. *Podocarpus reichei*, *Ceratozamia mexicana*, and *Cupressus lusitanica* are candidates for reproduction by seeds.

Finally, integral studies of *Bernardia mollis*, *Nopalxochia phyllanthoides*, and *Bouvardia xylostoides* are necessary, in order to establish their possible inclusion in the IUCN Red Lists (2003) and in the Appendix of CITES, based on their restricted distribution, few populations and number of mature plants in the field. Many of the species included in these recent Red Lists are less endangered that those that we outline here. Also, it will be important to change the risk category of these three species in the NOM-059, based on the arguments offered above. Exploitation of many of the species studied here must be controlled, and included in the NOM-007-RECNAT-1997, to establish the proceedings, criteria and specifications for the use, transport and storage of foliage, leaves, flowers, seeds and fruits.

Acknowledgments

We thank Juan J. Morrone, Mark Olson, Jaime Jiménez, Carlos Ruiz Jiménez, Tania Escalante, and two anonymous reviewers who kindly made suggestions to this manuscript. Alberto González helped us obtain the coordinates of collection points. We are also indebted to the staff of the herbaria cited in the text for their courtesy during our review of their specimens. Support from projects CONABIO W025, PAPIIT IN206202, and FOSEMARNAT-2004-01-311 are gratefully acknowledged. RCM was supported by a Research Doctoral Fellowship number 169858 from the Consejo Nacional de Ciencia y Tecnología (CONACyT), Mexico.

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